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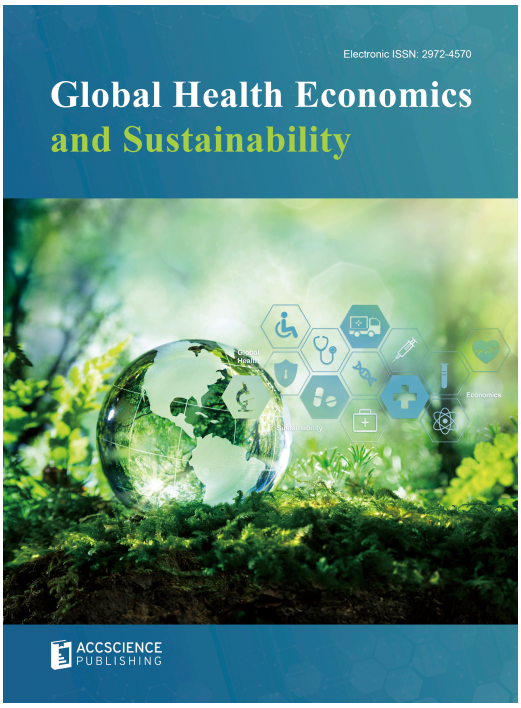


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GLOBAL HEALTH ECONOMICS AND SUSTAINABILITY

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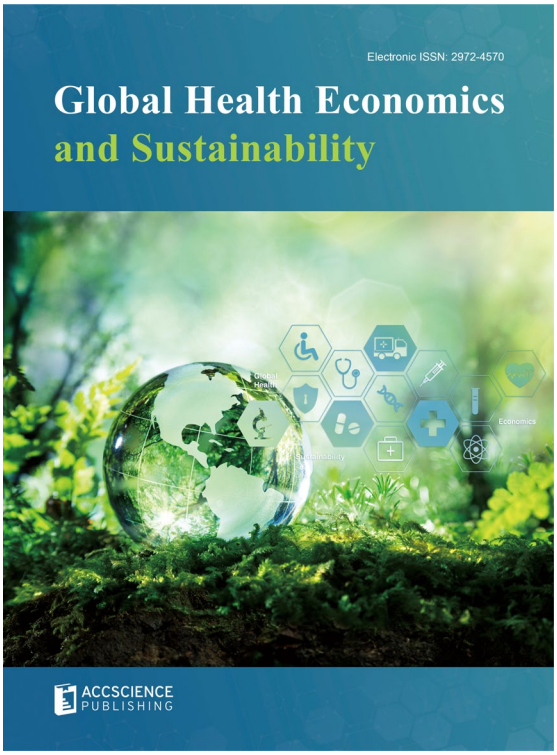
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Global Health Economics and Sustainability

REVIEW ARTICLE

Impact of energy consumption on life expectancy in lower-middle-income West African countries

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Abstract

Life expectancy is a key determinant of a nation's health and well-being. However, West African countries face several challenges in improving life expectancy, such as inadequate healthcare infrastructure, corruption, poor sanitation, and environmental quality due to environmental degradation. In addition, energy accessibility is an important determinant of health outcomes and environmental quality. The United Nations' Sustainable Development Goals 7, 12, 13, 14, and 15 are directly linked with energy access; achieving these goals will lead to an improvement in energy access. Therefore, in this study, using data obtained from the World Bank and the Central Bank of Nigeria Statistical Bulletin, we investigated the impact of energy consumption and corruption on life expectancy in lower-middle-income West African countries from 1990 to 2021. The results of the cross-sectional auto-regressive distributed lag technique showed that renewable energy has a positive and significant impact on life expectancy in lower-middle-income West African countries in both the short and long run. However, non-renewable energy was found to have a significant and negative impact on life expectancy in the long run and a negative but non-significant impact in the short run. Corruption had a debilitating effect on life expectancy in both the short and long run. We recommend that policymakers should make a conscious and deliberate push toward transitioning to renewable energy through public–private partnerships to provide affordable and clean energy while tackling corruption.

Keywords: Life expectancy; Non-renewable energy; Healthcare; Renewable energy; Corruption

1. Introduction

Life expectancy is a key indicator of the overall health and well-being of a country. West African countries face several challenges towards improving life expectancy, such as inadequate healthcare infrastructure, poor environmental quality, poverty, and infrastructure deficiency. Dutta & Williamson (2019) found that limited access

to healthcare, the incidence of infectious diseases, malnutrition, poor maternal and child health, limited education, poverty, political instability, weak infrastructure, lack of healthcare funding, inadequate sanitation, and economic crises are major challenges to improving life expectancy in West African countries. In 2021, life expectancy in some West African countries was relatively low; life expectancy in Nigeria, Ghana, and Ivory Coast (Côte d'Ivoire) was approximately 54.4, 64.4, and 57.5 years, respectively. According to Weitensfelder *et al.* (2024), the average life expectancy globally was 70 years for men and 75 years for women, whereas the average life expectancy at birth across Africa was 61 years for men and 65 years for women. However, these rates vary considerably across countries and regions due to diverse social, economic, and healthcare conditions. Improvements in healthcare infrastructure, access to education, economic development, and disease control measures lead to improvements in life expectancy.

Some West African countries have made efforts to increase life expectancy through improvements in healthcare, education, and economic development (World Health Organization, 2021). To further address the challenges involved in improving life expectancy in West Africa, environmental quality must be improved. For this reason, this study focused on energy consumption. The International Energy Agency (IEA, 2020) states that energy consumption is vital for improving living standards because it facilitates access to modern amenities and services. Reliable access to electricity enhances healthcare infrastructure by allowing continuous functioning of essential services, such as vaccine refrigeration, lighting for surgeries, and the operation of medical equipment (World Health Organization, 2021). Moreover, clean cooking fuels reduce air pollution in homes, thereby substantially reducing premature deaths caused by respiratory diseases, especially among children and women (Smith *et al.*, 2014).

Therefore, it can be inferred that energy accessibility is an essential determinant of well-being and health. Energy inaccessibility can lead to low living standards due to inadequate lighting and heating, which negatively affect health. Similarly, energy inaccessibility can hinder clean water access, thereby increasing the risk of diseases (Kandpal *et al.*, 2018). The World Health Organisation (2017) states that energy production/consumption is a significant contributor to greenhouse gas emissions, accounting for approximately 76% of global greenhouse gas emissions in 2020. The combustion of fossil fuels generates various pollutants and greenhouse gases, which contribute to global warming and climate change. Environmental degradation has been shown to be associated with a decrease in health quality, manifesting as increased neonatal and maternal mortality rates and low life expectancy, among other issues (Matthew *et al.*, 2018).

Understanding the connection between energy use and life expectancy in lower-middle-income countries in West Africa is important for policymakers and stakeholders when designing effective strategies for sustainable development and improving public health outcomes. West Africa comprises a diverse group of countries with varying levels of economic development, energy infrastructure, and healthcare systems. Lower-middle-income countries in West Africa face numerous challenges in meeting their energy demands, such as limited access to electricity, reliance on traditional biomass fuels, and inadequate energy infrastructure. These factors contribute to energy poverty and hinder socioeconomic progress, including healthcare advancements. There is considerable environmental degradation in Africa, leading to poor health status, despite the abundance of renewable energy resources. Africa's primary energy source is fossil fuels. Countries in West Africa are energy inefficient, which impedes their ability to achieve the Sustainable Development Goals of the United Nations (Chaabouni & Saidi, 2017; Destek & Aslan, 2017). According to the World Resource Institute (2020), in sub-Saharan Africa, contagious and airborne diseases remain a major cause of mortality, especially among children.

West Africa depends on natural gas and crude oil as energy sources. For example, Nigeria and Ghana depend on fossil fuels for electricity generation. According to Aderinto (2023), approximately 77% of electricity in Nigeria was generated using fossil fuels in 2018, which accounted for approximately 70% of West Africa's carbon dioxide (CO_2) emissions. Fossil fuel combustion produces CO_2 emissions, which significantly contribute to climate change (Sharma, 2017). In recent years, West Africa has experienced increasingly erratic weather conditions. The coastlines of Senegal, Togo, Benin, and Côte d'Ivoire have been ravaged by coastal degradation and erosion (UNFCCC, 2020). Energy inaccessibility has hindered the functioning of healthcare facilities, such as carrying out life-saving operations and vaccine storage (Franco *et al.*, 2017). Energy accessibility is essential for improving the standard of living, increasing longevity, and providing adequate healthcare services in developing countries (Lambert *et al.*, 2014). However, to increase energy accessibility and transition, effective governance, strong institutions, and a reduction in corruption are necessary.

Mackey & Liang (2012) argue that corruption in healthcare affects both developing and developed countries. According to Mackey & Bryan (2012),

corruption has two distinct forms: corruption with and without theft. In corruption without theft, a healthcare provider charges a government-approved fee for medical care and an additional fee (i.e., a bribe). The medical officer retains the bribe and remits the approved fee to the government treasury. This practice increases the cost of medical services and decreases output. In corruption with theft, the medical service provider receives the prescribed medical fee but fails to remit it to the government treasury and keeps it for himself. This practice decreases the cost of medical services because the provider keeps all the money for himself. This practice tends to reduce the quality and efficiency of medical services. Thus, corruption without theft decreases the quantity of medical services, and corruption with theft decreases the quality of medical services. Both forms of corruption have a negative impact on overall health outcomes, such as child mortality rates and life expectancy.

Cross-country and country-specific studies have been conducted to examine the connection between energy consumption and life expectancy in Africa. A few scholars have also investigated the impact of corruption on life expectancy in country-specific studies. For example, in a cross-country study, Weitensfelder *et al.* (2024) used generalized additive and non-linear models to investigate the effects of energy consumption, energy distribution, and clean energy on life expectancy and found that per capita energy consumption positively affects life expectancy. Similarly, Sargentis *et al.* (2021a) showed that energy production and consumption are positive indicators of life expectancy. In a cluster of 16 West African countries, Youssef *et al.* (2015) found that energy use positively affects health indicators. Similarly, Agbanike *et al.* (2019) found that life expectancy in Africa is negatively affected by energy consumption. Akokuwebe & Adekanbi (2017) examined how corruption impedes service delivery in relation to the distribution of drugs and how it affects mortality (12.7 deaths/1000 population) in Nigeria. However, these studies have overlooked the impact of differing levels of income or heterogeneity in income levels on the ability of countries to transition to clean energy. Income level has been shown to be a major determinant of energy consumption, which determines the standard of living (Weitensfelder *et al.*, 2024). Therefore, the impact of energy consumption on life expectancy in low-income countries may differ from that in high- and lower-middle-income countries, just as it differs between developing and developed countries. The 2019 World Bank Report grouped countries into four categories according to income level: high, upper-middle, lower-middle, and low-income countries. There are 16 countries in West Africa: Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, The Gambia, and Togo. Of these, Cabo Verde, Cote d'Ivoire, Ghana, Mauritania, Nigeria, and Senegal are classified as lower-middle-income countries. In this group of countries, Weitensfelder *et al.* (2024) found that there is a correlation between renewable energy and life expectancy and that this correlation is higher in high-income groups than in other income groups. Therefore, investigating the impact of energy consumption on life expectancy without considering the differences in income levels of different countries can yield misleading results. Instead of categorizing countries based on income level, this study examined whether energy consumption and corruption affect life expectancy in lower-middle-income countries, in West Africa from 1981 to 2021 and excluded high- and low-income countries. This study answered the following research questions. What is the impact of renewable energy on life expectancy in lower-middle-income countries in West Africa? How do non-renewable energy and corruption affect life expectancy in lower-middle-income countries in West Africa?

2. Literature review

2.1. Theoretical literature

The IEA (2020, p. 2) defines energy poverty as an "absence of sufficient choice in accessing adequate, affordable, reliable, quality, safe, and environmentally sound energy services to support development." It further defines energy poverty as the "lack of access to modern energy services, such as electricity and clean cooking facilities, which do not cause indoor air pollution." Figure 1 presents the framework for addressing the electricity access deficit in Africa and identifies barriers to energy accessibility. The energy sector can transform economies (by improving access to healthcare facilities and, ultimately, life expectancy) if these barriers are eliminated.

Figure 2 presents the energy ladder proposed by Choumert *et al.* (2017), which is a series of steps taken by households when transitioning from inefficient energy sources (traditional/transition fuels) to efficient energy sources (modern energy). Matinga *et al.* (2013) and Nthabiseng *et al.* (2018) showed that modern energy use improves healthcare, saves energy costs for healthcare providers, and allows households and healthcare providers to engage in other activities by freeing up their time. Therefore, as countries move up on the energy ladder, their life expectancy improves.

Nthabiseng *et al.* (2018) found that households and healthcare providers in developing countries use unclean energy sources and that energy users in Africa combine two or more energy sources (i.e., traditional and modern)

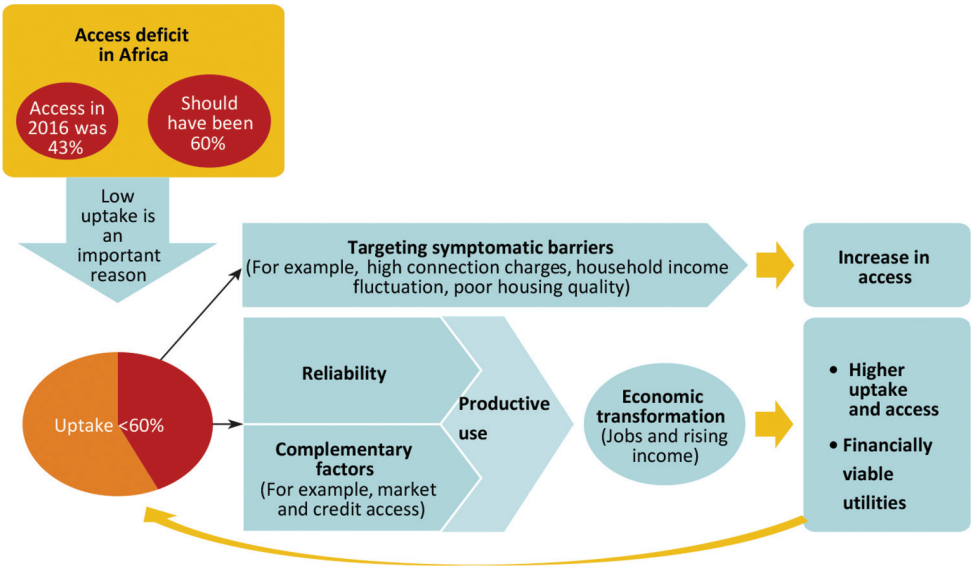


Figure 1. A framework for addressing the electricity access deficit in Africa
Source: Blimpo & Cosgrove-Davies (2019).

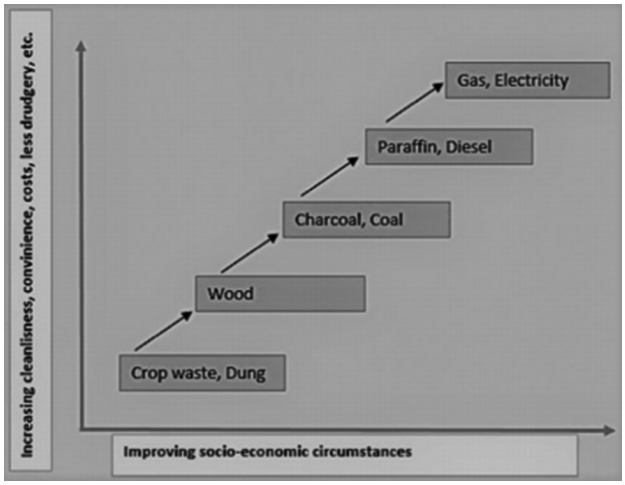


Figure 2. Energy ladder
Source: Choumert *et al.* (2017).

to satisfy their energy needs (Figure 3). While some high-income households, healthcare providers, and enterprises can use efficient energy sources (electricity and solar energy), most households cannot do so due to the costs involved, forcing them to continue using unclean energy sources (fossil or transition fuels) and, thus, leading to environmental degradation and higher health risks. Therefore, discussions on the life expectancy – energy consumption nexus in developing countries must take into account energy-stacking strategies (Figure 3) to improve health conditions and general well-being. However, these strategies are firmly rooted in income levels, which previous empirical studies have overlooked.

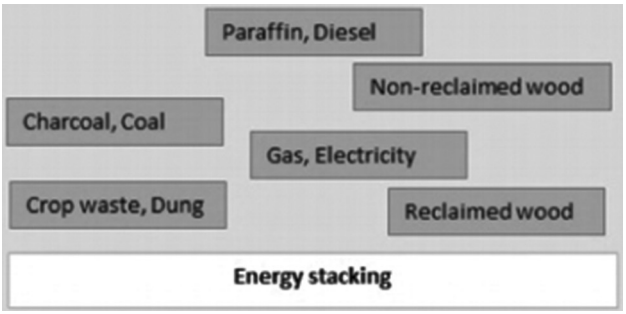


Figure 3. Energy stacking
Source: Nthabiseng *et al.* (2018).

2.1.1. Environmental sustainability within the neoclassical economic framework

Boulding (2013) and Dragulanescu & Dragulanescu (2013) theorized that an economic system is divided into two major interdependent components. First, the economic system, or the real economy, is where scarce resources are optimally allocated and value creation is undertaken. Corruption can derail the optimal allocation of scarce resources. Second, the environment supports life on earth and connects the ecosystem with the real economy. Environmental sustainability theory further acknowledges that the real economy is a sub-system that functions effectively only when it is supported by the environment. This imposes the need to balance the real economy and the environment to ensure the sustainability of both systems.

Michael Grossman's theory of healthcare demand (Grossman, 1972) is also relevant to this study. This theory

provides a framework to understand the interactions between environmental factors and human health. It is based on several key assumptions that guide its application and interpretation. In the context of environmental health, one prominent assumption is that the environment influences health outcomes to a large extent (Gatz *et al*., 2020).

2.2. Empirical literature

Empirical studies (regional, international, cross-country, and country-specific) on whether energy consumption affects life expectancy are reviewed below.

2.2.1. Cross-country studies in Africa

Using panel data from 16 African countries, Youssef *et al.* (2015) investigated the causal relationship between energy consumption and health indicators from 1971 to 2010. The study found that there is a strong causal relationship between energy consumption and health outcomes in several African countries and this causal relationship is unidirectional flowing from electricity consumption to health outcomes. Using autoregressive distributed lag (ARDL), Agbanike *et al.* (2019) extended the study of Youssef *et al*. (2015) to examine the link between energy consumption and life expectancy in Africa from 1971 to 2014; they found that although energy consumption significantly improves life expectancy in Africa, it also generates CO_2 emissions that diminish life expectancy in the long run. Aderinto (2023) further explored the connection between energy consumption and health outcomes in West African countries using pooled mean group and ARDL and found that in the short run, non-renewable energy has a negative effect on life expectancy while renewable energy has a positive and significant effect.

2.2.2. Cross-country studies in other regions

Using generalized additive proportional hazards and nonlinear models, Weitensfelder *et al.* (2024) investigated the effect of energy consumption, energy distribution, and clean energy use on life expectancy and found that a certain level of wealth and energy use is necessary for health and well-being; however, beyond a specific threshold, additional energy consumption has no beneficial effects. They further showed that life expectancy and per capita energy consumption increase over time but the increase is more pronounced for life expectancy. The approach used by Weitensfelder *et al.* (2024) is typical of the approach used by studies conducted in developed countries. Per capita energy consumption increases with life expectancy as most developed countries use cleaner energy than what is used in West African countries (i.e., fossil fuels and traditional biomass). Aderinto (2023) demonstrated that disaggregating energy use into renewable and non-renewable energy use is essential when analyzing African countries; lumping them together will yield deceptive results as the transition to renewable energy use in Africa is slow. Using fixed effects and threshold models, Wang *et al.* (2023) examined whether renewable energy improves life expectancy in 121 countries worldwide. They revealed that renewable energy positively affects life expectancy; however, the impact of renewable energy on life expectancy varies across different income levels. Using cross-sectional ARDL, Polcyn *et al.* (2023) examined whether energy consumption improved life expectancy from 1997 to 2019 in 46 Asian countries. They found that an increase in healthcare spending and energy use results in improved health outcomes in the long run and that CO_2 emissions are detrimental to health. They concluded that increasing health spending, energy consumption, and long-term economic growth will improve health outcomes. Using the Driscoll-Kraay standard error technique, Ebhota *et al.* (2023) investigated the impact of renewable energy consumption, air pollution, and economic development on life expectancy in Mexico, Indonesia, Nigeria, and Turkey; they found a positive and significant relationship between renewable energy consumption and life expectancy with a one-way causation – from renewable energy consumption to life expectancy. In contrast, in a panel study of emerging Asian economies, Anser *et al.* (2022) investigated the impact of energy use, economic activities, and greenhouse gas emissions on health outcomes from 1995 to 2018; they found that fossil fuel consumption and natural resource depletion harm human health while the use of efficient energy improves health outcomes. Sargentis *et al.* (2021a) examined the water–energy–food nexus and land development in Thessaly Plain, Greece; they found that energy use is strongly correlated with life expectancy and per capita gross domestic product (GDP). They further observed considerable inequalities in per capita energy use among countries. For instance, in countries with high GDP, transport and heating account for the largest share of energy use, whereas in countries with low GDP, cooking accounts for the largest share of energy consumption. This finding strongly suggests that income level is an important factor in the nexus between energy consumption and life expectancy. In another study, Sargentis *et al.* (2021b) showed that technological development positively correlates with increased inequality. However, technological development also offers a better and longer life to all community members. Therefore, an increase in technological advancement comes with an increase in energy consumption, which affects quality of life. They asserted that GDP per capita positively correlates with energy consumption; thus, GDP per capita can be expected

to exhibit the same pattern of behavior with life expectancy as per capita energy use is a good substitute for income. This conclusion is in line with that of Ostwald (1909), who observed that energy consumption correlates with life expectancy. Therefore, Sargentis *et al.* (2021a) concluded that energy production and consumption are strong and positive indicators of life expectancy.

2.2.3. Country-specific studies

Using ARDL, Jebbin & Adebisi (2023) examined the energy consumption–life expectancy relationship in Nigeria; they found that per capita electricity consumption and income per capita improve life expectancy, whereas fossil fuel, alternative, and nuclear energy negatively affect life expectancy. Similarly, Akintunde *et al.* (2021) investigated the energy consumption–life expectancy nexus in Nigeria from 1980 to 2017; they found that life expectancy decreases further when energy consumption interacts with poverty. This finding reinforced the notion that an increase in income is essential for increasing energy consumption and explained the continued use of fossil fuels by poor households. This result clearly shows that as the majority of people in Africa live below the poverty line, they would be adjudged energy-poor and consequently have low life expectancy. Using ARDL, Ezeh *et al.* (2020) examined the nexus between household electricity consumption and life expectancy; they found that household electricity consumption significantly and positively affects life expectancy.

Using ARDL, Omolua *et al.* (2023) investigated the nexus between corruption and life expectancy in Nigeria; they found that corruption has a significant and positive effect on life expectancy in Nigeria and recommended stringent measures to tackle corruption. This finding seemingly suggests that corruption is good for health outcomes, but their recommendations contradict the findings. Akokuwebe & Adekanbi (2017) examined how corruption impedes service delivery in relation to the distribution of drugs and how it affects mortality in Nigeria in 2016.

A critical assessment of the abovementioned empirical studies, especially cross-country studies, shows that these studies lumped all countries together irrespective of their income level. Qiang *et al.* (2023) showed that the renewable energy–life expectancy relationship varies with different income levels, therefore, the energy consumption–life expectancy nexus cannot be meaningfully determined while overlooking the level of development or income of the countries being studied. Therefore, this study used the World Bank country grouping based on income: low, lower-middle, upper-middle, and high-income countries to fill this gap in the literature.

3. Methodology

3.1. Theoretical framework

The energy consumption–life expectancy nexus has been investigated through the framework of Grossman's theory of healthcare demand. In this model, health is viewed as a form of capital in which individuals can invest. Health capital is accumulated through investments in factors, such as medical care, preventive measures, and a healthy lifestyle. The theoretical foundation of the present study is Grossman's theory of healthcare demand. The theory is relevant in optimizing health outcomes through the allocation of resources. The model is stated as follows:

$$H = F(Xt) \tag{3.1}$$

where H represents health outcome, and X is a vector of individual inputs in the health production function (i.e., energy consumption, GDP per capita, corruption perception index, health expenditure, and food production). The functional relationship among the variables is stated as follows:

$$LEXP = f(REC, NRE, GDPpc, HEXP, CPI, FP) \tag{3.2}$$

Equation 3.2 implies that life expectancy (LEXP) is a function of renewable energy consumption (REC), non-renewable energy consumption (NREC), GDP per capita (GDPpc), health expenditure (HEXP), corruption perception index (CPI), and food production (FP). The linearized form of Equation 3.2 is as follows:

$$LEXP = \beta_0 + \beta_1 REC + \beta_2 NREC + \beta_3 GDPpc + \beta_4 HEXP + \beta_5 CPI + \beta_6 FP + \mu_1$$

where *LEXP* denotes life expectancy at birth. *REC* denotes renewable energy consumption, *NREC* denotes non-renewable energy consumption, *GDPpc* denotes GDP per capita, *HEXP* denotes government health expenditure, *CPI* denotes the corruption perception index, and *FP* denotes food production. μ is the disturbance/error term. β_0 is a constant, and β_1, β_2, β_3, and β_4 are parameters to be estimated. GDP_{PC}, *CPI*, *FP*, and *HEXP* were added to the model as control variables for life expectancy.

3.2. Estimation technique

CS-ARDL was used in this study because this method overcomes the issue of endogeneity and cross-sectional dependence in our dataset.

3.3. *A priori* expectation

$LEXP/REC > 0$, $LEXP/NREC < 0$, $LEXP/GDPpc > 0$, $LEXP/HEXP > 0$, $LEXP/CPI < 0$, $LEXP/FP > 0$.

Except *CPI*, which is expected to have a negative relationship with *LEXP*, all of the other variables are expected

to have a positive relationship with *LEXP*. A panel ARDL model was used to estimate the results. Pre-test analyses, such as descriptive analysis, unit root test, and cointegration test were conducted to obtain the time series and descriptive properties of the data and avoid spurious estimates.

4. Analysis and interpretation

4.1. Results of the stationarity test

Table 1 presents the results of the augmented Dickie–Fuller (ADF) test comprising Fisher's Chi-square and Choi Z-statistics at 5% critical value.

Decision rule: Reject the null hypothesis (H_0) if the probabilities obtained from Fisher's Chi-square and Choi Z-statistic are greater than what is obtained from the ADF test at the 5% significance level; otherwise, accept H_0. Table 1 shows that at the first difference, the probability values of *LEXP*, *REC*, *NREC*, *GDPpc*, and *FP* obtained from Fisher's Chi-square and Choi Z-statistic were significant at less than the 5% significance level. Therefore, we rejected H_0 of *LEXP*, *REC*, *NREC*, and *FP* and accepted H_1, meaning that the variables at first difference were stationary. Furthermore, the probability values of *HEXP* and *CPI* obtained from Fisher's Chi-square and Choi Z-statistic were less than the 5% significance level. Therefore, we rejected H_0 of *HEXP* and *CPI* and accepted H_1 in that they have no unit root problems and are integrated at order zero.

4.2. Panel ARDL cointegration test

Pesaran *et al.* (2001) developed the ARDL to estimate relationships among variables. ARDL is used when the data series are stationary at level I(0), first difference I(1), or both. It can also verify if the time-series data exhibit cointegration. Table 2 shows that H_0 of no cointegration among the variables was rejected because the probability value was less than the 5% significance level.

It was confirmed that there is a long-run relationship between the dependent and independent variables; hence, we next estimated the long- and short-run results.

4.3. Evaluation of estimates

Table 3 presents the long- and short-run results of the ARDL model.

4.4. Discussion

Panel A of Table 3 shows that *REC* in lower-middle-income West African countries significantly and positively affected life expectancy in the long run. This implies that efficient/modern energy sources are not detrimental to the environment as they do not emit harmful pollutants. A greater reliance on renewable energy would result in reduced air pollution and improved air quality, leading to a lower incidence of health-related problems. This may increase life expectancy as clean air promotes better respiratory health. Several communities, especially in the developing world, lack reliable access to electricity. Transitioning to renewable energy can provide these communities a more consistent and affordable energy supply, positively affecting healthcare, education, sanitation, and overall quality of life. Better access to energy can lead to improved healthcare facilities, better refrigeration for vaccines and medicines, and enhanced communication

Table 1. Results of the panel unit root (ADF) test

Variables	ADF Chi-square & ADF Z-statistis at level	Prob.	ADF Chi-square & ADF Z-statistic at level	Prob.	Order of integration	Remarks
LEXP	3.48817 1.45025	0.9675 0.9265	5.22091–4.20572	0.00002 0.00005	1 (1)	Stationary
REC	4.29591 1.47421	0.9330 0.9298	45.7701–4.96379	0.00003 0.00007	1 (1)	Stationary
NREC	10.7879–0.79912	0.3743 0.2121	44.6879–5.63088	0.00006 0.00004	1 (1)	Stationary
GDPpc	9.93549–0.52612	0.4462 0.2994	47.9049–5.19037	0.00008 0.00002	1 (1)	Stationary
HEXP	16.0301–1.72279	0.0188 0.0425			1 (0)	Stationary
CPI	18.7265–2.21565	0.0439 0.0134			1 (0)	Stationary
FP	5.47272 1.61847	0.8815 0.9472	42.3002–4.56944	0.00002 0.00004	1 (1)	Stationary

Note: ADF: Augmented Dickie-Fuller. Source: Authors' computation, 2024, using Eviews 9. Abbreviation: GDP: Gross domestic product.

for medical services. These results corroborate those of Aderinto (2023) and Agbanike *et al.* (2019). They also confirm the findings of Qiang *et al.* (2023), who used the same estimation method to find that renewable energy has a positive and significant effect on life expectancy in 121 countries. In contrast, Noor & Cameron (2014) showed that wind turbines cause noise pollution and wildlife fatalities through collisions and take up a lot of space. Furthermore, Dunlap (2021, p. 91) observed that wind energy, acclaimed to be clean energy, "involves socially and ecologically destructive mining processes that produce large amounts of mining tailings (or waste) containing heavy metals, thorium and radioactive materials that go into the air, water, soil, animals, and people's bodies." This implies that there are drawbacks of renewable energy use, which must be guarded against. Even the recommendation of Weitensfelder *et al.* (2024), who called for energy efficiency and renewability as mitigating measures following a higher energy demand for economic growth, should be used with caution.

The results also revealed that the consumption of non-renewable energy (NREC) has a negative but non-significant relationship with life expectancy (LEXP). Although *NREC* negatively affects *LEXP*, the non-significance of the coefficient in the short run, shown in Panel B of Table 3, indicates that this effect does not manifest itself immediately. The long-run coefficient of *NREC* is significant, suggesting that its effects manifest themselves fully in the long run. This explains why the negative effect of non-renewable energy is not taken seriously and the sluggishness in embracing renewable energy. This finding is in line with that of Nkalu and Edeme (2019), who showed that life expectancy decreases due to the environmental effects of fossil fuels. Therefore, non-renewable energy consumption (NREC) is detrimental to longevity. The findings of Asgher *et al.* (2019) support this view in that non-renewable energy reduces environmental quality while increasing the mortality rate.

Indeed, increasing income (GDPpc) enhances life expectancy (LEXP). A higher GDP per capita enables governments to invest more in healthcare infrastructure, facilities, and medical technologies. This leads to improved access to quality healthcare services for citizens, thereby improving healthcare outcomes and life expectancy. The coefficient of GDP_{PC} was positive and non-significant in the short run. Although this conforms with our *a priori* economic expectation, it is rather surprising that this coefficient was not statistically significant. This is mainly because while the population of West African countries grows geometrically, their ability to produce output/

Table 2. ARDL cointegration test results

Variable	Coefficient	Std. error	t-statistic	Prob.
COINTE01	−0.310638	0.009827	−3.082517	0.0043

Source: Authors' computation, 2024 using Eviews 9.
Abbreviation: ARDL: Autoregressive distributed lag.

Table 3. ARDL long- and short-run results, dependent variable: *LEXP*

Variable	Coefficient	Std. error	t-statistic	*p*-value
Panel A: Long-run coefficients				
REC	0.624657	0.087810	7.113754	0.00002
NREC	−0.580912	0.083661	−6.943649	0.00003
GDP_{PC}	0.006412	0.000561	11.43314	0.00006
HEXP	6.600008	0.596038	11.07313	0.00002
CPI	−28.86016	2.135960	−13.51156	0.00001
FP	0.002898	0.010621	−0.272894	0.78610
Panel B: Short-run coefficients				
D (*REC*[−2])	0.147074	0.074008	1.987288	0.05250
D (*NREC*[−1])	−0.091490	0.060392	−1.514943	0.13620
D (GDP_{PC}[−1])	0.000230	0.000275	0.837404	0.40640
D (*HEXP*)	0.032988	0.072610	0.454322	0.65160
D (*CPI*[−2])	−0.199786	0.097450	2.050131	0.04570
D (*FP*[−2])	0.014632	0.005544	2.639065	0.01110
ECT = −0.*310638*	R^2=0.67833	Ad-R^2=0.55495	DW=1.932502	

Note: ECT: Error correction term; DW: Durbin-Watson; R2: R squared; Ad R2: Adjusted R2. Source: Authors' computation, 2024 using Eviews 9.
Abbreviations: ARDL: Autoregressive distributed lag; GDP: Gross domestic product.

income grows arithmetically. Therefore, GDP per head or per capita may not have a significant impact on improving the lives of most citizens in West Africa. For instance, even though Nigeria is rich in natural and human resources, it is one of the world's poorest nations. In contrast, the long-run coefficient of GDPpc was significant and positive; suggesting that economic growth considerably affects livelihoods when it is allowed to trickle down. This finding is in line with those of Acemoglu & Johnson (2007), Sargentis *et al.* (2021a), and Weitensfelder *et al.* (2024) who showed that an increase in income due to higher GDP per capita is associated with better healthcare access and outcomes. These findings support the fact that aggregating countries with differing income levels to determine the nexus between energy consumption and life expectancy can yield misleading results. This finding also resonates with the finding of Sargentis *et al.* (2021a), who showed that GDP per capita positively correlates with energy consumption and, thus, exhibits the same pattern of behavior with life expectancy.

The long-run coefficient of *HEXP* showed that it had a positive and significant effect on *LEXP* in lower-middle-income countries in West Africa. This implies that investing in healthcare can have profoundly positive effects on the overall well-being and longevity of a population. Although the impact may not be evident in the short run, as indicated by the non-significance of the parameter estimate, it will become evident in the long run as shown by the significant long-run estimates. However, achieving the best outcomes requires both increased spending and efficient allocation of resources. Higher health expenditure often leads to increased access to healthcare services, such as medical treatments, preventive measures, and screenings. This can result in better management of diseases and conditions, early detection of health issues, and more timely and effective interventions, all of which contribute to longer and healthier lives. Increased health expenditure also depends on an increase in income level.

CPI and *LEXP* have a negative and significant relationship both in the short (Panel B, Table 3) and long run (Panel A, Table 3). One major implication of this negative relationship is the potential adverse impact on public health and healthcare systems. Corruption within the healthcare sector can lead to misallocation of resources, embezzlement, and poor infrastructure, resulting in inadequate access to quality healthcare services. CMI (2008) highlighted that corruption in healthcare systems can compromise the delivery of essential medical services, leading to reduced life expectancy due to preventable diseases and lack of proper medical care. Moreover, the negative correlation between *CPI* and *LEXP* also points to broader governance issues in a country. High levels of corruption often signify weak governance, lack of accountability, and ineffective institutions. These conditions can hinder economic development and reduce living standards, affecting health outcomes and life expectancy. Rose-Ackerman (1999) emphasized that corruption erodes trust in the government and institutions, resulting in reduced public investments in crucial sectors, such as healthcare, further exacerbating public health challenges. The negative relationship between *CPI* and *LEXP* underscores the interconnectedness of corruption, governance, and public health. It highlights the urgent need for comprehensive anti-corruption measures and governance reforms to ensure efficient allocation of resources, improved healthcare access, and enhanced societal well-being. Addressing corruption positively affects governance and contributes to long and healthy lives for citizens.

Finally, *FP* has a negative but non-significant relationship with *LEXP*. A positive relationship between food production and life expectancy indicates that the distribution and accessibility of food are essential considerations for an improved and healthy life. However, even if food production increases, it does not necessarily mean that all segments of the population have equal access to nutritious and sufficient food. Thus, the impact of an increase in food production would be marginal. An increase in income makes access to food possible; poverty diminishes this access. Devereux (2007) found that food security, which includes both availability and accessibility, is critical in ensuring positive health outcomes and increasing life expectancy. In addition, the non-significant relationship highlights the importance of nutritional quality over quantity of food. Darmon & Drewnowski (2015) underscored that the nutritional composition of food, or a balanced diet, is essential for preventing diet-related diseases and improving longevity. Thus, merely increasing food production without considering nutritional value may not translate into significant improvements in life expectancy. The positive aspect of the relationship, even though non-significant, suggests that food production contributes positively to overall well-being. Adequate food availability is a baseline requirement for basic health and human survival. While other factors may have a strong influence on life expectancy, a steady food supply remains a fundamental necessity. In contrast, Sargentis *et al.* (2021b) showed that living prosperously (quality of life) is associated with higher caloric supply, which is in line with our *a priori* economic expectation. This may be true for many developed countries but not for developing countries.

5. Conclusion and recommendations

5.1. Conclusion

The study extended the literature by aggregating countries in West Africa with similar income levels to explore the energy consumption–life expectancy relationship and the role played by corruption on life expectancy. This aggregation was performed because we consider income to be a major determinant of the ability to transition from unclean to clean energy sources. Therefore, aggregating countries with different income levels may yield misleading results. As such, this study concentrated on lower-middle-income countries in West Africa. The results showed that renewable energy consumption has a significant and positive impact on life expectancy both in the short and long run. In contrast, non-renewable energy consumption has a significant and negative impact on life expectancy in the long run. These results are instructive. The negative consequences of non-renewable energy consumption do not readily manifest in the immediate term but their devastating effects will manifest themselves in the long run, by which time considerable damage would have been done to the environment and human health. The positive relationship between renewable energy consumption and life expectancy explains the clamor for energy transition. While this energy transition is progressing steadily in many developed countries, Africa lags far behind. Furthermore, corruption was implicated as a significant factor in diminishing life expectancy both in the short and long run. This finding strongly suggests that the gains from high income could dissipate due to corruption, slowing down the transition to renewable energy and the consequent deterioration in health from prolonged use of non-renewable energy. Therefore, we recommend that West African countries should embrace renewable energy and reduce the consumption of non-renewable energy to improve life expectancy. All forms of corruption should be tackled, especially in the healthcare sector. Finally, we recommend that as income is key to an improved life expectancy, policymakers should place an emphasis on pro-poor growth.

5.2. Recommendations

Given that renewable energy consumption has a positive and significant impact on life expectancy, we recommend that governments must move consciously and deliberately toward a transition to renewable energy use through partnerships with the private sector to provide affordable and clean energy. However, policymakers should not ignore the observation of Dunlap (2021) that "renewable energy also requires immense amounts of mineral and fossil fuel resources, both in the construction of machinery necessary for extraction and for the manufacturing, transportation, construction, and operation of industrial-scale 'renewable energy' systems." Moreover, wind energy also "involves socially and ecologically destructive mining processes that produce large amounts of mining tailings (or waste) containing heavy metals, thorium and radioactive materials that go into the air, water, soil, animals and people's bodies" (Dunlap, 2021). This implies that there are limits to renewable energy resources use.

As non-renewable energy consumption has a negative and significant effect on life expectancy, we recommend that policymakers provide a conducive business environment that is politically stable and provides effective governance and infrastructure to foster economic growth, reduce corruption, drive innovation, and consequently, improve access to energy.

The positive relationship found between GDP per capita and life expectancy underscores the intricate connection between economic development and health outcomes. It is important to improve living standards by raising the per capita income of the lower-middle-income West African countries. Policymakers should consider this relationship when formulating strategies for sustainable development that prioritize both economic growth and human health.

5.3. Study limitations

This study only investigated the impact of energy consumption and corruption on life expectancy in lower-middle-income countries in West Africa. The findings would be more robust if this study were extended to include low-income countries in West Africa as that would allow for a comparison between outcomes. This comparison would have enhanced the quality of this study.

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Conflict of interest

The authors declare they have no conflicts of interest.

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Ethics approval and consent to participate

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Availability of data

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References

Acemoglu, D., & Johnson, S. (2007). Disease and development: The effect of life expectancy on economic growth. *Journal of Political Economy,* 115(6):925-985.

https://doi.org/10.1086/529000

Aderinto, S. (2023). Energy Consumption, Environmental Quality and Health Nexus in West African Countries: Implications for Sustainable Development. Durham: Research Square, p.1-11.

https://doi.org/10.21203/rs.3.rs-3057950/v1

Agbanike, T.F., Nwani, C., Uwazie, U.I., Anochiwa, L.I., Onoja, T.G.C., & Ogbonnaya, I.O. (2019). Oil price, energy consumption and carbon dioxide (CO_2) emissions: Insight into sustainability challenges in Venezuela. *Latin American Economic Review*, 28(1):1-26.

Akintunde, T.S., Adagunodo, M., Akanbi, B.E., & Ogunleye, A.G. (2021). Interactive effect of energy consumption and poverty on life expectancy in Nigeria (1980-2017). *Economic Insights-Trends and Challenges*, 9(72):9-21.

Akokuwebe, M.E., & Adekanbi, D.M. (2017). Corruption in the health sector and implications for service delivery in Oyo State public hospitals. *Illorin Journal of Sociology*, 9(1):200-217.

Anser, M.K., Hanif, I., Vo, X.V., & Alharthi, M. (2020). The long-run and short-run influence of environmental pollution, energy consumption, and economic activities on health quality in emerging countries. *Environmental Science and Pollution Research*, 27:32518-32532.

Asghar, M.M., Wang, Z., Wang, B., & Zaidi, S.A.H. (2019). Nonrenewable energy-environmental and health effects on human capital: Empirical evidence from Pakistan. *Environmental Science Pollution Research International*, 27(3):2630-2646.

https://doi.org/10.1007/s11356-019-06686-7

Blimpo, M.P., & Cosgrove-Davies, M. (2019). *Electricity Access in sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact*. Africa Development Forum Series. Washington, DC: World Bank.

https://doi.org/10.1596/978-1-4648-1361-0

Boulding, K.E. (1966). The economics of the coming spaceship Earth. In: Jarrett, H. (Ed.), Environmental Quality in a Growing Economy. Baltimore: Johns Hopkins University Press.

Chaabouni, S., & Saidi, K. (2017). The dynamic links between carbon dioxide (CO_2) emissions, health spending, and GDP growth: A case study for 51 countries. *Environmental Research*, 158:137-144.

https://doi.org/10.1016/j.envres.2017.05.041

Choumert, J, Combes-Motel, P., & Le Roux, L. (2017). Stacking up the Ladder: A Panel Data Analysis of Tanzanian Household Energy Choices. Études et Documents, No 24. Clermont-Ferrand: CERDI.

CHR. Michelsen Institute. (2008). Corruption in the Health Sector. Anti-corruption Resource Centre, U4 (10). Available from: https://www.cmi.no/publications/file/3208-corruption-in-the-health-sector.pdf [Last accessed on 2024 Sep 30].

Darmon, N., & Drewnowski, A. (2015). Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. *Nutrition Reviews*, 73(10):643-660.

https://doi.org/10.1092/nutrit/nuv027

Destek, M.A., & Aslan, A. (2017). Renewable and non-renewable energy consumption and economic growth in emerging economies: Evidence from bootstrap panel causality. *Renewable Energy*, 111, 757-763.

https://doi.org/10.1016/j.renene.2017.05.008

Devereux, S. (2007). Impact of draughts and flood on food security and policy options to alleviate negative effects. *International Association of Agricultural Economists*, 37(s1):47-58.

https://doi.org/1111/j.1574-0862.2007.0023.x

Dragulanescu, I.V., & Dragulanescu, N. (2013). Some theories of environmental sustainability. *Romanian Statistical Review*, 12:14-23.

Dunlap, A. (2021). Does Renewable Energy Exist? Fossil Fuel+ Technologies and the Search for Renewable Energy. Berlin: Springer Nature.

https://doi.org/10.1007/978-3-030-73699-6_5

Dutta, S., & Williamson, S. (2019). Powering up Healthcare: How Energy Access for all Benefits Health. United States: World Bank Group.

Ebhota, O.S., Hongxing, Y., & Sampene, A.K. (2023). Air pollution and life expectancy: Newevidence from the MINT economies. *Heliyon*, 9:e22396.

Franco, A., Shaker, M., Kalubi, D., & Hostettler, S. (2017). A Review of sustainable energy access and technologies for

healthcare facilities in the Global South. *Sustainable Energy Technologies and Assessments*, 22:92-105.

Gatz, M., Betsch, M., Dirrichs, T., Schrading, S., Tingart, M., Michalik, R., *et al*. (2020). Eccentric and isometric exercises in Achilles Tendinopathy evaluated by the Visa-A Score and Share wave elastography. *Sports Health*, 12(4):373-381.

https://doi.org/10.1177/1941738119893996

Grossman, M. (1972). Health capital and demand for health. *Journal of Political Economy*, 80(2):223-255.

https://doi.org/10.1086/259880

IEA. (2020). Defining Energy Access. p.2. Available from: https://www.iea.org/articles/defining-energy-access-2020-methodology [Last accessed on 2024 Sep 30].

Jebbin, M.F., & Adebisi, S.A. (2023). Energy consumption and life expectancy in Nigeria. *International Journal of Advanced Studies in Economics and Public Sector Management,* 11(2):49-63.

https://doi.org/10.48028/iiprds/ijasepsm.v11.i2.05

Lambert, J., Hall, G., Balogh, C.A.S.S., Gupta, A., & Arnold, M. (2014). Energy, EROI and quality of life. *Energy Policy*, 64:153-167.

Mackey, T.K., & Liang, B.A. (2012). Combating healthcare corruption and fraud with improved global health governance. *BMC International Health and Human Rights* 12(1):23.

Matinga, M.N., Clancy, D.J.S., Doyle, V., & Annegarn, H. (2015). Behavioral challenges and the adoption of appropriate sustainable energy technologies. In: Guruswamy, L. (Ed.), International Energy and Poverty: The Emerging Contours. London: Routledge. p.146-59.

Matthew, O.A., Osabohien, R., Fagbeminiyi, F., & Fasina, A. (2018). Greenhouse gas emissions and health outcomes in Nigeria: Empirical insight from auto-regressive distribution lag technique. *International Journal of Energy Economics and Policy*, 8(3):43-50.

Nkalu, C., & Edeme, R.K. (2019). Environmental hazards and life expectancy in Africa: Evidence from GARCH model. *SAGE Open*, 9(1):1-20.

https://doi.org/10.1177/2158244019830500

Noor, A.A., & Cameron, M. (2014). The challenges and possible solutions of horizontal axis wind turbines as a clean energy solution for the future. *Renewable and Sustainable Energy Reviews*, 38:439-460.

https://doi.org/10.1016/j.rser.2014.06.004

Nthabiseng, M., Jiska de G., Abigail, K., & Hans, B. (2018). Determinants of energy use in the informal food sector. *Development Southern Africa*, 36(4):476-490.

https://doi.org/10.1080/0376835X.2018.1526059

Omolua, R.O., Tamunowariye, C., & Aniemeke, T.O. (2023). Impact of corruption on life expectancy in Nigeria. *International Journal of Business Systems and Economics*, 13(3):1-16.

Ostwald, W. (2015). Energetische Grundlagen der Kulturwissenschaft. Sacramento, CA, USA: Creative Media Partners, LLC.

Pesaran, M.H., Shin, Y., & Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3):289-326.

Polcyn, J., Voumik, L.C., Ridwan, M., Ray, S., & Vovk, V. (2023). Evaluating the influences of health expenditure, energy consumption, and environmental pollution on life expectancy in Asia. *International Journal of Environmental Research and Public Health*, 20:4000.

https://doi.org/10.3390/ijerph20054000

Qiang, W., Lili, W., & Rongrong, L. (2023). Does renewable energy help increase life expectancy? Insight from the linking renewable energy, economic growth, and life expectancy in 121 countries. *Energy Strategy Reviews*, 50:1-11.

Rose-Ackerman, S. (1999). Political corruption and democracy. *Connecticut Journal of International Law*, 14(2):363-378.

Sargentis, G.F., Iliopoulou, T., Dimitriadis, P., Mamassis, N., & Koutsoyiannis, D. (2021b). Stratification: An entropic view of society's structure. *World*, *2*:153-174.

Sargentis, G.F., Siamparina, P., Sakki, G.K., Efstratiadis, A., Chiotinis, M., & Koutsoyiannis, D. (2021a). Agricultural land or photovoltaic parks? The water- energy-food nexus and land development perspectives in the Thessaly plain, Greece. *Sustainability*, 13:8935.

https://doi.org/10.3390/su13168935

Sharma, S. (2017). Climate change and sustainability. *International Journal of Economics and Management Studies*, 4(6):22-27.

Smith, K.R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., *et al*. (2014). Millions dead: How do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. *Annual Review of Public Health*, 35:185-206.

United Nations Framework Convention on Climate Change Annual Report. (2020). Available from: https://unfccc.int/sites/default/files/resource/unfccc_annual_report_2020.pdf [Last accessed on 2024 May 10].

Wang, Q., Wang, L., & Li, R. (2023). Does renewable energy help increase life expectancy? Insight from the linking renewable energy, economic growth, and life expectancy in 121 countries. *Energy Strategy Reviews*, 50:101185.

https://doi.org/10.1016/j.esr.2023.1011854

Weitensfelder, L., Moshammer, H., & Ataniyazova, O. (2024). Energy consumption, energy distribution, and clean energy use together affect life expectancy. *Sustainability*, 16:678.

World Health Organisation. (2017). World Health Statistics:

Monitoring Health for SDGs. Available from: https://iris.who.int/bitstream/handle/10665/255336/9789241565486-eng.pdf [Last accessed on 2024 Sep 30].

World Resource Institute. (2020). Decarbonizing Energy Consumption. Available from: https://www.wri.org/initiatives/decarbonizing-energy-consumption [Last accessed on 2024 Sep 30].

World Health Organization. (2021). Energy Access for Health Facilities. Available from: https://www.who.int/teams/environment-climate-change-and-health/healthy-energy [Last accessed on 2024 Sep 30].

Youssef, A.B., Lannes, L., Rault, C., & Soucat, A. (2016). Energy Consumption and Health Outcomes in Africa. IZA Discussion Paper, No. 10325. p.1-31.

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

REVIEW ARTICLE

Medical microbiological diagnosis of sports-accidental infections: promoting global peace, quality health, and entrepreneurship; through One Health approach

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Abstract

Most diseases acquired from sporting activities are accidental and often influenced by environmental factors. Neglecting the environment in disease prevention is counterproductive. This was evident during the peak of the COVID-19 pandemic when many sporting activities were halted. Medical laboratory diagnostics, particularly microbiological techniques, detect infectious agents and help contain diseases, thereby fostering a healthy environment for entrepreneurship. Using a One Health approach, this review highlights the dual role of sporting activities in promoting healthy living and facilitating the spread of pathogens. Although sports are widely recognized for enhancing health, the link between microbiology and sports, and their combined roles in promoting global peace, quality health, and entrepreneurship, is not well understood. To address this knowledge gap, the main objective of this review is to examine the relationship between sports-accidental infections and their impact on global peace, health, and entrepreneurship. This review employs a combination of life experiences, observations, and literature analysis, drawing on both qualitative and quantitative data. The findings reveal various types of sports-accidental infections, including gastrointestinal, respiratory, skin, blood-borne, cardiovascular, and neurodegenerative infections. The results indicate that microbial infections significantly impair athletic performance, often necessitating a "return-to-sport" strategy, where athletes must fully recover before resuming sports activities. Sports-accidental infections are also associated with sudden deaths among athletes on the field, negatively affecting health, peace, and entrepreneurship. Microbiology plays a significant role in diagnosing, treating, and managing sports-accidental infections. Through medical laboratory diagnostics, such as microbiological investigations, many pandemics, including COVID-19, have been contained. Identifying infectious agents enables effective preventive measures, helping restore peace and health, and supporting economic activities. The review offers eight recommendations that aim to foster a safer, healthier, and more resilient sports environment, benefitting individual athletes and promoting broader societal goals of health, peace, and economic growth.

Keywords: COVID-19 pandemic; Diagnosis; Global peace; Entrepreneurship; Medical microbiology; Quality health; Promote; Sports-accidental infections

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1. Introduction

1.1. Understanding microbiology and sports-accidental infections

Most infections acquired during sports activities are accidental and are referred to as sports-accidental or sports-associated infections (DeNizio & Hewitt, 2019). Athletes need to maintain good health to excel in their profession; however, infectious diseases and injuries that lead to infections can significantly impair athletic performances (Bennett *et al*., 2022). The interaction between communicable and non-communicable diseases is complex; for example, non-communicable diseases such as diabetes can exacerbate the spread of communicable diseases (Baker *et al*., 2022; Boehme *et al*., 2023; Trojian *et al*., 2022), while communicable diseases such as schistosomiasis can also promote the onset of non-communicable diseases (Chiari & Gojanovic, 2023; Nincevic *et al*., 2023; Tetteh-Quarcoo *et al*., 2022).

Sports, such as football, offer insights into how individuals interact with their environment (Papagiannis *et al*., 2022). Neglecting environmental factors in disease prevention is counterproductive, akin to a pig muddying itself while claiming to bathe (McInerney, 2023; Nannoni *et al*., 2020). To effectively combat diseases, it is crucial to address environmental factors that contribute to both infectious and non-communicable diseases.

The spread of infectious diseases is often influenced by non-communicable factors, as seen during the COVID-19 pandemic (Mackenzie & Smith, 2020; Papagiannis *et al*., 2022) and other outbreaks (Buckee *et al*., 2021; Qiu *et al*., 2021). This underscores the importance of the One Health approach, which promotes disease prevention and quality healthcare delivery through a multifaced perspective.

Life experiences can be subjective, akin to viewing the numbers "6" or "9," "16" or "91," and "19" or "61" – what appears as one figure to some may look entirely different to others based on religious, cultural, or personal beliefs (Pulle, 2021; Olocha, 2022). Such differences can contribute to the spread of pathogens. During the peak of the COVID-19 pandemic, especially during lockdowns, health experts identified gatherings as key routes for SARS-CoV-2 transmission (Ksinan Jiskrova *et al*., 2021; Posel *et al*., 2021), highlighting the need for lockdowns and social distancing measures. Despite these guidelines, some religious leaders, believing in the omnipotence of their faith, continued to meet secretly for prayers, resulting in SARS-CoV-2 infections among many of them (Barbaros, 2022; Bartkowski, 2023; Nrenzah & Okyerefo, 2021).

While faith plays a crucial role in providing hope, it is important not to conflate spiritual beliefs with scientific findings. For example, actions such as watching or participating in pornography may be viewed as sinful by some Christians and Muslims, whereas others, such as traditionalists or sex workers, may not share this perspective (Olocha, 2022). Although these beliefs may have limited immediate consequences, infectious pathogens and violence do not discriminate based on religion, race, tribe, political affiliations, or social status. Embracing interpersonal differences, much like players in a football team working together, can foster peace, health, and productivity. Avoiding outdated behaviors that promote division or the spread of infections, such as those witnessed during the COVID-19 pandemic (Barbaros, 2022; Bartkowski, 2023; Nrenzah & Okyerefo, 2021; Perry & Grubbs, 2022), aligns with the principles taught in sports.

The "One Health approach," comprising various definitions and strategies, emphasizes addressing health problems through a multidisciplinary perspective (Ghai *et al*., 2022; Mackenzie & Jeggo, 2019). It is an effective method for tackling many interconnected challenges of the 21st century, beyond just infectious diseases. Addressing one problem while neglecting others is like pouring water on a rock – ineffective and unsustainable. This is why the One Health approach, advocated for many years, remains essential (Mackenzie & Jeggo, 2019). It aligns with the World Health Organization (WHO)'s comprehensive definition of health (Armitage, 2023; Oleribe *et al*., 2018; Schramme, 2023).

The concept of One Health has evolved over time, known by various names such as "One Medicine, One World, or One Health," dating back approximately

200 years (Mackenzie & Jeggo, 2019). Although its principles were intermittently discontinued, they were recognized as essential approaches for addressing threats posed by infectious diseases between 2003 and 2004. The One Health approach was first put into action during the early 2003 outbreak of severe acute respiratory disease (SARS), marking its practical implementation (Mackenzie & Jeggo, 2019). One Health addresses a wide range of health problems by identifying underlying causes through multidisciplinary and collaborative approaches.

Applied in the current work, the One Health framework helps readers understand how microbiology and sports lessons can contribute to solving broader societal problems, emphasizing the importance of prioritizing health. Among the various definitions of One Health, the one provided by the United States Centers for Disease Control and Prevention and the One Health Commission is particularly prominent (Mackenzie & Jeggo, 2019). It defines One Health as "a collaborative, multisectoral, and transdisciplinary" approach that addresses health issues with a global vision, working together to protect people, animals, plants, and their shared environment (Mackenzie & Jeggo, 2019; Souza, 2011). This approach is highly relevant to managing sports-accidental infections.

1.2. Problem statement

Football is the heartbeat of many globally, yet there is limited information linking football matches to human behavior. Lessons learned from football and infectious diseases can help promote global peace, quality health, and entrepreneurship. Unfortunately, there is negligible literature linking the lessons from sports, such as football, and microbiological investigations (de Miranda *et al*., 2022; Siddig & Hay, 2022) that could foster global peace, quality health, and entrepreneurship.

Infectious diseases resulting from injuries are among the most prevalent health issues globally (Waleed *et al*., 2023; Yan *et al*., 2022). Injuries can lead to various infections, including viral diseases such as tetanus and herpes simplex, fungal infections such as *Tinea pedis* and *Tinea corporis*, and bacterial diseases such as cellulitis or pneumonia (DeNizio & Hewitt, 2019; Peterson *et al*., 2019; Saleh *et al*., 2023; WHO, 2023). Major microbial infections can be acquired during sporting activities through injury, inhalation of pathogens, or direct contact (Yan, 2022; Dixon *et al*., 2021; Jaworski & Rygiel, 2020).

Individuals can become infected not only through injuries sustained during sports but also from exposure to unhealthy environments surrounding sporting activities (Herrero, 2020; Martykanova *et al*., 2019; Yan *et al*., 2022). Research indicates that athletes were injured or infected during sporting activities, and they, in turn, contaminated playing grounds, parks, and stadiums (Herrero, 2020; Martykanova *et al*., 2019; Yan *et al*., 2022). Athletes were also at risk of infection when exposed to contaminated environmental sources, such as muddy playing grounds at beaches (Lima & Bayraktar, 2022; Nicklas, 2022; Suresh & Patil, 2023).

Common beach sports include beach soccer (Lima & Bayraktar, 2022; Krzywanski *et al*., 2021), beach volleyball (Nicklas *et al*., 2022), beach basketball (Suresh & Patil, 2023), and tennis (Ferrari *et al*., 2021). Beach soccer, often used as a fitness and performance test (França *et al*., 2023; Larsen *et al*., 2021), has led to infections among many players (Lima & Bayraktar, 2022; Shimakawa *et al*., 2016). If sporting activities are conducted near areas where animals are reared (Allan *et al*., 2018; Day, 2016), athletes are at risk of contracting zoonotic diseases (Esposito *et al*., 2023; Natarajan & Miller, 2017; Pierce, 2018).

Infected players can spread infections to colleagues through contact during competition for the ball (Gallotta *et al*., 2022). Parasitic infections among athletes are frequently reported after sporting activities, especially those held in muddy environments (Abbas *et al*., 2020; DeNizio & Hewitt, 2019; Herrero, 2020; Yan *et al*., 2022). Sports-accidental infections are not limited to athletes alone; these infections can be transmitted between athletes and the general public through various means (Davies *et al*., 2017; Pennino *et al*., 2023; Yan *et al*., 2022). Infectious diseases could account for suicidality ideations/suicides among athletes (Boehme *et al*., 2023; Kader *et al*., 2023; Ueda *et al*., 2023), hence the need for a One Health approach.

Researchers have explored the relationship between peace and quality health (Abuelaish *et al*., 2020; Arya, 2019; Klinkmann & Vienken, 2008; Pett, 2018; Pulle, 2022; Pulle *et al*., 2022), including statements from the WHO's Director-General (WHO, 2020). Heart diseases and mental health disorders have been reported in athletes, sometimes resulting in sudden deaths from heart failure or cardiac arrest (Farzam *et al*., 2023; Han *et al*., 2023; Kader *et al*., 2023). Findings from previous studies establish a causal relationship between infectious diseases, heart conditions, and psychiatric disorders (Boehme *et al*., 2023; Tesfaye & Tadele, 2022).

The current study hypothesizes that reported cases of suicides or sudden deaths among athletes are caused by sports-accidental infections, associated mental illnesses, and heart diseases. There is limited literature linking microbiology and sporting activities to the promotion of global peace, quality health, and entrepreneurship. To address these knowledge gaps, the main objective of this

study is to review the literature on the connection between sports-accidental infections and global peace, quality health, and entrepreneurship – focusing on microbiology and sports lessons.

The specific objectives of this study are:

(i) To identify the most common forms of sports-accidental infections.
(ii) To determine the effects of sports-accidental infections on global peace, quality health, and entrepreneurship.
(iii) To demonstrate the diagnostic roles of medical laboratories in preventing sports-accidental infections to promote global peace, quality health, and entrepreneurship.

2. Methods

In this study, three main methods were used: observations, the authors' life experiences, and comprehensive literature reviews (Figure 1). In addition, some informal comparisons were conducted between real-life situations and sporting activities, such as football. These comparisons were not based on statistical calculations to establish associations but rather aimed to draw qualitative parallels. For instance, the unifying effect of scoring a goal among team members and supporters is evident, as seen in the FIFA World Cup (Historyofsoccer.info., 2023). This phenomenon promotes unity and does not require statistical validation.

The primary online databases utilized for retrieving literature included PubMed, Google Scholar, Web of Science, Scopus, and ScienceDirect. Professional blogs, journal articles, and news websites related to the research topic were also used. Personal observations of football matches, particularly FIFA World Cups, provided additional insights. Unhealthy experiences and articles containing information that could cause societal problems were excluded, except where they could be used to advise others on promoting healthy and peaceful coexistence for economic stability.

The study population primarily comprised footballers, their teams, and the matches they participated in. The behavior of referees was analyzed, particularly actions that promoted peace, such as making fair decisions, accepting legitimate goals, rejecting offside calls, and issuing appropriate cards. Conversely, biased decisions that led to player dissent, such as accepting offside goals or showing undeserved cards, were also considered. In addition, articles on other sporting activities, such as boxing, volleyball, and basketball, were reviewed. Articles on infectious diseases, especially those diagnosed in medical laboratories using microbiological investigations, were also reviewed.

Multiple techniques were used to search for literature (Figure 1). Observations of football matches, especially those played in stadiums during FIFA World Cups, provided additional experiential data. These observations helped identify knowledge gaps and questions that require further investigation. To address these gaps, a combination of personal experiences, observations, and comprehensive literature reviews was conducted.

Using keywords such as "microbiology," "sports infections," "quality health," "peace," "entrepreneurship," "football," "highest paid job," "highest paid footballer," and "World Cup dominant winners," publications were retrieved from the database, excluding unrelated literature. Although the current study is primarily a comprehensive literature review, some aspects of systematic review were applied. The PRISMA checklist (Sohrabi *et al.*, 2021) was used as a guide for including and excluding literature. Articles published before 2010 were excluded based on publication year (Figure 1). For example, searches such as "highest paid football players of the world, 2022" helped

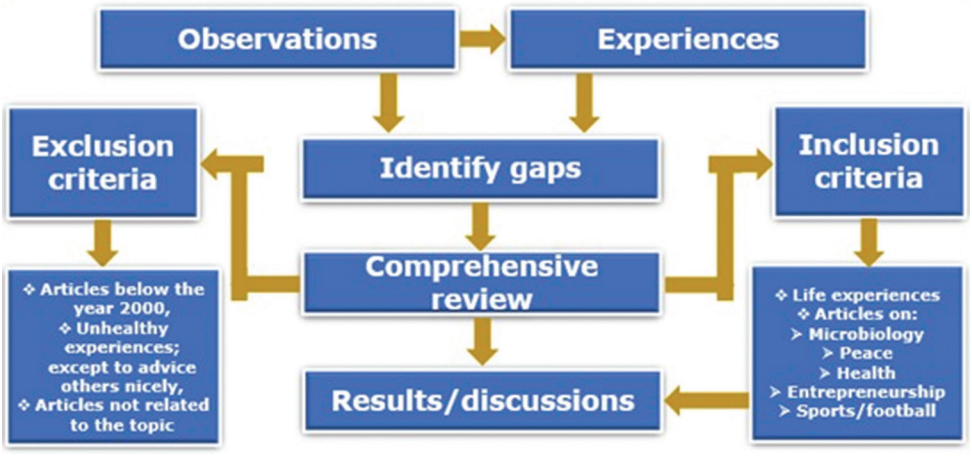


Figure 1. Flowchart of the review process. Source: Adapted from Ben Pulle's Peace Designs, created using Microsoft PowerPoint

narrow the focus. FIFA World Cup's dominant winners often had peaceful and healthy training environments, fostering players capable of defending, striking, and scoring goals (Fifa.com, 2022) (Table 1).

Table 1. Several tests and their reference ranges for screening or confirming sports-accidental infections during a periodic health evaluation

Test	Normal reference ranges
Hematology	
Full blood count	Parameter dependent
Ferritin	26 – 388 ug/L
C-reactive protein	<9.1 mg/L
Erythrocyte sedimentation rate	
Males<50 years old	≤15 mm/h
Males>50 years old	≤20 mm/h
Females<50 years old	≤20 mm/h
Females>50 years old	≤30 mm/h
Children	≤10 mm/h
Serology	
Hepatitis B	Non-reactive or reactive
Hepatitis C	Non-reactive or reactive
Human immunodeficiency virus	Non-reactive or reactive
Venereal disease research laboratory	Non-reactive or reactive
Renal function	
Renal function tests	Parameter dependent
Urinalysis	Negative or positive
Creatinine	71 – 115 umol/L
Cardiovascular	
Fasting lipid profile	
Total cholesterol	<5.2 mmol/L
Triglycerides	<1.7 mmol/L
High-density lipoprotein	1.04 – 1.55 mmol/L
Low-density lipoprotein	<2.60 mmol/L
Fasting blood sugar	4.1 – 5.9 mmol/L
Bone/muscle function	
Vitamin D	Severe deficiency: <10 ng/mL
	Deficiency: 10 – 20 ng/mL
	Insufficiency: 20 – 30 ng/mL
	Sufficiency: >30 ng/mL
Calcium	2.12 – 2.52 mmol/L
Alkaline phosphatase	50 – 136 U/L
Systemic infections	
Blood culture	Bacteria type or no bacterial growth

Source: Adapted from Bakken *et al.* (2016), Nehring *et al.* (2023), Papavarnavas *et al.* (2022), and Tishkowski & Gupta (2023).

2.1. Statistical analysis

The literature retrieved for the current study was managed and stored using Microsoft Office 2021 (Microsoft Corporation, US). Some images and figures were created using Microsoft PowerPoint, captured through screenshots, and used in the analysis (Figures 2 and 3). Statistical analyses, such as the number of references retrieved from each database, were conducted using Microsoft Excel 2021. Data were primarily presented in tables and figures.

3. Results presentation and analysis

The main aim of the current study was to review the literature on the linkage between sports-accidental infections and global peace, quality health, and entrepreneurship – focusing on microbiology and sports lessons. Three specific objectives were used to provide detailed information to help readers understand this linkage.

A total of 330 references were initially reviewed, of which over half, specifically 248, were journal articles. This was followed by 46 references retrieved from news websites, including six WHO websites, four blog posts, and one magazine. Eighteen book references were used, including one quote from the Holy Bible (Table 2).

The references were refined to 202 articles. Of these, over half – 168 – were journal articles. This was followed by 20 references from news websites, including three from WHO websites. Fourteen book references were included, with one being from a WHO website.

3.1. Identifying the most common sports-accidental infections

Collaborative efforts among health professionals and other disciplines are highly beneficial, but infectious diseases remain among the leading causes of morbidity. Environmental interactions, especially zoonotic infections from pets (Day, 2016; Rijks *et al.*, 2016), have contributed to the increased spread of infectious diseases (Baker *et al.*, 2022; Kalinda & Temfack, 2023; Okoroiwu *et al.*, 2020). This situation is aggravated by global climate change (Mahmud *et al.*, 2020). Sporting activities are one avenue through which humans interact with their environment and become infected (DeNizio & Hewitt, 2019; Olocha, 2022; Yan *et al.*, 2022). The most common sports-accidental infections and the ways athletes contracted these infections are illustrated in Figure 4.

The most common infections among athletes are skin infections and upper respiratory tract infections (URTIs), such as COVID-19 or influenza (Lin & Decker, 2010; O'Connor, 2018; Valtonen *et al.*, 2021; Yan *et al.*, 2022) (Figure 4). Approximately 69.8% of these infections affect

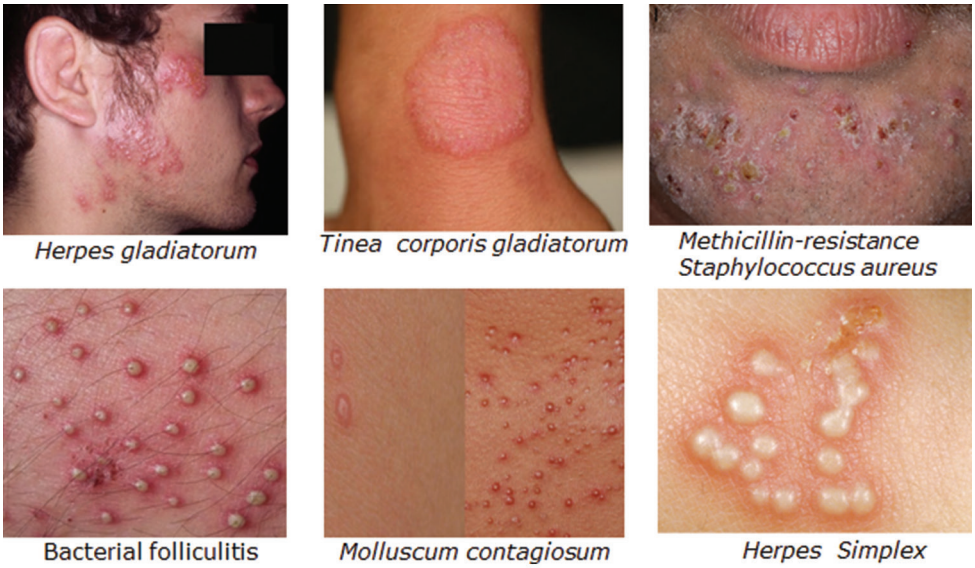


Figure 2. Examples of contact-related skin infections. Source: Adapted from Lincoln & Likness (2011), Martykanova *et al.* (2019), Peterson *et al.* (2019), and Zinder *et al.* (2010)

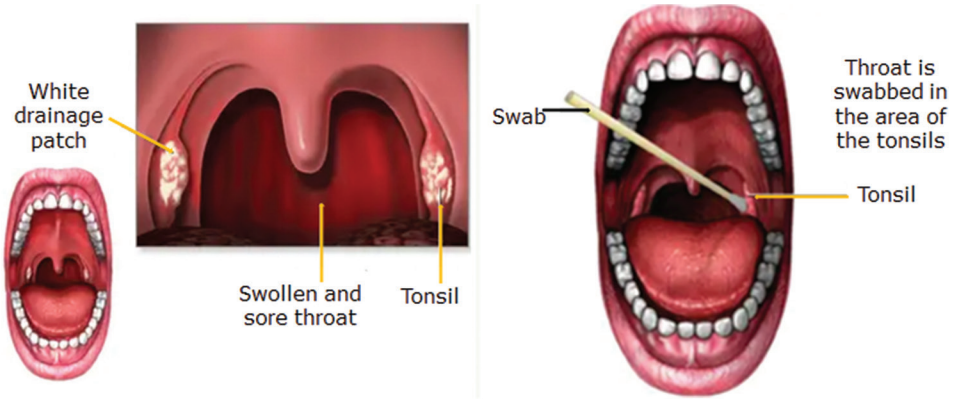


Figure 3. Collection of samples for diagnosing sports-accidental infections and pharyngitis: sterile swab and an indication of proper samples collection areas. Source: Adapted from Vorvick (2021)

the upper respiratory tract (Yan *et al.*, 2022) (Figure 4). Infectious agents commonly acquired from sports activities include viruses such as *Haemophilus influenzae* and hepatitis B virus; fungi such as *Aspergillus fumigatus* or *Cryptococcus neoformans*; bacteria including *Bordetella pertussis* and *Chlamydophila pneumoniae*; and parasites such as *Giardia lamblia* and *Cryptosporidium parvum* (Jaworski & Rygiel, 2020; Papagiannis *et al.*, 2020; Watanabe, 2019).

Infected or injured individuals can develop systemic complications (Ahmadinejad *et al.*, 2014; Herrero, 2020), resulting in incapacitation that may prevent them from working. This risk was a key reason for prioritizing the prevention of other diseases during sporting activities amid the COVID-19 pandemic (Alhussaini *et al.*, 2023; Yan *et al.*, 2022). Respiratory tract infections transmitted through droplets, air, or contacts are identified as the leading causes of morbidity in sports (Natarajan & Miller, 2017; Nincevic *et al.*, 2023; Svendsen *et al.*, 2016; Yan *et al.*, 2022).

All forms of infections can become systemic and spread to the bloodstream, as seen in skin or wound infections caused by *Staphylococcus aureus* and *Streptococcus pyogenes* (Cravez *et al.*, 2020; Kanwal & Vaitla, 2023; Şahin *et al.*, 2022). The major sports-accidental infections identified were skin infections, URTIs, fecal-oral/gastrointestinal infections, and blood-borne infections (Figures 2 and 4).

3.1.1. Other pressing sports-accidental infections discovered: The hypothesis

In addition to the major sports-accidental infections, heart/cardiovascular diseases (Farzam *et al.*, 2023; Han

Table 2. Literature on laboratory diagnosis of infections (including sports-accidental infections)

Study title	Information	Author (s)/Year
Role of serum calcium levels as a biomarker for dengue severity and prognosis: Insights from a cross-sectional analytic study	Patients with dengue fever often have low calcium levels (hypocalcemia). Calcium levels are associated with many infections.	Remya *et al*., 2024
Serum calcium and magnesium levels in patients with type 2 diabetes and COVID-19 infection requiring hospitalization – correlations with various parameters	Changes in calcium levels occur in most infections, notably severe dengue. Low total cholesterol, low-density lipoprotein, and high-density lipoprotein are observed in COVID-19 cases.	Reștea *et al*., 2024
Biological significance of CRP, the ancient acute phase functionary	CRP is biologically essential, primarily produced in the liver of vertebrates but found in various tissues of invertebrates.	Bhattacharya & Munshi, 2023
CRP	CRP was discovered in 1930 by Tillett and Francis as a substance in the serum of patients with acute inflammation that reacts with the "C" carbohydrate antigen of the pneumococcus capsule.	Nehring *et al*., 2023
Erythrocyte sedimentation rate	The erythrocyte sedimentation rate is not highly specific, but red blood cell levels are generally low in infections, cancer, or autoimmune conditions.	Tishkowski & Gupta, 2023
CRP as a marker of inflammation in children and adolescents with metabolic syndrome: A systematic review and meta-analysis	This study examines the association between metabolic syndrome in children and the inflammatory response, using CRP as a marker.	Podeanu *et al*., 2023
Correlation between high-sensitivity CRP (Hs-CRP) and neutrophil-to-lymphocyte ratio (NLR) with functional capacity in post-COVID-19-syndrome patients	This study investigates the correlation between Hs-CRP and NLR with functional capacity (VO_2 max) in post-COVID-19 syndrome patients undergoing moderate- and high-intensity supervised cardiopulmonary exercise.	Widasari *et al*., 2023
Study of correlation of serum calcium level with disease severity in dengue patients	Low calcium levels are observed in nearly 80% of dengue cases, especially in severe cases, facilitating dengue virus attachment to monocytes, macrophages, T cells, and B cells.	Kumar *et al*., 2022.
Diagnostic value of CRP levels in postoperative infectious complications after bariatric surgery: A systematic review and meta-analysis	This study discusses the role of CRP levels in assessing the risk of postoperative infectious complications, such as anastomotic leaks and intra-abdominal abscesses, following bariatric surgery.	Lee *et al*., 2019

Abbreviation: CRP: C-reactive protein.

et al., 2023) and neurogenerative diseases (Ueda *et al*., 2023) or psychological problems (Kader *et al*., 2023; Parr *et al*., 2023) are becoming increasingly common among athletes. These conditions are now recognized as leading causes of death in athletes. Numerous cases of heart failure have been reported, resulting in the deaths of some athletes on the field (D'Ascenzi *et al*., 2022; Farzam *et al*., 2023; Han *et al*., 2023; Wasfy *et al*., 2016).

Pathogens are known to cause both heart and psychological problems in athletes, contributing to suicidal thoughts and suicides (Costanza *et al*., 2021; Sun *et al*., 2020). Cardiac infections caused by SARS-CoV-2 have been confirmed in COVID-19 patients (Bauer *et al*., 2022; Chiari & Gojanovic, 2023). In addition, psychological problems triggered by the COVID-19 pandemic (Asadi-Pooya *et al*., 2022; Jennings *et al*., 2022; Nincevic *et al*., 2023) provide evidence that pathogens can induce mental health disorders.

Many heart and mental health conditions are triggered by pathogens that infect injured athletes, contributing to suicides in this population (Costanza *et al*., 2021; Pichler *et al*., 2023; Sun *et al*., 2020). These problems, along with associated suicidal ideations, are particularly common among male footballers (Rao *et al*., 2015), though other athletes, especially those in high-contact sports such as boxing and ice hockey, are also at significant risk (Costanza *et al*., 2021). These findings support the hypothesis that reported cases of suicides or sudden deaths among athletes are caused by sports-accidental infections, related mental illnesses, and heart diseases.

3.2. Determining the effects of sports-accidental infections on global peace, quality health, and entrepreneurship

The sayings "health is wealth" (Klinkmann & Vienken, 2008; Oleribe *et al*., 2018) and "your health is your wealth" (Carlson,

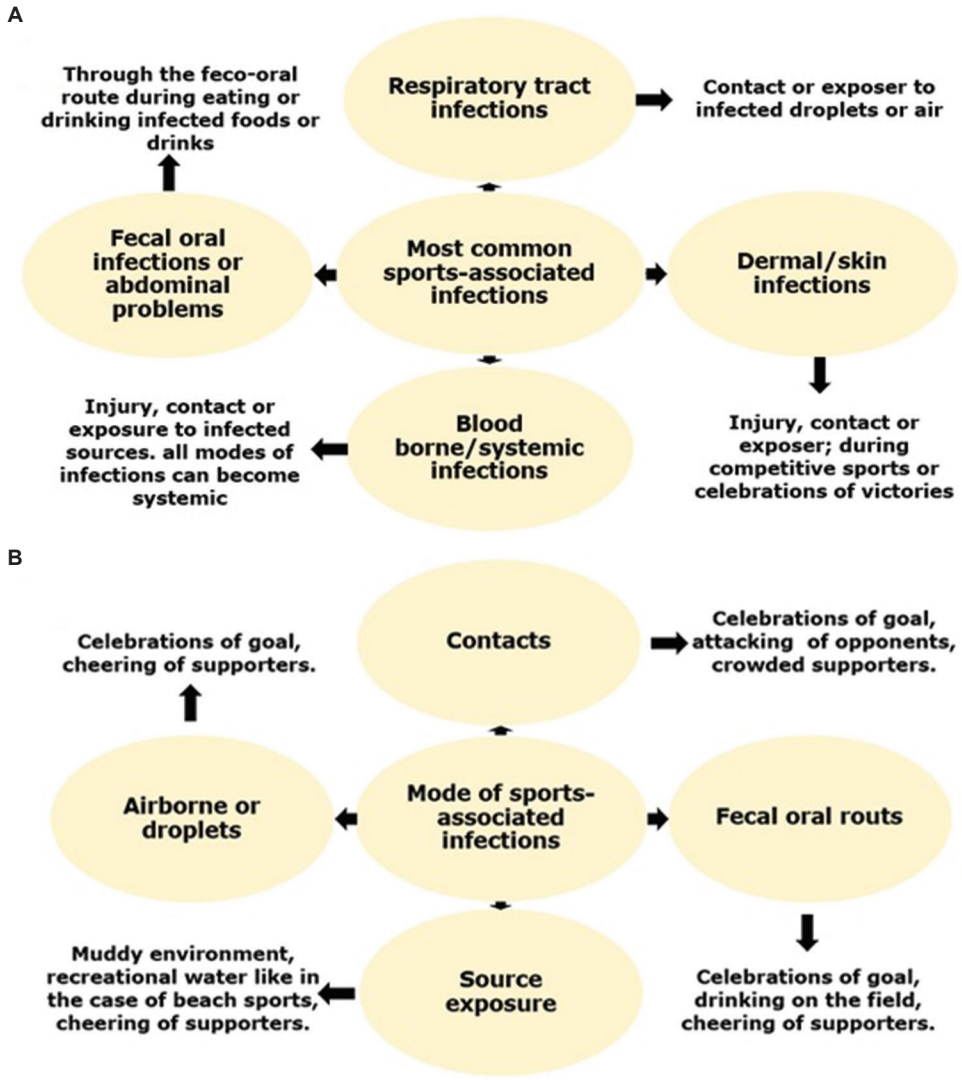


Figure 4. The most common sports-accidental infections and how athletes contract infections. (A) Major sports-accidental infections among athletes. (B) Major avenues by which athletes contracted infections. Source: Adapted from Ahmadinejad *et al.* (2014), DeNizio & Hewitt (2019), Herrero (2020), Peterson *et al.* (2019), and Yan *et al.* (2022)

2016; Pett, 2018) reflect the realistic relationship between quality health and entrepreneurship (Pulle, 2022; Pulle *et al.*, 2022). These concepts align with the WHO's definition of health as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity" (Armitage, 2023; Oleribe *et al.*, 2018; Schramme, 2023).

It is difficult for sick, poor, or hungry individuals to maintain peace (Cann, 2022; Cazzato *et al.*, 2022; NGS, 2023; Nincevic *et al.*, 2023). This is one reason why the United Nations (UN) prioritize poverty and hunger as the first and second Sustainable Development Goals, respectively (NGS, 2023; Un.org., 2023).

The WHO's One Health approach emphasizes the synergies required for achieving quality healthy (Ghai *et al.*, 2022; Mackenzie & Jeggo, 2019). Martin Seligman's PERMA model outlines five criteria of well-being (Kovich *et al.*, 2023; Kyriazos *et al.*, 2018; Seligman, 2011) that are intrinsically linked to the environment or society. This connection extends to sporting activities and sports-accidental infections. From the perspective of microbiologists and other scientists, the role of the gut microbiome in host immunity and disease causation is well established (Bacci *et al.*, 2021; Di Dio *et al.*, 2022; Markou & Apidianakis, 2014; O'Brien *et al.*, 2022).

Athletes who are healthy before participating in sports activities often become infected afterward. Similarly, stadiums and training parks, initially free or low in infections, can become contaminated after sporting

activities (Martykanova *et al*., 2019). For example, before training on a mat, only two microbial species, *Acinetobacter schindleri* and *Pseudomonas stutzeri*, were isolated. After training, four infectious agents – *Acinetobacter lwoffii*, *S. aureus*, *Staphylococcus epidermidis*, and *Micrococcus luteus* – were identified (Martykanova *et al*., 2019). This illustrates that as athletes acquire infections from sports activities, they can also transmit infections to stadiums and parks.

Sports-accidental infections negatively impact players' performances. The "return-to-play" policy is an effective disease control strategy that prohibits infected athletes from participating until fully recovered (Herrero, 2020; Nincevic *et al*., 2023; Yao *et al*., 2021). This approach helps prevent the spread of infections, which could escalate in pandemics. During the COVID-19 pandemic, many nations implemented lockdowns to contain the virus, requiring athletes to recover at home before rejoining their teams (Börjesson *et al*., 2017; Nincevic *et al*., 2023; Lindblad *et al*., 2022; Yao *et al*., 2021).

Before an athlete is qualified to participate in a game, they must be part of the training process that leads to player selection. Infectious diseases or injuries can prevent athletes from taking part, effectively disqualifying talented players (Ahmadinejad *et al*., 2014; Likness, 2011). All types of infections can disqualify athletes from competition (Martínez *et al*., 2017; Newberger & Gupta, 2023; Nincevic *et al*., 2023).

Sports-accidental infections impede athletes' progress, just as infectious diseases can affect global peace and entrepreneurship. A current example is the COVID-19 pandemic, which negatively affected global peace, quality health, and entrepreneurship (Ksinan Jiskrova *et al*., 2021; Nincevic *et al*., 2023; Posel *et al*., 2021; Pulle, 2022), including sports when people were confined to their homes for extended periods. Evidence shows that COVID-19 reduced the performance of some football players (Nincevic *et al*., 2023).

Injuries, infections, and diseases impede quality health, peace, and entrepreneurship (Pulle, 2022; Pulle *et al*., 2022). For example, *S. pyogenes* alone causes infections in approximately 18.1 million people globally, with an associated annual mortality of 500,000 individuals, making it a pathogen of public health importance (Avire *et al*., 2021). Although not the most common cause of infections in athletes and non-athletes, *S. pyogenes* is responsible for many diseases that negatively affect athletes' performances and well-being. The most common soft tissue infection caused by *S. pyogenes* is pharyngitis, commonly known as sore throat (Avire *et al*., 2021; Newberger & Gupta, 2023; Stevens & Brt, 2016).

Infectious diseases that require an athlete to recover before returning to sport can inflict psychological trauma. Depending on the nature of the disease, the type of sporting activity, the nature of the competition, and the duration of the return-to-sport process (Lindsay *et al*., 2021; Yung *et al*., 2022), the psychological impact can be similar to that caused by a broken heart (Smith, 2022). Individuals experiencing severe emotional distress often exhibit depression, lose interest in daily activities, and withdraw from social interactions, which are particularly severe when pharyngitis is accompanied by infective endocarditis, another condition that can be caused by *S. pyogenes* (Dass & Kanmanthareddy, 2023; Primera *et al*., 2023; Smith, 2022).

In extreme cases, some individuals may contemplate or commit suicide (Smith, 2022). The signs and symptoms of emotional distress from a broken heart are not significantly different from the pain caused by pharyngitis due to *S. pyogenes* (Chatzantonis *et al*., 2020) and the psychological impact of the return-to-sport process due to infection, especially when the infection becomes systemic.

Infections can lead to inevitable depression and anxiety among infected athletes (Lindsay *et al*., 2021; Shafiee *et al*., 2017; Yung *et al*., 2022). These are serious health problems that can exacerbate other health conditions, such as anemia and mental health. Depression is identified as one of the most common indicators of mental illness, affecting nearly 350 million people globally (Shafiee *et al*., 2017). Some individuals with depression may resort to substance abuse (Mills, 2023; Shakespeare *et al*., 2021), which can be worsened by infections, including sports-accidental infections.

3.3. Identifying the diagnostic roles of medical laboratories in preventing sports-accidental infections for global peace, quality health, and entrepreneurship

Treating patients without identifying the cause is akin to fighting an unknown enemy in warfare. This analogy is particularly relevant in disease prevention, disease control, and healthcare delivery (Lindblad *et al*., 2022; Nincevic *et al*., 2023; Yao *et al*., 2021). Microbiological investigations play a critical role in identifying infectious agents, which are essential for providing effective and quality health care, especially during pandemics. This principle also applies to managing sports-accidental infections. Once the pathogen is identified and treated/cured, the athlete can safely return to sports (Börjesson *et al*., 2017; Lindblad *et al*., 2022; Nincevic *et al*., 2023).

Accurate diagnosis relies on selecting the correct sample. For example, if an athlete presents with a skin infection, the optimal diagnostic samples would be skin

snips or scrapings. If lesions, pus, or open wounds are present, pus or wound swabs should be collected (Ashoobi *et al*., 2023; Phan *et al*., 2023). In cases of respiratory tract infections, such as pharyngitis, a throat swab is the most reliable sample (Vorvick, 2021) (Figure 3). Proper sample collection is crucial, as incorrect techniques can lead to inaccurate results.

Wound swabs are collected from skin infections containing pus or exudates and from open wounds using a sterile swab stick (Ashoobi *et al*., 2023; Cravez *et al*., 2020; Phan *et al*., 2023). Samples such as blood, pus, wound swabs, sputum, urine, stool, cerebrospinal fluid, and high vaginal swabs can be stained directly. Culturing the pathogen represents another effective method for pathogen identification (Ashurst & Edgerley-Gibb, 2023; CDC, 2022) (Figure 5). Staining, particularly following colonial morphology assessment, is a crucial initial step in pathogen identification, particularly for beginner microbiologists (Figure 5).

The choice of diagnostic test is determined by the type of infection suspected, which is based on the patient's signs, symptoms, physical or medical examination, and case definition. For example, if a respiratory tract infection such as pharyngitis is suspected, the gold standard diagnostic test is a throat swab for culture and sensitivity (Kanwal & Vaitla, 2023; Şahin *et al*., 2022; Vorvick, 2021) (Figure 3). For conditions such as nephritic syndrome, glomerulonephritis, or urinary tract infections, a urine routine examination is typically requested (Hashmi, 2022; Pero *et al*., 2020).

Urine analysis is also employed as a screening test to assess or monitor the health of athletes (Pero *et al*., 2020). If an athlete is suspected of having an abdominal or intestinal infection, a stool routine examination is requested. Maintaining good health is essential for athletes to participate in sporting activities and perform professionally (Börjesson *et al*., 2017; Chiari & Gojanovic, 2023; Yung *et al*., 2022). Microbiological diagnosis through culture and sensitivity testing determines the most effective or sensitive antimicrobial agents that can destroy or inhibit pathogens (Go *et al*., 2022; Kamde & Anjankar, 2022; Papavarnavas *et al*., 2022; Zhao *et al*., 2023). This process simplifies the interpretation of results for physicians or consultants, enabling them to provide targeted treatment that facilitates athletes' recovery and return to play (Go *et al*., 2022; Kristóf & Pongrácz, 2016; Turner *et al*., 2019).

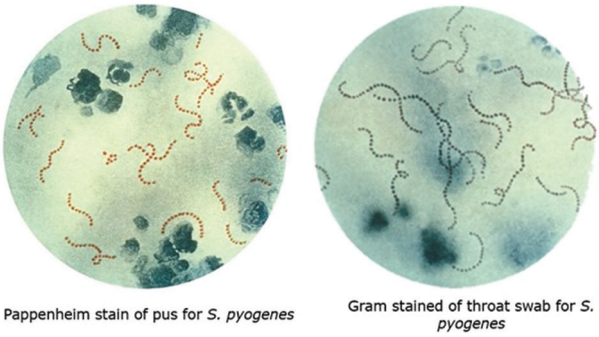


Figure 5. Stained preparations showing the morphological structure of *Streptococcus pyogenes* from pus and throat swab. Source: Adapted from Ashurst & Edgerley-Gibb (2023) and CDC (2022)

Microbiology plays a critical role in most medical laboratory diagnoses, confirming infections and diseases for patient treatment and disease prevention. For instance, when blood is used to investigate which infectious agent is responsible for an outbreak, it highlights the linkage between hematology and microbiology (Chelidze *et al*., 2019; Go *et al*., 2022; Hosseinpour *et al*., 2022; Kanuru & Sapra, 2022). Similarly, if the identification of a pathogen relies on chemical reactions, such as those used to identify isolates in culture or urinalysis (Bono & Reygaert, 2021; Chelidze *et al*., 2019), it demonstrates the linkage between biochemistry and microbiology.

Tables 1 and 3 highlight that cardiovascular, bone, and muscle functions are crucial for athletes, especially those in high-intensity sports such as boxing and wrestling. Infectious diseases, vitamin deficiencies, and calcium deficiencies negatively affect the functionality of these systems. Medical laboratory diagnosis plays a pivotal role in detecting these conditions, including C-reactive protein (CRP) levels, which are dual functional in promoting both pro-inflammatory and anti-inflammatory properties (Nehring *et al*., 2023; Remya *et al*., 2024; Reştea *et al*., 2024).

Using CRP is helpful in detecting infectious diseases, as it reveals acute or chronic inflammation, such as systemic lupus erythematosus or rheumatoid arthritis. High-sensitivity CRP is also used to assess cardiac risk, with levels below 1 mg/dL indicating low risk, levels from 1 mg/dL to 3 mg/dL indicating moderate risk, and values above 3 mg/dL associated with an increased risk of cardiovascular disease (Lee *et al*., 2019; Nehring *et al*., 2023).

Although CRP does not provide specific information about a particular infectious disease, it serves as a non-specific marker of inflammation. It has gained attention as a predictive test for postoperative infectious complications, particularly following bariatric surgery (Lee *et al*., 2019).

CRP plays a multifaceted role in enhancing the host's immune system. It is involved in both the upregulation and downregulation of cytokine production and chemotaxis. Its unique ability to bind to phosphocholine-containing

Table 3. Databases used to retrieve literature and the number of articles retrieved

Type of article source	Number of literature retrieved
Academic database	
PubMed	181
Google Scholar	42
Web of Science	25
Scopus	19
ScienceDirect	10
Semantic Scholar	9
Index Copernicus International	2
Total	248
Books	
Bible quotes	1
Academic books	17
Total	18
News websites	35
Blog posts	4
Magazine	1
WHO websites	6
Unpublished literature	1

Source: Adapted from Ben Pulle's Peace Designs and Writing, created using Microsoft Word Office 2021.
Note: Thirty-nine journal articles were retrieved from two or more databases. Therefore, when calculating the total number of journal articles, the figure would be 287 instead of 248. This duplication applies to articles with unavailable full texts on certain databases but retrieved from others. For example, two journals initially retrieved from PubMed and Google Scholar were also accessed from the WHO website.

substances, such as pneumococcal C-polysaccharide, in the presence of Ca^{2+}, underscores its role in the immune response (Bhattacharya & Munshi, 2023). These functions contribute to the tertiary prevention of diseases affecting athletes (Mercurio *et al*., 2017).

A study investigated the association between metabolic syndrome in children and the inflammatory response using CRP. CRP, known as a nonspecific marker of inflammation, was measured for its reliability as a marker for inflammation in children and adolescents with metabolic syndrome. The results established a linkage between metabolic syndrome and elevated CRP levels compared to healthy children (Podeanu *et al*., 2023).

Numerous diagnostic tests are available to help physicians or health professionals confirm sports-accidental infections (Table 3). These include urine and stool routine examinations, sputum tests for acid–fast bacilli, skin snips or scrapings for wet preparations, staining, culture and sensitivity, rapid diagnostic tests, and molecular investigations. Blood tests are particularly versatile, supporting hematological, serological, renal function, and electrolyte tests, as well as evaluations of cardiovascular and musculoskeletal health (Bakken *et al*., 2016).

Blood culture and sensitivity tests are used to identify systemic infections in athletes and football players. Blood cultures are typically requested for patients suspected of having systemic infections or sepsis (Go *et al*., 2022; Hosseinpour *et al*., 2022). Depending on the type of infection, blood or other cultures can accurately identify the specific microorganism responsible (Go *et al*., 2022; Papavarnavas *et al*., 2022).

4. Discussion

The literature revealed that sports-accidental infections are transmitted through various pathways, including direct contact, fecal-oral routes, airborne or infected droplets, and exposure to contaminated sources. Other transmission modes, such as sexually transmitted infections, although not explicitly mentioned, fall under contact transmission and source exposure (Figure 4B). The most common route through which athletes contract blood-borne pathogens is through direct contact during sports activities (Bauer *et al*., 2022; Kolören & Dubey, 2020; McGrew, 2023; Mak *et al*., 2022). The most frequently observed infections among athletes include skin infections, URTIs, blood-borne infections, and fecal-oral infections (Figure 4).

The findings on the common types of infections among athletes and their modes of transmission align with the principle of the One Health approach (Ghai *et al*., 2022; Mackenzie & Jeggo, 2019) and the WHO's definition of health (Armitage, 2023; Oleribe *et al*., 2018; Schramme, 2023). These frameworks highlight that athletes can be infected through various routes and that multiple forms of infections, termed sports-accidental infections, can be diagnosed in this population. These results address the first objective of this study by demonstrating why the One Health approach is applicable in this context.

Preventing sports-accidental infections during sporting activities is important, as sports events contribute to economic development but can also serve as vectors for disease transmission. The importance of preventing infections during sporting activities was emphasized by the second objective of the study. It found that in the WHO's definition of health, inclusive environmental factors support the importance of infection prevention in sports settings. For example, studies on *Pseudomonas aeruginosa* quorum-sensing mechanisms illustrate how immunity in the intestinal and respiratory tracts can be influenced (Muggeo *et al*., 2023; Singh *et al*., 2023). Athletes with skin infections may experience disfigurement, stigmatization,

and decreased quality of life, impacting their ability to work and meet basic needs (Koçak *et al*., 2021).

The findings further indicate that sports-accidental infections have the potential to spread through environmental routes, becoming pandemic threats if proper preventive measures are not strategically implemented. Consequently, the return-to-sport (Lindsay *et al*., 2021; Yung *et al*., 2022) strategy for preventing sports-accidental infections is a crucial and effective approach. Reflecting on the challenges posed by the COVID-19 pandemic, the study highlights that infections such as sports-accidental infections significantly impact individuals' physical and mental health, disrupt daily economic activities, and ultimately affect national and global economic development (Antunes, 2020; Ksinan Jiskrova *et al*., 2021; Nincevic *et al*., 2023; Posel *et al*., 2021).

The WHO campaign for promoting a more active lifestyle for a healthier world can be effectively achieved through competitive sports (França *et al*., 2023; WHO, 2018). This agrees with the third objective of this study, particularly in the context of diagnosis and treatment. Sporting activities extend beyond games and entertainment; they function as exercise routines that help strengthen the immune system of athletes (Campbell & Turner, 2018; WHO, 2018).

Research findings indicate that athletes who regularly engage in exercise during their training can better resist infectious diseases, especially URTIs (Flegr, 2021; Sellami *et al*., 2023). Exercise plays a crucial role in boosting both the mucosal humoral immune system and non-mucosal humoral and cellular immunity. Sellami *et al*. (2023) have revealed that moderate exercise induces humoral immunity in disabled athletes. The study also highlights the linkage between exercise, health, and disease prevention, clarifying how white blood cells – including lymphocytes, monocytes, and granulocytes (neutrophils, eosinophils, and basophils) – are integral to immune function (Sellami *et al*., 2023). These findings, obtained through medical laboratory diagnosis, support the third objective of this study. The findings are consistent with those of Hosseinpour *et al*. (2022), who also acknowledged the role of white blood cells in building the immune system through moderate exercise. Lymphocytes, specifically $CD4^+$ (helper T), $CD8^+$ (cytotoxic, suppressor T), B lymphocytes, and natural killer cells, each play significant roles in maintaining the body's immunological functions.

During the COVID-19 pandemic, exercise was widely advocated as a means to boost the immune system, particularly during lockdown periods (Benzing *et al*., 2021; Ricci *et al*., 2023; Wijngaards *et al*., 2022). This approach integrated concepts from medical microbiology, immunology (Sellami *et al*., 2023), hematology (Sellami *et al*., 2023), biochemistry (Ashoobi *et al*., 2023; Bono & Reygaert, 2021), physiology (Sellami *et al*., 2023), and psychology (Boehme *et al*., 2023; Góralczyk-Bińkowska *et al*., 2022).

However, it is important to note that strenuous or excessive exercise and training increase the risk of respiratory tract infections. Modifications in exercise routines (Benzing *et al*., 2021; Bloomquist *et al*., 2021; Faude *et al*., 2022) were necessary to ensure that these exercises do not increase exposure to respiratory infections, such as SARS-CoV-2, or exacerbate their severity. This agrees with findings from several studies (Herrero, 2020; Palladino, 2021; Sellami *et al*., 2023).

During the COVID-19 pandemic, microbiological investigations, including rapid diagnostic tests and molecular detection methods, were crucial in identifying SARS-CoV-2 (Abdurrahman *et al*., 2022; González-Vázquez & Arenas, 2023; Navero-Castillejos *et al*., 2022). According to medical microbiology, normal gut flora are typically acquired through exposure to microorganisms. For example, *Bifidobacterium longum*, a gut flora, plays a critical role in the maintenance of gut immunity. Lysozymes produced by this bacterium inhibit the invasion of Gram-positive bacteria by hydrolyzing the β-(1,4)-glycosidic bond that links N-acetylmuramic acid and N-acetylglucosamine, key components of the peptidoglycan structure in the bacterial cell wall. This hydrolysis disrupts the cell wall, ultimately destroying the bacteria (Du *et al*., 2021; Notarbartolo *et al*., 2022; Ragland & Criss, 2017; Wu *et al*., 2019).

Research indicates that gut flora can also improve brain health (Boehme *et al*., 2023; Ghannoum *et al*., 2021; Severance & Yolken, 2020). This idea was particularly valuable during the peak of the COVID-19 pandemic, as maintaining a healthy gut microbiome was linked to better management of mental health conditions such as depression. Recommendations included consuming nutritious meals, using probiotics, and adapting positive health behaviors and healthy lifestyles (Ghannoum *et al*., 2021). An imbalance in gut flora, immunosuppression, or changes in microbiome composition can lead to mental health disorders, including major depressive disorder, schizophrenia, bipolar disorder, autism spectrum disorder, and attention-deficit hyperactivity disorder (Góralczyk-Bińkowska *et al*., 2022; Mitrea *et al*., 2022; Severance & Yolken, 2020).

Cardiovascular diseases, which are leading causes of death in athletic settings, often result in heart failure and are frequently associated with microbial infections, supporting the study's hypothesis. Supplementation with vitamin B has been identified as an essential dietary intervention that

can help prevent atherosclerosis and other cardiovascular diseases (Choi *et al*., 2023; Herrmann & Herrmann, 2022; Jenkins *et al*., 2021; O'Connor *et al*., 2022). These findings align with other research demonstrating the importance of nutritious food consumption in preventing both communicable and non-communicable diseases (Calder *et al*., 2020; Ellwanger *et al*., 2021; Fan *et al*., 2022). Furthermore, it has been shown that infections caused by viruses are less likely to progress to disease states if professional dietitians or nutrition officers provide proper nutritional guidance to athletes or individuals at risk (Calder *et al*., 2020; Mohammadi *et al*., 2023; Pal *et al*., 2022).

The One Health approach uses a multifaceted strategy to prevent diseases, which perfectly fits the study's context since sports-accidental infections are also multidimensional and involve various factors, including infectious agents and pathogens, athletes, and their supporters at sporting events. This approach targets all contributing factors to the spread of pathogens (Ellwanger *et al*., 2021; Ghai *et al*., 2022; Mackenzie & Jeggo, 2019), thereby helping to prevent diseases.

In sports such as football, rules are implemented to prevent injuries, including issuing yellow and red cards to aggressive players (Nalwala, 2022; Owayo.com., n.d.). Similarly, guidelines exist for handling harmful chemical, biological, radiological, and nuclear (CBRN) agents, which pose significant risks to human health. This is particularly relevant in microbiology, where managing exposure to CBRN agents often referred to as "CBRN terrorism" (Binder & Ackerman, 2023; Gawlik-Kobylińska, 2022; Kumar *et al*., 2010; NATO, 2022).

4.1. Other pressing sports-accidental infections supporting the research hypothesis

The results indicated that cardiovascular diseases (Farzam *et al*., 2023; Han *et al*., 2023), neurogenerative diseases (Ueda *et al*., 2023), and mental illnesses (Kader *et al*., 2023; Parr *et al*., 2023) are increasingly common among athletes. These findings agree with literature indicating that, although heart failure is the major cause of sudden death in athletes (D'Ascenzi *et al*., 2022; Farzam *et al*., 2023; Han *et al*., 2023), other sports-accidental infections also contribute to cardiovascular and psychiatric conditions, as well as neurogenerative diseases (Brancaccio *et al*., 2020). Pathogens such as *Staphylococcus aureus* and *Streptococcus pneumoniae* are known to cause infective endocarditis (Berge *et al*., 2023; Grapsa *et al*., 2022; Henriet *et al*., 2022).

Numerous cases of heart failure have been reported among athletes, sometimes resulting in death (D'Ascenzi *et al*., 2022; Farzam *et al*., 2023; Han *et al*., 2023; Wasfy *et al*., 2016). Research indicates that congenital heart problems are the leading cause of sudden death among younger athletes, whereas atherosclerotic coronary artery disease is the predominant cause in older athletes >35 years (D'Ascenzi *et al*., 2022; Farzam *et al*., 2023; Han *et al*., 2023). Both congenital heart defects and atherosclerotic coronary artery diseases are major contributors to heart disease and mortality in athletes (D'Ascenzi *et al*., 2022; Farzam *et al*., 2023; Han *et al*., 2023). These health conditions can also contribute to broader economic crises, as seen during the COVID-19 pandemic (Nicola *et a*l., 2020).

Atherosclerosis is influenced by multiple factors, with microbial infections and dietary habits being significant contributors (Lawson & Glenn, 2021; Pahwa & Jialal, 2023). Microbial infections, including bacteria, viruses, parasites, and fungi, are implicated in the development of both atherosclerosis and congenital heart diseases (Berge *et al*., 2023; Boehme *et al*., 2023; Jung & Lee, 2022; Tesfaye & Tadele, 2022). These findings support the hypothesis of this study: "Reported cases of suicides or sudden deaths among athletes are caused by sports-accidental infections that lead to mental illnesses and heart diseases." Increasing awareness and understanding of these issues could significantly help address the ongoing challenges in clinical medicine and public health (Mercurio *et al*., 2017).

5. Conclusion, suggestions, and recommendations

The current review indicates that once an infectious disease emerges, it is often challenging to eliminate or eradicate it. Notable examples include the COVID-19 pandemic, HIV, tuberculosis, and influenza (Jha & Rathish, 2022; Ricci *et al*., 2023). Influenza, known as the "mother of all pandemic," has persisted for over a century and continues to pose significant public health challenges (Morens & Taubenberger, 2018). Sports-accidental infections can exacerbate existing health problems.

Sports-accidental infections can also contribute to job losses, as seen during the COVID-19 pandemic, which in turn can increase the risk of heart attack due to associated stress and economic hardship (Roy *et al*., 2021). However, microbiological investigations have played significant roles in managing pandemics like COVID-19 by identifying infectious agents, which enable the implementation of preventive measures. For athletes experiencing a heart attack, immediate first aid, including cardiopulmonary resuscitation and defibrillation, is crucial (Carrington *et al*., 2023). Engaging in moderate physical activities, such as farming, walking, running, working, cycling, sports, and cooking, contributes significantly to quality health and well-being (WHO, 2018).

5.1. Suggestions and recommendations

Based on the findings of the current review, the following suggestions and recommendations are proposed:

- Preventing sports-accidental infections is a collective responsibility that starts with everyone, with health professionals and authorities leading this campaign.
- Health managers, disease control officers, health promotion/education officers, and medical laboratories should educate the general public about the risks and prevention of sports-accidental infections.
- Prevention protocols established during the COVID-19 pandemic can be effectively adapted by sports health experts to prevent sports-accidental infections.
- Before major sporting events, such as the FIFA World Cup, all athletes, participating nations, and host nations should undergo screenings by sports health experts to identify and manage potential infections.
- Similar to recommendations made during the peak of the COVID-19 pandemic, everyone, including athletes, should adopt a healthy lifestyle and consume nutritious meals daily to strengthen their immune systems.
- FIFA should incorporate peace and health messages during every World Cup by inviting resource persons to speak on these topics.
- The return-to-sports protocol implemented during the pandemic should continue to be refined and enforced by sports medical teams to prevent sports-accidental infections that could lead to sudden deaths of athletes on the field, until better alternatives, such as vaccinations, become available.
- Discriminatory behavior against infected individuals contributes to the spread of infections. It is crucial for health experts to promote inclusivity and understanding to effectively control the transmission of diseases.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

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Writing – original draft: Benjamin Niriwa Pulle
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Consent for publication

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Availability of data

Data can be requested from the corresponding author.

References

Abbas, I.E., Villena, I., & Dubey, J.P. (2020). A review on toxoplasmosis in humans and animals from egypt. *Parasitology*, 147(2):135-159.

https://doi.org/10.1017/S0031182019001367.

Abdurrahman, L., Fang, X., & Zhang, Y. (2022). Molecular insights of SARS-CoV-2 infection and molecular treatments. *Current Molecular Medicine*, 22(7):621-639.

https://doi.org/10.2174/1566524021666211013121831

Abuelaish, I., Goodstadt, M.S., & Mouhaffel, R. (2020). Interdependence between Health and Peace: A call for a new paradigm. *Health Promotion International*, 35(6):1590-1600.

https://doi.org/10.1093/heapro/daaa023

Ahmadinejad, Z., Alijani, N., Mansori, S., & Ziaee, V. (2014). Common sports-related infections: A review on clinical pictures, management and time to return to sports. *Asian Journal of Sports Medicine*, 5(1):1-9.

https://doi.org/10.5812/asjsm.34174

Allan, K.J., Halliday, J.E.B., Moseley, M., Carter, R.W., Ahmed, A., Goris, M.G.A., *et al.* (2018). Assessment of animal hosts of pathogenic *Leptospira* in Northern Tanzania. *PLoS Neglected Tropical Diseases*, 12(6):e0006444.

https://doi.org/10.1371/journal.pntd.0006444

Alhussaini, N., W., Z., Elshaikh, U., A., M., Hamad, N., A., Nazzal, M., A., Abuzayed, M., & Al-Jayyousi, G., F. (2023). A scoping review of the risk factors and strategies followed for the prevention of COVID-19 and other infectious diseases during sports mass gatherings: Recommendations for Future FIFA World Cups. *Frontiers Public Health*, 10:1078834.

https://doi.org/10.3389/fpubh.2022.1078834.

Antunes, M.J. (2020). The global burden of rheumatic heart disease: Population-related differences (it is not all the same!). *Brazilian Journal of Cardiovascular Surgery*, 35(6):958-963.

https://doi.org/10.21470/1678-9741-2020-0514

Armitage, R. (2023). The WHO's definition of health: A baby to be retrieved from the bathwater? *British Journal of General Practice*, 73(727):70-71.

https://doi.org/10.3399/bjgp23X731841

Arya, N. (2019). Approaching peace through health with a critical eye: Peace review. *Journal of Social Justice,* 31(2):131-138.

https://doi.org/10.1080/10402659.2019.1667560

Asadi-Pooya, A.A., Akbari, A., Emami, A., Lotfi, M., Rostamihosseinkhani, M., Nemati, H., *et al.* (2022). Long COVID syndrome-associated brain fog. *Journal of Medical Virology*, 94(3):979-984.

https://doi.org/10.1002/jmv.27404

Ashoobi, M.T., Asgary, M.R., Sarafi, M., Fathalipour, N., Pirooz, A., Jafaryparvar, Z., *et al.* (2023). Incidence rate and risk factors of surgical wound infection in general surgery patients: A cross-sectional study. *International Wound Journal*, 20(7):2640-2648.

https://doi.org/10.1111/iwj.14137

Ashurst, J.V., & Edgerley-Gibb, L. (2023). Streptococcal pharyngitis. In: StatPearls. Treasure Island, FL: StatPearls Publishing.

Avire, N.J., Whiley, H., & Ross, K. (2021). A review of *Streptococcus pyogenes*: Public health risk factors, prevention and control. *Pathogens*, 10(2):248.

https://doi.org/10.3390/pathogens10020248

Bacci, G., Rossi, A., Armanini, F., Cangioli, L., De Fino, I., Segata, N., *et al.* (2021). Lung and gut microbiota changes associated with *Pseudomonas aeruginosa* infection in mouse models of cystic fibrosis. *International Journal of Molecular Sciences*, 22(22):12169.

https://doi.org/10.3390/ijms222212169

Baker, R.E., Mahmud, A.S., Miller, I.F., Rajeev, M., Rasambainarivo, F., Rice, B.L., *et al.* (2022). Infectious disease in an era of global change. *Nature Reviews Microbiology*, 20:193-205.

https://doi.org/10.1038/s41579-021-00639-z

Bakken, A., Targett, S., Bere, T., Adamuz, M.C., Tol, J.L., Whiteley, R., *et al.* (2016). Health conditions detected in a comprehensive periodic health evaluation of 558 professional football players. *British Journal of Sports Medicine*, 50(18):1142-50.

https://doi.org/10.1136/bjsports-2015-095829

Barbaros, J.P., Klee, K., Hill, T.D., Garcia-Alexander, G., Ellison, C.G., & Burdette, A.M. (2022). For better or for worse? An integrative perspective of message framing moderators' effects on vaccination sustainable health behavior change. *Sustainability*, 14(23):15793.

https://doi.org/10.3390/su142315793

Bartkowski, J.P.A. (2023). Fear god, not COVID-19: Is conservative protestantism associated with risky pandemic lifestyles? *Healthcare* (*Basel*), 11(4):582.

https://doi.org/10.3390/healthcare11040582

Bauer, P., Kraushaar, L., Dörr, O., Keranov, S., Nef, H., Hamm, C., *et al.* (2022). Vascular alterations among male elite athletes recovering from SARS-Cov-2 infection. *Scientific Reports*, 12:8655.

https://doi.org/10.1038/s41598-022-12734-z

Bennett, H., Chalmers, S., Arnold, J., Milanese, S., Blacket, C., Niculescu, A., *et al.* (2022). The relationship between performance and injury in junior Australian football athletes. *International Journal of Sports Physiology and Performance*, 17(5):761-767.

https://doi.org/10.1123/ijspp.2021-0308

Benzing, V., Nosrat, S., Aghababa, A., Barkoukis, V., Bondarev, D., Chang, Y.K., *et al.* (2021). Staying active under restrictions: changes in type of physical exercise during the initial COVID-19 Lockdown. *International Journal of Environmental Research and Public Health*, 18(22):12015.

https://doi.org/10.3390/ijerph182212015

Berge, A., Carlsén, C., Petropoulos, A., Gadler, F., & Rasmussen, M. (2023). *Staphylococcus aureus* bacteraemia, cardiac implantable electronic device, and the risk of endocarditis: A retrospective population-based cohort study. *European Journal of Clinical Microbiology and Infectious Diseases*, 42(5):583-591.

https://doi.org/10.1007/s10096-023-04585-x

Bhattacharya, S., & Munshi, C. (2023). Biological significance of C-reactive protein, the ancient acute phase functionary. *Frontiers in Immunology*, 14:1238411.

https://doi.org/10.3389/fimmu.2023.1238411

Binder, M.K., & Ackerman, G.A. (2023). CBRN Terrorism. Oxford: Oxford Research Encyclopedia International Studies.

https://doi.org/10.1093/acrefore/9780190846626.013.706

Bloomquist, K., Krustrup, P., Fristrup, B., Sørensen, V., Helge, J.W., Helge, E.W., *et al.* (2021). Effects of football fitness training on lymphedema and upper-extremity function in women after treatment for breast cancer: A randomized trial. *Acta Oncologica*, 60(3):392-400.

https://doi.org/10.1080/0284186X.2020.1868570

Boehme, M., Guzzetta, K., Wasén, C., & Cox, L. (2023). The gut microbiota is an emerging target for improving brain health during ageing. *Gut Microbiome*, 4:E2.

https://doi.org/10.1017/gmb.2022.11

Bono, M.J., & Reygaert, W.C. (2021). Urinary Tract Infection. Treasure Island, FL: StatPearls.

Börjesson, M., Arvidsson, D., Rensburg, C.J.V., & Schwellnus, M. (2017). Return to play after infectious disease. *Return to Play in Football*, 4:755-769.

https://doi.org/10.1007/978-3-662-55713-6_56

Brancaccio, M., Mennitti, C., Laneri, S., Franco, A., De Biasi, M.G., Cesaro, A., *et al.* (2020). Methicillin-resistant *Staphylococcus aureus*: Risk for general infection and endocarditis among athletes. *Antibiotics* (*Basel*), 9(6):332.

https://doi.org/10.3390/antibiotics9060332

Buckee, C., Noor, A., & Sattenspiel, L. (2021). Thinking clearly about social aspects of infectious disease transmission. *Nature*, 595:205-213.

https://doi.org/10.1038/s41586-021-03694-x

Calder, P.C., Carr, A.C., Gombart, A.F., & Eggersdorfer, M. (2020). Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*, 12(4):1181.

https://doi.org/10.3390/nu12041181

Campbell, J.P., & Turner, J.E. (2018). Debunking the myth of exercise-induced immune suppression: Redefining the impact of exercise on immunological health across the lifespan. *Front Immunol*, 9:648.

https://doi.org/10.3389/fimmu.2018.00648

Cann, M. (2022). About a Hungry Man is an Angry Man by Muna Cann. Essays. Availabnle from: https://www.yyzartistsoutlet.org/2022/01/a-hungry-man-is-an-angry-man-an-installation-by-gustavo-artigas [Last accessed on 2023 May 01].

Carlson, K. (2016). Your Health is Your Wealth. Living the Big Stuff. Available from: https://kristinecarlson.com/your-health-is-your-wealth [Last accessed on 2018 Dec 25].

Carrington, M., Providência, R., Chahal, C.A.A., D'Ascenzi, F., Cipriani, A., Ricci, F., *et al.* (2023). Cardiopulmonary resuscitation and defibrillator use in sports. *Frontiers in Cardiovascular Medicine*, 9:819609.

https://doi.org/10.3389/fcvm.2022.819609

Cazzato, V., Vicario, C.M., & Urgesi, C. (2022). When hunger makes everything better looking!: The effect of hunger on the aesthetic appreciation of human bodies, faces and objects. *BMC Psychology,* 10:98.

https://doi.org/10.1186/s40359-022-00807-7

CDC Centers for Disease Control and Prevention. (2022). Strep Throat. Group A Streptococcal (GAS) Disease. Available from: https://www.cdc.gov/groupastrep/diseases-hcp/strep-throat.html on [Last accessed on 2023 Sep 14].

Chatzantonis, G., Meier, C., Bietenbeck, M., Rueckert, J., Dorsel, T., Yilmaz, A., *et al.* (2020). Surprising diagnosis in a patient with acute coronary syndrome: A case report of acute streptococcal pharyngitis-associated perimyocarditis. *European Heart Journal - Case Reports*, 4(2):1-6.

https://doi.org/10.1093/ehjcr/ytaa017

Chelidze, K., Thomas, C., Chang, A.Y., & Freeman, E.E. (2019). HIV-related skin disease in the era of antiretroviral therapy: Recognition and management. *American Journal of Clinical Dermatology*, 20(3):423-442.

https://doi.org/10.1007/s40257-019-00422-0

Chiari, M., & Gojanovic, B. (2023). Covid-19: Critères de retour au sport chez les athlètes d'élite [Covid 19: Return to Sport Criteria for Elite Athletes]. *Revue Médicale Suisse*, 19(835):1362-1369.

https://doi.org/10.53738/REVMED.2023.19.835.1362

Choi, R., Park, W., Chun, G., Lee, S.G., & Lee, E.H. (2023). The utilization of serum folate and homocysteine tests and the prevalence of folate deficiency in reproductive-age Korean women during the COVID-19 pandemic. *Nutrients*, 15:3236.

https://doi.org/10.3390/nu15143236

Costanza, A., Radomska, M., Zenga, F., Amerio, A., Aguglia, A., Serafini, G., *et al.* (2021). Severe suicidality in athletes with chronic traumatic encephalopathy: A case series and overview on putative ethiopathogenetic mechanisms. *International Journal of Environmental Research and Public Health*, 18(3):876.

https://doi.org/10.3390/ijerph18030876

Cravez, E.M., Nasreddine, A.Y., & Halim, A. (2020). Persistent *Streptococcus pyogenes* infection of the forearm following blunt trauma. *Case Reports in Plastic Surgery and Hand Surgery*, 7(1):139-144.

https://doi.org/10.1080/23320885.2020.1858715

D'Ascenzi, F., Valentini, F., Pistoresi, S., Frascaro, F., Piu, P., Cavigli, L., *et al.* (2022). Causes of sudden cardiac death in young athletes and non-athletes: Systematic review and meta-analysis: Sudden cardiac death in the young. *Trends in Cardiovascular Medicine*, 32(5):299-308.

https://doi.org/10.1016/j.tcm.2021.06.001

Dass, C., & Kanmanthareddy, A. (2023). Rheumatic Heart Disease. Treasure Island, FL: StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK538286 [Last accessed on 2023 Sep 15].

Davies, H.D., Jackson, M.A., Rice, S.G., Committee on Infectious Diseases, & Council on Sports Medicine and Fitness. (2017). Infectious diseases associated with organized sports and outbreak control. *Pediatrics*, 140(4):e20172477.

https://doi.org/10.1542/peds.2017-2477

Day, M.J. (2016). Pet-related infections. *American Family Physician*, 94(10):794-802.

de Miranda, D.A.P., Gomes, S.V.C., Filgueiras, P.S., Corsini, C.A., Almeida, N.B.F., Silva, R.A., *et al.* (2022). Long COVID-19 syndrome: A 14-months longitudinal study during the two first epidemic peaks in Southeast Brazil. *Transactions*

of the Royal Society of Tropical Medicine and Hygiene, 116(11):1007-1014.

https://doi.org/10.1093/trstmh/trac030

DeNizio, J.E., & Hewitt, D.A. (2019). Infection from outdoor sporting events-more risk than we think? *Sports Medicine Open*, 5:37.

https://doi.org/10.1186/s40798-019-0208-x

Di Dio, M., Calella, P., Cerullo, G., Pelullo, C.P., Di Onofrio, V., Gallè, F., *et al.* (2022). Effects of probiotics supplementation on risk and severity of infections in athletes: A systematic review. *International Journal of Environmental Research and Public Health*, 19(18):11534.

https://doi.org/10.3390/ijerph191811534

Dixon, B.C., Fischer, R.S.B., Zhao, H., O'Neal, C.S., Clugston, J.R., & Gibbs, S.G. (2021). Contact and SARS-CoV-2 infections amongst college football athletes in the Southeastern conference during the COVID-19 pandemic. *JAMA Network Open*, 4(10):e2135566.

https://doi.org/10.1001/jamanetworkopen.2021.35566

Du, M., Xie, X., Yang, S., Li, Y., Jiang, T., Yang, J., *et al.* (2021). Lysozyme-like protein produced by *Bifidobacterium longum* regulates human gut microbiota using *in vitro* models. *Molecules*, 26(21):6480.

https://doi.org/10.3390/molecules26216480

Ellwanger, J.H., Veiga, A.B.G., Kaminski, V.L., Valverde-Villegas, J.M., Freitas, A.W., Q., & Chies, J.A.B. (2021). Control and prevention of infectious diseases from a one health perspective. *Genetics and Molecular Biology*, 44(1 Suppl 1):e20200256.

https://doi.org/10.1590/1678-4685-GMB-2020-0256

Esposito, M.M., Turku, S., Lehrfield, L., & Shoman, A. (2023). The impact of human activities on zoonotic infection transmissions. *Animals* (*Basel*), 13:1646.

https://doi.org/10.3390/ani13101646

Fan, Y., Yao, Q., Liu, Y., Jia, T., Zhang, J., & Jiang, E. (2022). Underlying causes and co-existence of malnutrition and infections: An exceedingly common death risk in cancer. *Frontiers in Nutrition*, 9:814095.

https://doi.org/10.3389/fnut.2022.814095

Farzam, K., Rajasurya, V., & Ahmad, T. (2023). Sudden death in Athletes. In: StatPearls. Treasure Island, FL: StatPearls Publishing.

Faude, O., Müller, S., Schreiber, S., Müller, J., Nebiker, L., Beaudouin, F., *et al.* (2022). A video-based analysis of situations bearing the risk of respiratory disease transmission during football matches. *Scientific Reports*, 12:3034.

https://doi.org/10.1038/s41598-022-07121-7

Ferrari, R., de Oliveira Carpes, L., Domingues, L.B., Jacobsen, A., Frank, P., Jung, N., *et al.* (2021). Effect of recreational beach tennis on ambulatory blood pressure and physical fitness in hypertensive individuals (BAH Study): Rationale and study protocol. *BMC Public Health*, 21(1):56.

https://doi.org/10.1186/s12889-020-10117-5

Fifa.com. (2022). Argentina v France. Final. FIFA World Cup Qatar 2022™. Highlights (No Commentary). The Final Highlights. Available from: https://www.fifa.com/fifaplus/en/watch/4ilYIKbO8iu4gTr3luSggD [Last accessed on 2023 Jan 04].

Flegr, J. (2021). Toxoplasmosis is a risk factor for acquiring SARS-Cov-2 infection and a severe course of COVID-19 in the Czech and slovak population: A preregistered exploratory internet cross-sectional study. *Parasit Vectors*, 14(1):508.

https://doi.org/10.1186/s13071-021-05021-9

França, C., Martinho, D.V., Gouveia, É.R., Martins, F., Marques, A., Ribeiro, T., *et al.* (2023). Changes in estimated body composition and physical fitness of adolescent boys after one year of soccer training. *Journal of Children*, 10(2):391.

https://doi.org/10.3390/children10020391

Gallotta, M.C., Zimatore, G., Cardinali, L., Falcioni, L., Bonavolontà, V., Curzi, D., *et al.* (2022). Physical education on the beach: An alternative way to improve primary school children's skill- and health-related outcomes during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, 19:3680.

https://doi.org/10.3390/ijerph19063680

Gawlik-Kobylińska, M. (2022). Current issues in combating chemical, biological, radiological, and nuclear threats to empower sustainability: A systematic review. *Applied Sciences,* 12(16):8315.

https://doi.org/10.3390/app12168315

Ghai, R.R., Wallace, R.M., Kile, J.C., Shoemaker, T.R., Vieira, A.R., Negron, M.E., *et al.* (2022). A generalizable one health framework for the control of zoonotic diseases. *Scientific Reports*, 12:8588.

https://doi.org/10.1038/s41598-022-12619-1

Ghannoum, M.A., Ford, M., Bonomo, R.A., Gamal, A., & McCormick, T.S. (2021). A microbiome-driven approach to combating depression during the COVID-19 pandemic. *Frontiers in Nutrition*, 8:672390.

https://doi.org/10.3389/fnut.2021.672390

Go, J.R., Challener, D., Campioli, C.C., Sohail, M.R., Palraj, R., Baddour, L.M., *et al.* (2022). Clinical significance of *Staphylococcus aureus* in a single positive blood culture bottle. *Open Forum Infectious Diseases*, 9(2):ofab642.

https://doi.org/10.1093/ofid/ofab642

González-Vázquez, L.D., & Arenas, M. (2023). Molecular evolution of SARS-CoV-2 during the COVID-19 pandemic. *Genes* (*Basel*), 14(2):407.

https://doi.org/10.3390/genes14020407

Góralczyk-Bińkowska, A., Szmajda-Krygier, D., & Kozłowska, E. (2022). The microbiota-gut-brain axis in psychiatric disorders. *International Journal of Molecular Sciences*, 23(19):11245.

https://doi.org/10.3390/ijms231911245

Grapsa, J., Blauth, C., Chandrashekhar, Y.S., Prendergast, B., Erb, B. Jr., Mack, M., *et al.* (2022). *Staphylococcus aureus* infective endocarditis. *JACC Patient Pathways. JACC Case Reports*, 4(1):1-12.

https://doi.org/10.1016/j.jaccas.2021.10.002

Han, J., Lalario, A., Merro, E., Sinagra, G., Sharma, S., Papadakis, M., *et al.* (2023). Sudden cardiac death in athletes: Facts and fallacies. *Journal of Cardiovascular Development and Disease*, 10(2):68.

https://doi.org/10.3390/jcdd10020068

Hashmi, M. (2022). Nephritic syndrome. In: Pandey, J. (Ed.). Medical Reference, Nephritic Syndrome. Available from: https://www.statpearls.com/ArticleLibrary/viewarticle/25697 [Last accessed on 2022 May 11].

Henriet, S.S.V., Langereis, J.D., Lo, S.W., Bentley, S., Mesman, R.J., Fejzic, Z., *et al.* (2022). Endocarditis caused by nontypeable *Streptococcus pneumon*. *Clinical Infectious Diseases*, 75(4):719-722.

https://doi.org/10.1093/cid/ciac079

Herrero, H. (2020). Sports AND Infections. *Injury Health Risk Manage Sports*, 11:281-286.

https://doi.org/10.1007/978-3-662-60752-7_42

Herrmann, W., & Herrmann, M. (2022). The controversial role of HCY and vitamin B deficiency in cardiovascular diseases. *Nutrients*, 14(7):1412.

https://doi.org/10.3390/nu14071412

Historyofsoccer.info. (2023). Which Teams Have Won the World Cup: Most Wins by Country. Development of the Game. Available from: https://historyofsoccer.info/which-teams-have-won-the-world-cup on [Last accessed on 2032 Jan 06].

Hosseinpour, M., Hatamnejad, M.R., Montazeri, M.N., Bazrafshan Drissi, H., Khezrabadi, A.A., Shojaeefard, E., *et al.* (2022). Comparison of the red blood cell indices based on accuracy, sensitivity, and specificity to predict one-year mortality in heart failure patients. *BMC Cardiovascular Disorders*, 22:532.

https://doi.org/10.1186/s12872-022-02987-x

Jaworski, C.A., & Rygiel, V. (2020). Acute illness in the athlete. *Clinics in Sports Medicine*, 38(2019):577-595.

https://doi.org/10.1016/j.csm.2019.05.001

Jenkins, D.J.A., Spence, D., Giovannucci, E.L., Kim, Y.I., Josse, R.G., Vieth, R., *et al.* (2021). Supplemental vitamins and minerals for cardiovascular disease prevention and treatment: JACC Focus Seminar. *Journal of the American College of Cardiology*, 77:423-436.

https://doi.org/10.1016/j.jacc.2020.09.619

Jennings, G., Monaghan, A., Xue, F., Duggan, E., & Romero-Ortuño, R. (2022). Comprehensive clinical characterisation of brain fog in adults reporting long COVID symptoms. *Journal of Clinical Medicine*, 11(12):3440.

https://doi.org/10.3390/jcm11123440

Jha, S.K., & Rathish, B. (2022). Genitourinary tuberculosis. In: StatPearls. Treasure Island, FL: StatPearls Publishing.

Jung, S.H., & Lee, K.T. (2022). Atherosclerosis by virus infection-a short review. *Biomedicines*, 10(10):2634.

https://doi.org/10.3390/biomedicines10102634

Kader, M., Pasternak, B., Lim, C.E., Neovius, M., Forssblad, M., Svanström, H., *et al.* (2023). Depression and anxiety-related disorders and suicide among swedish male elite football players: A nationwide cohort study. *British Journal of Sports Medicine*, 58:66-73.

https://doi.org/10.1136/bjsports-2023-107286

Kalinda, C., & Temfack, E. (2023). Closing the gap in our understanding of infectious diseases. *BMC Infectious Diseases*, 23:412.

https://doi.org/10.1186/s12879-023-08389-4

Kamde, S.P., & Anjankar, A. (2022). Pathogenesis, diagnosis, antimicrobial therapy, and management of infective endocarditis, and its complications. *Cureus*, 14(9):e29182.

https://doi.org/10.7759/cureus.29182

Kanuru, S., & Sapra, A. (2022). Eosinophilia. Treasure Island, FL: StatPearls Publishing.

Kanwal, S., & Vaitla, P. (2023). *Streptococcus pyogenes*. In: StatPearls. Treasure Island, FL: StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554528 [Last accesec on 2023 Sep 14].

Klinkmann, H., & Vienken, J. (2008). Health is wealth! Is wealth health? *Prilozi*, 29(2):13-23.

Koçak, O., İlme, E., & Younis, M.Z. (2021). Mediating role of satisfaction with life in the effect of self-esteem and education on social media addiction in Turkey. *Sustainability*, 13(16):9097.

https://doi.org/10.3390/su1aa3169097

Kolören, Z., & Dubey, J.P. (2020). A review of toxoplasmosis in humans and animals in Turkey. *Parasitology*, 147(1):12-28.

https://doi.org/10.1017/S0031182019001318

Kovich, M.K., Simpson, V.L., Foli, K.J., Hass, Z., & Phillips, R.G. (2023). Application of the PERMA model of well-being in undergraduate students. *International Journal of Community Well-Being*, 6(1):1-20.

https://doi.org/10.1007/s42413-022-00184-4

Kristóf, K., & Pongrácz, J. (2016). Interpretation of blood microbiology results - function of the clinical microbiologist. *EJIFCC*, 27(2):147-55.

Krzywanski, J., Kuchar, E., & Mierzynski, R. (2021). Cutaneous larva migrans in a beach volleyball player. *IDCases*, 24:e01084.

https://doi.org/10.1016/j.idcr.2021.e01084

Ksinan Jiskrova, G., Bobák, M., Pikhart, H., & Ksinan, A.J. (2021). Job loss and lower healthcare utilisation due to COVID-19 among older adults across 27 European Countries. *Journal of Epidemiology and Community Health*, 75(11):1078-1083.

https://doi.org/10.1136/jech-2021-216715

Kumar, G., Saini, R.P., & Rani, A. (2022). Study of correlation of serum calcium level with disease severity in dengue patients. *Journal of the Association of Physicians of India*, 70(4):11-12.

Kumar, V., Goel, R., Chawla, R., Silambarasan, M., & Sharma, R.K. (2010). Chemical, biological, radiological, and nuclear decontamination: Recent trends and future perspective. *Journal of Pharmacy and Bioallied Sciences*, 2(3):220-238.

https://doi.org/10.4103/0975-7406.68505

Kyriazos, T.A., Stalikas, A., Prassa, K., Yotsidi, V., Galanakis, M., & Pezirkianidis, C. (2018). Validation of the flourishing scale (FS), greek version and evaluation of two well-being models. *Psychology*, 9(7):1789-1813.

https://doi.org/10.4236/psych.2018.97105

Larsen, M.N., Ermidis, G., Brito, J., Ørner, C., Martins, C., Lemos, L.F., *et al.* (2021). Fitness and performance testing of male and female beach soccer players-a preliminary investigation. *Frontiers in Sports and Active Living*, 3:636308.

https://doi.org/10.3389/fspor.2021.636308

Lawson, J.S., & Glenn, W.K. (2021). Infection and food combine to cause atherosclerotic coronary heart disease - review and hypothesis. *International Journal of Cardiology. Heart and Vasculature*, 35:100807.

https://doi.org/10.1016/j.ijcha.2021.100807

Lee, Y., McKechnie, T., Doumouras, A.G., Handler, C., Eskicioglu, C., Gmora, S., *et al.* (2019). Diagnostic value of C-reactive protein levels in postoperative infectious complications after bariatric surgery: A systematic review and meta-analysis. *Obesity Surgery*, 29(7):2022-2029.

https://doi.org/10.1007/s11695-019-03832-5

Lima, Y., & Bayraktar, B. (2022). Injuries in elite level male beach soccer players: A prospective three year study. *Physician Sportsmed*, 50(3):251-256.

https://doi.org/10.1080/00913847.2021.1889933

Lin, L., & Decker, C.F. (2010). Respiratory tract infections in athletes. *Disease-a-Month*, 56(7):407-413.

https://doi.org/10.1016/j.disamonth.2010.05.001

Lincoln, P., & Likness, D.O. (2011). Common dermatologic infections in athletes and return-to-play guidelines. *Journal of Osteopathic Medicine*, 111(6):373-379.

https://doi.org/10.7556/jaoa.2011.111.6.373

Lindblad, N., Hänninen, T., Valtonen, M., Heinonen, O.J., Waris, M., & Ruuskanen, O. (2022). Influenza a outbreaks in two professional ice hockey teams during COVID-19 epidemic. *Viruses*, 14(12):2730.

https://doi.org/10.3390/v14122730

Lindsay, R.K., Wilson, J.J., Trott, M., Olanrewaju, O., Tully, M.A., López-Sánchez, G.F., *et al.* (2021). What are the recommendations for returning athletes who have experienced long term COVID-19 symptoms? *Annals of Medicine*, 53(1):1935-1944.

https://doi.org/10.1080/07853890.2021.1992496

Mackenzie, J., & Smith, D.W. (2020). COVID-19: A novel zoonotic disease caused by a coronavirus from china: What we know and what we don't. Microbes Australia, 41(1):45-50.

https://doi.org/10.1071/MA20013

Mackenzie, J.S., & Jeggo, M. (2019). The one health approach - why is it so important? *Tropical Medicine and Infectious Disease*, 4:88.

https://doi.org/10.3390/tropicalmed4020088

Mahmud, A.S., Martinez, P.P., He, J., & Baker, R.E. (2020). The impact of climate change on vaccine-preventable diseases: Insights from current research and new directions. *Current Environmental Health Reports*, 7:384-391.

https://doi.org/10.1007/s40572-020-00293-2

Mak, L.Y., Beasley, I., & Kennedy, P.T.F. (2022). Chronic viral hepatitis in elite athletes: Approaches to risk assessment, prevention and management. *Sports Medicine Open*, 8(1):123.

https://doi.org/10.1186/s40798-022-00517-9

Markou, P., & Apidianakis, Y. (2014). Pathogenesis of intestinal *Pseudomonas aeruginosa* infection in patients with cancer. *Frontiers in Cellular and Infection Microbiology*, 3:115.

https://doi.org/10.3389/fcimb.2013.00115

Martínez, M.E., Grenón, S.L., López, O.H., Leguizamón, L.B., Mollerach, M.E., & von Specht, M.H. (2017). Descripción de 3 casos de infecciones de piel y tejidos blandos por *Streptococcus pneumoniae* [Description of 3 Cases of Skin and Soft Tissue Infections Caused by Streptococcus pneumoniae]. *Revista Argentina de Microbiología*, 49(2):142-145.

https://doi.org/10.1016/j.ram.2016.12.005

Martykanova, D.S., Davletova, N.C., Zemlenuhin, I.A., Volchkova, V.I., Mugallimov, S.M., Ahatov, A.M., *et al.* (2019). Skin microbiota in contact sports athletes and selection of antiseptics for professional hygiene. *BioMed Research International*, 2019:9843781.

https://doi.org/10.1155/2019/9843781

McGrew, C. (2023). Bloodborne pathogens and sports. O'Connor, F.G., & Grayzel, J. (Eds.). Show. Available from: https://medilib.ir/uptodate/show/99730 [Last accessed on 2023 Dec 25].

McInerney, M. (2023). Are pigs clean? Fun facts and common misconceptions about pigs. Lifestyle. Pigs. Available from: https://thehumaneleague.org/article/are-pigs-clean on [Last accessed on 2024 Jan 30].

Mercurio, U., Troiano, G., Manfreda, F., Piscitelli, L., Schiavone, A., Bisaccia, M., *et al.* (2017). Tertiary prevention in athletes' diseases: New challenges for the clinical medicine and the public health. *Annali di Igiene: Medicina Preventiva e di Comunita*, 29(4):336-337.

https://doi.org/10.7416/ai.2016.2161

Mills, M.L. (2023). Impairment, disability, and substance use disorder. *Substance Use and Misuse*, 58(2):221-228.

https://doi.org/10.1080/10826084.2022.2155475

Mitrea, L., Nemeş, S.A., Szabo, K., Teleky, B.E., & Vodnar, D.C. (2022). Guts imbalance imbalances the brain: A review of gut microbiota association with neurological and psychiatric disorders. *Frontiers in Medicine*, 9:813204.

https://doi.org/10.3389/fmed.2022.813204

Mohammadi, A.H., Behjati, M., Karami, M., Abari, A.H., Sobhani-Nasab, A., Rourani, H.A., *et al.* (2023). An overview on role of nutrition on COVID-19 immunity: Accumulative review from available studies. *Clinical Nutrition Open Science*, 47:6-43.

https://doi.org/10.1016/j.nutos.2022.11.001

Morens, D.M., & Taubenberger, J.K. (2018). The mother of all pandemics is 100 years old (and going strong)!. *American Journal of Public Health*, 108(11):1449-1454.

https://doi.org/10.2105/AJPH.2018.304631

Muggeo, A., Coraux, C., & Guillard, T. (2023). Current concepts on *Pseudomonas aeruginosa* interaction with human airway epithelium. *PLoS Pathogens*, 19(3):e1011221.

https://doi.org/10.1371/journal.ppat.1011221

Nalwala, A.A. (2022). Yellow card in football: Know its use and history. News. Available from: https://olympics.com/en/news/football-yellow-card-rules-history [Last accessed on 2023 Jan 13].

Nannoni, E., Aarnink, A.J.A., Vermeer, H.M., Reimert, I., Fels, M., & Bracke, M.B.M. (2020). Soiling of pig pens: A review of eliminative behaviour. *Animals* (*Basel*), 10(11):2025.

https://doi.org/10.3390/ani10112025

Natarajan, P., & Miller, A. (2017). Recreational infections. *Infectious Diseases*, 2017:643-646.e1.

https://doi.org/10.1016/B978-0-7020-6285-8.00071-X

NATO, North Atlantic Treaty Organization. (2022). NATO's Chemical, Biological and Nuclear (CBRN) Defence Policy. E-library. Available from: https://www.nato.int/cps/en/natohq/official_texts_197768.htm [Last accessed on 2023 Nov 23].

Navero-Castillejos, J., Casals-Pascual, C., Narváez, S., Cuesta, G., Hurtado, J.C., Fernandez, M., *et al.* (2022). Diagnostic performance of six rapid antigen tests for SARS-CoV-2. *Microbiology Spectrum*, 10(2):e0235121.

https://doi.org/10.1128/spectrum.02351-21

Nehring, S.M., Goyal, A., & Patel, B.C. (2023). C reactive protein. In: StatPearls. Treasure Island, FL: StatPearls Publishing.

Newberger, R., & Gupta, V. (2023). *Streptococcus* Group A. StatPearls. Treasure Island, FL: StatPearls Publishing.

NGS, National Geographic Society. (2023). Sustainable Development Goals. Education Resources. Available from: https://education.nationalgeographic.org/resource/sustainable-development-goals [Last accessed on 2023 Dec 13].

Nicklas, A., Rückel, L.M., Noël, B., Varga, M., Kleinert, J., Boss, M., *et al.* (2022). Gaze behavior in social interactions between beach volleyball players-an exploratory approach. *Frontiers in Psychology*, 13:945389.

https://doi.org/10.3389/fpsyg.2022.945389

Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., *et al.* (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International Journal of Surgery*, 78:185-193.

https://doi.org/10.1016/j.ijsu.2020.04.018

Nincevic, J., Jurcev-Savicevic, A., Versic, S., Modric, T., Turic, A., Bandalovic, A., *et al.* (2023). How different predominant SARS-CoV-2 variants of concern affected clinical patterns and performances of infected professional players during two soccer seasons: An observational study from split, croatia. *International Journal of Environmental Research and Public Health*, 20(3):1950.

https://doi.org/10.3390/ijerph20031950

Notarbartolo, V., Giuffrè, M., Montante, C., Corsello, G., & Carta, M. (2022). Composition of human breast milk microbiota and its role in children's health. *Pediatric Gastroenterology, Hepatology and Nutrition*, 25(3):194-210.

https://doi.org/10.5223/pghn.2022.25.3.194

Nrenzah, G., & Okyerefo, M.P.K. (2021). Religion and commodification: The ghanaian churches' Covid-19 economy. *Ghana Journal of Religion and Theology*, 11(1-2):134-155.

https://doi.org/10.4314/gjrt.v11i1-2.9

O'Brien, M.T., O'Sullivan, O., Claesson, M.J., & Cotter, P.D. (2022). The athlete gut microbiome and its relevance to health and performance: A review. *Sports Medicine*, 52(Suppl 1):119-128.

https://doi.org/10.1007/s40279-022-01785-x

O'Connor, E.A., Evans, C.V., Ivlev, I., Rushkin, M.C., Thomas, R.G., Martin, A., *et al.* (2022). Vitamin and mineral supplements for the primary prevention of cardiovascular disease and cancer: Updated evidence report and systematic review for the US preventive services task force. *JAMA*, 327(23):2334-2347.

https://doi.org/10.1001/jama.2021.15650

O'Connor, M.B. (2018). Influenza vaccine attitudes in amateur GAA club footballers. *Irish Medical Journal*, 111(6):781.

Okoroiwu, H.U., Uchendu, K.I., & Essien, R.A. (2020). Causes of morbidity and mortality among patients admitted in a tertiary hospital in Southern Nigeria: A 6 year evaluation. *PLoS One*, 15(8):e0237313.

https://doi.org/10.1371/journal.pone.0237313

Oleribe, O.O., Ukwedeh, O., Burstow, N.J., Gomaa, A.I., Sonderup, M.W., Cook, N., *et al.* (2018). Health: Redefined. *Pan African Medical Journal*, 30:292.

https://doi.org/10.11604/pamj.2018.30.292.15436

Olocha, B. (2022). "I Don't feel guilty acting porn", says afro candy. News, Lifestyle. Available from: https://newsbreak.ng/i-dont-feel-guilty-acting-porn-says-afro-candy [Last accessed on 2022 May 08].

Owayo.com. (n.d.). Soccer: Cards and Sanctions - Red Cards, Yellow Cards, Penalty Kicks: A Summary of the Main Soccer Rules. Magazine Overview, Rules of the Game Soccer: Cards and Sanctions. Available from: https://www.owayo.com/magazine/soccer-rules-cards-sanctions-us.htm on [Last accessed on 2023 Feb 24].

Pahwa, R., & Jialal, I. (2023). Atherosclerosis. In: StatPearls. Treasure Island, FL: StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK507799 [Last accessed on 2023 Nov 03].

Pal, J., Sethi, D., Taywade, M., & Pal, R. (2022). Role of nutrition and diet during COVID-19 pandemic: A narrative review. *Journal of Family Medicine and Primary Care*, 11(9):4942-4948.

https://doi.org/10.4103/jfmpc.jfmpc_1311_21

Palladino, M. (2021). Complete blood count alterations in COVID-19 patients: A narrative review. *Biochemia Medica* (*Zagreb*), 31(3):030501.

https://doi.org/10.11613/BM.2021.030501

Papagiannis, D., Laios, T., Tryposkiadis, K., Kouriotis, K., Roussis, X., Basdekis, G., *et al.* (2022). COVID-19 infection among elite football players: A nationwide prospective cohort study. *Vaccines* (*Basel*), 10(5):634.

https://doi.org/10.3390/vaccines10050634

Papagiannis, D., Rachiotis, G., Xanthopoulos, A., Simou, A., Zilidis, C., & Triposkiadis, F. (2020). Vaccination practices and influenza in professional football players in greece. *Occupational Medicine* (*Lond*), 70(3):200-202.

https://doi.org/10.1093/occmed/kqaa004

Papavarnavas, N.S., Brink, A.J., Dlamini, S., Wasserman, S., Whitelaw, A., Ntusi, N.A.B., *et al.* (2022). Practice update to optimise the performance and interpretation of blood cultures: 2022. *South African Medical Journal*, 112(6):397-402.

https://doi.org/10.7196/SAMJ.2022.v112i6.16537

Parr, J.V.V., Uiga, L., Marshall, B., & Wood, G. (2023). Soccer heading immediately alters brain function and brain-muscle communication. *Frontiers in Human Neuroscience*, 17:1145700.

https://doi.org/10.3389/fnhum.2023.1145700

Pennino, F., Fiorilla, C., Sorrentino, M., Armonia, U., Parisi, A., Mirizzi, P.D., *et al.* (2023). Investigating awareness regarding travel-related infectious disease prevention in a metropoli. *Tropical Medicine and Infectious Disease*, 8(10):476.

Pero, R., Brancaccio, M., Mennitti, C., Gentile, L., Arpino, S., De Falco, R., *et al.* (2020). Urinary biomarkers: Diagnostic tools for monitoring athletes' health status. *International Journal of Environmental Research and Public Health*, 17(17):6065.

https://doi.org/10.3390/ijerph17176065

Perry, S.L., & Grubbs, J.B. (2022). Did worship attendance during lockdown promote COVID-19 infection? Evidence from national panel data. *Socius: Sociological Research for a Dynamic World*, 8:1-11.

https://doi.org/10.1177/23780231221100376

Peterson, A.R., Nash, E., & Anderson, B.J. (2019). Infectious disease in contact sports. *Sports Health*, 11(1):47-58.

https://doi.org/10.1177/1941738118789954

Pett, W. (2018). Your health is your true wealth! Mind, Body, Spirit. Available from: https://www.wendiepett.com/your-health-is-your-true-wealth [Last accessed on 2018 Dec 25].

Phan, S., Feng, C.H., Huang, R., Lee, Z.X., Moua, Y., Phung, O.J., *et al.* (2023). Relative abundance and detection of *Pseudomonas aeruginosa* from chronic wound infections globally. *Microorganisms*, 11(5):1210.

https://doi.org/10.3390/microorganisms11051210

Pichler, E.M., Ewers, S., Ajdacic-Gross, V., Deutschmann, M., Exner, J., Kawohl, W., *et al.* (2023). Athletes are not at greater risk for death by suicide: A review. *Scandinavian Journal of Medicine and Science in Sports*, 33(5):569-585.

https://doi.org/10.1111/sms.14316

Pierce, E.S. (2018). How did lou gehrig get lou gehrig's disease? *Mycobacterium avium* subspecies paratuberculosis in manure, soil, dirt, dust and grass and amyotrophic lateral sclerosis (Motor Neurone Disease) clusters in football, rugby and soccer players. *Medical Hypotheses*, 119:1-5.

https://doi.org/10.1016/j.mehy.2018.07.009

Podeanu, M.A., Turcu-Stiolica, A., Subțirelu, M.S., Stepan, M.D.,

Ionele, C.M., Gheonea, D.I., *et al.* (2023). C-reactive protein as a marker of inflammation in children and adolescents with metabolic syndrome: A systematic review and meta-analysis. *Biomedicines*, 11(11):2961.

https://doi.org/10.3390/biomedicines11112961

Posel, D., Oyenubi, A., & Kollamparambil, U. (2021). Job loss and mental health during the COVID-19 lockdown: Evidence from South Africa. *PLoS One*, 16(3):e0249352.

https://doi.org/10.1371/journal.pone.0249352

Primera, G., Hogan, K., Schlecht, H., & Gallagher, M. (2023). Aortic valve infective endocarditis due to *Streptococcus pyogenes*: A case report. *IDCases*, 31:e01697.

https://doi.org/10.1016/j.idcr.2023.e01697

Pulle, B.N. (2021). Politics of insults, especially in Covid-19 pandemic, threaten modern democracy and peace, please stop; a review. Part one: Understanding what politics is. *IOSR Journal of Humanities and Social Science*, 26(2):49-61.

https://doi.org/10.9790/0837-2602014961

Pulle, B.N. (2022). Identifying the 5Ps of life for global peace, health and entrepreneurship: Prayers, preparation, patience, praises, and PEACE. *IOSR Journal of Humanities and Social Science*, 27(1):56-72.

https://doi.org/10.9790/0837-2701065672.

Pulle, B.N., Gyamea, H., Dumba, J., Firm, E., Asaana, D.A., Ampofo, D., *et al.* (2022). Promote global peace, health and entrepreneurship using human anatomical structures: Sexual satisfaction, husband or wife's responsibility? Part 1. *International Journal of Innovative Research in Medical Science*, 7(9):480-491.

https://doi.org/10.23958/ijirms/vol07-i09/1478

Qiu, D., Li, Y., Li, L., He, J., Ouyang, F., & Xiao, S. (2021). Infectious disease outbreak and post-traumatic stress symptoms: A systematic review and meta-analysis. *Frontiers in Psychology*, 12:668784.

https://doi.org/10.3389/fpsyg.2021.668784

Ragland, S.A., & Criss, A.K. (2017). From bacterial killing to immune modulation: Recent insights into the functions of lysozyme. *PLoS Pathogens*, 13(9):e1006512.

https://doi.org/10.1371/journal.ppat.1006512

Rao, A.L., Asif, I.M., Drezner, J.A., Toresdahl, B.G., & Harmon, K.G. (2015). Suicide in national collegiate athletic association (NCAA) athletes: A 9-year analysis of the NCAA resolutions database. *Sports Health*, 7(5):452-457.

https://doi.org/10.1177/1941738115587675

Remya, S.R., Kumar, A., & Sharma, R. (2024). Role of serum calcium levels as a biomarker for dengue severity and prognosis: Insights from a cross-sectional analytic study. *National Journal of Medical Research*, 14(2):56-60.

https://doi.org/10.55489/njmr.14022024978

Reştea, P.A., Tigan, Ş., Fritea, L., Vicaş, L.G., Marian, E., Mureşan, M.E., *et al.* (2024). Serum calcium and magnesium levels in patients with type 2 diabetes and COVID-19 infection requiring hospitalization—correlations with various parameters. *Microbiological Research*, 15(2):431-446.

https://doi.org/10.3390/microbiolres15020029

Ricci, P., Pallocci, M., Treglia, M., Ricci, S., Ferrara, R., Zanovello, C., *et al.* (2023). The effect of physical exercise during COVID-19 lockdown. *Healthcare (Basel)*, 11(11):1618.

https://doi.org/10.3390/healthcare11111618

Rijks, J.M., Cito, F., Cunningham, A.A., Rantsios, A.T., & Giovannini, A. (2016). Disease risk assessments involving companion animals: An overview for 15 selected pathogens taking a european perspective. *Journal of Comparative Pathology*, 155(1 Suppl 1):S75-S97.

https://doi.org/10.1016/j.jcpa.2015.08.003

Roy, S., Dutta, R., & Ghosh, P. (2021). Identifying key indicators of job loss trends during COVID-19 and beyond. *Social Sciences and Humanities Open*, 4(1): 100153.

https://doi.org/10.1016/j.ssaho.2021.100163

Şahin, A., Yüksel, N.C., Karadağ Öncel, E., Kara Aksay, A., Yılmaz, N., & Yılmaz Çiftdoğan, D. (2022). Clinical and laboratory features of invasive group a streptococcal infections: 8 years experience. *Turkish Archives of Pediatrics*, 57(1):75-80.

https://doi.org/10.5152/turkarchpediatr.2022.21221

Saleh, D., Yarrarapu, S.N.S., & Sharma, S. (2023). Herpes Simplex Type 1. Treasure Island, FL: StatPearls Publishing.

Schramme, T. (2023). Health as complete well-being: The WHO definition and beyond. *Public Health Ethics*, 16:210-218.

https://doi.org/10.1093/phe/phad017

Seligman, M.E. (2011). Flourish: A Visionary New Understanding of Happiness and Well-Being. New York, NY: Free Press-Simon & Schuster Inc.

Sellami, M., Puce, L., & Bragazzi, N.L. (2023). Immunological response to exercise in athletes with disabilities: A narrative review of the literature. *Healthcare* (*Basel*), 11(12):1692.

https://doi.org/10.3390/healthcare11121692

Severance, E.G., & Yolken, R.H. (2020). From infection to the microbiome: An evolving role of microbes in schizophrenia. *Current Topics in Behavioral Neurosciences*, 44:67-84.

https://doi.org/10.1007/7854_2018_84

Shafiee, M., Tayefi, M., Hassanian, S.M., Ghaneifar, Z., Parizadeh, M.R., Avan, A., *et al.* (2017). Depression and anxiety symptoms are associated with white blood cell count and red cell distribution width: A sex-stratified analysis in a population-

based study. *Psychoneuroendocrinology*, 84:101-108.

https://doi.org/10.1016/j.psyneuen.2017.06.021

Shakespeare, T., Ndagire, F., & Seketi, Q. (2021). Triple jeopardy: Disabled people and the COVID-19 pandemic. *The Lancet*, 397:1331-1333.

https://doi.org/10.1016/S0140-6736(21)00625-5

Shimakawa, T., Shimakawa, Y., Kawasoe, Y., Yoshimura, K., Chinen, Y., Eimon, K., *et al.* (2016). Beach soccer injuries during the japanese national championships. *The Orthopaedic Journal of Sports Medicine*, 4(1):2325967115625636.

https://doi.org/10.1177/2325967115625636

Siddig, E.E., & Hay, R. (2022). Laboratory-based diagnosis of scabies: A review of the current status. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 116(1):4-9.

https://doi.org/10.1093/trstmh/trab049

Singh, V.K., Almpani, M., Wheeler, K.M., & Rahme, L.G. (2023). Interconnections of *Pseudomonas aeruginosa* quorum-sensing systems in intestinal permeability and inflammation. *mBio*, 14(2):e0352422.

https://doi.org/10.1128/mbio.03524-22

Smith, S. (2022). How to heal a broken heart: 20 effective ways. In: Blog - Marriage Life, Relationship Advice and Tips. Available from: https://www.marriage.com/advice/relationship/ways-to-mend-a-broken-heart [Last accessed on 2023 Sep 15].

Sohrabi, C., Franchi, T., Mathew, G., Kerwan, A., Nicola, M., Griffin, M., *et al.* (2021). PRISMA 2020 statement: What's new and the importance of reporting guidelines. *International Journal of Surgery*, 88:105918.

https://doi.org/10.1016/j.ijsu.2021.105918

Souza, M.J. (2011). One health: Zoonoses in the exotic animal practice. *Veterinary Clinics of North America: Exotic Animal Practice*, 14(3):421-426.

https://doi.org/10.1016/j.cvex.2011.05.007

Stevens, D.L., & Bryant, A.E. (2016). Impetigo, erysipelas and cellulitis. In: J.J. Ferretti. *Streptococcus pyogenes*: Basic Biology to Clinical Manifestations. Oklahoma City (OK): University of Oklahoma Health Sciences Center. Available from: https://www.ncbi.nlm.nih.gov/books/NBK333408 [Last accessed on 2023 Aug 21].

Sun, G., Zhao, J., Tian, S., Zhang, L., & Jia, C. (2020). psychological strain and suicidal ideation in athletes: The multiple mediating effects of hopelessness and depression. *International Journal of Environmental Research and Public Health*, 17(21):8087.

https://doi.org/10.3390/ijerph17218087

Suresh, T.N., & Patil, S. (2023). Effect of ground and beach sand on plyometric training among basketball players. *AIP Conference Proceedings*, 2581(1):080002.

https://doi.org/10.1063/5.0126286

Svendsen, I.S., Taylor, I.M., Tønnessen, E., Bahr, R., & Gleeson, M. (2016). Training-related and competition-related risk factors for respiratory tract and gastrointestinal infections in elite cross-country skiers. *British Journal of Sports Medicine*, 50(13):809-815.

https://doi.org/10.1136/bjsports-2015-095398

Tesfaye, E., & Tadele, H. (2022). Bacterial sepsis among children with congenital heart disease in tikur anbessa specialized hospital, Addis Ababa, Ethiopia. *Ethiopian Journal of Health Sciences*, 32(3):523-532.

https://doi.org/10.4314/ejhs.v32i3.7

Tetteh-Quarcoo, P.B., Ampong, A., Dayie, N., Ahenkorah, J., Udofia, E.A., Afutu, E., *et al.* (2022). Dynamics in morbidity markers and cytological observations made in urine of schistosoma haematobium-infected children: Pre- and post-praziquantel treatment in an endemic setting. *Medical Sciences* (*Basel*), 10(1):14.

https://doi.org/10.3390/medsci10010014

Tishkowski, K., & Gupta, V. (2023). Erythrocyte sedimentation rate. In: StatPearls. Treasure Island, FL: StatPearls Publishing.

Trojian, T., Colberg, S., Harris, G., Oh, R., Dixit, S., Gibson, M., *et al.* (2022). American medical society for sports medicine position statement on the care of the athlete and athletic person with diabetes. *Clinical Journal of Sport*, 32(1):8-20.

https://doi.org/10.1097/JSM.0000000000000906

Turner, P., Fox-Lewis, A., Shrestha, P., Dance, D.A.B., Wangrangsimakul, T., Cusack, T.P., *et al.* (2019). Microbiology investigation criteria for reporting objectively (MICRO): A Framework for the reporting and interpretation of clinical microbiology data. *BMC Medicine*, 17(1):70.

https://doi.org/10.1186/s12916-019-1301-1

Ueda, P., Pasternak, B., Lim, C.E., Neovius, M., Kader, M., Forssblad, M., *et al.* (2023). Neurodegenerative disease among male elite football (Soccer) players in Sweden: A cohort study. *Lancet Public Health*, 8(4):e256-e265.

https://doi.org/10.1016/S2468-2667(23)00027-0

Un.org. (2023). Take Action for the Sustainable Development Goals. The 17 Goals. Available from: https://www.un.org/sustainabledevelopment/sustainable-development-goals on [Last accessed on 2023 Dec 13].

Valtonen, M., Grönroos, W., Luoto, R., Waris, M., Uhari, M., Heinonen, O.J., *et al.* (2021). Increased risk of respiratory viral infections in elite athletes: A controlled study. *PLoS One*, 16(5):e0250907.

https://doi.org/10.1371/journal.pone.0250907

Vorvick, L.J. (2021). Strep Throat (Streptococcal Pharyngitis). Patient Info. Available from: https://www.pennmedicine.org/for-patients-and-visitors/patient-information/conditions-

treated-a-to-z/strep-throat-streptococcal-pharyngitis [Last accessed on 2023 Aug 21].

Waleed, N., Alhussaini, Z., Abushara, U., Elshaikh, M., Hamad, N.A., Nazzal, M.A., *et al.* (2023). A scoping review of the risk factors and strategies followed for the prevention of COVID-19 and other infectious diseases during sports mass gatherings: Recommendations for future FIFA World Cups. *Frontiers in Public Health*, 10:1078834.

https://doi.org/10.3389/fpubh.2022.1078834

Wasfy, M.M., Hutter, A.M., & Weiner, R.B. (2016). Sudden cardiac death in athletes. *Methodist Debakey Cardiovascular Journal*, 12(2):76-80.

https://doi.org/10.14797/mdcj-12-2-76

Watanabe, D. (2019). Cutaneous herpesvirus infection. *Brain Nerve*, 71(4):302-308. Japanese.

https://doi.org/10.11477/mf.1416201266

WHO, World Health Organization. (2018). More Active People for a Healthier World: Global Action on Physical Activity 2018-2030. Switzerland: WHO.

WHO, World Health Organization. (2020). WHO Health and Peace Initiative. Available from: https://www.who.int/initiatives/who-health-and-peace-initiative [Last accessed on 2021 Nov 06].

WHO, World Health Organization. (2023). Herpes Simplex Virus. Newsroom, Fact Sheets. Available from: https://www.who.int/news-room/fact-sheets/detail/herpes-simplex-virus [Last accessed on 2023 Aug 23].

Widasari, N., Heriansyah, T., Ridwan, M., Munirwan, H., & Kurniawan, F.D. (2023). Correlation between high sensitivity C reactive protein (Hs-CRP) and neutrophil-to- lymphocyte ratio (NLR) with functional capacity in post COVID-19 syndrome patients. *Narra Journal*, 3(2):e183.

https://doi.org/10.52225/narra.v3i2.183

Wijngaards, I., Del Pozo Cruz, B., Gebel, K., & Ding, D. (2022). Exercise frequency during the COVID-19 pandemic: A longitudinal probability survey of the US population. *Preventive Medicine Reports*, 25:101680.

https://doi.org/10.1016/j.pmedr.2021.101680

Wu, T., Jiang, Q., Wu, D., Hu, Y., Chen, S., Ding, T., *et al.* (2019). What is new in lysozyme research and its application in food industry? A review. *Food Chemistry*, 274:698-709.

https://doi.org/10.1016/j.foodchem.2018.09.017

Yan, X., Fang, Y., Li, Y., Jia, Z., & Zhang, B. (2022). Risks, epidemics, and prevention measures of infectious diseases in major sports events: Scoping review. *JMIR Public Health Surveillance*, 8(12):e40042.

https://doi.org/10.2196/40042

Yao, K.V., Szybinski, S., Varghese, M., & Fazekas, M. (2021). Viral diseases and youth sports: How to handle common infections that sideline athletes. *Pediatric Annals*, 50(11):e454-e460.

https://doi.org/10.3928/19382359-20211017-01

Yung, K.K., Ardern, C.L., Serpiello, F.R. & Robertson, S. (2022). A framework for clinicians to improve the decision-making process in return to sport. *Sports Medicine - Open*, 8:52.

https://doi.org/10.1186/s40798-022-00440-z

Zhao, N., Song, Y., Xie, X., Zhu, Z., Duan, C., Nong, C., *et al.* (2023). Synthetic biology-inspired cell engineering in diagnosis, treatment, and drug development. *Signal Transduction and Targeted Therapy*, 8:112.

https://doi.org/10.1038/s41392-023-01375-x

Zinder, S.M., Basler, R.S.W., Foley, J., Scarlata, C., & Vasily, D.B. (2010). National athleteic trainers' association position statement: Skin diseases. *Journal Athletic Training*, 45(4):411-428.

https://doi.org/10.4085/1062-6050-45.4.411

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REVIEW ARTICLE

COVID-19 changed our world: A systematic review

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic profoundly reshaped political, religious, economic, social, and financial institutions across the globe. More than 80 countries imposed border closures, shut down business activities, and advised citizens to self-quarantine. The pandemic also caused schools to close indefinitely, affecting approximately 1.5 billion children worldwide. This study sought to integrate the diverse effects of COVID-19 on varied human interests and offer a comprehensive overview of the effects of the pandemic. A systematic literature review encompassing the period between February 2019 and December 2022 was conducted using Web of Science, PubMed, and Google Scholar. The search included keywords related to the impact of COVID-19 on health, education, economics, and the environment, and articles were selected based on pre-defined inclusion criteria. The literature review was limited by its specific time frame, potential publication bias, and language restrictions. Nevertheless, the study findings highlight critical areas for prospective policy interventions and recommend that future research endeavors should address the diverse effects of the pandemic across varied sectors. This literature review revealed that COVID-19 exerted far-reaching consequences beyond health, impacting mental and emotional well-being, education, financial and economic stability, social dynamics, business operations, travel and tourism, and the environment. The pandemic introduced a profoundly challenging period of human history, revealing itself as more than just a health crisis: it signified a significant threat to multiple facets of global life. Despite the successful rollout of the severe acute respiratory syndrome coronavirus-2 vaccine, an ongoing public debate persists regarding whether COVID-19 will reemerge or eventually wane.

Keywords: Coronavirus disease 2019; Genomic susceptibility; Economy; Education; Environment; Mental health and impact

1. Introduction

The global balance was disrupted when severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) emerged in Wuhan, China, in December 2019 and resulted in the coronavirus disease 2019 (COVID-19) pandemic (Lai *et al*., 2020). The virus spread quickly, prompting the World Health Organization (WHO) to declare it a public health emergency of international concern on January 30, 2020 (Chan *et al*., 2020; Li *et al*., 2020). Coronaviruses were already known but the SARS-CoV-2 marked the third major outbreak of respiratory illnesses caused by these viruses (Zhong *et al*., 2003). SARS-CoV-2 is considered zoonotic, which means it can spread from animals to humans. It has been linked to varied animals and birds including camels, pigs, turkeys, mice, dogs, and bats (Geller *et al*., 2012; Anthony *et al*., 2017). This virus spreads from animals to humans through airborne particles and disperses from person to person primarily through droplets, infected hands, or contaminated surfaces such as skin contact with an incubation period of 2 – 14 days (Zhai *et al*., 2020) (Figure 1). The pandemic substantively affected even the most developed countries and posed a serious threat to low- and middle-income countries. It particularly impacted nations in Africa, where people are very vulnerable to infectious diseases (Lone & Ahmad, 2020; Shastri *et al*., 2020).

COVID-19 had caused 473,797 deaths globally as of June 24, 2020, from 9,129,146 confirmed cases. By November 25, 2022, the WHO reported 636,440,663 confirmed cases and 6,606,624 deaths worldwide (Figure 2). The highest number of cases were registered in Europe (264,065,011), followed by the Americas (181,462,467), the Western Pacific (97,712,745), Southeast Asia (60,621,308), the eastern Mediterranean (23,187,814), and Africa (9,390,554) (WHO, 2023). The first confirmed COVID-19 case in India was reported in Kerala on January 30, 2020, making India the first in Asia and the fourth globally to record confirmed cases (Chehal *et al*., 2021). The situation escalated rapidly, with cases of infection rising from 32 on March 2, 2020, to a peak of 2,738,957 on May 3, 2021. Significant surges were also observed on specific dates with 148,249 cases on March 15, 2021, and 2,115,110 cases on January 17, 2022, followed by a critical decline. India recorded 456,183 confirmed cases during the early months of the pandemic and confirmed 14,476 deaths, primarily in Maharashtra and Delhi (Aneja & Ahuja, 2021).

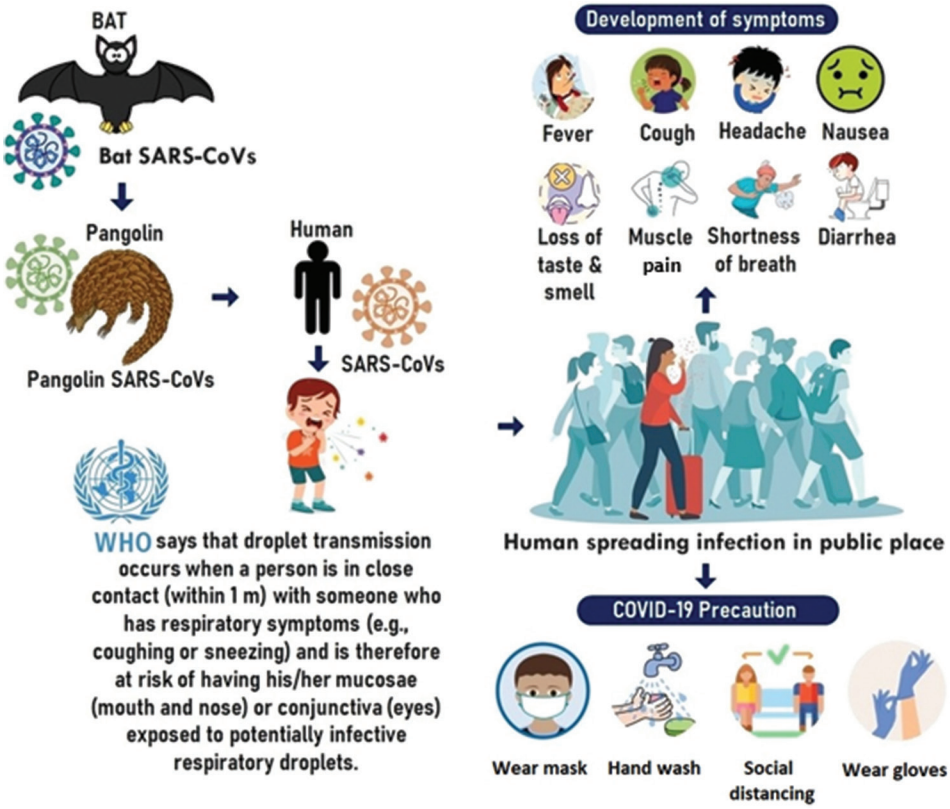


Figure 1. Infographic of COVID-19 infection. Image created by the authors
Abbreviation: SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2.

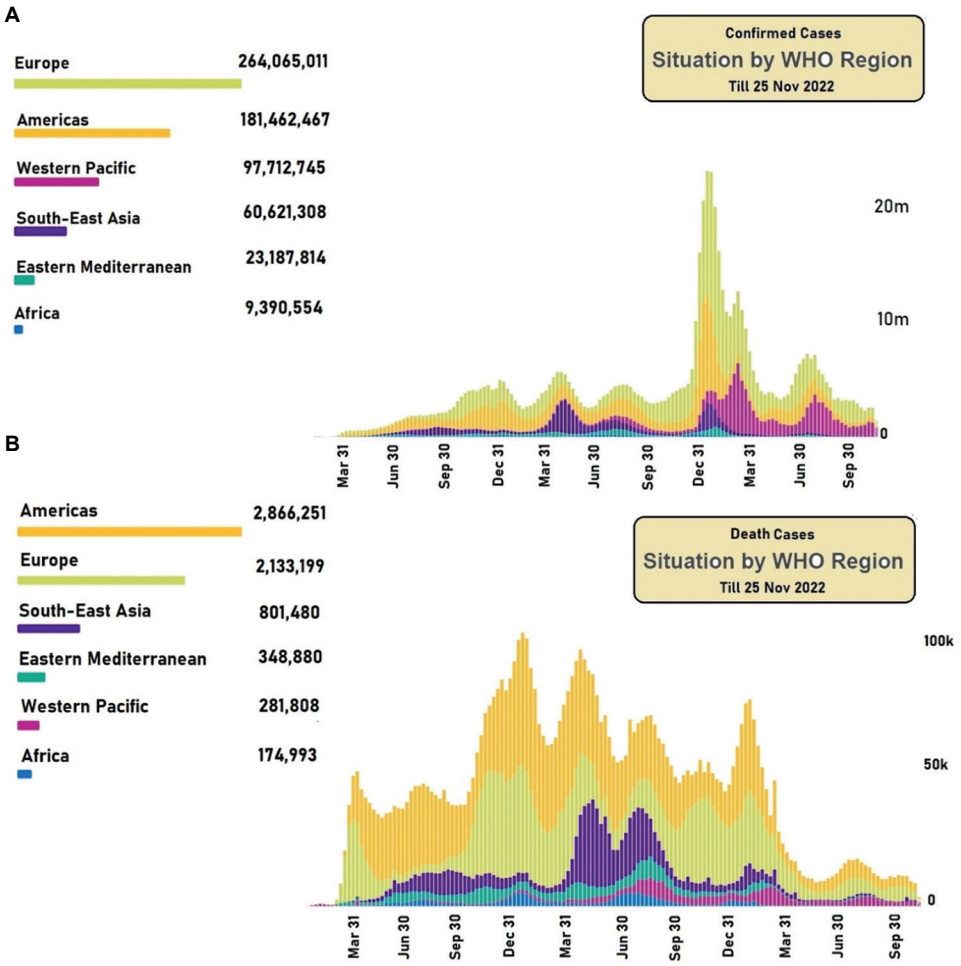


Figure 2. WHO Coronavirus (COVID-19) (November 25, 2022). (A) Presentation of infected cases in different regions of the world. (B) Graph depicting the total number of mortalities in different regions of the world
Abbreviation: WHO: World Health Organization.

The rapid global spread of COVID-19 highlighted its contagious nature, prompting nations including India to enforce travel restrictions, social distancing, and strict lockdowns. These measures were vital to curbing infections, especially during the first wave. Notably, countries with shorter lockdowns witnessed more cases per person but registered a lower average fatality rate (5.45%) than nations with longer lockdowns, which reported a higher average rate of 12.70% (Coccia, 2021). However, self-isolation and quarantine mandates caused increased mental health issues including loneliness, anxiety, depression, and harmful behaviors (Kumar & Nayar, 2021) exacerbated by continuous newscasts about the outbreak (Li *et al.*, 2020). The fear of quarantine and social stigma caused many people in India to avoid testing (Rewerska-Juśko & Rejdak, 2022). The impact of the pandemic was widespread, affecting healthcare workers, the economy, travel, the stock markets, factories, migrant labor, and research. The extensive and disruptive effects of SARS-CoV-2 have marked it as one of the most significant pandemics in history (Singh & Yi, 2021). Therefore, the present review explored and assessed the impact of COVID-19 on diverse domains such as the economy, society, environment, education, and health to understand the widespread effects of the pandemic. This review intensively encompassed myriad aspects of the pandemic and would particularly benefit readers seeking a comprehensive understanding of this period of human history.

2. Material and methods

This systematic review was conducted using multiple databases including Google Scholar, PubMed, Springer, and Elsevier. It encompassed the period spanning February 2019 to December 2022. The search strategy entailed employing specific keywords and phrases related to the impact of COVID-19: for instance, "COVID-19

and health," "COVID-19 and education," "COVID-19 and economics," and "COVID-19 and environment." We restricted our evaluation to articles published in English to ensure comprehensive and unbiased coverage. Thus, we utilized language filters to exclude non-English publications.

The present review incorporated both primary and secondary sources including scientific papers, meta-analyses, systematic reviews, and peer-reviewed articles. We excluded unpublished, incomplete, or partially available data as well as publications in languages other than English to mitigate potential biases and maintain consistency and reliability. The relevant authors (A.S., K.S., A.C.P., G.K., S.B., A.J., and S.S.) independently verified the validity of the included data to ensure accuracy.

In addition, we efforted substantially to eliminate any undesirable characteristics that could affect the study's outcomes. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram (Figure 3) illustrates the flow, identification, and screening process utilized for the study and demonstrates our systematic approach to controlling variables and reducing bias in our review.

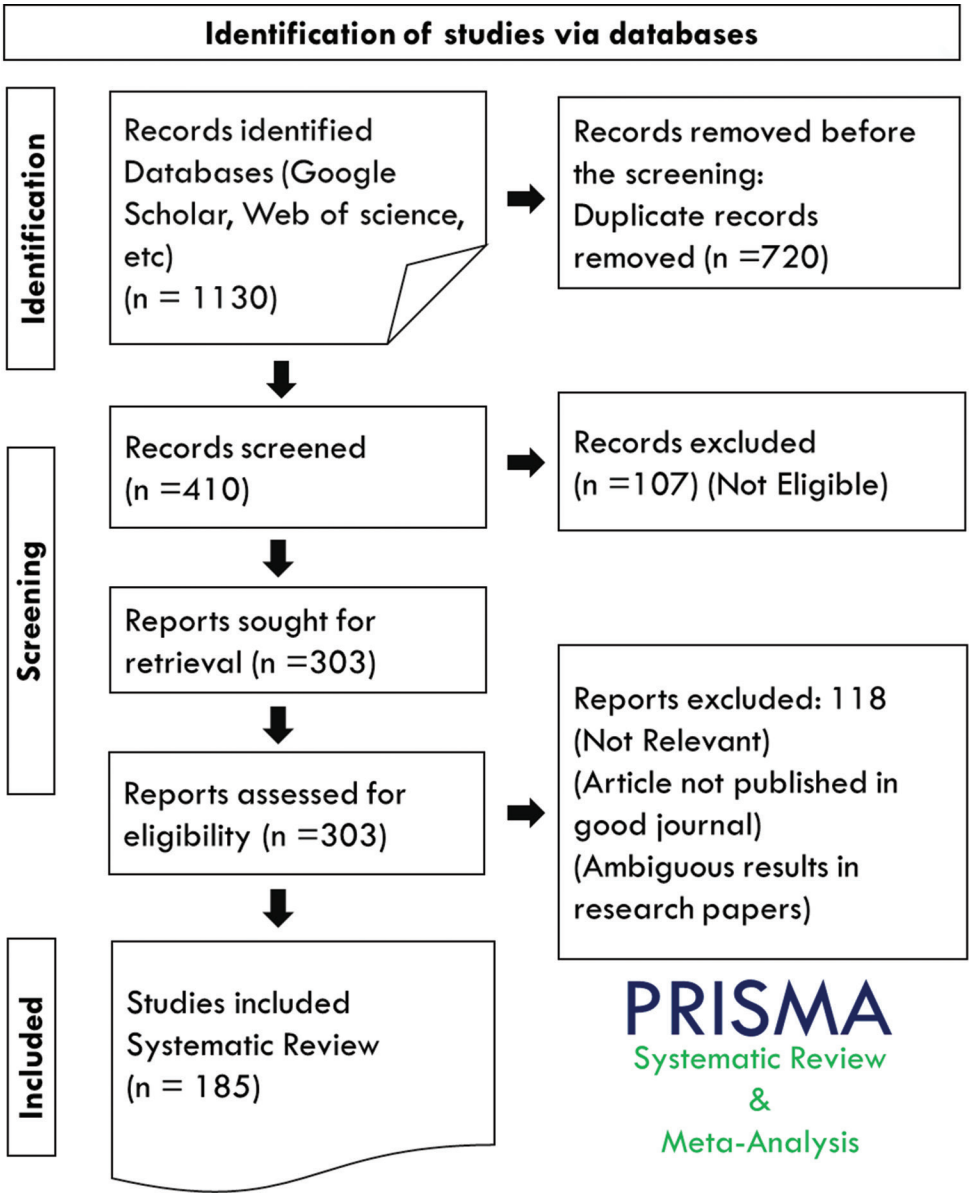


Figure 3. Preferred reporting items for systematic reviews and meta-analyses flow diagram representing the schematic representation of data extraction from online databases

3. Results

After completing our systematic literature survey, we identified and evaluated a comprehensive array of studies relevant to the impact of COVID-19. Initially, we identified 1,130 articles; however, this number was honed to 185 articles after excluding irrelevant studies. The PRISMA flow diagram (Figure 3) illustrates the stream of information through the different phases of the review including the identification, screening, and inclusion of studies.

The literature highlighted that the COVID-19 pandemic critically disrupted life worldwide, affecting nearly every aspect of human life and resources (Hiscott *et al*., 2020). A key question consequently emerged: was this virus novel or related to earlier viruses? Coronaviruses have infected humans since the 1960s, and typically cause mild respiratory symptoms or the common cold. However, the recent SARS-CoV-2 outbreak represented the third major occurrence of respiratory illnesses triggered by this virus family in the last 20 years and significantly disrupted the global socioeconomic system.

The first known case of pneumonia caused by SARS-CoV was reported in Foshan, China, in November 2002 (Zhong *et al*., 2003). More than 8,000 cases had been recorded by July 2003, resulting in 774 deaths. A small outbreak in 2004 added four more cases that generated symptoms such as fever, headaches, coughing, and shortness of breath (Zhao, 2007). MERS-CoV emerged in Saudi Arabia in 2012, affecting more than 2,494 people and causing 858 deaths. MERS-CoV was less contagious than SARS-CoV but was more lethal: it resulted in kidney failure in patients (Baharoon & Memish, 2019; Chakraborty & Maity, 2020). A new coronavirus, SARS-CoV-2, was identified in Wuhan, China, in December 2019. This coronavirus instigated a pandemic that resulted in millions of reported fatalities by early March 2021.

3.1. Structure and genome of COVID-19

Structurally, the COVID-19 virus is spherical and features single-stranded (positive-sense) RNA linked to a nucleoprotein in a matrix protein-encased capsid (Figure 4A). The viral genome contains distinguishing traits such as a different N-terminal portion inside the spike proteins; the genes for the key structural proteins are arranged in the 5′-3′ order as S, E, M, and N5. Several minor ORFs can be identified downstream of the nucleocapsid gene and between the conserved genes (envelope, ORF1ab, membrane, spike, and nucleocapsid) (Figure 4A) (Mousavizadeh & Ghasemi, 2021). The virus's ability to adapt to a new environment/host tropism through mutations in the spike protein creates unwanted situations for researchers who try to cope immediately with the virus (Figure 4B) (Li, 2016; Graham & Baric, 2010). The spike protein binds to acetyl-CoA dehydrogenase 2; thus, it initiates the COVID-19 infection and permits it to penetrate cells and cause the contagion. Figure 5 presents the detailed life cycle of the virus**.** However, an intriguing question arises: was the possibility of susceptibility to infection caused by a risk factor, or did it result merely from exposure?

3.2. Susceptibility to COVID-19 infection

Varied risk factors influence one's susceptibility to COVID-19 and can be broadly categorized as genetic and environmental features (Singh *et al*., 2022). Environmental factors and lifestyle choices function significantly in modifying vulnerabilities determined by genetic pre-dispositions. For instance, severe or pre-existing conditions such as renal disease or anemia are linked to a higher risk of severe COVID-19 outcomes (Tao *et al*., 2021). Hospitalization-related factors such as the need for supplemental oxygen and severe vitamin D deficiency are associated with an increased risk of mortality (Bhargava *et al*., 2020; Carpagnano *et al*., 2021). Nutritional deficiencies have been observed in a substantial proportion of COVID-19 patients, particularly zinc insufficiency. Such deficits generate greater complications, increase the risk of death, and mandate prolonged hospital stays (Jothimani *et al*., 2020). In addition, hormonal changes have been noted in males who have recovered from the infection: Low levels of luteinizing hormone, 17β-estradiol/estrogen, and testosterone indicative of hypogonadism were observed at a 7-month follow-up (Salonia *et al*., 2022).

COVID-19 impacts more than just the lungs; it affects several vital organs and can induce varied comorbid conditions. For instance, Khoo *et al*.'s (2021) observational study found that COVID-19 patients exhibited lower levels of thyroid-stimulating hormone and free thyroxine (FT4) compared to uninfected individuals. Diabetes is another major concern: Diabetic patients with COVID-19 were at higher risk of intensive care unit admission but no significant increase was noted in their mortality rates (Al-Salameh *et al*., 2021). Metz *et al*. reported a higher risk of cesarean delivery, premature births, and hypertensive disorders in pregnant patients with severe COVID-19 (Metz *et al*., 2021). Neurological issues were also observed, for instance, stroke, neuromuscular problems, altered mental status, anosmia, headaches, seizures, encephalopathy, and encephalitis. Some patients also experienced mild to moderate confusion (García-Azorín *et al*., 2021; Abildúa *et al*., 2021).

Mortality rates from COVID-19 were notably higher for individuals with specific health conditions: for instance,

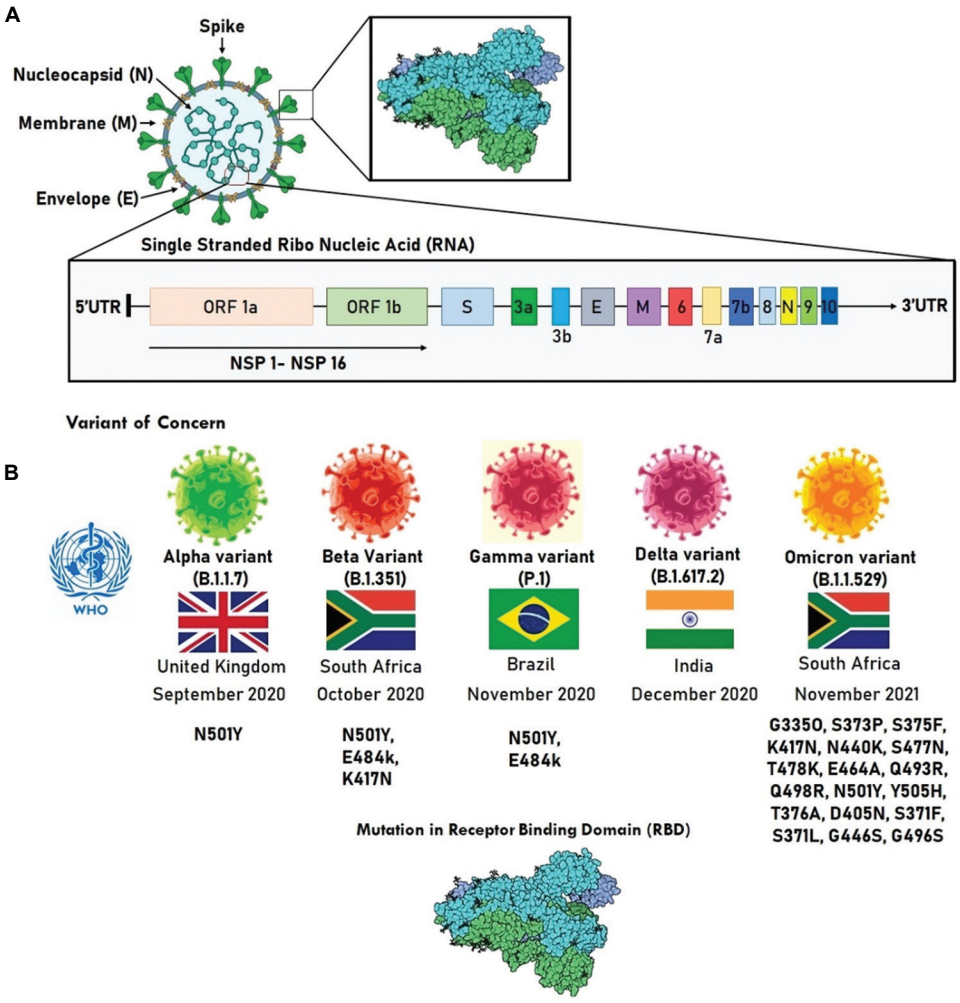


Figure 4. Different COVID-19 variants from different countries. (A) Structure of COVID-19, including the component of genes of COVID-19; (B) Variant of concern. Image created by the authors

people who were older, male, or obese (Docherty *et al.*, 2020), or who suffered from pulmonary hypertension, chronic cardiac conditions (Pagnesi *et al.*, 2020), diabetes, chronic obstructive pulmonary disease, liver diseases, and chronic kidney disease (Iaccarino *et al.*, 2020). Patients at lower risk of death also often experienced persistent symptoms, and up to 70% of such individuals exhibited organ damage 4 months after their initial symptoms. The affected organs included the heart, lungs, kidneys, liver, pancreas, and spleen (Dennis *et al.*, 2021). Vaccines significantly reduced mortality rates but debates persist about whether COVID-19 can be eradicated or could reemerge (Murray, 2022).

4. Impact of COVID-19

Governments worldwide implemented strict lockdowns when the pandemic began, and self-isolation was mandated to curb the spread of COVID-19. These measures were effective in preventing infections (Coccia, 2021) but they also exerted a significant negative impact. As Figure 6 illustrates, the lockdowns affected many sectors including business (Donthu & Gustafsson, 2020), economy, health, and education (Jiang *et al.*, 2021; Shastri *et al.*, 2020; Nicola *et al.*, 2020; Haleem *et al.*, 2020). The sections that follow detail how strict lockdowns adversely impacted diverse aspects of society and affected resources.

4.1. Mental and emotional health

Mental health is defined as the state of well-being in which individuals can manage daily challenges and contribute constructively to society (World Health Organization, 2004; Galderisi *et al.*, 2015). The COVID-19 pandemic disrupted this balance, primarily because preventive measures such as lockdowns confined people to their

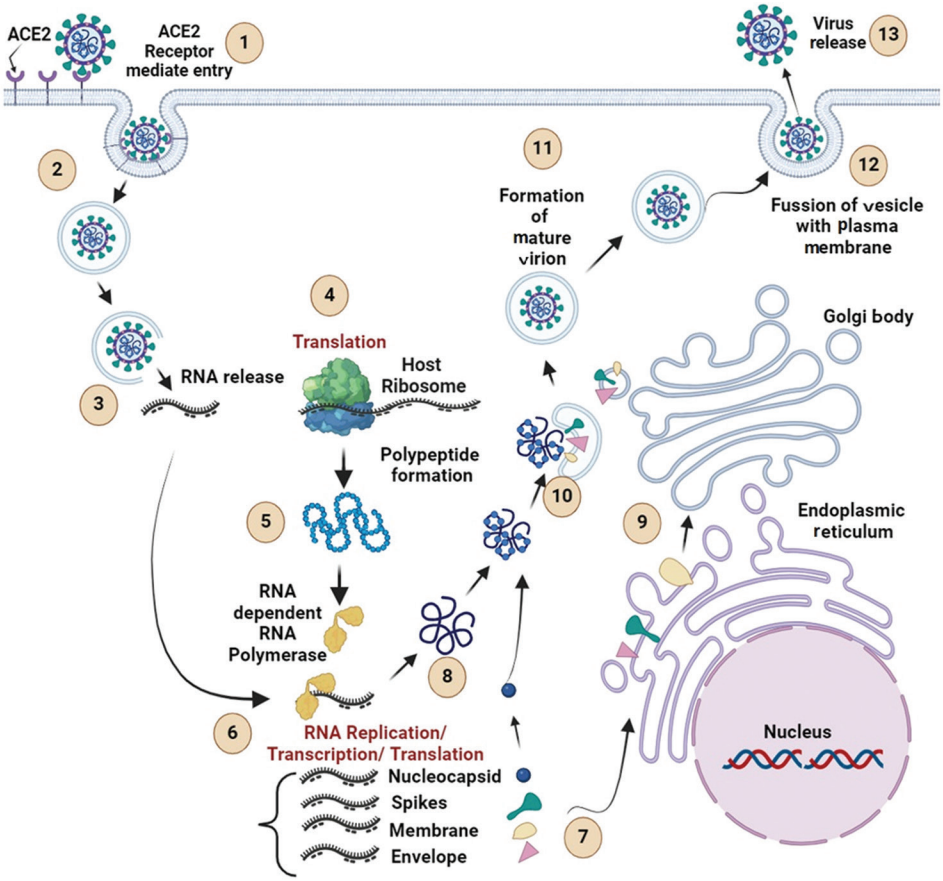


Figure 5. Schematic representation of the life cycle of COVID-19: (1) Membrane fusion at the plasma membrane following endocytosis; (2) This fusion is mediated by conformational changes in the glycoprotein induced by angiotensin-converting enzyme 2 (ACE2) binding; (3) After entering the host cell, COVID-19 releases its genomic ssRNA into the cytoplasm; (4) Here, the genome RNA is first translated into viral replicase polyprotein; (5) These polyproteins are later on are further cleaved by viral proteases into a total of 16 non-structural proteins (NSP) that form a replication-transcription complex (RTC); (6) The negative-sense (- sense) genomic RNA is generated and used as a template to produce positive-sense (+ sense) by RTC; (7) S protein membrane (M) protein and envelope (E) protein are transcribed, subsequently translated in the rough endoplasmic reticulum (RER), and transported to the Golgi complex; (8) The nucleocapsid (N) structural protein and viral RNA are replicated, transcribed, and synthesized in the cytoplasm; (9) In the RER and Golgi complex, the COVID-19 glycoprotein is subjected to cotranslational and post-translational processing including signal peptide removal, trimerization, extensive glycosylation and subunit cleavage; (10) The N protein is subsequently associated with the positive-sense genomic RNA to become a nucleo-protein complex (nucleocapsid),which is further assembled together with S, M, and E proteins as well as other viral proteins and followed by budding into the lumen of the ER-Golgi intermediate compartment to form mature virions; (11 – 13) The mature virions then reach the plasma membrane where they become fused with plasma membranes and exit the cell through exocytosis. Image created by the authors.

homes except to accomplish essential tasks such as visiting medical facilities and buying provisions (Park *et al.*, 2022). Such restrictions increase stress, confusion, and anxiety in individuals (Brooks *et al.*, 2020; Lima *et al.*, 2020). Notably, these issues were often more severely experienced by people without pre-existing mental health conditions than people who already suffered from mental health problems (Kang *et al.*, 2020; Qiu *et al.*, 2020; Singh *et al.*, 2023).

Studies linked increased social media use during lockdowns to reduced physical activity, which was associated with health problems such as early aging, obesity, cardiovascular issues, muscle atrophy, bone loss, and decreased aerobic capacity (Kang *et al.*, 2020; Qiu *et al.*, 2020; Maugeri *et al.*, 2020). Financial difficulties, job losses, and separation from family members because of the mandated restraints also heightened depression and anxiety in people (Jean-Baptiste *et al.*, 2020). The impact was particularly profoundly sensed by children and adolescents who sensed increased anxiety and uncertainty because of school closures that disrupted their daily routines, social interactions, and access to educational resources (Imran *et al.*, 2020; Guan *et al.*, 2020).

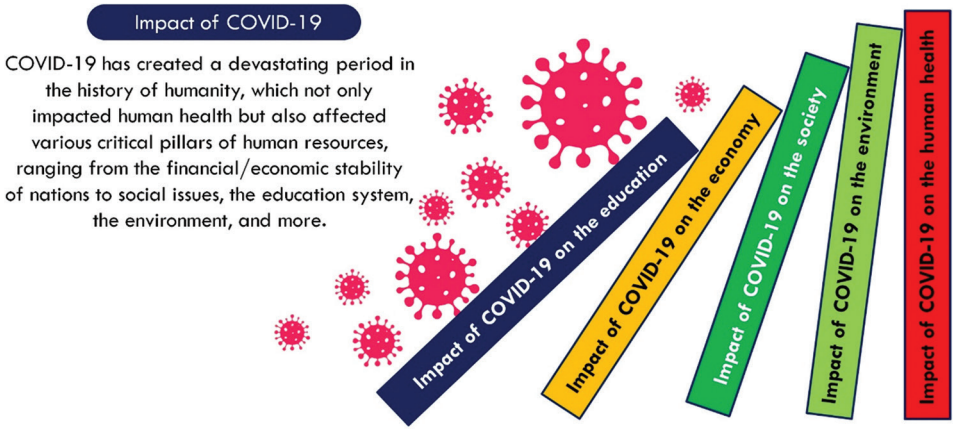


Figure 6. Graphical representation of the impact of COVID-19 on different aspects of human societies. Image created by the authors
Abbreviation: COVID-19: Coronavirus disease 2019.

4.1.1. Social media and psychological well-being

In the last decade, social media has become a crucial tool for raising public health awareness; this role intensified during the COVID-19 pandemic as people increasingly turned to platforms such as Facebook, Twitter, YouTube, Instagram, Snapchat, and WhatsApp for information. Such usage surged 87% after lockdowns were announced and helped to reduce mental stress, supported online learning, and facilitated remote work (Chand, 2021). However, the negative aspects of social media became more apparent as the pandemic progressed. People began to share misinformation disseminated by unreliable sources and believed false assertions about the prevention and treatment of COVID-19 despite the availability of accurate guidance from official health websites. Unofficial and religious pages propagated misrepresentations that became linked to poorer psychological well-being (Hernández-García & Giménez-Júlvez, 2020).

The adverse effects of social media were particularly severe in developing countries such as India. Panic fueled on social media platforms caused shortages of essential items such as masks and hand sanitizers even before the first COVID-19 case was reported. False claims were made about the virus's survival on surfaces and its airborne transmission and exaggerated news were distributed about mass casualties in China. Such fabrications generated widespread fear and anxiety. Moreover, stress and discrimination intensified because of rumors about extended lockdowns and racism toward people from India's northeastern regions who were mistakenly associated with Chinese origins (Kadam & Atre, 2020). Further, the elderly were significantly psychologically and physically distressed. The rapid spread of unscientific information altered societal perceptions and resulted in the increased emotional abuse of older citizens, causing heightened depression in this population (Anwar *et al.*, 2020). Thus, social media facilitated communication during the pandemic but also enabled the dissemination of false information, exacerbating mental and emotional health difficulties.

4.1.2. COVID-19 and the mental health of teachers

The pandemic significantly impacted the educational sector worldwide, prompting a swift transition from offline face-to-face learning to online remote education. This shift presented both teachers and students with several challenges because the rapid adoption of information and communication technologies became central to teaching and learning processes. The mental health of teachers, who are often regarded as "nation builders," became a major concern. Poor mental health is often associated with elevated stress levels and can undermine the effectiveness of teaching-learning processes (Borrelli *et al.*, 2014). Consequently, changes in the working conditions of teachers could be correlated with variations in their mental health states (Fernández Cruz *et al.*, 2018).

The Internet provided valuable educational tools; however, inadequate technical abilities and unreliable digital infrastructures intensified the learning disparities that existed across regions (Hidalgo-Andrade *et al.*, 2021). Many educators were unprepared for the technological challenges posed by the pandemic. Teachers struggled with online education because they were insufficiently prepared and lacked the requisite technological capabilities and pedagogies for remote teaching. Stress levels increased as teachers faced the prospect of disengaged students who were unresponsive to assignments and distracted by their surroundings (Hassan *et al.*, 2020). The psychological well-being of teachers was also affected by personal issues

such as concerns about their future and family health, the pressure to satisfy the expectations of students, parents, and school administrations, financial difficulties, and the need to balance professional and personal or family responsibilities (Jakubowski & Sitko-Dominik, 2021). These factors collectively contributed to the declining mental and emotional well-being of teachers.

4.1.3. COVID-19 and the mental health of children and adolescents

Schools function crucially in the lives of students, providing them with educational resources as well as valuable opportunities to interact with teachers and peers. However, children often become less physically active on weekends or during summer breaks when they are not in school. They tend to spend more time facing screens, experience irregular sleep patterns, and consume less nutritious food. These changes can contribute to weight gain and poor cardiorespiratory health (Brazendale *et al*., 2017). The COVID-19 pandemic intensified such problems by imposing physical limitations and social isolation on children and adolescents. Thus, it significantly impacted every aspect of the lives of youngsters. Relatively fewer children contracted the disease but the more wide-ranging effects of social exclusion, school closures, and isolation exerted profound negative effects on their emotional and mental well-being (Meherali *et al*., 2021).

The shift from face-to-face learning to online education introduced substantial stressors for children, particularly in developing nations such as India in which online teaching was not widely established before the pandemic. According to UNESCO, school closures affected 320 million students in India and nearly 1.725 billion students globally by May 18, 2020. Key obstacles included the paucity of digital devices, insufficient digital skills, and unreliable Internet connections (Hassan *et al*., 2020). Children and adolescents in Jammu and Kashmir experienced severe Internet connectivity issues in the early stages of COVID-19 because of restricted 4G access, which further hampered their education. As a result, the children faced increased pandemic-related stressors such as limited educational resources, fear of infection, boredom, inadequate personal space at home, and family financial losses. These factors contribute to heightened anxiety, depression, sleep disturbances, appetite changes, and social dysfunction in children and adolescents (Brooks *et al*., 2020).

4.1.4. COVID-19 and the mental health of medical professionals

Health-care professionals (HCPs) faced an elevated risk of burnout during the pandemic and were significantly more likely to experience stress, anxiety, and depression. The surge in their caseloads necessitated longer working hours, often with limited resources and questionable infrastructure (Shigemura *et al*., 2020). Personal protective equipment (PPE) was crucial for their safety but it also caused great physical discomfort and sometimes resulted in breathing difficulties. Many HCPs felt unprepared for their roles because of the absence of pre-existing guidelines or evidence-based treatments for the new virus (Huang *et al*., 2020). Medical care professionals (MCPs) also feared infecting loved ones and concerns about autoinoculation further compounded their stress (Kang *et al*., 2020). Many HCPs isolated themselves from their usual social circles and changed their daily routines to safeguard others; in some cases, they even separated themselves from their families. Notwithstanding these drawbacks, the pandemic elevated HCPs to superhero status, enhancing the perceived value of their roles and boosting their job satisfaction. However, public recognition also increased pressure on them and reduced room for error. The media portrayal of HCPs as heroes was driven by the sensational nature of the pandemic and underscored the need for positive reinforcement and acknowledgment (Sandesh *et al*., 2020). Consequently, the COVID-19 pandemic evidently exerted a profound negative impact on the mental health of a significant number of healthcare workers.

4.1.5. COVID-19 and migrant workers

The impact of the pandemic was especially severe on migrant workers and the homeless, who were often bereft of stable shelters and were thus more vulnerable to social, psychological, and emotional trauma (Verma & Prakash, 2020). Many migrants were already among the most marginalized social groups and their survival depended on daily wages. Thus, their immediate anxieties during the pandemic included securing food, housing, and health care even as they grappled with the fear of contracting or spreading infection, worried about the loss of wages, and agonized about the safety of their families (Singh, 2020). Besides such challenges, migrants also sometimes confront negative reactions and intimidation from local communities.

In response, the state and central governments in India attempted to mitigate such issues by providing shelter and food to migrant workers. However, the effectiveness of these measures remains uncertain. Media reports frequently highlighted the struggles of migrants traveling long distances to return home on foot or by bicycle. According to the International Labor Organization, the pandemic resulted in a 6.7% reduction in working hours globally, and 195 million full-time jobs were lost in the second quarter of 2020 alone (International Labour Organization, 2020). A total of 255 million full-time jobs

and working hours were lost by the end of 2020 (Raut, 2020). Tragically, many individuals died en route or upon reaching their destinations (Kumar *et al*., 2020). Conflicts between government agencies were also reported about the logistics of returning migrants to their places of origin. These cumulative factors caused migrant workers significant mental distress.

4.2. Impact of COVID-19 on society

Physical distancing instigated new survival patterns during the COVID-19 pandemic. People stayed home, developed new hobbies, and focused more on work than on household chores. This increased time at home strengthened family bonds because individuals who previously struggled to connect because of work commitments were now compelled to spend more time together. Mobile phones and the Internet became essential for continued interactions and these means helped people to adapt to new routines and balance their professional tasks with their household responsibilities (Verma & Prakash, 2020).

However, the initially positive experience of being together in proximity soon succumbed to mental health challenges. In particular, children suffered because they were forced to isolate from their peers, stay at home, and adhere to social distancing norms, which changed their brain architecture and induced psychological distress (Gautam *et al*., 2020). The elderly also experienced significant mental health problems, particularly exhibiting depressive symptoms that were exacerbated by their difficulties with smartphones and Internet services and their restricted access to outpatient clinics and essential medications (Nikolakakis *et al*., 2019; Mansour *et al*., 2020; Yang *et al*., 2020). Frontline workers including police officers and healthcare personnel experienced heightened stress, anxiety, and depression because of the demands imposed on them by the pandemic (Chen *et al*., 2020). Women reported significantly higher levels of stress, anxiety, and post-traumatic stress disorder symptoms, and displayed more severe overall psychological effects (Wang *et al*., 2020a & b; Liu *et al*., 2020a & b; Daulay, 2021). In addition, mothers participating in homeschooling for children with autism spectrum disorders faced challenges such as coping with maladaptive behaviors, inadequate teaching skills, and insufficient support, which led to increased parental distress.

4.3. Impact of COVID-19 on education

The first wave of the COVID-19 pandemic presented universities and colleges worldwide with the challenge of balancing infection control against their educational responsibilities. The debate about whether to continue in-person classes or switch to online instruction became focal and many institutions speedily adopted remote learning technologies as a viable alternative to physical presence in class. Universities and private sector educational institutions swiftly devised effective strategies to transition to virtual learning systems (VLS) despite numerous complexities, limited resources, and technology constraints. The employed strategies included professional training for faculty, staff, and students along with the institution of quality assurance measures to ensure the effectiveness of online education (Maqsood *et al*., 2021).

Recent research endeavors have highlighted diverse approaches to delivering science, technology, engineering, math, and medicine education via teaching laboratories in virtual or remote environments. Bhute *et al*. (2021) suggested that the amalgamation of technologies such as IoT sensors and augmented or virtual reality can revitalize traditional labs, enhance student experiences, and inspire innovative pedagogies. In the context of Indian business schools, Chaturvedi *et al*. referenced concepts mooted by John Dewey, Kolb, Jack Mezirow, and Jean Piaget and identified six key teaching techniques that could help construct successful integrated learning environments. Their suggestions included (1) utilizing online knowledge repositories and virtual labs to transform digital spaces, (2) shaping educational practices through critical thinking, (3) offering diverse course genres on demand, (4) enhancing resilience through active participation and conflict resolution, (5) fostering focused and inquisitive education, and (6) embracing experiential education that values classroom diversity (Chaturvedi *et al*., 2021). Such initiatives intend to encourage academics and educators to develop effective pedagogies tailored to the needs of Indian student populations.

Medical education was substantively disrupted during the COVID-19 pandemic because the in-person learning and practical experience crucial for specializations such as dentistry (Chang *et al*., 2021), plastic surgery (Cho & Hong, 2021), and clinical radiography (Ofori-Manteaw *et al*., 2022; Chen *et al*., 2022) were severely impacted. The pandemic jeopardized the opportunities students could avail of to acquire essential hands-on knowledge and precluded the inculcation of skills typically acquired through active, face-to-face activities. Co *et al*. recommended the development of new tools and software to address such challenges: for instance, e-learning portals, online anatomy education, surgical skills training, and virtual reality platforms that could facilitate learning through online lectures (Co *et al*., 2022). Clinical instructors adapted to the absence of real patients by themselves simulating patients and utilizing clinical case scenarios incorporating genuine patient imagery and electronic medical records (Park *et al*., 2021).

Tuma *et al.* emphasized the need to replace traditional face-to-face activities with alternative surgical curricular components (Tuma *et al.*, 2021). Ng (2021) explored pre-registration adjustments in the Medical Radiation Science curriculum in response to the pandemic, noting their impact on varied stakeholders. Smith & Farra (2022) highlighted significant healthcare reforms triggered by the pandemic, including changes in nursing practices and education. Investigations comparing traditional classroom settings with VLS indicated that online learning can prove more effective because it offers benefits such as easier tracking of student progress, increased engagement, scheduling flexibility, enhanced efficiency, and improved academic collaborations (Hong *et al.*, 2021).

VLS emerged as crucial tools that allowed educational continuity during the pandemic but their implementation posed several challenges. Principal problems included technological difficulties, high costs, low student engagement, and trouble with focus maintenance. Specific concerns for medical students included two-dimensional representations in anatomy or surgical skill courses, limited time to engage in academic discussions, and the refusal of health institutions to accept trainees for practical experience stints during the pandemic (Ofori-Manteaw *et al.*, 2022). VLS cannot completely replace traditional in-person instruction but they offer notable advantages and serve as valuable educational aids in difficult times (Onigbinde *et al.*, 2021; Hilburg *et al.*, 2020). Hao *et al.* underscored the growing significance of Internet-based learning for medical and nursing students, both now and in the future (Hao *et al.*, 2022). Discrete research groups (Patil *et al.*, 2022; Chen *et al.*, 2022) have also highlighted the rapid advancements and improvements in radiology education during the pandemic. A hybrid approach combining simulation-based innovations, virtual readouts, virtual teaching seminars, and remote work could potentially refine the traditional model of in-person instruction by delivering flexibility, increasing convenience, and offering residents more wide-ranging exposure (Patil *et al.*, 2022).

The imperative of remote learning disproportionately impacted children belonging to racial minorities, living in poverty, requiring special education, or speaking English as a second language (Hoofman & Secord, 2021; Garg *et al.*, 2020). Studies conducted across different regions have revealed that inadequate online education infrastructure and the shortage of qualified personnel were significant issues. For example, the absence of sustainable online systems and limited Internet access in remote and rural areas were major obstacles in Nepal (Pal *et al.*, 2021). Similarly, Oyedotun identified critical online education challenges in Guyana: the paucity of computers, laptops, or tablets; insufficient prior preparation of both students and educators; inadequate national infrastructure; slow Internet speeds; inconsistent electricity supply; ineffective course delivery; and poor student-teacher engagement. Issues such as long working hours, compromised deadlines, limited review capabilities, and concerns over mental health, cybersecurity, and viral exposure further exacerbated the difficulties faced by students and educators (Oyedotun, 2020).

Discrete surveys have been conducted with students in different countries: for instance, in the Kitwe district in Zambia (Mukuka *et al.*, 2021), at Western Michigan University in the United States (Al-Mawee *et al.*, 2021), and at an Afghan university (Noori, 2021). Most students articulated both good and bad aspects of distance learning, such as the loss of social connection or the flexibility of time and place (Al-Mawee *et al.*, 2021) in places where most residents did not enjoy adequate access to ICT, power, or online services (Mukuka *et al.*, 2021). Reuge *et al.* (2021) published a paper titled "Education response to COVID-19 pandemic, a special issue proposed by UNICEF: Editorial review." This review article included comments from UNICEF on the effects of school closures, the efficacy of remote learning solutions, equality-related implications, and the prevention of learning losses, and presented ideas about more effectively reopening schools. The transition from in-person to online apparently exerted a negative impact on the well-being of students enrolled in higher education institutions in discrete nations such as Turkey (Topuz *et al.*, 2021), Pakistan (Maqsood *et al.*, 2021), and Ethiopia (Mengistie, 2021). Students in these countries suffered mostly from anxiety and depression, and such psychiatric abnormalities were more prevalent in adolescent populations. Most students with mental health difficulties belonged to migrant contexts, were female, or did not own substantial social support resources (Van de Velde *et al.*, 2021; Fretheim *et al.*, 2021).

4.4. Impact of COVID-19 on business

The COVID-19 crisis opened doors to innovation and offered many commercial organizations the opportunity to adopt new business models that could help them navigate the difficulties posed by the pandemic. However, the crisis also introduced significant obstacles for enterprises. The initial economic impact was characterized by abrupt decreases in the aggregate demand as well as supply; thus, many businesses were jeopardized and their revenues were significantly diminished (Seetharaman, 2020). For instance, Internet-based businesses found it difficult to sell their products online because lockdowns severely restricted import and export activities (Hasanat *et al.*,

2020). However, certain sectors such as the pharmaceutical, healthcare, vitamin, and herbal industries experienced growth and success during this period. Nonetheless, small businesses were particularly vulnerable: Many of them confronted the higher risk of closure as sales plummeted across nearly every industry (Apedo-Amah *et al*., 2020). Small- and medium-sized enterprises (SMEs) were profoundly affected because the COVID-19 pandemic stagnated their growth and disrupted their supply chains, placing both businesses and individuals under immense pressure. Many small businesses were forced to shut down permanently because extended periods of inactivity caused significant financial losses (Guo *et al*., 2020). Varied stakeholders such as regulators and public administrations executed financial support measures to address such challenges and assist SMEs. Governments worldwide launched policies to mitigate the adverse impact on SMEs. For example, the United States government passed the CARES Act, establishing several temporary programs to address the adverse economic effects of the COVID-19 outbreak (Song *et al*., 2020).

The informal sector encompasses around 90% of India's workforce, and street vendors represent 14% of this informal labor force. The lockdown resulted in government regulations that restricted the operating hours of vendors, which severely affected their incomes. To cope with this difficulty, vendors were compelled to travel from one colony to another to reach more customers. Their circumstances worsened as many daily wage earners took to selling vegetables, which increased the number of sellers while the demand remained the same. The heightened competition forced vendors to lower prices, which further reduced their profits. Furthermore, many vendors lost regular customers who preferred to buy their provisions from nearby sellers (Meher, 2021). Similarly, the lockdown significantly impacted grocery stores in India. Panic buying triggered by news of the lockdown caused stock shortages (Jain, 2020), and many grocery stores were partially or fully closed. Thus, customers encountered long queues, unreliable deliveries, inflated prices, and limited product selections (Bandyopadhyaya & Bandyopadhyaya, 2021).

The hospitality sector is a major source of global employment and denotes a significant source of income; this statement applies particularly to the restaurant sector. The pandemic impaired human movement; thus, most eateries were closed for sit-in meals as governments increasingly enacted laws stipulating social isolation and lockdowns. Family-friendly eateries, bars, and taverns were adversely affected by such mandates. Fast food restaurants suffered the same effects and most such operations ran at <20% capacity, resulting in significant financial losses and curtailing both direct and indirect jobs (Nhamo *et al*., 2020).

A COVID-19-caused decrease was noted in the number of active firms in all industries including construction, personal services, hotels, restaurants, and transportation. The travel and tourism industries were among the sectors that were most severely impacted because many nations banned travel to curb the spread of infection. The exports of skin and leather products, clothing, automobiles, and footwear also decreased by more than 20% (Kalogiannidis, 2020). Transportation sectors including air, rail, road, and water transportation were all affected. The intricate supply and demand trends also significantly impacted passenger and freight transportation. Commercial flight activity diminished by almost 75% from 2019 levels by mid-April 2020, and global road transport activity reduced by nearly 50% from 2019. In addition, the UK's restrictions on public transportation decreased the number of subway trips in London by 95%. The global cessation of aviation activity made mobility extremely problematic (Abu-Rayash & Dincer, 2020).

Health-care services aimed at satisfying the health-related needs of people represented one of the fastest-growing industries in both developed and developing nations. Any health system is centered on healthcare workers, whose activities aim to improve the health outcomes of communities (George *et al*., 2014). Healthcare workers were in high demand because of the additional work required during the pandemic. Thus, health-care systems sought and aimed to retain skilled workers to avoid staff shortages that could jeopardize the future safety of societies (Winter *et al*., 2020) and job opportunities increased in health-care systems across the globe. Pharmacy services served as the principal foundation of public health during the recent pandemic. Essentially, the market was taken over by the Internet, and customers frequently purchased medications online. Online pharmacies offered advantages over traditional chain pharmacies but also posed some risks to patient safety. Most people prefer to procure their medicines online because of the COVID-19 lockdowns (Singh *et al*., 2020). In sum, the health sector flourished in terms of employment and revenue during COVID-19.

The steady growth of Internet users worldwide and the growing awareness of populaces became strong drivers of the rapid expansion of online shopping before the COVID-19 outbreak. In addition, the increasing number of products launched online and the low-price offers for bulk purchases boosted online consumer purchases. Moreover, the wider variety of product options helped the expansion of global electronic markets (Boore *et al*., 2017). Numerous restrictions were imposed on businesses and individuals

during the COVID-19 pandemic, significantly accelerating the transition toward the digitalization of commerce (Fetzer *et al*., 2020). Studies identified e-commerce as a dependent variable because the declines or increases in the demand for online platforms were influenced largely by the global spread of the virus and the individual behaviors resulting from the pandemic (Ahmad & Hui, 2020). In addition, these two variables; the steady growth of Internet users worldwide and growing awareness of online shopping increased general interest in web-based business markets and were considered reasons for individual shifts toward web-based businesses (Li & Li, 2020).

4.5. Impact of COVID-19 on travel and tourism

Traveling is one of the best ways of meeting new people and discovering new destinations, provided journeys are free from incidences of illnesses, crimes, and disasters. Of course, the chances of such adverse occurrences are quite slim, and generally, such risks can be minimized or eliminated with accurate knowledge. Thus, travel journals are filled with unforgettable memories. A pandemic or epidemic is one of the most terrifying situations for travel-related organizers or planners, and such situations can render disease prevention difficult or impossible. Pandemics are transported between locations by travelers; thus, travelers risk contracting COVID-19 and infecting others who come into contact with them on their journeys (Hollingsworth *et al*., 2006).

Travel-related infections have a long history. For example, almost 66% of around 8000 people infected with the SARS virus infection between November 2002 and June 2003 lived in China, and 5% resided in Hong Kong (Mackey & Liang, 2012). However, numerous other nations were also affected worldwide. The advent of the COVID-19 infection exerted a significant negative impact on the activities of diverse industries, including tourism. Scrutiny of the effects of the spread of the virus in the early stages of infection (regardless of official quarantine restrictions) would probably yield a significant drop in "social ingestion," which encompasses dining out, domestic travel, attending cultural events, participating in trade shows, etc. (Hasanat *et al*., 2020). It is widely known that the tourist sector substantively boosts the economy of nations (Do Valle *et al*., 2006), and China's inbound and outbound tourism markets are considered among the world's most popular. The Chinese tourism industry contributes the largest proportion of the country's revenue from domestic trips, which account for around CN¥ 5,128 billion in annual revenue for China (https://asianjournals.org/online/index.php/ajms/article/view/213/96).

Thus, China's tourism industry was extremely affected by the COVID-19 outbreak in the nation (Hoque *et al*., 2020). The tourism bureau of the Chinese government reported that the country alone brought in about $127.3 billion in 2019 (https://www.bloomberg.com/news/articles/2020-02-13/coronavirus-s-effect-on-tourism-will-carry-into-2021-experts-say), and the major detrimental effect to the industry resulted from the rate of cancellations of travel and tourism agreements between China and other Asian countries (Chen *et al*., 2018; Hoque *et al*., 2020).

Research conducted by the World Travel and Tourism Council (WTTC) revealed that up to 75 million jobs would immediately be placed at risk because of COVID-19. The WTTC believed that the global effects of the Coronavirus pandemic would result in the daily loss of 1 million jobs in the travel and tourism sector. According to the WTTC's projections, as many as 75 million people worldwide faced the prospect of losing their employment and the gross domestic product (GDP) of the travel and tourism sector would suffer a loss of $ 2.1 trillion by 2020. Thus, research findings indicated that the impact of the pandemic would be adverse, considerable, and substantial (Mao *et al*., 2010). Chinese consumption would not represent the only factor to adversely impact the tourism economy; rather, country-specific effects would accrue as the virus spread outside of China. According to the pessimistic projections of the Organization for Economic Co-operation and Development (OECD), global GDP expansion would decrease by 1.5% in 2020, with a 3.75% drop in world trade volumes. Other forecasts also posited dramatic outcomes (McKibbin & Fernando, 2020).

4.6. COVID-19 and financial losses

A nation is built by its people, and countries develop because of their economies, which depend on their citizens. However, as previously discussed, the world's political, religious, economic, social, and financial systems changed drastically because of the COVID-19 pandemic. Therefore, the governments of different nations announced lockdowns to limit the exposure, restricting human movement (Kishore *et al*., 2021). However, lockdowns became a negative variable that decreased the GDP of discrete nations. Research has shown that countries with quarantine lockdowns officially confirmed that day (i.e., Austria, Belgium, Brazil, Canada, Italy, and Spain) were hit harder by the financial markets than nations with a lower debt-to-GDP ratio, despite both falling by nearly 15% after the WHO declared COVID-19 a pandemic (Iglesias, 2022). It was found that longer-term lockdowns hampered GDP growth: the average contraction of GDP (index 2010 = 100) from the second quarter of 2019 to the second quarter of 2020 in countries imposing longer lockdowns

(i.e., around 2 months) was approximately 21% compared to 13% in countries imposing shorter lockdowns (i.e., around 15 days). Therefore, containment strategies based on prolonged societal lockdowns systematically weakened the economic systems of nations (Coccia, 2021; Makridis & Hartley, 2020). The non-interventionist herd immunity approach of the United States was also shown to impose high costs (Chen *et al*. 2021).

The GDP of several of the world's most important economic regions fell, including the Americas, Europe, Northeast Asia, the Western Pacific, and the Arctic. It was initially predicted that the GDP loss resulting from untreated COVID-19 could equate to a total of US$1.4 trillion by 2030 assuming that 60% of the population would become infected in 3 years. This figure would amount to a tax of 0.6% of the GDP in 2019 (in 2010 US dollar terms) or around 7.7% of the GDP in 2019 (Verma *et al*., 2021). According to the findings of Martinho *et al*. (Martinho *et al*., 2021), the convergence indicators of the OECD countries from the end of 2017 to the end of 2019 were obliterated by the pandemic, particularly in the first two quarters of 2020.

After the initial decline in the GDP of different nations, researchers attempted to ascertain risk-related variables based on the published data. Scholars determined some risk predictors of a country's susceptibility to the COVID-19 shock as poor GDP dynamics and strong sensitivity of bond yields to VIX in the period before the pandemic (Janus, 2021; Iluno *et al*. 2021), GDP per capita, population density, income inequality (Feng *et al*. 2022), and discretionary measures adopted by governments (Kaufmann, 2020). These variables were thought to instigate the overall decline in the GDPs of nations (Havrlant *et al*. 2021; Azomahou *et al*. 2021; Kaufmann, 2020; Verma *et al*. 2021; Chen *et al*. 2021). Researchers also proposed high-potential recovery plans based on oil price estimates and empirical findings. Social safety net policy, economic transformation, innovation, technology revolution, fiscal restraint, and climate-friendly stability were deemed the most likely means of mitigating the amount of damage (Azomahou *et al*. 2021; Chudik *et al*., 2021; Khurshid & Khan, 2021; Auerbach *et al*., 2021).

4.7. COVID-19 on the environment

The global environment has deteriorated significantly; the pollutant levels and Air Quality Indices of many regions have exceeded permissible limits. However, the measures taken to curb the spread of the coronavirus and the resulting slowdown in economic activities during the pandemic exerted a notable impact on the environment. Restricted human activities positively affected water bodies, air quality, and forests; however, negative effects were also observed because of the presence of aerosols, nitrogen dioxide (NO_2), and ozone (O_3). The Central Pollution Control Board (CPCB) in India reported a slight improvement in the quality of river water across the country during the lockdown. Major pollution sources such as industrial activities were temporarily stopped or considerably reduced. Hence, the quality of varied indigenous water supplies was expected to improve because of the reduced discharge of contaminants (Sivakumar *et al*., 2020). The organic pollution levels in surface waters decreased during the lockdown period and oxygen saturation levels increased. However, fecal contamination levels remained unchanged (MoS and MoEFCC), largely because of consistent human waste production, which is closely linked to population density. Several studies reported improvements in the surface waters of rivers, lakes, and groundwater (Patel *et al*., 2020; Lokhandwala & Gautam, 2020; Yunus *et al*., 2020; Selvam *et al*., 2020; Bhattacharya *et al*., 2021).

Restrictions imposed on motorboat traffic during Italy's lockdown resulted in a significant improvement in water purity: for instance, the clear waters in Venice revealed seaweed and other aquatic life (Mack, 2020). The deserted beaches in Florida offered turtles a safe haven where they could lay their eggs (CNN, 2020). Similarly, the absence of crowds in the Dubai Marina allowed rare sightings of Eagle rays near the docks (CNN, 2020). The decreased industrial effluent discharge into Venice's canals resulted in cleaner waters, attracting schools of fish and swans, and creating an unusually calm and quiet urban environment (Mack, 2020). In India, the Ganges Dolphin was spotted in Kolkata after nearly three decades. This remarkable occurrence was reported by *The Times of India* on April 25, 2020, and was attributed to the decreased pollution during the lockdown (CPCB, 26 May 2020). Thus, the lockdown in India apparently yielded the unintended consequence of significantly initiating the cleaning of the Ganges River, India's most sacred yet heavily polluted water source (Times of India, 2020). The average suspended particulate matter (PM) content of Vembanad Lake also decreased by 15.9%, reflecting better water quality than the previous year (Yunus *et al*., 2020). New York's air pollution levels decreased by about 50% because of pandemic-related measures (Henriques, 2020). Overall, the COVID-19 lockdowns contributed to a healthier aquatic environment and enhanced biodiversity across the globe.

Researchers observed significant reductions in greenhouse gas (GHG) emissions during the initial COVID-19 lockdowns because of the widespread closure of industries, transportation, and businesses. Data

obtained from continuous ambient air quality monitoring stations in major Indian cities vis-à-vis the first and second lockdown phases from March 25, 2020, to May 3, 2020, disclosed a notable decrease in pollutants. This decline in air PM was attributed to the cessation of industrial activities, reduced traffic congestion, paused construction work, and diminished human action. Specifically, PM with a diameter of <2.5 μm decreased by 9 – 70%, and PM with a diameter of <10 μm diminished by 20 – 68%. In addition, sulfur dioxide (SO_2) levels dropped by 19 – 77%, and NO_2 levels fell by 20 – 87%. This temporary improvement in air quality highlighted the environmental benefits of reduced industrial and vehicular activities during the lockdown. Scholars believe that cars and aviation contribute predominantly to emissions and respectively account for almost 72% and 11% of the GHG emissions in the transportation sector (Henriques, 2020).

A study conducted by the University of West Georgia found that carbon dioxide emissions would be reduced by ten tons if 100 students stopped traveling to school or university. State-imposed restrictions during the COVID-19 outbreak resulted in significant reductions in GHG emissions, approximating the extent noted in Italy and China (CDP, 2020). China reported a nearly 25% drop in carbon emissions during this period (Myllyvirta, 2020). Airborne pollutants such as NO_2 and CO_2 also decreased in discrete regions (McMahon *et al*., 2020). Wang *et al*. used the community multi-scale air quality model to assess pollutant reductions in China and found that limiting traffic and industrial activity helped but the sole use of these measures was insufficient in improving air quality in poor weather conditions (Wang *et al*., 2020). The study emphasized the need to endeavor further to achieve substantial reductions in air pollution. Another study conducted in Barcelona, Spain (Tobias *et al*., 2020), observed decreased air pollution during the outbreak and reported notable reductions in Black Carbon and NO_2. However, PM with a diameter of <10 μm evinced only a minor decrease, and increased O_3 levels were reported because of reduced nitrogen oxide titration of O_3.

NO_2 is a highly reactive pollutant produced from the combustion of carbon fuels, primarily from vehicular emissions, and is harmful to human health even with short-term exposure. NO_2 can cause cellular inflammation, bronchial hyperresponsiveness, and respiratory issues, leading to 4.6 million deaths annually (Muhammad *et al*., 2020; Latza *et al*., 2009). Long-term exposure to NO_2 levels as low as 0.1 parts per million can lead to chronic conditions such as bronchitis and emphysema and affect lung function (Boningari & Smirniotis, 2016). The reduced industrial activity and fewer on-road vehicles during the COVID-19 lockdowns resulted in a significant decrease in NO_2 levels, and reductions of up to 30% were observed globally (NASA, 2020). O_3 exerts differing effects depending on its location at the ground level or the upper atmosphere: stratospheric O_3 protects against UV rays but ground-level O_3 can be harmful. Increased O_3 concentrations were noted during the quarantine period and were linked to decreased levels of the mix of nitrogen oxides because of varied chemical reactions (Hashim *et al*., 2021; Martorell-Marugán *et al*., 2021). Such decreases led to significant O_3 increases in several regions: 183% in Chandigarh, India; 525% in Baghdad, Iraq; 56.3% in Spain; 14% in California, U.S.A.; and 49.8% in Wuhan, China (Fu *et al*., 2020).

4.7.1. Impact of COVID-19 on forests

The National Wildlife Foundation has stated that paper constitutes 60% of school and university waste. In addition, 16 trees are needed to produce one ton of paper, and recycling ten tons of paper saves about 100 barrels of crude oil (Sun *et al*., 2008). E-learning reduces the need for paper and consequently decreases the number of trees felled across the world. It also lowers costs incurred by students by digitizing registration, administration, curricula, and study materials (Sun *et al*., 2008). A study conducted in the Netherlands found that e-learning reduced CO_2 emissions and decreased the carbon footprints of students and staff members (Versteijlen *et al*., 2017). Moreover, e-learning helps to prevent the detrimental environmental effects of the annual discarding of 350 million printer cartridges that will take approximately 1,000 years to decompose (Sun *et al*., 2008).

However, some negative environmental outcomes were also noted during the COVID-19 pandemic: for instance, medical waste increased. Wuhan generated 240 metric tons of biological waste daily at the peak of the outbreak peak, 6 times its average quantity (Zuo, 2020). Plastic medical masks made from polypropylene further exacerbated environmental problems because their decomposition poses problems (CDP, 2020; Robert, 2020; https://www.who.int/news/item/01-02-2022-tonnes-of-covid-19-health-care-waste-expose-urgent-need-to-improve-waste-management-systems).

In addition, numerous investigations were conducted to determine the presence of SARS-CoV-2 in municipal raw wastewater in the Netherlands (Medema *et al*., 2020), the United States (Wu *et al*., 2020), Australia (Ahmed *et al*., 2020), France (Wurtzer *et al*., 2020), India (Kumar *et al*., 2020a-c), Turkey (Kocamemi *et al*., 2020), the United Arab Emirates (Hasan *et al*., 2021), Bangladesh (Ahmed *et al*., 2020, Jakariya *et al*., 2021). The results of these investigations offer a more comprehensive image of

the outbreak: SARS-CoV-2 genetic pre-dispositions were found in untreated water infected by coronaviruses and untreated sewage from insufficient wastewater treatment plants released into aquatic bodies (Chen *et al*., 2021). The effects of natural contributors such as seawater and desert dust over Italy, Greece, and the entire eastern Mediterranean region is one reason why the levels of PM <10 μm did not drop as much as NO_2 and other gaseous pollutants. Thus, researchers have indicated the need for more thorough research of the causes of the decline in PM <10 μm (Conte *et al*., 2020).

4.7.2. Impact of COVID-19 on aerosols

Diverse aerosols were employed to disinfect streets, buildings, and homes to combat SARS-CoV-2. However, the frequent use of such disinfectants can eliminate beneficial organisms and disrupt ecological balance (Elsaid *et al*., 2021). Aerosol levels in the midpeninsula region of India improved despite nationwide lockdowns, compared to quantities noted before the lockdown. A significant increase was noted in aerosol loading in 2020: Aerosol optical depth (AOD) anomalies were predominantly positive even though some regions exhibited slight negative anomalies. Notably, AOD levels declined in northern and southern India, Pakistan, and Bangladesh during the lockdowns compared to climatology, whereas positive anomalies persisted in the midpeninsula region (Pandey & Vinoj, 2021). The COVID-19 pandemic was a critical historical event because it profoundly impacted human health as well as the financial, economic, social, educational, and environmental aspects of human existence. Despite the vaccine rollouts, ongoing debates persist about the potential of future COVID-19 outbreaks (Murray *et al*., 2022). This situation underscores the need to continuously monitor the perceptions and awareness levels of populations. A pressing need also exists for enhanced communication strategies and institutional endeavors to effectively address such issues (Genovese *et al*., 2022).

5. Strengths and weaknesses of this review

We record several strengths and weaknesses of the current state-of-the-art review that must be considered in evaluating its quality and comprehensiveness.

The strengths of our review include our detailed examination of the structure and genome of COVID-19, which accords essential insights into the infectious mechanisms and vulnerabilities of the virus. Notably, the review encompasses the impact of COVID-19 on seven diverse domains of human existence: Mental health, society, education, business, travel and tourism, financial health, and the environment. This extensive scope enabled us to deliver a comprehensive understanding of the multifaceted effects of the pandemic on discrete aspects of human life and global systems. This pioneering review contributes significantly to the extant literature by integrating such wide-ranging effects into a single analysis. In so doing, it offers a broad yet insightful perspective on the widespread consequences of the pandemic.

Despite its comprehensive approach, the review admits to limitations resulting from its broad scope. Our attempts to address such a wide array of domains in a single article restricted the depth of the analysis that could be accomplished for each area. This extensive coverage necessitated a balance between breadth and detailed exploration and could have resulted in gaps, oversimplifications, or a less detailed treatment of some domains. The inherent challenges of incorporating a vast span of impact in a single study underscore the difficulties of comprehensively capturing the intricate and nuanced effects of COVID-19. Thus, our review delivers a valuable overview but could benefit if more focused and in-depth studies are conducted in the future to complement and enhance the knowledge of the effects of COVID-19 on specific domains.

6. Conclusion

The COVID-19 pandemic imposed devastating effects on nearly every aspect of human life. This respiratory infection overwhelmed healthcare systems worldwide and caused significant economic disruption. It affected industries such as tourism, hospitality, and retail. It also impacted education, increased loneliness, and foregrounded gaps in global governance. The pandemic accelerated digital adoption and technology use but exerted mixed environmental effects. It reduced air pollution but increased plastic waste from PPEs. The repercussions of COVID-19 were profound: they affected health, financial stability, social interactions, and other facets. Despite widespread vaccinations, debates continue about the long-term impact of this disease and the preparedness of human societies for future global health crises.

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References

Abildúa, M.A., Atienza, S., Monteiro, G.C., Aguirre, M.E., Aguayo, L.I., Álvarez, E.F., *et al.* (2021). Encephalopathy and encephalitis during acute SARS-CoV-2 infection. Spanish Society of Neurology's COVID-19 Registry. *Neurología*, 36(2):127-134.

https://doi.org/10.1016/j.nrl.2020.11.013

Abu-Rayash, A., & Dincer, I. (2020). Analysis of mobility trends during the COVID-19 coronavirus pandemic: Exploring the impacts on global aviation and travel in selected cities. *Energy Research and Social Science*, 68:101693.

https://doi.org/10.1016/j.erss.2020.101693

Ahmad, T., & Hui, J. (2020). One health approach and coronavirus disease 2019. *Human Vaccines and Immunotherapeutics*, 16(4):931-932.

https://doi.org/10.1080/21645515.2020.1732168.

Ahmed, F., Islam, M.A., Kumar, M., Hossain, M., Bhattacharya, P., Islam, M.T., *et al.* (2021). First detection of SARS-CoV-2 genetic material in the vicinity of COVID-19 isolation Centre in Bangladesh: Variation along the sewer network. *The Science of the Total Environment*, 776, 145724.

https://doi.org/10.1016/j.scitotenv.2021.145724

Al-Mawee, W., Kwayu, K.M., & Gharaibeh, T. (2021). Student's perspective on distance learning during COVID-19 pandemic: A case study of Western Michigan University, United States. *International Journal of Educational Research Open*, 2:100080.

https://doi.org/10.1016/j.ijedro.2021.100080

Al-Salameh, A., Bennis, Y., Cariou, B., & Lalau, J.D. (2021). The association between metformin treatment and COVID-19 outcomes according to metformin continuation during hospitalisation. *Diabetes and Metabolism*, 47(6):101297.

https://doi.org/10.1016/j.diabet.2021.101297

Aneja, R., & Ahuja, V. (2021). An assessment of socioeconomic impact of COVID-19 pandemic in India. *Journal of Public Affairs*, 21(2):e2266.

https://doi.org/10.1002/pa.2266

Anthony, S.J., Johnson, C.K., Greig, D.J., Kramer, S., Che, X., Wells, H., *et al.* (2017). Global patterns in coronavirus diversity. *Virus Evolution*, 3(1):vex012.

https://doi.org/10.1093/ve/vex012

Anwar, A., Malik, M., Raees, V., & Anwar, A. (2020). Role of mass media and public health communications in the COVID-19 pandemic. *Cureus*, 12(9):e10453.

https://doi.org/10.7759/cureus.10453

Apedo-Amah, M.C., Avdiu, B., Cirera, X., Cruz, M., Davies, E., Grover, A., *et al.* (2020). Unmasking the Impact of COVID-19 on Businesses: Firm Level Evidence from Across the World. The World Bank, Washington, DC. Available from: https://hdl.handle.net/10986/34626 [Last accessed on 2024 Dec 06].

Auerbach, A.J., Gorodnichenko, Y., & Murphy, D. (2021). Inequality, fiscal policy and COVID19 restrictions in a demand-determined economy. *European Economic Review*, 137:103810.

https://doi.org/10.1016/j.euroecorev.2021.103810

Azomahou, T.T., Ndung'u, N., & Ouedraogo, M. (2021). Coping with a dual shock: The economic effects of COVID-19 and oil price crises on African economies. *Resources Policy*, 72:102093.

https://doi.org/10.1016/j.resourpol.2021.102093

Baharoon, S., & Memish, Z.A. (2019). MERS-CoV as an emerging respiratory illness: A review of prevention methods. *Travel Medicine and Infectious Disease*, 32:101520.

https://doi.org/10.1016/j.tmaid.2019.101520

Bandyopadhyaya, V., & Bandyopadhyaya, R. (2024). Understanding the impact of COVID-19 pandemic outbreak on grocery stocking behaviour in India: A pattern mining approach. *Global Business Review*, 25(3):750-770.

https://doi.org/10.1177/0972150921988955

Bhargava, A., Fukushima, E.A., Levine, M., Zhao, W., Tanveer, F., Szpunar, S.M., *et al.* (2020). Predictors for severe COVID-19 infection. *Clinical Infectious Diseases*, 71(8):1962-1968.

https://doi.org/10.1093/cid/ciaa674

Bhattacharya, P., Kumar, M., Islam, M.T., Haque, R., Chakraborty, S., Ahmad, A., *et al.* (2021). Prevalence

of SARS-CoV-2 in communities through wastewater surveillance-a potential approach for estimation of disease burden *Current Pollution Reports*, 7(2):160-166.

Bhute, V.J., Inguva, P., Shah, U., & Brechtelsbauer, C. (2021). Transforming traditional teaching laboratories for effective remote delivery-a review. *Education for Chemical Engineers*, 35:96-104.

Boningari, T., & Smirniotis, P.G. (2016). Impact of nitrogen oxides on the environment and human health: Mn-based materials for the NOx abatement. *Current Opinion in Chemical Engineering*, 13:133-141.

https://doi.org/10.1016/j.coche.2016.09.004

Boore, C., James, N.M., & Iraki, X. (2017). Strategic issues in e-Health implementation in developing countries: The Kenyan healthcare sector. *Global Scientific Journals*, 5(7):50-62.

Borrelli, I., Benevene, P., Fiorilli, C., D'Amelio, F., & Pozzi, G. (2014). Working conditions and mental health in teachers: A preliminary study. *Occupational Medicine (Oxford, England)*, 64(7):530-532.

https://doi.org/10.1093/occmed/kqu108

Brazendale, K., Beets, M.W., Weaver, R.G., Pate, R.R., Turner-McGrievy, G.M., Kaczynski, A.T., *et al.* (2017). Understanding differences between summer vs. school obesogenic behaviors of children: The structured days hypothesis. *International Journal of Behavioral Nutrition and Physical Activity*, 14:1-14.

Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N., *et al.* (2020). The psychological impact of quarantine and how to reduce it: Rapid review of the evidence. *Lancet* (*London, England*), 395(10227):912-920.

https://doi.org/10.1016/S0140-6736(20)30460-8

Carpagnano, G.E., Di Lecce, V., Quaranta, V.N., Zito, A., Buonamico, E., Capozza, E., *et al.* (2021). Vitamin D deficiency as a predictor of poor prognosis in patients with acute respiratory failure due to COVID-19. *Journal of Endocrinological Investigation*, 44(4):765-771.

https://doi.org/10.1007/s40618-020-01370-x

CDP. (2020). *The Relationship between Climate Change and Coronavirus (Covid-19).* CDP Turkey. Available from: https://cdpturkey.sabanciuniv.edu/tr/content/iklim-coronavirus [Last accessed on 2020 Apr 20].

Central Pollution Control Board. (2021). *Annual Report on Solid Waste Management (2020-21).* Central Pollution Control Board. Available from: https://cpcb.nic.in:contentReference[oaicite:0]{index=0}:contentReference[oaicite:1]{index=1} [Last accessed on 2021 Aug 26].

Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. *Science of the Total Environment*, 728:138882.

https://doi.org/10.1016/j.scitotenv.2020.138882

Chan, J.F.W., Yuan, S., Kok, K.H., To, K.K.W., Chu, H., Yang, J., *et al.* (2020). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: A study of a family cluster. *The lancet*, 395(10223):514-523.

https://doi.org/10.1016/S0140-6736(20)30154-9

Chand, A.A. (2021). Abuse of social media during COVID-19 pandemic in Fiji. *International Journal of Surgery*, 92:106012.

https://doi.org/10.1016/j.ijsu.2021.106012

Chang, J.Y.F., Wang, L.H., Lin, T.C., Cheng, F.C., & Chiang, C.P. (2021). Comparison of learning effectiveness between physical classroom and online learning for dental education during the COVID-19 pandemic. *Journal of Dental Sciences*, 16(4):1281-1289.

https://doi.org/10.1016/j.jds.2021.07.016

Chaturvedi, S., Purohit, S., & Verma, M. (2021). Effective teaching practices for success during COVID 19 pandemic: Towards phygital learning. *Frontiers in Education*, 6:1-10.

https://doi.org/10.3389/feduc.2021.646557

Chehal, D., Gupta, P., & Gulati, P. (2021). COVID-19 pandemic lockdown: An emotional health perspective of Indians on Twitter. *The International Journal of Social Psychiatry*, 67(1):64-72.

https://doi.org/10.1177/0020764020940741

Chen, C., Hayward, K., Khan, S.J., Örmeci, B., Pillay, S., Rose, J.B., *et al.* (2021). Role of wastewater treatment in COVID-19 control. *Water Quality Research Journal*, 56(2):68-82.

https://doi.org/10.2166/wqrj.2020.025

Chen, D., Ayoob, A., Desser, T.S., & Khurana, A. (2022). Review of learning tools for effective radiology education during the COVID-19 era. *Academic Radiology*, 29(1):129-136.

https://doi.org/10.1016/j.acra.2021.10.006

Chen, M.P., Lee, C.C., Lin, Y.H., & Chen, W.Y. (2018). Did the SARS epidemic weaken the integration of Asian stock markets? Evidence from smooth time-varying cointegration analysis. *Economic Research-Ekonomska Istraživanja*, 31(1):908-926.

https://doi.org/10.1080/1331677X.2018.1456354

Chen, Q., Liang, M., Li, Y., Guo, J., Fei, D., Wang, L., *et al.* (2020). Mental health care for medical staff in China during the COVID-19 outbreak. *The Lancet Psychiatry*, 7(4):e15-e16.

https://doi.org/10.1016/S0140-6736(20)30185-9

Chen, S., Prettner, K., Kuhn, M., & Bloom, D.E. (2021). The economic burden of COVID-19 in the United States: Estimates and projections under an infection-based herd immunity approach. *The Journal of the Economics of Ageing*, 20:100328.

https://doi.org/10.1016/j.jeoa.2021.100328

Cho, M.J., & Hong, J.P. (2021). The emergence of virtual education during the COVID-19 pandemic: The past, present, and future of the plastic surgery education. *Journal of Plastic, Reconstructive and Aesthetic Surgery*, 74(6):1413-1421.

https://doi.org/10.1016/j.bjps.2020.12.099

Chudik, A., Mohaddes, K., Pesaran, M.H., Raissi, M., & Rebucci, A. (2021). A counterfactual economic analysis of Covid-19 using a threshold augmented multi-country model. *Journal of International Money and Finance*, 119:102477.

https://doi.org/10.1016/j.jimonfin.2021.102477

CNN. (2020). *Marine Conservation Efforts in the UAE.* CNN Travel. Available from: https://edition.cnn.com/travel/article/marine-conservation-uae-spc-intl/index.html [Last accessed on 2024 Dec 06].

Co, M., Cheung, K.Y.C., Cheung, W.S., Fok, H.M., Fong, K.H., Kwok, O.Y., *et al.* (2022). Distance education for anatomy and surgical training - A systematic review. *The Surgeon: Journal of the Royal Colleges of Surgeons of Edinburgh and Ireland*, 20(5):e195-e205.

https://doi.org/10.1016/j.surge.2021.08.001

Coccia, M. (2021). The relation between length of lockdown, numbers of infected people and deaths of Covid-19, and economic growth of countries: Lessons learned to cope with future pandemics similar to Covid-19 and to constrain the deterioration of economic system. *Science of the Total Environment*, 775:145801.

https://doi.org/10.1016/j.scitotenv.2021.145801

Conte, M., Merico, E., Cesari, D., Dinoi, A., Grasso, F.M., Donateo, A., *et al.* (2020). Long-term characterisation of African dust advection in south-eastern Italy: Influence on fine and coarse particle concentrations, size distributions, and carbon content. *Atmospheric Research*, 233:104690.

https://doi.org/10.1016/j.atmos res.2019.104690

Daulay, N. (2021). Home education for children with autism spectrum disorder during the COVID-19 pandemic: Indonesian mothers experience. *Research in Developmental Disabilities*, 114:103954.

https://doi.org/10.1016/j.ridd.2021.103954

Dennis, A., Wamil, M., Alberts, J., Oben, J., Cuthbertson, D.J., Wootton, D., *et al.* (2021). Multiorgan impairment in low-risk individuals with post-COVID-19 syndrome: A prospective, community-based study. *BMJ Open*, 11(3):e048391.

https://doi.org/10.1136/bmjopen-2020-048391

Do Valle, P.O., Silva, J.A., Mendes, J., & Guerreiro, M. (2006). Tourist satisfaction and destination loyalty intention: A structural and categorical analysis. *International Journal of Business Science and Applied Management*, 1(1):25-44.

https://hdl.handle.net/10419/190577

Docherty, A.B., Harrison, E.M., Green, C.A., Hardwick, H.E., Pius, R., Norman, L., *et al.* (2020). Features of 20 133 UK patients in hospital with covid-19 using the ISARIC WHO Clinical Characterisation Protocol: Prospective observational cohort study. *BMJ*, 369:m1985.

https://doi.org/10.1136/bmj.m1985

Donthu, N., & Gustafsson, A. (2020). Effects of COVID-19 on business and research. *Journal of business research*, 117: 284-289.

https://doi.org/10.1016/j.jbusres.2020.06.008

Elsaid, K., Olabi, V., Sayed, E.T., Wilberforce, T., & Abdelkareem, M.A. (2021). Effects of COVID-19 on the environment: An overview on air, water, wastewater, and solid waste. *Journal of Environmental Management*, 292:112694.

https://doi.org/10.1016/j.jenvman.2021.112694

Feng, Q., Wu, G.L., Yuan, M., & Zhou, S. (2022). Save lives or save livelihoods? A cross-country analysis of COVID-19 pandemic and economic growth. *Journal of Economic Behavior and Organization*, 197:221-256.

https://doi.org/10.1016/j.jebo.2022.02.027

Fernández Cruz, F.J., Fernández Díaz, M.J., & Rodríguez Mantilla, J.M. (2018). El proceso de integración y uso pedagógico de las TIC en los centros educativos madrileños. *Educación XX1: Revista de la Facultad de Educación*, 21(2):395-416.

https://doi.org/10.5944/educxx1.17907

Fetzer, T., Hensel, L., Hermle, J., & Roth, C. (2021). Coronavirus perceptions and economic anxiety. *Review of Economics and Statistics*, 103(5):968-978.

https://doi.org/10.48550/arXiv.2003.03848

Fretheim, A., Helleve, A., Løyland, B., Sandbekken, I.H., Flatø, M., Telle, K., *et al.* (2021). Relationship between teaching modality and COVID-19, well-being, and teaching satisfaction (campus & corona): A cohort study among students in higher education. *Public Health in Practice*, 2:100187.

https://doi.org/10.1016/j.puhip.2021.100187

Fu, G., Hasekamp, O., Rietjens, J., Smit, M., Di Noia, A., Cairns, B., *et al.* (2020). Aerosol retrievals from different polarimeters during the ACEPOL campaign using a common retrieval algorithm. *Atmospheric Measurement Techniques*, 13(2): 553-573.

https://doi.org/10.5194/amt-13-553-2020

Galderisi, S., Heinz, A., Kastrup, M., Beezhold, J., & Sartorius, N. (2015). Toward a new definition of mental health. *World Psychiatry*, 14(2):231-233.

https://doi.org/10.1002/wps.20231

García-Azorín, D., Sierra, Á., Trigo, J., Alberdi, A., Blanco, M.,

Calcerrada, I., *et al.* (2021). Frequency and phenotype of headache in covid-19: A study of 2194 patients. *Scientific Reports*, 11(1):14674.

https://doi.org/10.1038/s41598-021-94220-6

Garg, S., Aggarwal, D., Upadhyay, S.K., Kumar, G., & Singh, G. (2020). Effect of COVID-19 on school education system: Challenges and opportunities to adopt online teaching and learning. *Humanities and Social Sciences Reviews*, 8(6):10-17.

https://doi.org/10.18510/hssr.2020.862

Gautam, M., Thakrar, A., Akinyemi, E., & Mahr, G. (2020). Current and future challenges in the delivery of mental healthcare during COVID-19. *SN Comprehensive Clinical Medicine*, 2(7):865-870.

Geller, C., Varbanov, M., & Duval, R.E. (2012). Human coronaviruses: Insights into environmental resistance and its influence on the development of new antiseptic strategies. *Viruses*, 4(11):3044-3068.

https://doi.org/10.3390/v4113044

Genovese, C., La Fauci, V., Di Pietro, A., Trimarchi, G., Odone, A., Casuccio, A., *et al.* (2021). COVID-19 pandemic: Opinions and behavior of Italian general population during the first epidemic phase. *Acta Bio-Medica De L'ateneo Parmense*, 92(3):e2022262.

https://doi.org/10.23750/abm.v93i3.12262

George, P.P., Papachristou, N., Belisario, J.M., Wang, Wark, P.A., Cotic, Z., *et al.* (2014). Online eLearning for undergraduates in health professions: A systematic review of the impact on knowledge, skills, attitudes and satisfaction. *Journal of Global Health*, 4(1):010406.

https://doi.org/10.7189/jogh.04.010406

Graham, R.L., & Baric, R.S. (2010). Recombination, reservoirs, and the modular spike: Mechanisms of coronavirus cross-species transmission. *Journal of Virology*, 84(7):3134-3146.

https://doi.org/10.1128/JVI.01394-09

Guan, H., Okely, A.D., Aguilar-Farias, N., Del Pozo Cruz, B., Draper, C.E., *et al.* (2020). Promoting healthy movement behaviours among children during the COVID-19 pandemic. *The Lancet. Child and Adolescent Health*, 4(6):416-418.

https://doi.org/10.1016/S2352-4642(20)30131-0

Guo, H., Yang, Z., Huang, R., & Guo, A. (2020). The digitalization and public crisis responses of small and medium enterprises: Implications from a Covid-19 survey. *Frontiers of Business Research in China*, 14(19):1-25.

https://doi.org/10.1186/s11782-020-00087-1

Haleem, A., Javaid, M., & Vaishya, R. (2020). Effects of COVID-19 pandemic in daily life. *Current Medicine Research and Practice*, 10(2):78-79.

https://doi.org/10.1016/j.cmrp.2020.03.011

Hao, X., Peng, X., Ding, X., Qin, Y., Lv, M., Li, J., *et al.* (2022). Application of digital education in undergraduate nursing and medical interns during the COVID-19 pandemic: A systematic review. *Nurse Education Today*, 108:105183.

https://doi.org/10.1016/j.nedt.2021.105183

Hasan, S.W., Ibrahim, Y., Daou, M., Kannout, H., Jan, N., Lopes, A., *et al.* (2021). Detection and quantification of SARS-CoV-2 RNA in wastewater and treated effluents: Surveillance of COVID-19 epidemic in the United Arab Emirates. *Science of the Total Environment*, 764:142929.

https://doi.org/10.1016/j.scitotenv.2020.142929

Hasanat, M.W., Hoque, A., Shikha, F.A., Anwar, M., Hamid, A.B.A., & Tat, H.H. (2020). The impact of coronavirus (COVID-19) on e-business in Malaysia. *Asian Journal of Multidisciplinary Studies*, 3(1):85-90.

Hashim, B.M., Al-Naseri, S.K., Al-Maliki, A., & Al-Ansari, N. (2021). Impact of COVID-19 lockdown on NO2, O3, PM2. 5 and PM10 concentrations and assessing air quality changes in Baghdad, Iraq. *Science of the Total Environment*, 754:141978.

https://doi.org/10.1016/j.scitotenv.2020.141978

Hassan, M.M., Mirza, T., & Hussain, M.W. (2020). A critical review by teachers on the online teaching-learning during the COVID-19. *International Journal of Education and Management Engineering*, 10(8):17-27.

https://doi.org/10.5815/ijeme.2020.05.03

Havrlant, D., Darandary, A., & Muhsen, A. (2021). Early estimates of the impact of the COVID-19 pandemic on GDP: A case study of Saudi Arabia. *Applied Economics*, 53(12):1317-1325.

https://doi.org/10.1080/00036846.2020.1828809

Henriques, M. (2020). Will Covid-19 have a Lasting Impact on the Environment. BBC News. p.26. Available from: https://www.bbc.com/future/article/20200326-covid-19-the-impact-of-coronavirus-on-the-environment [Last accessed on 2024 Dec 06].

Hernández-García, I., & Giménez-Júlvez, T. (2020). Assessment of health information about COVID-19 prevention on the internet: Infodemiological study. *JMIR Public Health and Surveillance*, 6(2):e18717.

https://doi.org/10.2196/18717

Hidalgo-Andrade, P., Hermosa-Bosano, C., & Paz, C. (2021). Teachers' Mental health and self-reported coping strategies during the COVID-19 pandemic in Ecuador: A mixed-methods study. *Psychology Research and Behavior Management*, 14:933-944.

https://doi.org/10.2147/PRBM.S314844

Hilburg, R., Patel, N., Ambruso, S., Biewald, M.A., & Farouk, S.S. (2020). Medical education during the coronavirus disease-2019 pandemic: Learning from a distance. *Advances in Chronic Kidney Disease*, 27(5):412-417.

https://doi.org/10.1053/j.ackd.2020.05.017

Hiscott, J., Alexandridi, M., Muscolini, M., Tassone, E., Palermo, E., Soultsioti, M., *et al.* (2020). The global impact of the coronavirus pandemic. *Cytokine and Growth Factor Reviews*, 53:1-9.

https://doi.org/10.1016/j.cytogfr.2020.05.010

Hollingsworth, T.D., Klinkenberg, D., Heesterbeek, H., & Anderson, R.M. (2011). Mitigation strategies for pandemic influenza A: balancing conflicting policy objectives. *PLoS Computational Biology*, 7(2):e1001076.

https://doi.org/10.1371/journal.pcbi.1001076

Hong, J.C., Liu, Y., Liu, Y., & Zhao, L. (2021). High school students' online learning ineffectiveness in experimental courses during the COVID-19 pandemic. *Frontiers in Psychology*, 12:738695.

https://doi.org/10.3389/fpsyg.2021.738695

Hoofman, J., & Secord, E. (2021). The effect of COVID-19 on education. *Pediatric Clinics of North America*, 68(5): 1071-1079.

https://doi.org/10.1016/j.pcl.2021.05.009

Hoque, A., Shikha, F.A., Hasanat, M.W., Arif, I., & Hamid, A.B.A. (2020). The effect of coronavirus (COVID-19) in the tourism industry in China. *Asian Journal of Multidisciplinary Studies*, 3(1):52-58.

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., *et al.* (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet*, 395(10223): 497-506.

https://doi.org/10.1016/S0140-6736(20)30183-5

Iaccarino, G., Grassi, G., Borghi, C., Ferri, C., Salvetti, M., & Volpe, M. (2020). Age and multimorbidity predict death among COVID-19 patients: Results of the SARS-RAS study of the Italian Society of Hypertension. *Hypertension*, 76(2):366-372.

https://doi.org/10.1161/HYPERTENSIONAHA.120.15324

Iglesias, E.M. (2022). The influence of extreme events such as Brexit and Covid-19 on equity markets. *Journal of Policy Modeling*, 44(2):418-430.

https://doi.org/10.1016/j.jpolmod.2021.10.005

Iluno, C., Taylor, J., Akinmoladun, O., Aderele, O., & Ekum, M. (2021). Modelling the effect of Covid-19 mortality on the economy of Nigeria. *Research in Globalization*, 3:100050.

https://doi.org/10.1016/j.resglo.2021.100050

Imran, N., Zeshan, M., & Pervaiz, Z. (2020). Mental health considerations for children & adolescents in COVID-19 Pandemic. *Pakistan Journal of Medical Sciences*, 36:67-72.

https://doi.org/10.12669/pjms.36.COVID19-S4.2759

International Labour Organization. (2009). Available from: https://www.ilo.org/resource/news/ilo-covid-19-causes-devastating-losses-working-hours-and-employment-0 [Last accessed on 2024 Dec 06].

Jain, S.A. (2020). A study of changes in individual income, spending & saving pattern as a result of COVID-19 situation in India. *Tathapi*, 19(13):339-368.

Jakariya, M., Ahmed, F., Islam, M.A., Ahmed, T., Marzan, A.A., Hossain, M., *et al.* (2021). Wastewater based surveillance system to detect SARS-CoV-2 genetic material for countries with on-site sanitation facilities: An experience from Bangladesh. *MedRxiv*, 2021-07.

Jakubowski, T.D., & Sitko-Dominik, M.M. (2021). Teachers' mental health during the first two waves of the COVID-19 pandemic in Poland. *PLoS One*, 16(9):e0257252.

https://doi.org/10.1371/journal.pone.0257252

Janus, J. (2021). The COVID-19 shock and long-term interest rates in emerging market economies. *Finance Research Letters*, 43:101976.

https://doi.org/10.1016/j.frl.2021.101976

Jean-Baptiste, C.O., Herring, R.P., Beeson, W.L., Dos Santos, H., & Banta, J.E. (2020). Stressful life events and social capital during the early phase of COVID-19 in the US. *Social Sciences and Humanities Open*, 2(1):100057.

https://doi.org/10.1016/j.ssaho.2020.100057

Jiang, P., Fu, X., Fan, Y.V., Klemeš, J.J., Chen, P., Ma, S., *et al.* (2021). Spatial-temporal potential exposure risk analytics and urban sustainability impacts related to COVID-19 mitigation: A perspective from car mobility behaviour. *Journal of Cleaner Production*, 279:123673.

https://doi.org/10.1016/j.jclepro.2020.123673

Jothimani, D., Kailasam, E., Danielraj, S., Nallathambi, B., Ramachandran, H., Sekar, P., *et al.* (2020). COVID-19: Poor outcomes in patients with zinc deficiency. *International Journal of Infectious Diseases*, 100:343-349.

https://doi.org/10.1016/j.ijid.2020.09.014

Kadam, A.B., & Atre, S.R. (2020). Negative impact of social media panic during the COVID-19 outbreak in India. *Journal of Travel Medicine*, 27(3):taaa057.

https://doi.org/10.1093/jtm/taaa057

Kalogiannidis, S. (2020). Covid impact on small business. *International Journal of Social Science and Economics Invention*, 6(12):387-391.

https://doi.org/10.23958/ijssei/vol06-i12/257

Kang, L., Ma, S., Chen, M., Yang, J., Wang, Y., Li, R., *et al.* (2020). Impact on mental health and perceptions of psychological care among medical and nursing staff in Wuhan during the 2019 novel coronavirus disease outbreak: A cross-sectional study. *Brain, Behavior, and Immunity*, 87:11-17.

https://doi.org/10.1016/j.bbi.2020.03.028

Kaufmann, S. (2020). COVID-19 outbreak and beyond: The information content of registered short-time workers for GDP now-and forecasting. *Swiss Journal of Economics and Statistics*, 156(1):12.

Khoo, B., Tan, T., Clarke, S.A., Mills, E.G., Patel, B., Modi, M., *et al.* (2021). Thyroid function before, during, and after COVID-19. *The Journal of Clinical Endocrinology and Metabolism*, 106(2):e803-e811.

https://doi.org/10.1210/clinem/dgaa830

Khurshid, A., & Khan, K. (2021). How COVID-19 shock will drive the economy and climate? A data-driven approach to model and forecast. *Environmental Science and Pollution Research*, 28(3):2948-2958.

Kishore, N., Kahn, R., Martinez, P.P., De Salazar, P.M., Mahmud, A.S., & Buckee, C.O. (2021). Lockdowns result in changes in human mobility which may impact the epidemiologic dynamics of SARS-CoV-2. *Scientific Reports*, 11(1):6995.

https://doi.org/10.1038/s41598-021-86297-w

Kocamemi, B.A., Kurt, H., Hacıoglu, S., Yaralı, C., Saatci, A.M., & Pakdemirli, B. (2020). First data-set on SARS-CoV-2 detection for Istanbul wastewaters in Turkey. *MedRxiv*, 2020-05.

https://doi.org/10.1101/2020.05.03.20089417

Kumar, A., & Nayar, K.R. (2021). COVID 19 and its mental health consequences. *Journal of Mental Health*, 30(1):1-2.

https://doi.org/10.1080/09638237.2020.1757052

Kumar, K., Mehra, A., Sahoo, S., Nehra, R., & Grover, S. (2020). The psychological impact of COVID-19 pandemic and lockdown on the migrant workers: A cross-sectional survey. *Asian Journal of Psychiatry*, 53:102252.

https://doi.org/10.1016/j.ajp.2020.102252

Kumar, M., Mohapatra, S., Mazumder, P., Singh, A., Honda, R., Lin, C., *et al.* (2020). Making waves perspectives of modelling and monitoring of SARS-CoV-2 in aquatic environment for COVID-19 pandemic. *Current Pollution Reports*, 6:468-479.

Kumar, M., Patel, A.K., Shah, A.V., Raval, J., Rajpara, N., Joshi, M., *et al.* (2020). First proof of the capability of wastewater surveillance for COVID-19 in India through detection of genetic material of SARS-CoV-2. *The Science of the Total Environment*, 746:141326.

https://doi.org/10.1016/j.scitotenv.2020.141326

Lai, C.C., Shih, T.P., Ko, W.C., Tang, H.J., & Hsueh, P.R. (2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *International Journal of Antimicrobial Agents*, 55(3):105924.

https://doi.org/10.1016/j.ijantimicag.2020.105924

Latza, U., Gerdes, S., & Baur, X. (2009). Effects of nitrogen dioxide on human health: systematic review of experimental and epidemiological studies conducted between 2002 and 2006. *International Journal of Hygiene and Environmental Health*, 212(3):271-287.

https://doi.org/10.1016/j.ijheh.2008.06.003

Li, F. (2016). Structure, function, and evolution of coronavirus spike proteins. *Annual Review of Virology*, 3(1):237-261.

https://doi.org/10.1146/annurev-virology-110615-042301

Li, K.J., & Li, X. (2020). COVID-19 pandemic: Social distancing, public policy, and market response. *Public Policy, and Market Response*.

https://doi.org/10.2139/ssrn.3593813

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., *et al.* (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *The New England Journal of Medicine*, 382(13):1199-1207.

https://doi.org/10.1056/NEJMoa2001316

Lima, C.K.T., Carvalho, P.M.M., Lima, I.A.A.S., Nunes, J.V.A.O., Saraiva, J.S., de Souza, R.I., *et al.* (2020). The emotional impact of Coronavirus 2019-nCoV (new Coronavirus disease). *Psychiatry Research*, 287:112915.

https://doi.org/10.1016/j.psychres.2020.112915

Liu, H., Wang, L.L., Zhao, S.J., Kwak-Kim, J., Mor, G., & Liao, A.H. (2020). Why are pregnant women susceptible to COVID-19? An immunological viewpoint. *Journal of Reproductive Immunology*, 139:103122.

https://doi.org/10.1016/j.jri.2020.103122

Liu, N., Zhang, F., Wei, C., Jia, Y., Shang, Z., Sun, L., *et al.* (2020). Prevalence and predictors of PTSS during COVID-19 outbreak in China hardest-hit areas: Gender differences matter. *Psychiatry Research*, 287:112921.

https://doi.org/10.1016/j.psychres.2020.112921

Lokhandwala, S., & Gautam, P. (2020). Indirect impact of COVID-19 on environment: A brief study in Indian context. *Environmental Research*, 188:109807.

https://doi.org/10.1016/j.envres.2020.109807

Lone, S.A., & Ahmad, A. (2020). COVID-19 pandemic - an African perspective. *Emerging Microbes and Infections*, 9(1):1300-1308.

https://doi.org/10.1080/22221751.2020.1775132

Mack, E. (2020). Global coronavirus shutdowns let the environment breathe a bit easier.

Mackey, T.K., & Liang, B.A. (2012). Combating healthcare corruption and fraud with improved global health governance. *BMC International Health and Human Rights*, 12:23.

https://doi.org/10.1186/1472-698X-12-23

Makridis, C., & Hartley, J. (2020). The cost of COVID-19: A rough

estimate of the 2020 US GDP impact. *Special Edition Policy Brief*.

https://doi.org/10.2139/ssrn.3570731

Mansour, R., Tsamakis, K., Rizos, E., Perera, G., Das-Munshi, J., Stewart, R., *et al.* (2020). Late-life depression in people from ethnic minority backgrounds: Differences in presentation and management. *Journal of Affective Disorders*, 264: 340-347.

https://doi.org/10.1016/j.jad.2019.12.031

Mao, C.K., Ding, C.G., & Lee, H.Y. (2010). Post-SARS tourist arrival recovery patterns: An analysis based on a catastrophe theory. *Tourism Management*, 31(6):855-861.

https://doi.org/10.1016/j.tourman.2009.09.003

Maqsood, A., Abbas, J., Rehman, G., & Mubeen, R. (2021). The paradigm shift for educational system continuance in the advent of COVID-19 pandemic: Mental health challenges and reflections. *Current Research in Behavioral Sciences*, 2:100011.

https://doi.org/10.1016/j.crbeha.2020.100011

Martorell-Marugán, J., Villatoro-García, J.A., García-Moreno, A., López-Domínguez, R., Requena, F., Merelo, J.J., *et al.* (2021). DatAC: A visual analytics platform to explore climate and air quality indicators associated with the COVID-19 pandemic in Spain. *The Science of the Total Environment*, 750:141424.

https://doi.org/10.1016/j.scitotenv.2020.141424

Maugeri, G., Castrogiovanni, P., Battaglia, G., Pippi, R., D'Agata, V., Palma, A., *et al.* (2020). The impact of physical activity on psychological health during Covid-19 pandemic in Italy. *Heliyon*, 6(6):e04315.

https://doi.org/10.1016/j.heliyon.2020.e04315

McKibbin, W.J., & Fernando, R. (2020). Global macroeconomic scenarios of the COVID-19 pandemic.

https://doi.org/10.2139/ssrn.3635103

Medema, G., Heijnen, L., Elsinga, G., Italiaander, R., & Brouwer, A. (2020). Presence of SARS-Coronavirus-2 RNA in sewage and correlation with reported COVID-19 prevalence in the early stage of the epidemic in the Netherlands. *Environmental Science and Technology Letters*, 7(7):511-516.

https://doi.org/10.1021/acs.estlett.0c00357

Meher, S.R., Ranjan, A., Shukla, P., & Atram, Y. (2021). Effect of Covid-19 lockdown on the livelihood of street vendors in Maharashtra, India. *International Journal of Community Medicine and Public Health*, 8(11):5297-5303.

https://doi.org/10.18203/2394-6040.ijcmph20214263

Meherali, S., Punjani, N., Louie-Poon, S., Abdul Rahim, K., Das, J.K., Salam, R.A., *et al.* (2021). Mental health of children and adolescents amidst COVID-19 and past pandemics: A rapid systematic review. *International Journal of Environmental Research and Public Health*, 18(7):3432.

https://doi.org/10.3390/ijerph18073432

Mengistie, T.A. (2021). Higher education students' learning in COVID-19 pandemic period: The Ethiopian context. *Research in Globalization*, 3:100059.

https://doi.org/10.1016/j.resglo.2021.100059

Metz, T.D., Clifton, R.G., Hughes, B.L., Sandoval, G., Saade, G.R., Grobman, W.A., *et al.* (2021). Disease severity and perinatal outcomes of pregnant patients with coronavirus disease 2019 (COVID-19). *Obstetrics and Gynecology*, 137(4): 571-580.

https://doi.org/10.1097/AOG.0000000000004339

Mousavizadeh, L., & Ghasemi, S. (2021). Genotype and phenotype of COVID-19: Their roles in pathogenesis. *Journal of Microbiology, Immunology, and Infection*, 54(2):159-163.

https://doi.org/10.1016/j.jmii.2020.03.022

Muhammad, S., Long, X., & Salman, M. (2020). COVID-19 pandemic and environmental pollution: A blessing in disguise? *The Science of the Total Environment*, 728:138820.

https://doi.org/10.1016/j.scitotenv.2020.138820

Mukuka, A., Shumba, O., & Mulenga, H.M. (2021). Students' experiences with remote learning during the COVID-19 school closure: Implications for mathematics education. *Heliyon*, 7(7):e07523.

https://doi.org/10.1016/j.heliyon.2021.e07523

Murray, C.J. (2022). COVID-19 will continue but the end of the pandemic is near. *Lancet*, 399:417-419.

https://doi.org/10.1016/S0140-6736(22)00100-3

Myllyvirta, L. (2020). Coronavirus has Temporarily Reduced China's CO_2 Emissions by a Quarter. Carbon Brief. Available from: https://www.carbonbrief.org/analysis-coronavirus-has-tempo [Last accessed on 2020 Apr 20].

NASA. (1996). *Aerosols*. United States: The National Aeronautics and Space Administration.

Ng, C.K.C. (2022). A review of the impact of the COVID-19 pandemic on pre-registration medical radiation science education. *Radiography*, 28(1):222-231.

https://doi.org/10.1016/j.radi.2021.07.026

Nhamo, G., Dube, K., Chikodzi, D., Nhamo, G., Dube, K., & Chikodzi, D. (2020). Restaurants and COVID-19: A focus on sustainability and recovery pathways. In: Counting the Cost of COVID-19 on the Global Tourism Industry. Cham: Springer, p.205-224.

Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., *et al.* (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International Journal of Surgery*, 78:185-193.

https://doi.org/10.1016/j.ijsu.2020.04.018

Nikolakakis, N., Dragioti, E., Paritsis, N., Tsamakis, K.,

Christodoulou, N.G., & Rizos, E.N. (2019). Association between happiness and psychopathology in an elderly regional rural population in Crete. *Psychiatrike Psychiatriki*, 30(4):299-310.

https://doi.org/10.22365/jpsych.2019.304.299

Noori, A.Q. (2021). The impact of COVID-19 pandemic on students' learning in higher education in Afghanistan. *Heliyon*, 7(10):e08113.

https://doi.org/10.1016/j.heliyon.2021.e08113

Ofori-Manteaw, B.B., Dzidzornu, E., & Akudjedu, T.N. (2022). Impact of the COVID-19 pandemic on clinical radiography education: Perspective of students and educators from a low resource setting. *Journal of Medical Imaging and Radiation Sciences*, 53(1):51-57.

https://doi.org/10.1016/j.jmir.2021.11.002

Onigbinde, O.A., Chia, T., Oyeniran, O.I., & Ajagbe, A.O. (2021). The place of cadaveric dissection in post-COVID-19 anatomy education. *Morphologie*, 105(351):259-266.

https://doi.org/10.1016/j.morpho.2020.12.004

Oyedotun, T.D. (2020). Sudden change of pedagogy in education driven by COVID-19: Perspectives and evaluation from a developing country. *Research in Globalization*, 2:100029.

https://doi.org/10.1016/j.resglo.2020.100029

Pagnesi, M., Baldetti, L., Beneduce, A., Calvo, F., Gramegna, M., Pazzanese, V., *et al.* (2020). Integrated clinical role of echocardiography in patients with COVID-19. *Heart*, 106(23):1864-1865.

https://doi.org/10.1136/heartjnl-2020-318310

Pal, K.B., Basnet, B.B., Pant, R.R., Bishwakarma, K., Kafle, K., Dhami, N., *et al.* (2021). Education system of Nepal: Impacts and future perspectives of COVID-19 pandemic. *Heliyon*, 7(9):e08014.

Pandey, S.K., & Vinoj, V. (2021). Surprising changes in aerosol loading over India amid COVID-19 lockdown. *Aerosol and Air Quality Research*, 21(3):200466.

https://doi.org/10.4209/aaqr.2020.07.0466

Park, A.H., Zhong, S., Yang, H., Jeong, J., & Lee, C. (2022). Impact of COVID-19 on physical activity: A rapid review. *Journal of Global Health*, 12:05003.

https://doi.org/10.7189/jogh.12.05003

Park, H., Shim, S., & Lee, Y.M. (2021). A scoping review on adaptations of clinical education for medical students during COVID-19. *Primary Care Diabetes*, 15(6):958-976.

https://doi.org/10.1016/j.pcd.2021.09.004

Patel, J., Patel, K., Mudgal, A., Panchal, H., & Sadasivuni, K.K. (2020). Experimental investigations of atmospheric water extraction device under different climatic conditions. *Sustainable Energy Technologies and Assessments*, 38:100677.

https://doi.org/10.1016/j.seta.2020.100677

Patil, N.S., Gunter, D., & Larocque, N. (2022). The impact of the COVID-19 pandemic on radiology resident education: Where do we go from here? *Academic Radiology*, 29(4): 576-583.

https://doi.org/10.1016/j.acra.2021.11.015

Qiu, J., Shen, B., Zhao, M., Wang, Z., Xie, B., & Xu, Y. (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: Implications and policy recommendations. *General Psychiatry*, 33(2):e100213.

https://doi.org/10.1136/gpsych-2020-100213

Raut, D.N. (2020). Effects of COVID-19 on employment of India. *IRE Journals*, 3(11):2456-8880.

Reuge, N., Jenkins, R., Brossard, M., Soobrayan, B., Mizunoya, S., Ackers, J., *et al.* (2021). Education response to COVID 19 pandemic, a special issue proposed by UNICEF: Editorial review. *International Journal of Educational Development*, 87:102485.

https://doi.org/10.1016/j.ijedudev.2021.102485

Rewerska-Juśko, M., & Rejdak, K. (2022). Social stigma of patients suffering from COVID-19: Challenges for health care system. *Healthcare* (*Basel*), 10(2):292.

https://doi.org/10.3390/healthcare10020292

Robert, B. (2020). Discarded Coronavirus Masks Clutter Hong Kong's Beaches, Trails. Reuters. Available from: https://www.reuters.com/article/us-health-coronavirus-hongkong-environmeidUSKBN20Z0PP [Last accessed on 2020 Apr 20].

Salonia, A., Pontillo, M., Capogrosso, P., Gregori, S., Carenzi, C., Ferrara, A.M., *et al.* (2022). Testosterone in males with COVID-19: A 7-month cohort study. *Andrology*, 10(1): 34-41.

https://doi.org/10.1111/andr.13097

Sandesh, R., Shahid, W., Dev, K., Mandhan, N., Shankar, P., Shaikh, A., *et al.* (2020). Impact of COVID-19 on the mental health of healthcare professionals in Pakistan. *Cureus*, 12(7):e8974.

https://doi.org/10.7759/cureus.8974

Seetharaman, P. (2020). Business models shifts: Impact of Covid-19. *International Journal of Information Management*, 54:102173.

https://doi.org/10.1016/j.ijinfomgt.2020.102173

Selvam, S., Jesuraja, K., Roy, P.D., Venkatramanan, S., Khan, R., Shukla, S., *et al.* (2022). Human health risk assessment of heavy metal and pathogenic contamination in surface water of the Punnakayal estuary, South India. *Chemosphere*, 298:134027.

https://doi.org/10.1016/j.chemosphere.2022.134027

Shastri, S., Singh, K., Kumar, S., Kour, P., & Mansotra, V. (2020).

Time series forecasting of Covid-19 using deep learning models: India-USA comparative case study. *Chaos, Solitons and Fractals*, 140:110227.

https://doi.org/10.1016/j.chaos.2020.110227

Shigemura, J., Ursano, R.J., Morganstein, J.C., Kurosawa, M., & Benedek, D.M. (2020). Public responses to the novel 2019 coronavirus (2019-nCoV) in Japan: Mental health consequences and target populations. *Psychiatry and Clinical Neurosciences*, 74(4):281-282.

https://doi.org/10.1111/pcn.12988

Singh, D., & Yi, S.V. (2021). On the origin and evolution of SARS-CoV-2. *Experimental and Molecular Medicine*, 53:537-547.

https://doi.org/10.1038/s12276-021-00604-z

Singh, K., & Malhotra, D. (2023). Meta-health: Learning-to-learn (Meta-learning) as a next generation of deep learning exploring healthcare challenges and solutions for rare disorders: A systematic analysis. *Archives of Computational Methods in Engineering*, 30:4081-4112.

https://doi.org/10.1007/s11831-023-09927-8

Singh, K., Kumar, S., Shastri, S., Sudershan, A., & Mansotra, V. (2022) Black fungus immunosuppressive epidemic with Covid-19 associated mucormycosis (zygomycosis): A clinical and diagnostic perspective from India. *Immunogenetics*, 74:197-206.

https://doi.org/10.1007/s00251-021-01226-5

Singh, O.P. (2020), Mental health of migrant laborers in COVID-19 pandemic and lockdown: Challenges ahead. *Indian Journal of Psychiatry*, 62(3):233-234.

https://doi.org/10.4103/psychiatry.IndianJPsychiatry_422_20

Sivakumar, N., Sathishkumar, R., Selvakumar, G., Shyamkumar, R., & Arjunekumar, K. (2020). Phyllospheric microbiomes: Diversity, ecological significance, and biotechnological applications. *Plant Microbiomes for Sustainable Agriculture*, 25:113-172.

Smith, S.J., & Farra, S.L. (2022). The impact of Covid-19 on the regulation of nursing practice and education. *Teaching and Learning in Nursing*, 17:302-305.

https://doi.org/10.1016/j.teln.2022.01.004

Song, H., Yang, Y., & Tao, Z. (2020). How different types of financial service providers support small-and medium-enterprises under the impact of COVID-19 pandemic: From the perspective of expectancy theory. *Frontiers of Business Research in China*, 14(27):1-27.

https://doi.org/10.1186/s11782-020-00095-1

Sun, P.C., Tsai, R.J., Finger, G., Chen, Y.Y., & Yeh, D. (2008). What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers and Education*, 50(4):1183-1202.

Tao, K., Tzou, P.L., Nouhin, J., Gupta, R.K., de Oliveira, T., Kosakovsky Pond, S.L., *et al.* (2021). The biological and clinical significance of emerging SARS-CoV-2 variants. *Nature Reviews Genetics*, 22(12):757-773.

https://doi.org/10.1038/s41576-021-00408-x

Times of India. (2020c). Available from: https://timesofindia.indiatimes.com/travel/things-to-do/lockdown-effect-gangeticdolphins-spotted-at-kolkata-ghats-after-30-years/as75375783.cms [Last accessed on 2020 May 26].

Tobias, J.A., Sheard, C., Pigot, A.L., Devenish, A.J., Yang, J., Sayol, F., *et al.* (2022). AVONET: Morphological, ecological and geographical data for all birds. *Ecology Letters*, 25(3):581-597.

Topuz, Ş., Sezer, N.Y., Aker, M.N., Gönenç, İ.M., Cengiz, H.Ö., & Korucu, A.E. (2021). A SWOT analysis of the opinions of midwifery students about distance education during the Covid-19 pandemic a qualitative study. *Midwifery*, 103:103161.

Tuma, F., Kamel, M.K., Shebrain, S., Ghanem, M., & Blebea, J. (2021). Alternative surgical training approaches during COVID-19 pandemic. *Annals of Medicine and Surgery*, 62:253-257.

https://doi.org/10.1016/j.amsu.2021.01.057

Van de Velde, S., Buffel, V., van der Heijde, C., Çoksan, S., Bracke, P., Abel, T., *et al.* (2021). Depressive symptoms in higher education students during the first wave of the COVID-19 pandemic. An examination of the association with various social risk factors across multiple high- and middle-income countries. *SSM Population Health*, 16:100936.

Verma, A.K., & Prakash, S. (2020). Impact of covid-19 on environment and society. *Journal of Global Biosciences*, 9(5):7352-7363.

Verma, P., Dumka, A., Bhardwaj, A., Ashok, A., Kestwal, M.C., & Kumar, P. (2021). A statistical analysis of impact of COVID19 on the global economy and stock index returns. *SN Computer Science*, 2(1):1-13.

Versteijlen, M., Salgado, F.P., Groesbeek, M.J., & Counotte, A. (2017). Pros and cons of online education as a measure to reduce carbon emissions in higher education in the Netherlands. *Current Opinion in Environmental Sustainability*, 28:80-89.

Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C.S., *et al.* (2020a). Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *International Journal of Environmental Research and Public Health*, 17(5):1729.

Winter, V., Schreyögg, J., & Thiel, A. (2020). Hospital staff shortages: Environmental and organizational determinants and implications for patient satisfaction. *Health Policy (Amsterdam, Netherlands)*, 124(4):380-388.

https://doi.org/10.1016/j.healthpol.2020.01.001

World Health Organization. (2004). Available from: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response [Last accessed on 2024 Dec 06].

World Health Organization. (2023). WHO Coronavirus (COVID-19) Dashboard > Cases [Dashboard]. Available from: https://data.who.int/dashboards/covid19/cases

Wu, F., Xiao, A., Zhang, J., Gu, X., Lee, W.L., Kauffman, K., *et al.*, (2020). SARS-CoV-2 Titers in Wastewater are Higher than Expected From Clinically Confirmed Cases. medRxiv.

Wurtzer, S., Marechal, V., Mouchel, J.M., Maday, Y., Teyssou, R., Richard, E., *et al.* (2020). Evaluation of lockdown impact on SARS-CoV-2 dynamics through viral genome quantification in Paris wastewaters. MedRxiv.

Yang, Y., Li, W., Zhang, Q., Zhang, L., Cheung, T., & Xiang, Y.T. (2020). Mental health services for older adults in China during the COVID-19 outbreak. *The Lancet Psychiatry*, 7(4):e19.

https://doi.org/10.1016/S2215-0366(20)30079-1

Yunus, A.P., Masago, Y., & Hijioka, Y. (2020). COVID-19 and surface water quality: Improved lake water quality during the lockdown. *Science of the Total Environment*, 731:139012.

Zhai, P., Ding, Y., Wu, X., Long, J., Zhong, Y., & Li, Y. (2020). The epidemiology, diagnosis and treatment of COVID-19. *International Journal of Antimicrobial Agents*, 55(5):105955.

https://doi.org/10.1016/j.ijantimicag.2020.105955

Zhao, G.P. (2007). SARS molecular epidemiology: A Chinese fairy tale of controlling an emerging zoonotic disease in the genomics era. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 362(1482):1063-1081.

https://doi.org/10.1098/rstb.2007.2034

Zhong, N.S., Zheng, B.J., Li, Y.M., Poon, Xie, Z.H., Chan, K.H., *et al.* (2003). Epidemiology and cause of severe acute respiratory syndrome (SARS) in Guangdong, People's Republic of China, in February, 2003. *Lancet* (*London, England*), 362(9393):1353-1358.

https://doi.org/10.1016/s0140-6736(03)14630-2

Zuo, M. (2020). Coronavirus Leaves China with Mountains of Medical Waste. South China Morning Post. Available from: https://www.scmp.com/news/china/society/article/3074722/coronavirus-leaves-china-mountains-medical-waste [Last accessed on 2020 Apr 20].

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

PERSPECTIVE ARTICLE

Cost-effectiveness of promoting population health management through education, seminars, and participatory learning for individuals diagnosed with chronic diseases

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Abstract

Population health management is a sustainable, strategic, and interprofessional collaboration that focuses on the health needs of individuals diagnosed with and living with chronic diseases. A chronic disease is defined as a longstanding health condition that persists for more than a year and requires ongoing medical care, such as heart disease, cancer, and diabetes. Since many chronic diseases are incurable, the management and financial burden of chronic diseases remain significant concerns for individuals, clinicians, and health-care systems. Preventing and managing chronic diseases through health promotion and education continues to be a fundamental cost-effective strategy. Educational seminars and participatory learning for individuals with chronic diseases play an important role in improving health outcomes and reducing health-care costs. This perspective aims to highlight objective insights into how health education contributes to cost-effectiveness and strategic population health management.

Keywords: Cost; Education; Effectiveness; Health; Management; Population

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1. Introduction

Population health management is a sustainable, strategic, and interprofessional collaboration that focuses on the health needs of individuals diagnosed with and living with chronic diseases (Struijs *et al.*, 2015). A chronic disease is defined as a longstanding health condition that persists for more than a year and requires ongoing medical care, such as heart disease, cancer, and diabetes (CDC, 2022). Since many chronic diseases are incurable, managing and addressing the extensive financial commitments involved remain significant concerns for individuals, clinicians, and health-care systems (Oksman *et al.*, 2017). Globally, an estimated 10 million deaths are attributed to chronic diseases, many of which are preventable through the adoption of healthy behaviors; failure to adopt a healthy lifestyle has a significant economic impact (Violán *et al.*, 2014). A cost-

effective, integrative health-care system that promotes positive health outcomes for individuals diagnosed with chronic diseases has been recognized as a key component of population health management (Lyles *et al*., 2020). This approach is regarded as an economic health structure that is reliant on interprofessional health data and the collaboration of different health-care disciplines, all contributing to cost-effective health-care delivery (Cronin *et al*., 2021). The strategic initiative of population health management is identified as a bridge, connecting health systems with community services (Steenkamer *et al*., 2017), especially within population groups that may lack adequate access to healthcare or appropriate health-care services (Alderwick *et al*., 2015).

With the growing number of demographic groups being diagnosed with chronic diseases, avoidable health and social inequalities are likely to increase, resulting in an economic burden that plagues life expectancy and quality of life (Romero *et al*., 2018). Chronic disease prevention and management are recognized as valuable, cost-effective strategies for managing these demographic groups, as they bridge the gap between social services, community care, and hospital administration (Lang *et al*., 2018). This perspective on educational seminars and participatory learning for individuals diagnosed with chronic diseases aims to provide objective insights into how health education contributes to cost-effectiveness and strategic population health management.

2. Educational seminars and participatory learning for individuals with chronic diseases

Educational seminars play a pivotal role in improving the health outcomes of individuals diagnosed with chronic diseases. Chronic disease prevention and management through health promotion and education continue to be fundamental cost-effective strategies (Lang *et al*., 2018). However, the effectiveness of educational seminars and participatory learning for individuals with chronic diseases depends on various factors, such as health behavioral changes and participatory involvement (Prochaska *et al*., 2008). Health education that promotes self-management of chronic diseases may directly and indirectly benefit individuals by increasing knowledge about chronic diseases, improving self-care behavior, and reducing health-care-related costs (Campbell *et al*., 2022). However, active participation from individuals with chronic diseases can be a barrier or challenge to effectively implementing a cost-effective educational strategy that improves health outcomes. The success of participatory health education has proven to reduce hospitalization and health-care costs, especially when the interventions are focused on a single disease, such as a respiratory or cardiovascular condition (Panagioti *et al*., 2014). Recent evidence has highlighted the importance of patient education and active learning programs in promoting a healthy lifestyle, improving health outcomes, and preventing functional decline among older adults in the community who are diagnosed with chronic illnesses (Uemura *et al*., 2023; Uemura *et al*., 2021). Health education strategies, such as media and marketing of health education programs, have been identified as crucial tools for communicating the importance of health education among different population groups (Kim & Gu, 2023). The development of these health education programs is often facilitated by health surveys, which enhance understanding of individuals' levels of health-related knowledge, health literacy, and health education related to social determinants of health, chronic disease management, and positive health outcome promotion (Zhang *et al*., 2021). Various systematic reviews have examined the cost-effectiveness of educational interventions and their impact on chronic disease management (Loveman *et al*., 2003; Odnoletkova *et al*., 2014).

The concept of population health management is founded on a sustainable, strategic, and interprofessional approach to managing populations diagnosed with chronic diseases (Struijs *et al*., 2015). The management infrastructure is also dependent on empowering individuals to be active participants in their management of care, fostering a collaborative and sustainable approach to cost-effective population health management. To this end, educational seminars and participatory learning for individuals with chronic diseases play an important role in achieving primary objectives such as improving health outcomes, reducing the financial cost of individualized healthcare, and seeking remedial interventions to overcome the long-term expenditure associated with chronic diseases. According to Campbell *et al*. (2022), the long-term management of chronic diseases requires active involvement from patients in their care. Given the complexity of chronic diseases, collaborative patient education helps patients make informed decisions regarding their management plans, thereby contributing to the development of cost-effective and economically sustainable long-term care plans.

3. Cost-effective and strategic population health management through evidence-based knowledge

According to Kivelä *et al*. (2014), self-management interventions that incorporate evidence-based knowledge improve clinical outcomes, enhance quality of life, and promote

healthier self-management behaviors. Cost-effective care management is heavily driven by evidence-based knowledge, which can be identified in two phases. The first phase involves understanding how evidence-based knowledge is implemented within the population health management infrastructure to promote positive health outcomes within a demographic group. Gourevitch *et al.* (2019) state that the principles of population health focus on promoting health, preventing disease, and eliminating health inequities through relevant research, dissemination of findings, and the promotion of the best available researched evidence. The second phase is the implementation of evidence-based findings through educational seminars and participatory learning, with a focus on individuals diagnosed with or living with chronic diseases. Educational seminars have proven useful and successful strategies for effective decision-making in health-care management, facilitating improved health outcomes for individuals living with chronic diseases (Ahmed *et al.*, 2015).

According to Jull *et al.* (2021), when patients and clinicians collaborate to make decisions about screening, treatments, or the management of chronic conditions using evidence-based information, it provides patients with informed choices and the opportunity to express preferences regarding their care management. The best available evidence regarding health-care management options enables individuals to make informed decisions on cost-effective care packages, which are selected based on current knowledge, evidence, and shared decision-making (Coulter, 2018).

Cost-effective population health management requires primary and secondary health-care systems to work cohesively (Steenkamer *et al.*, 2017). The integration of evidence-based knowledge remains a significant factor when making crucial decisions about health-care management. Chronic disease prevention and management, with the integration of evidence-based information, remains a top priority in achieving cost-effective population health management.

4. The future of economic sustainability in population health management

The integration of educational seminars, participatory learning, and evidence-based knowledge is fundamental to achieving economic sustainability, especially when the primary goal is to promote positive health outcomes for individuals diagnosed with chronic diseases. Successful population health management is expected to lead to a healthier population, reduced health-care utilization, and decreased economic strain (Alderwick *et al.*, 2015). Developing innovative approaches to address chronic diseases of high-risk populations through educational seminars, participatory learning, and evidence-based knowledge is crucial for improving overall health and health outcomes. Evidence supports a positive correlation between health education and improved health (Yu *et al.*, 2022). This emphasis is especially important in middle-income countries, where the burden of chronic diseases is substantial, and health outcomes are closely tied to financial investments aimed at maximizing health and quality of life (Muka *et al.*, 2015). Thus, incorporating educational seminars, participatory learning, and evidence-based knowledge into an integrative process is recognized as a sustainable, strategic, and interprofessional approach to population health management.

5. Conclusion

This perspective on educational seminars and participatory learning for individuals diagnosed with chronic diseases has objectively highlighted key factors that contribute to cost-effective and strategic population health management. The prevention and management of chronic diseases through health promotion and education continue to be a fundamental, cost-effective strategy. Health education is recognized as one of the most effective methods for facilitating health-care management options, enabling individuals to make informed decisions regarding cost-effective care packages that effectively manage their chronic diseases. The integration of educational seminars, participatory learning, and evidence-based knowledge within the health system achieves a sustainable, strategic, and interprofessional approach to population health management.

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References

Ahmed, M., El Degwy, H., Ali, M., & Hegazy, N. (2015). The effect of educational intervention on knowledge, attitude and glycemic control in patients with type 2 diabetes mellitus. *International Journal of Community Medicine and Public Health*, 2(3):302-307.

https://doi.org/10.18203/2394-6040.ijcmph20150487

Alderwick, H., Ham, C., & Buck, D. (2015). Population Health Systems-Going beyond Integrated Care. London: The King's Fund.

Campbell, Z.C., Dawson, J.K., Kirkendall, S.M., McCaffery, K.J., Jansen, J., Campbell, K.L., *et al.* (2022). Interventions for improving health literacy in people with chronic kidney disease. *Cochrane Database of Systematic Reviews*, 12(12):Cd012026.

https://doi.org/10.1002/14651858.CD012026.pub2

CDC. (2022). About Chronic Diseases. Available from: https://www.cdc.gov/chronic-disease/about/index.html [Last accessed on 2024 Aug 28].

Coulter, A. (2018). National Strategies for Implementing Shared Decision Making. Germany: Bertelsmann Stiftung.

Cronin, C.E., Franz, B., & Schuller, K.A. (2021). Expanding the population health workforce: Strategic priorities of hospital organizations in the United States. *Population Health Management*, 24(1):59-68.

https://doi.org/10.1089/pop.2019.0138

Gourevitch, M.N., Curtis, L.H., Durkin, M.S., Fagerlin, A., Gelijns, A.C., Platt, R., *et al.* (2019). The emergence of population health in US Academic medicine: A qualitative assessment. *JAMA Network Open*, 2(4):e192200.

https://doi.org/10.1001/jamanetworkopen.2019.2200

Jull, J., Köpke, S., Smith, M., Carley, M., Finderup, J., Rahn, A.C., *et al.* (2021). Decision coaching for people making healthcare decisions. *Cochrane Database of Systematic Reviews*, 11(11):Cd013385.

https://doi.org/10.1002/14651858.CD013385.pub2

Kim, M., & Gu, H. (2023). Relationships between health education, health behaviors, and health status among Migrants in China: A cross-sectional study based on the China migrant dynamic survey. *Healthcare* (*Basel*), 11(12):1768.

https://doi.org/10.3390/healthcare11121768

Kivelä, K., Elo, S., Kyngäs, H., & Kääriäinen, M. (2014). The effects of health coaching on adult patients with chronic diseases: A systematic review. *Patient Education and Counseling*, 97(2):147-157.

https://doi.org/10.1016/j.pec.2014.07.026

Lang, A., Warren, M., & Kaulman, L. (2018). A Funding Crisis for Public Health and Safety: State-by-state Public Health Funding and Key Health Facts: 2018. Available from: https://collections.nlm.nih.gov/catalog/nlm:nlmuid-101739319-pdf [Last accessed on 2024 Aug 28].

Loveman, E., Cave, C., Green, C., Royle, P., Dunn, N., & Waugh, N. (2003). The clinical and cost-effectiveness of patient education models for diabetes: A systematic review and economic evaluation. *Health Technology Assessment*, 7(22):iii, 1-190.

https://doi.org/10.3310/hta7220

Lyles, L.F., Hildebrandt, H., & Mair, A. (2020). Population health management approach: integration of community-based pharmacists into integrated care systems: Reflections from the U.S., achievements in Scotland and discussions in Germany. *International Journal of Integrated Care*, 20(2):13.

https://doi.org/10.5334/ijic.5431

Muka, T., Imo, D., Jaspers, L., Colpani, V., Chaker, L., van der Lee, S.J., *et al.* (2015). The global impact of non-communicable diseases on healthcare spending and national income: A systematic review. *European Journal of Epidemiology*, 30(4):251-277.

https://doi.org/10.1007/s10654-014-9984-2

Odnoletkova, I., Goderis, G., Pil, L., Nobels, F., Aertgeerts, B., Annemans, L., *et al.* (2014). Cost-effectiveness of therapeutic education to prevent the development and progression of type 2 diabetes: Systematic review. *Journal of Diabetes and Metabolism*, 5(9):1-7.

https://doi.org/10.4172/2155-6156.1000438

Oksman, E., Linna, M., Hörhammer, I., Lammintakanen, J., & Talja, M. (2017). Cost-effectiveness analysis for a tele-based health coaching program for chronic disease in primary care. *BMC Health Services Research*, 17(1):138.

https://doi.org/10.1186/s12913-017-2088-4

Panagioti, M., Richardson, G., Small, N., Murray, E., Rogers, A., Kennedy, A., *et al.* (2014). Self-management support interventions to reduce health care utilisation without compromising outcomes: A systematic review and meta-analysis. *BMC Health Services Research*, 14:356.

https://doi.org/10.1186/1472-6963-14-356

Prochaska, J.J., Spring, B., & Nigg, C.R. (2008). Multiple health behavior change research: An introduction and overview. *Preventive Medicine*, 46(3):181-188.

https://doi.org/10.1016/j.ypmed.2008.02.001

Romero, D., Echeverria, S.E., Duffy, M., Roberts, L., & Pozen, A. (2018). Development of a wellness trust to improve population health: Case-study of a United States urban center. *Preventive Medicine Reports*, 10:292-298.

https://doi.org/10.1016/j.pmedr.2018.03.009

Steenkamer, B.M., Drewes, H.W., Heijink, R., Baan, C.A., & Struijs, J.N. (2017). Defining population health management: A scoping review of the literature. *Population Health Management*, 20(1):74-85.

https://doi.org/10.1089/pop.2015.0149

Struijs, J.N., Drewes, H.W., Heijink, R., & Baan, C.A. (2015). How to evaluate population management? Transforming the care continuum Alliance population health guide toward a broadly applicable analytical framework. *Health Policy*, 119(4):522-529.

https://doi.org/10.1016/j.healthpol.2014.12.003

Uemura, K., Tsukasa, K., Watanabe, A., Okamoto, H., & Yamada, M. (2023). Association between community-level health literacy and frailty in community-dwelling older adults. *Aging Clinical and Experimental Research*, 35(6):1253-1261.

https://doi.org/10.1007/s40520-023-02405-y

Uemura, K., Yamada, M., & Okamoto, H. (2021). The effectiveness of an active learning program in promoting a healthy lifestyle among older adults with low health literacy: A randomized controlled trial. *Gerontology*, 67(1):25-35.

https://doi.org/10.1159/000511357

Violán, C., Foguet-Boreu, Q., Roso-Llorach, A., Rodriguez-Blanco, T., Pons-Vigués, M., Pujol-Ribera, E., *et al.* (2014). Burden of multimorbidity, socioeconomic status and use of health services across stages of life in urban areas: A cross-sectional study. *BMC Public Health*, 14:530.

https://doi.org/10.1186/1471-2458-14-530

Yu, S., Guo, X., Li, G., Yang, H., Zheng, L., & Sun, Y. (2022). Low educational status correlates with a high incidence of mortality among hypertensive subjects from Northeast Rural China. *Frontiers in Public Health*, 10:951930.

https://doi.org/10.3389/fpubh.2022.951930

Zhang, F., Or, P.P.L., & Chung, J.W.Y. (2021). How different health literacy dimensions influences health and well-being among men and women: The mediating role of health behaviours. *Health Expectations*, 24(2):617-627.

https://doi.org/10.1111/hex.13208

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

PERSPECTIVE ARTICLE

Substance use recovery: Global health perspectives and experiences

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Abstract

Addictive behavior treatment networks comprise harm-reduction services and recovery programs. Recovery is an approach toward interventions for addictive behavior that focuses on the individual's empowerment, abilities, and life skills. Rehabilitation-oriented programs have evolved from traditional therapeutic communities to comprehensive services that are integrated into social and health networks and delivered by multidisciplinary professionals. This paper aims to analyze the development of recovery programs, drawing from quantitative and qualitative data from an action research approach. It also presents theoretical models and best practices for recovery. In summary, recovery-oriented programs must be integrated with harm-reduction networks, social and employment services, and health systems. Furthermore, as recovery is based on empowerment and peer social support, there is an urgent need to develop structured programs to address these issues. Moreover, there is a need to design and implement specific interventions for a broad range of populations and develop evaluation systems to assess the effectiveness and relevance of recovery-oriented programs.

Keywords: Addictive behaviors; Recovery; Treatment network

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1. Introduction

Since the 1970s, the labels "addict," "drug addict," or "junkie" have been linked to individuals who consume opiates intravenously. This association is linked to other stereotypes that, in turn, amplify the stigma these individuals experience, such as HIV, mental health problems, and crime. This identification makes it extremely difficult to access profiles of people with addiction problems, such as women, young cannabis users, cocaine users who maintain functional capacities, and other at-risk individuals (European Monitoring Center for Drug Dependence and Addiction [EMCDDA], 2017).

Individuals with an addictive disorder, often regardless of substance or problem behavior, are typically linked, in a stereotypical manner, to violence, drug trafficking, and prostitution (especially with female users in the case of the latter). In addition, these individuals are often labeled as being responsible for their problems, which are associated with the concept of "vice" and a lack of willpower, overlooking the fact that addiction is a health issue (National Institute on Drug Abuse, 1997; United Nations Office for Drugs and Crime [UNODC], 2012). The consequences of these stigmas include poor adherence to treatment and frequent abandonment initiation of treatment by individuals

who feel that the program does not meet their needs or interests, leading to persistent failure in achieving recovery (UNODC, 2012). As a result, intervention programs fail to be effective, as they are unable to support individuals throughout treatment and meet long-term objectives (Granfield & Cloud, 2001).

Stigmatization is influenced not only by the consumers but also by the responsibility and influence of those around them – their families, healthcare professionals, policymakers, journalists, and the media – all of whom play a role, directly or indirectly, in perpetuating this stigma toward drug users (EMCDDA, 2017; UNODC, 2012).

2. Recovery in addictive behavior treatment networks

Treatment policies and intervention practices for drug addiction and addictive behavior are based on harm reduction, recovery, and the provision of sustainable livelihoods (UNODC, 2012). Harm-reduction programs aim to mitigate the primary negative consequences of drug use, in particular, drug-related infections and criminal behaviors (Laespada & Iraurgi, 2009). However, "recovery" encompasses more than simply the reduction or elimination of drug use. It can even occur as a result of spontaneous remission (Yates, 2010), a phenomenon sometimes referred to as "natural recovery" (Best, 2012). Moreover, recovery entails being an active member of society (Yates, 2010). While "recovery" is sometimes used interchangeably with "rehabilitation," there are key distinctions between these two concepts:

- Rehabilitation is defined as a process aimed at helping individuals with certain impairments or difficulties (such as physical problems, addictions, or psychological issues) to reintegrate into society and improve their psychosocial functioning, enabling them to progress in life. It attempts to create a regulated and independent social environment to the furthest extent possible (Granfield & Cloud, 2001).
- Recovery implies participatory action within the social context, aiming to reintegrate individuals in a broad sense. White & Cloud (2008) argue that long-term recovery is better predicted by recovered capacities than by associated pathologies (White & Cloud, 2008).

A key distinction is that rehabilitation is typically driven by professionals, whereas recovery is initiated and sustained by individuals themselves. As such, successful reintegration into society requires the active participation of the individual undergoing recovery. Recovery can thus be understood as an evolutionary and involutionary process.

3. Recovery: Key concepts

Recovery (Best, 2012; Yates, 2010) is a central concept in the treatment and social reintegration of individuals with addictive behaviors. As previously explained, recovery does not merely involve reducing or eliminating drug (including alcohol) use, nor does it equate to "natural recovery," in which individuals achieve abstinence on their own (Granfield & Cloud, 2001). Instead, it involves becoming an active member of society (Yates, 2010; Best, 2012). Recovery involves developing personal autonomy, engaging in socially valuable roles, maintaining significant socio-affective relationships, and achieving a level of socio-communitarian integration that enables individuals to live satisfactory lives (Best, 2012). In recovery processes, it is crucial to promote increased social participation activities, such as employment, civil engagement, volunteering, and involvement in social networks (Best, 2012). Active participation in these activities has been shown to foster progress in the recovery process (Best, 2012).

Best *et al.* (2020) define three key concepts related to recovery: (1) contagion, the ability of individuals to positively influence their social environment; (2) connection, which highlights an individual's capacity to form a sense of community; and (3) homophily, which describes the tendency to associate and form connections with similar individuals.

Another important aspect of recovery is "recovery capital" (RECCAP), which Granfield & Cloud (2001) define as "…the breadth and depth of internal and external resources that can be drawn upon to initiate and sustain recovery from AOD [alcohol and other drugs] problems." RECCAP, particularly restorative capital, is linked to social capital, which refers to the connections between individuals and their social networks, as well as the abilities, norms of reciprocity, trust, and connections formed between the recovering individual and their reference group (Best, 2012; Yates, 2010). The concept of "recapitalization", as the way to improve capacities, abilities and skills, has been applied in various contexts, especially concerning individuals, communities, and societies (Best *et al.*, 2020; Molina-Fernández, 2023).

White & Cloud (2008, p. 23) state as follows:

Recovery Capital constitutes the potential antidote for the problems that have long plagued recovery efforts: Insufficient motivation to change AOD use, emotional distress, pressure to use within intimate and social relationships, interpersonal conflict, and other situations that pose risks for relapse. (…) Strategies that target family and community Recovery Capital can elevate long-term

recovery outcomes, as well as improve the quality of life for individuals and families in long-term recovery.

According to these authors, three key elements should be considered when assessing (RECCAP): (1) supporting screening and brief intervention programs; (2) ensuring ongoing monitoring of RECCAP levels; and (3) using RECCAP levels to help determine the level of care decisions. In addition, there are three phases for enhancing RECCAP: (1) assessing strengths and weaknesses; (2) planning individualized care based on the person's strengths; and (3) fostering strong, solid links between the recovering individual and groups and organizing activities oriented toward recovery.

Best (2012, as cited in MacGregor, 2012) classifies RECCAP into several types.

- Personal RECCAP, including the skills and abilities regained or enhanced during recovery, especially emotional abilities (Best, 2012).
- Social RECCAP, referring to the impact of recovery on social reference groups, especially families and social networks (Granfield & Cloud, 2001).
- Collective RECCAP, referring to the broader societal impact of individuals suffering from addiction on their recovery context, especially with respect to the balance of costs and benefits involved (Best, 2012). Benefits include economic gains from reintegrating individuals into the workforce and reduced costs resulting from lower demands on care, legal, criminal, and health services (Best, 2012; Best & Aston, 2015). To calculate the cost-benefit balance, all investments made during the recovery process (inputs) and the benefits realized during and after the process (outputs) must be considered.

To fully understand the concept of RECCAP it is essential to analyze the personal circumstances and specific health, social, and psychological needs of the person concerned (Boyle & Johnstone, 2014). For people with addiction problems, this approach (EMCDDA, 2017) is likely to be effective. Groshkova *et al.* (2012) propose the assessment of recovery capital (ARC) as a method to evaluate recovery progress during treatment. Subsequent research has identified three common elements in international rehabilitation programs: (1) the link between reduced drug use, improved skills, and reduced criminal behavior (Best *et al.*, 2020; Best & Aston, 2015), (2) the importance of family ties (Best, 2012), and (3) the positive role of intimacy in therapy and the influence of peer groups (Stevens *et al.*, 2015). Social support (Molina Fernández *et al.*, 2022; Stevens *et al*, 2015) has been shown to be associated with improvements in long-term recovery maintenance (Best, 2012; Best *et al.*, 2020; Yates, 2010).

4. Public health and recovery: International experiences

International consensus recognizes the need to address addiction through a biopsychosocial perspective (Hall *et al.*, 2015). This approach emphasizes that interventions should include elements such as rehabilitation (Yates, 2010) and social support (Molina Fernández *et al.*, 2022), which are effective in the long term (UNODC, 2012).

Coordination between health systems, especially medicine, alternative therapies, and social intervention services related to addictive behavior, is another area that needs attention (Milkman & Wanberg, 2012). This coordination is considered highly beneficial because it significantly increases the efficiency of networks and services reliant on professionals who are accustomed to working in multidisciplinary contexts (Molina Fernández *et al.*, 2022). An example of an addictive behaviors treatment network is presented in Figure 1.

An example of a successful health promotion initiative is the development of a social rehabilitation project called "Recovery City" (Best, 2012). This project uses a community intervention model called CHIME, which is based on scientific data and is designed to rehabilitate individuals with addictive behaviors. CHIME is based on the multi-country evaluated and revised recovery framework (Best, 2012; Vanderplasschen *et al.*, 2014; Best *et al.*, 2017)), which focuses on two psychosocial variables: Perceived social support (Stevens *et al.*, 2015) and the use of human resources and abilities. CHIME is an acronym for the key components of the model:

- Connection (social support networks and connections)
- Hope (hope and motivation)
- Identity (social and personal identity)
- Meaning (the significance the individual places on their social support network)
- Empowerment (personal and social competence and empowerment).

To achieve the model's objectives, the following steps are emphasized:

1. Focusing on promoting healing rather than eliminating the disease
2. Basing the intervention on the individual's personal goals and desires
3. Clarifying the individual's role and that of others (supporters) in achieving these goals
4. Working with the individual's abilities, strengths, and interests
5. Emphasizing community resources over individual resources or projects

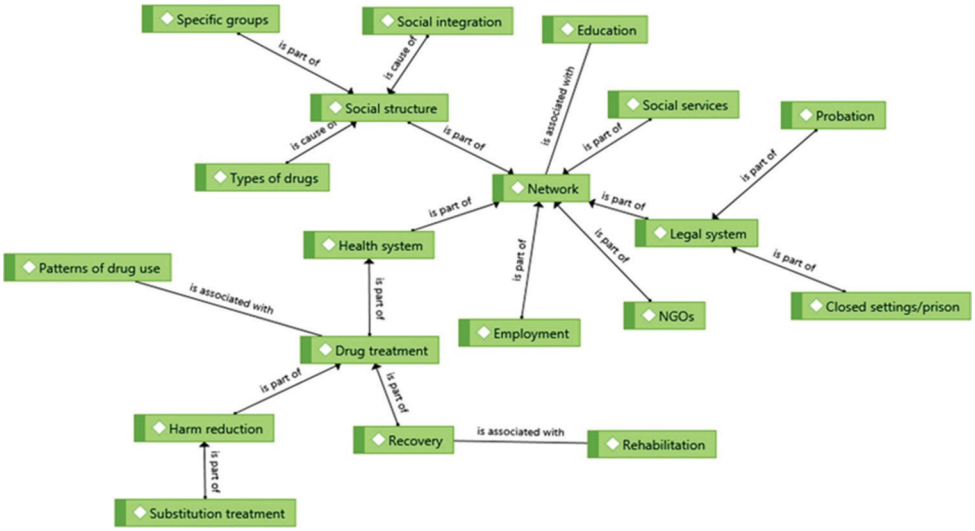


Figure 1. Addictive behaviors treatment network (including recovery) map of categories

6. Acknowledging that uncertainty, frustration, and disagreements are inevitable steps toward greater self-determination.

This model adopts an optimistic view, suggesting that individuals with substance use and/or mental health difficulties do not necessarily need traditional "therapy" to lead productive, fulfilling, and meaningful lives. It avoids an hierarchical approach, and professionals, individuals, and families collaborate while considering the individual's family and social and cultural context.

Europe has implemented these processes in a standardized manner (Best, 2012; Leamy *et al.*, 2011; Vanderplasschen *et al.*, 2014), with a notable example being the "Recovery City" (Best, 2012). This initiative has been introduced in cities such as Ghent (Belgium) and Gothenburg and Stockholm (Sweden) to reduce the risks associated with drug use and related issues, especially crime and social emergencies, and improve coexistence and citizen participation (Best *et al.*, 2020).

Another success story is the "Triple R HERMESS" model (Barzanti *et al.*, 2017), which demonstrates key concepts from the exchange of best practices during the Triple R project ("HOME/2014/JDRU/AG/DRUG/7092-Triple R: Rehabilitation and Reintegration").

The project aims to standardize intervention models focused on peer learning and subsequent reintegration, promoting entrepreneurship and social employment. The primary goal of this project is to enhance the recovery of individuals with addiction problems by developing and exchanging innovative methods that facilitate recovery, especially in professional and social contexts. These methods include the exchange of information on drug abuse prevention, psychosocial intervention models, and the identification and dissemination of good practices. The key activities of the project involve documenting peer learning practices and social entrepreneurship strategies relevant to the recovery context of individuals with addiction issues in Europe (EMCDDA, 2017). The methodology combines qualitative and quantitative analysis of primary data with quantitative analysis of secondary data (reports and case studies). Data collection methods include questionnaires (n = 158) and semi-structured interviews (n = 18), with two phases: (1) exploratory interviews and questionnaires, and (2) data analysis and follow-up interviews. Table 1 summarizes the key recovery models, theoretical frameworks, and most commonly used tools and programs among the various organizations studied during the Triple R project.

The Triple R program developed an intervention model based on peer learning and social-emotional development called the "Triple R HERMESS" model of rehabilitation and recovery. The theoretical models of HERMESS include the empowerment, capacity, and social learning models. HERMESS integrates key elements from Triple R's good practice transfer program.

Figure 2 presents a visual chart of the lessons learned from the Triple R program, which can assist professionals, practitioners, and policymakers interested in understanding the primary elements of effective recovery programs.

5. Conclusion

This paper argues that recovery from addiction is a process involving many factors and cannot be reduced to

Table 1. Summary of Models of Recovery (Molina Fernández *et al.*, 2022)

Model	Country/ies	Framework	Tools	Programs	NGO
Biopsychosocial	Spain (international)	Medical, psychological, and social (environmental) models	Motivation, behavioral change, emotional modulation, social capital	Outpatient and residential facilities	Proyecto Hombre, CEIS
PCP	The United States and Canada (international)	Sociological model skills, Empowerment, "housing first"	Motivational interviews, design of case, action plan, social capital	Focused on social reintegration	Dianova, Institute Pulla
CHIME	Belgium, the United Kingdom, and Sweden	Skills, empowerment, and environmental models	Social support, services network, motivation, social capital	Community intervention	EURAD, Popov
HERMESS	Belgium, Croatia, Spain, Italy, and Sweden	Skills model and empowerment	Motivation, behavioral change, training in skills, pre-professional training	Therapeutic communities, social reintegration enterprises, entrepreneurship	San Patrignano, BASTA, Stijena

Abbreviation: PCP: Person centred planning.

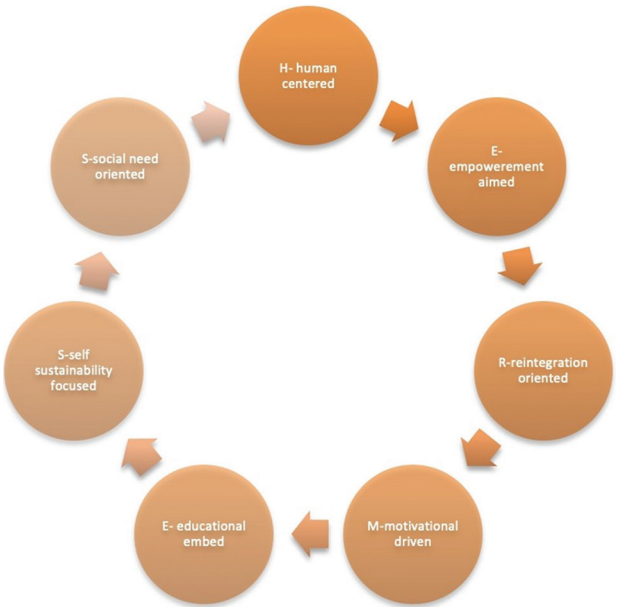


Figure 2. HERMESS model visual chart (Bazanti *et al.*, 2017)

a purely medical or pathological issue. Social interventions, especially social support and networks, are crucial in addressing addictive behavior (Best *et al.*, 2020). Moreover, drug addiction treatment resources should include multidisciplinary teams; this offers substantial advantages in providing comprehensive recovery services. It is also essential to ensure that professionals receive complementary training on transversal aspects to facilitate better detection of problems and enable effective and equitable program design and interventions (Milkman & Wanberg, 2012).

Using proven best practice models such as the HERMESS recovery model (Barzanti *et al.*, 2017) or ARC through the Living in Recovery questionnaire (Best *et al.*, 2020) can increase the relevance and effectiveness of recovery-based programs, both as healthcare and social responses to addictive behavior issues (EMCDDA, 2017). Identifying the strengths and challenges faced by such interventions may help identify the individuals and groups most likely to have successful recovery programs (Best *et al.*, 2020).

For successful development and implementation of recovery programs, the various risk groups that currently exist should be extensively researched (EMCDDA, 2017; Molina-Fernández, 2023). Furthermore, there is an urgent need to design effective adaptations of interventions that are tailored to the specific needs and problems of different profiles of people with addiction issues, such as women, young cannabis users, or functional cocaine users. The more concrete and precise we are when designing interventions, the more effective they will be, leading to a better prognosis (Molina-Fernández, 2023). This approach is particularly important for women undergoing treatment. There is substantial scientific evidence showing that women have special needs and vulnerabilities that must be addressed when receiving treatment; however, these factors are rarely considered (Molina Fernández *et al.*, 2022), suggesting a need for women-specific programs and initiatives tailored to each woman's unique circumstances (Molina-Fernández *et al.*, 2022).

It is important to move beyond the binary debate between "harm reduction" and "recovery" and recognize that both types of intervention are necessary, leading to an integrated, comprehensive intervention system (Molina-Fernández, 2023). Future studies must also consider cultural aspects and factors related to substance

use and treatment, especially the influence of social and cultural factors on individuals' recovery process (Molina-Fernández, 2023).

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Conflict of interest

The authors declare no conflicts of interest.

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References

Barzanti, M., Blixt, C., Carrena, S., DiRenzo, M., Franzen, A., & Molina, A. (2017). Triple R Handbook on Social Reintegration of Recovered Drug Users. Rimini: EU/San Patrignano.

Best, D. (2012). Addiction Recovery: A Movement for Personal Change and Social Growth in the UK. Pavilion: Brighton.

Best, D., & Aston, E. (2015). Long term recovery from addiction: Criminal justice involvement and positive criminology? In: Ronel, N., & Segev, D., (eds.), Positive Criminology: Routledge Frontiers of Criminal Justice. UK: Routledge, p.177-193.

Best, D., Bliuc, A.M., Iqbal, M., Upton, K., & Hodgkins, S. (2017). Mapping social identity change in online networks of addiction recovery. *Addiction Research and Theory,* 26(3):163-173.

https://doi.org/10.1080/16066359.2017.1347258

Best, D., Vanderplasschen, W., & Nisic, M. (2020). Measuring capital in active addiction and recovery: The development of the strengths and barriers recovery scale (SABRS). *Substance Abuse Treatment, Prevention, and Policy*, 15(1), 40.

https://doi.org/10.1186/s13011-020-00281-7

Boyle, M., & Johnstone, L. (2014). Alternatives to psychiatric diagnosis. *Lancet Psychiatry,* 1(6), 409–411.

https://doi.org/10.1016/S2215-0366(14)70359-1

EMCDDA (Observatorio Europeo de las Drogas y las Toxicomanías). (2017). Respuestas Sanitarias y Sociales a Los Problemas Relacionados Con Las Drogas: Una Guía Europea. Luxemburgo: Oficina de Publicaciones de la Unión Europea.

Granfield, R., & Cloud, W. (2001). Social context and "natural recovery": The role of social capital in the resolution of drug-associated problems. *Substance Use and Misuse*, 36(11):1543-1570.

https://doi.org/10.1081/ja-100106963

Groshkova, T., Best, D., & White, W. (2013). The assessment of recovery capital: Properties and psychometrics of a measure of addiction recovery strengths. *Drug and Alcohol Review*, 32(2):187-194.

https://doi.org/10.1111/j.1465-3362.2012.00489.x

Hall, W., Carter, A., & Forlini, C. (2015). The brain disease model of addiction: Is it supported by the evidence and has it delivered on its promises? *The Lancet Psychiatry*, 2(1):105-110.

https://doi.org/10.1016/S2215-0366(14)00126-6

Laespada, T., & Iraurgi, I. (2009). Reducción De Daños: Lo Aprendido De La Heroína. Deusto: Universidad de Deusto.

Leamy, M., Bird, V., Le Boutillier, C., Williams, J., & Slade, M. (2011). Conceptual framework for personal recovery in mental health: Systematic review and narrative synthesis. *The British Journal of Psychiatry: The Journal of Mental Science*, 199(6):445-452.

https://doi.org/10.1192/bjp.bp.110.083733

MacGregor, S. (2012). Addiction recovery: A movement for social change and personal growth in the UK, by David Best, Brighton. *Drugs: Education, Prevention and Policy*, 19:351-352.

https://doi.org/10.3109/09687637.2012.692594

Milkman, H. & Wanberg, K. (2012). Pathways to Self-Discovery

and Change: A Guide for Responsible Living. United States: SAGE Publications.

Molina Fernández, A., Saiz Galdós, J., Cuenca Montesino, M.L., Gil Rodríguez, F., Mena García, B., & Hansen Rodríguez, G. (2022). Recovery programmes for intervention about substances abuse disorders: European good practices. *Revista Española de Drogodependencias*, 47(1):33-46.

https://doi.org/10.54108/red.10003

Molina-Fernández, A. (2023). La Recuperación de Adicciones en Europa: Teoría, Modelo y Métodos. De La Dependencia De Las Sustancias a La Recuperación De Las Personas. United States: Editorial Aula Magna, McGraw-Hill Interamericana de España.

National Institute on Drug Abuse. (1997). Preventing Drug Use Among Children and Adolescents: A Research-Based Guide. Bethesda: NIH.

Stevens, E., Jason, L.A., Ram, D., & Light, J. (2015). Investigating social support and network relationships in substance use disorder recovery. *Substance Abuse*, 36(4):396-399.

https://doi.org/10.1080/08897077.2014.965870

United Nations Office for Drugs and Crime. (2012). TREATNET Quality Standards for Drug Dependence Treatment and Care Services. Vienna: UNODC.

Vanderplasschen, W., Vandevelde, S., & Broekaert, E. (2014). Therapeutic Communities for Addictions in Europe. Available Evidence, Current Practices and Future Challenges for Recovery Oriented Treatment in Therapeutic Communities for Drug Addicts. Lisbon, Portugal: EuropeanMonitoring Centre for Drugs and Drug Addiction (EMCDDA).

White, W., & Cloud, W. (2008). Recovery capital: A primer for addictions professionals. *Counsellor*, 9(5):22-27.

Yates, R. (2010). Tackling Addiction: Pathways to Recovery. London: Jessica Kingsley Publication.

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

PERSPECTIVE ARTICLE

Impact of education, poverty, and demographic background on maternal mortality, fertility, and family planning in Pakistan

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Abstract

In recent decades, maternal mortality has significantly reduced on a global scale. However, persistent inequities have undermined these advances in middle- and low-income countries. Therefore, there has been a shift toward more inclusive approaches, such as human capital formation. This perspective article analyzes maternal mortality, fertility, and family planning outcomes in Pakistan, comparing them with educational attainment, socioeconomic status, and demographics. Pakistan's maternal mortality rate among those with a rural background is 21% higher than those with an urban background in the country. Historically, the country's total fertility rate (TFR) has been gradually declining, from 4.9 in 1990 – 1991 to 4.1 in 2006 – 2007, to 3.8 in 2012 – 2013, and to 3.6 in 2017 – 2018. However, there are stark disparities in TFR based on demographic background, education, and poverty. Meanwhile, the contraceptive prevalence rate (CPR) has remained stagnant for the past two decades, largely due to inadequate initiatives in poverty reduction, education, and rural development. Pakistan has committed to reducing maternal mortality and fertility and increasing CPR under the International Conference on Population Development, Family Planning 2030, and the recommendations of Pakistan's Council of Common Interest. Along with these goals, infrastructure development, in (interprovincial roads connecting rural and urban areas and alternative energy initiatives) presents promising prospects for economic growth, poverty reduction, and increased employment opportunities. The paper concludes that health service delivery measures cannot sustain improvements in maternal health, fertility, and family planning indicators alone. Rather, a multipronged strategy focused on poverty reduction, education, and reductions in rural–urban disparities is essential for sustained progress.

Keywords: Family planning; Maternal mortality; Fertility; Socioeconomic status; Education; Demographic background

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1. Introduction

In recent decades, a remarkable reduction has been observed in maternal and child mortality worldwide. For example, maternal mortality decreased by up to 38% from 2000 to 2017. However, middle-income countries continue to lag behind in maternal, neonatal, and child health outcomes (PMNCH, n.d.).

A possible explanation for this disparity is that health outcomes are closely linked with human capital development. Human capital formation has become central to contemporary policy discourse on inequities regarding socioeconomic status, education, skill attainment, and health. The World Bank (2020) defines human capital as the "attainment of quality of life in terms of health, education, and skill development." That is, human capital comprises the knowledge, skills, and health individuals accumulate over their lifetime (World Bank, 2020). The Human Capital Index (HCI) is calculated based on health and education dimensions, including child and adult survival rates, stunting, and expected years of schooling. The HCI ranges from 0 to 1: A child born today would score a value of 1 if they fully benefit from health and education opportunities. Meanwhile, a score of 0 represents the lowest level of human capital.

Comparing the HCI of several Asian, Middle Eastern, and African countries reveals varying levels. Countries such as Pakistan, Afghanistan, Iraq, and Senegal score between 0.4 and 0.42. In contrast, countries such as Sri Lanka, Iran, Malaysia, Indonesia, and Saudi Arabia score between 0.54 and 0.6 (Figure 1).

Within Pakistan, a comparison between provinces, differentiated by gender and conducted by the World Bank, highlights disparities between the North and the South. The southern provinces of Sindh (ranging from 0.36 to 0.35 for men and women) and Balochistan (ranging from 0.35 to 0.32 for men and women) show lower HCI scores than the northern provinces of Punjab (0.43 for men and women) and Khyber Pakhtunkhwa (KP; from 0.45 to 0.35 for men and women) (Figure 2).

A multivariate analysis of the literature indicates that educational attainment, socioeconomic status, and urban–rural characteristics correlate with maternal and child health and family planning outcomes. A study conducted in India using data from five rounds of national health surveys illustrates the differential impact of maternal education on child mortality. Secondary and higher education among mothers significantly reduces the under-five mortality rate. Likewise, women with secondary education in urban areas have lower under-five mortality rates compared with those in rural areas (Moradhvaj & Samir, 2023). Furthermore, there is a correlation between increased poverty and adverse effects on child health (Arif, 2004). Therefore, education and urbanization have positive causal effects on fertility and mortality. The evidence suggests that higher levels of parental education result in lowered child mortality. Meanwhile, fertility rates decline once parents surpass the threshold of primary education. Notably, in urbanized societies, education tends to be uniformly and inversely related to fertility (Cochrane, 1986).

In summary, the persistent inequities and gaps in human capital have serious implications for maternal and child health, fertility, and family planning. Three factors – education level, demographic background (rural vs. urban), and socioeconomic status – play vital roles in shaping these outcomes. This paper argues that reductions in maternal mortality and fertility and increases in contraceptive prevalence rate (CPR), cannot be sustained without structural reforms in education, social protection, and women empowerment. These factors are further discussed in the following sections in relation to maternal health, fertility, and family planning uptake.

2. Status and disparities in maternal health, fertility, and family planning

Historically, progress on indicators of maternal health, fertility trends, and family planning uptake in Pakistan has been inconsistent, with periods of slow and rapid advancements. However, overall progress remains disappointing, despite decades of investment by the public and private sectors and development partners. In the 1990s, Pakistan made notable strides in family planning through key initiatives in the public and private sectors. These included the introduction of 100,000 lady health workers at the grassroots level in the public sector and social marketing and franchising efforts in the private sector. These interventions contributed to an increase in CPR from 12% in 1991 to 28% within a decade in 2006 – 2007 (NIPS, 2006). However, because these interventions were not accompanied by sustained reforms in education, social protection, poverty reduction, or women's empowerment, the gains could not be maintained, despite some progress in these sectors. The following sections provide an overview of trends in maternal mortality, fertility, and family planning.

2.1. Maternal mortality

Pakistan's maternal mortality ratio (MMR) was reported to be 186/100,000 live births in 2019, with significant differences observed between provinces (NIPS, 2019; Figure 3).

As seen in Figure 3, variations in MMR are evident based on demographic characteristics. For instance, the rural MMR was 199/100,000 live births, almost 21% higher than the urban MMR (158/100,000 live births) in the year 2019. The rural MMR is higher due to factors such as poor infrastructure, lack of human resources, limited mobility of women accessing health care due to factors such as the lacking transportation services, limited decision-

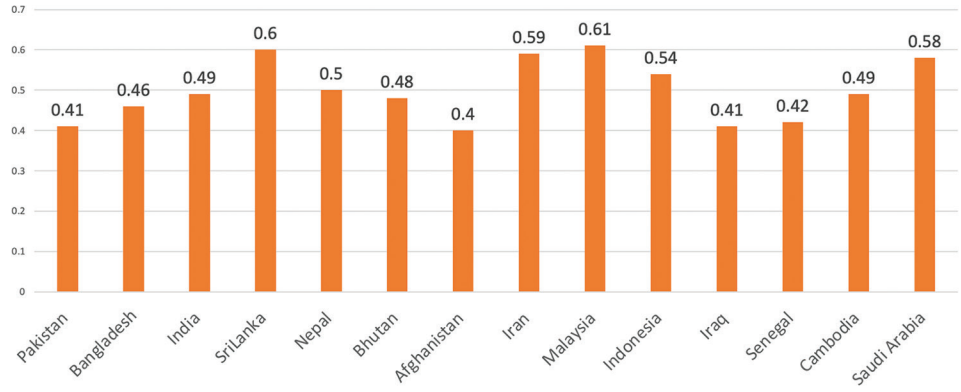


Figure 1. Human Capital Index for selected Asian, African, and Middle Eastern Countries (WB, 2020)

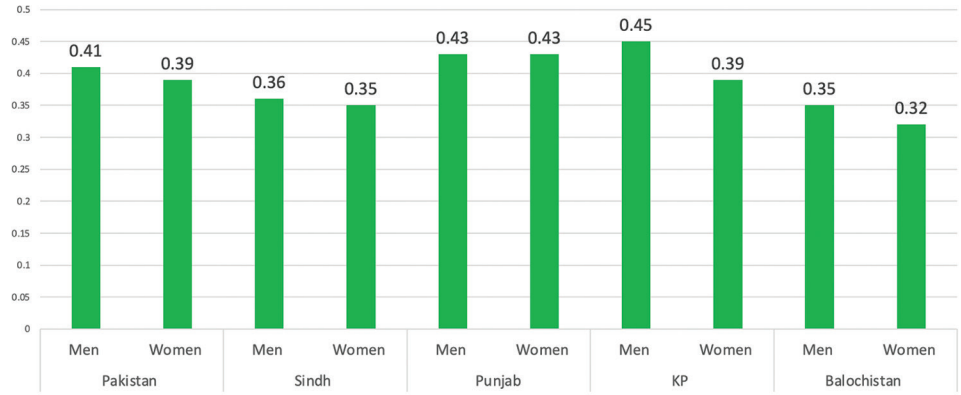


Figure 2. Human Capital Index for Pakistan: A comparison between provinces (WB, n.d.). Abbreviation: KP: Khyber Pakhtunkhwa.

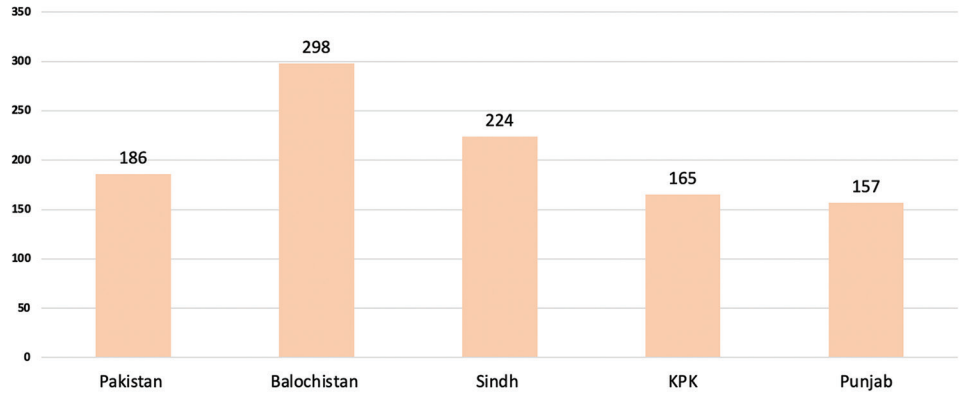


Figure 3. Maternal mortality ratio in Pakistan. Abbreviation: KPK: Khyber Pakhtunkhwa.

making power for women, fewer prospects for educational attainment, and lower socioeconomic status. Disparities between provinces are also notable, with northern provinces, namely, Punjab and KP[1] having MMRs of 157 and 165 out of 100,000 live births, respectively, whereas southern provinces, namely, Sindh and Balochistan report MMRs of 224 and 298 out of 100,000 live births, respectively. These disparities can be attributed to underdeveloped infrastructure and issues in health-care access, compounded by an increased prevalence of multidimensional poverty.

Although the devolution due to the 18th Constitutional Amendment in 2010 has led to increased provincial

[1] KP or KPK: Khyber Pakhtunkhwa – a province of Pakistan

investments in the health sector, improving antenatal and postnatal care, deliveries assisted by skilled birth attendants, and institutional deliveries, these improvements are yet to be reflected in a significantly lowered MMR. A possible explanation is the high large-scale migration rate from rural to urban areas, from the northern to southern regions of the country, and even from other countries, which has resulted in vast slum and peri-urban areas. These areas may be undermining sustained improvements in the health sector, as they are often unplanned thus, deprived of educational opportunities, poverty reduction measures, and prospects for women's empowerment. In general, however, there has been significant improvement in antenatal care, postnatal care, and institutional deliveries across the country owing to increased awareness and access to services.

2.2. Fertility trends

Fertility decline in Pakistan has historically been slow, as highlighted by a comparison of four rounds of the Pakistan Demographic and Health Survey (PDHS). The total fertility rate (TFR) was 4.9 in 1990 – 1991, 4.1 in 2006 – 2007; 3.8 in 2012 – 2013; and 3.6 in 2017 – 2018 (PDHS, 2006 – 2007). At present, the TFR is 3.6 children per woman of reproductive age (15 – 49 years). There is a significant disparity between urban and rural TFRs, with urban and rural areas reporting TFRs of 2.9 and 3.9, respectively. Analysis of fertility through demographic background shows that fertility is highest among women with no education, from rural backgrounds, and in the lowest wealth quintile (Figure 4). The TFR for women with no education is 4.2, compared with 2.6 for those with higher education. Meanwhile, in terms of wealth quintiles, the TFR for women in the lowest quintile is 4.9, whereas it is 2.8 for those in the highest quintile. Those in urban areas show lower TFR compared with those in rural areas (2.9 vs. 3.9, respectively; PDHS 2017 – 2018, NIPS, 2017-18n.d.).

Comparing the wanted fertility rate with TFR offers additional insights. In urban areas, the wanted fertility rate was 2.4, compared with 3.2 in rural areas. Women with no education had higher wanted fertility rates (3.5) than those with higher education (2.2). The wanted fertility rate among women in the lowest wealth quintile was 4, whereas it was 2.4 in the highest wealth quintile. These findings suggest that background characteristics have a significant influence on fertility outcomes (Table 1).

2.3. CPR

Pakistan's CPR showed a significant increase during the 1990s. However, progress has been slow after this rise. The CPR increased from 12% in 1990 – 1991 to 29.6% in 2006 – 2007, with notable growth in "any method" (combination of modern and traditional methods) and "modern method" (only non-traditional methods). However, progress stagnated in subsequent years, with the CPR reaching 35.4% in 2012 – 2013 and even declining slightly to 34.2% in 2017 – 2018 (Figure 5). According to the 2017 – 2018 PDHS, the current use of any contraceptive method in rural areas is 29.4%, and that in urban areas is 42.5%. The use of any method of contraception is 28.6% among women with no education, and this rises to 44% among those with higher education. A significant disparity is also observed between the lowest (20.1%) and highest wealth quintiles (44.5%). These figures suggest that family planning services have

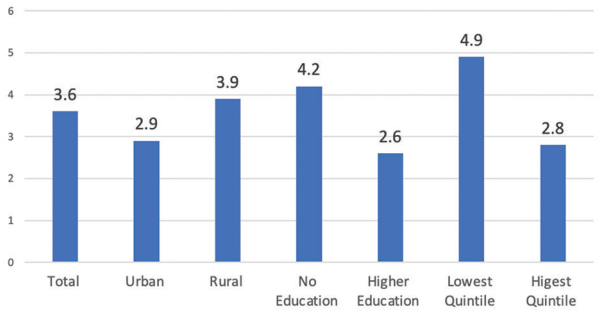


Figure 4. Fertility trends by background characteristics (PDHS, NIPS, 2017 – 2018)

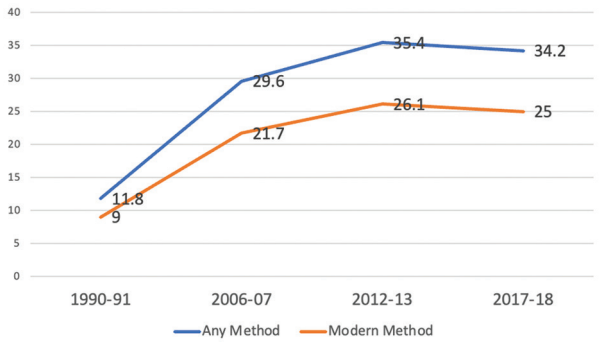


Figure 5. Contraceptive prevalence rate trends from 1990 – 1991 to 2017 – 2018 (PDHS various Reports)

Table 1. Background characteristics versus fertility outcomes

Background Characteristics	Fertility outcomes	Wanted fertility
Urban	2.4	-
Rural	3.2	-
No education	-	3.5
Higher education	-	2.2
Lowest quintile	-	4
Highest quintile	-	2.4

not been complemented by interventions in education, rural development, and poverty reduction.

3. Differentials based on residential background, education, and poverty

Secondary data revealed consistency in high maternal mortality and fertility rates and low CPR when compared across educational attainment, rural background, and wealth quintiles.

3.1. Residential background

Pakistan's population reached 241.4 million in the 2023 digital census (Pakistan Bureau of Statistics, 2023), with an alarming annual growth rate of 2.55%. The rural population constitutes 147.7 million (61%) whereas the urban population is 93.7 million (39%). On comparing across provinces, 84.9%, 59.2%, 46%, and 69% of the population in KP, Punjab, Sindh, and Balochistan, respectively, reside in rural areas. As noted previously, a rural background – characterized by limited infrastructure and services – contributes to high maternal mortality and fertility and low family planning uptake.

3.2. Educational background

In Pakistan, 74 million young people aged 5 – 24 have never been to school. A total of 23, 17, 8, and only 5 million young people have completed primary, matriculation, intermediate, and graduate education, respectively (World Bank, n.d.). Pakistan's literacy rate is 60%, with urban and rural literacy at 78% and 59%, respectively. Girls' education is an important driver of social progress and directly impacts maternal mortality, fertility, and family planning uptake. In 2019 – 2020, before the onset of the COVID-19 pandemic, 37% of girls in Pakistan had never attended school (World Bank, n.d.). The data consistently show that lower levels of education are associated with higher maternal mortality and fertility and lower contraceptive use.

3.3. Poverty

Pakistan experienced a decline in poverty during the 1970s and 1980s, but this trend was not sustained due to policy instability. Recently, significant reductions in poverty have occurred through initiatives such as the Benazir Income Support Program (BISP). According to the Ministry of Planning and Development, 24.3% of the population (55 million people) live below the poverty line. Women's economic empowerment is an important determiner of poverty levels in a society. In Pakistan, women's labor force participation is only 23%, meaning that three out of every four women are not part of the labor force (World Bank, n.d.). Such low participation rates highlight the need for macro-level policy changes to include women in the country's economic development.

4. Future prospects of improvement in maternal health, fertility, and contraception

The data demonstrate close associations between maternal mortality, fertility, and contraception with three fundamental factors: Educational level, socioeconomic status, and demographic background. Due to the poor status of these factors, interventions in Pakistan have failed to sustain gains in reducing maternal mortality and fertility and improving contraceptive use. Progress in education, poverty reduction, and rural development remains slow, reflected in sluggish improvements in indicators for maternal health, fertility, and contraception.

As a signatory to the United Nations' Sustainable Development Goals (SDGs), Pakistan has committed to reducing maternal mortality to <70/100,000 live births and eradicating extreme poverty (defined as earning <1.25 US$ a day) whereas halving multidimensional poverty by 2030 (Federal SDGs Support Unit, n.d.). Regarding family planning, commitments were made under the FP2020 London Summit of 2012, the Family Planning 2030 (FP2030) initiative, and through the Council of Common Interests (CCI) – a constitutional forum in Pakistan. Based on these commitments, Pakistan has resolved to achieve a CPR of 60%, a fertility rate of 2.2, and a population growth rate of 1.1% by 2030.

It is important to assess the achievability of these goals. In this regard, a UN report offers valuable insights. The report analyzed low, medium, and high population growth trajectories in relation to CPR and TFR. This analysis can be compared with Pakistan's commitments for 2030, benchmarked against averages for developing countries and regional countries (Asia and the Near East). For developing countries, the report predicts that by 2030, the CPR for low, medium, and high population growth will be 69%, 59%, and 49%, respectively. In other words, low population growth is associated with higher CPR and vice versa. Likewise, the projected TFR for low, medium, and high population growth in 2030 is 1.8, 2.4, and 2.8, respectively (Moreland *et al.*, 2010). According to Pakistan's 2023 Census, the population growth rate is 2.55%, which is rather high and makes the country the fifth most populous country in the world. Consequently, Pakistan may struggle to achieve its CPR and TFR goals for 2030 unless population growth slows.

Further reflecting on the relationship between socioeconomic factors, CPR, TFR, and mortality, Warren C.

Robinson's landmark review of Pakistan's family planning program from 1955 to 1977 is particularly insightful.

"Modern theories of fertility predict that contraceptive usage rises with income and education. There is a configuration of factors – income, female employment, literacy, and infant mortality – which are clearly linked to fertility through contraception. Where these variables are negative, the results of any program will be uncertain…. One might say that the Family Planning Scheme in Pakistan represents a good test of whether family planning can take hold in a situation in which the setting is basically adverse" (Robinson, 1978).

In this context, Pakistan requires a holistic development approach that integrates the health and population sectors while implementing structural reforms to reduce poverty, enhance education – particularly for girls – and mitigate rural–urban inequality. In addition, women's empowerment through the transformation of social and gender norms should be prioritized.

There is substantial evidence of the interlinkages between socioeconomic factors and outcomes related to maternal, neonatal, child, and adolescent health; family planning; and TFR. In recent years, there has been a renewed focus on these issues, alongside universal health coverage (UHC) and multisectoral interventions, that is, life skills-based education and infrastructure development, in Pakistan. Sindh implemented its FP2020 roadmap, the Costed Implementation Plan (CIP), which this author developed in the context of the 2012 London Summit. The CIP received national and international acclaim (Folsom & Tamar, 2022; CIP, 2015), prompting other provinces to replicate some of the best practices. Moreover, there was a renewed focus on family planning and reproductive health, significantly influenced by the 2017 Population Census, which revealed rapid population growth. This led the Supreme Court of Pakistan to take a *suo moto* action in 2018. The Supreme Court's recommendations were forwarded to the CCI and endorsed in the same year. These initiatives are expected to positively impact fertility, contraception, and maternal health.

The CCI recommendations include multifaceted policy commitments and institutional mechanisms to ensure accountability. The policies cover family planning, reproductive health, FP2030 commitments, UHC, and poverty reduction measures, such as social protection programs and health insurance. The BISP, which provides financial support to the poorest women in society, is also expected to have a positive impact. To ensure the implementation of the CCI recommendations and FP2030 commitments, a federal task force led by the prime minister and provincial task forces led by the chief ministers of the provinces have been established. The Country Engagement Working Group, which includes federal and provincial ministries and department partners, reviews progress every quarter. These reforms have attracted investments from bilateral and multilateral donors in areas such as family planning; reproductive maternal, newborn, and child health; UHC; and social protection. If these multisectoral reforms, bolstered by institutional mechanisms, are successful, Pakistan is likely to meet its national and international commitments to a large extent.

5. Conclusion

This paper highlights that poor educational background, low socioeconomic status, and rural underdevelopment contribute to negative outcomes in maternal mortality, fertility, and family planning uptake. While Pakistan has made progress in maternal, neonatal, and child health, as well as in measures to improve education, poverty reduction, and infrastructure development, more sustained and cohesive reforms are needed. In this context, recent reforms under CCI recommendations, FP2030, and UHC provide a glimmer of hope. Broader initiatives in infrastructure development and alternate energy may help further reduce the rural–urban divide and improve economic opportunities.

In conclusion, a multipronged strategy that focuses on poverty reduction, improving education, and reducing rural–urban disparities is essential for achieving sustained progress in health and population outcomes. Such an approach is particularly important in light of Pakistan's broader policy objectives, including the SDGs, FP2030, and the goals set by the International Conference on Population Development in 2019.

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References

Arif, G.M. (2004). Child health and poverty in Pakistan. *The Pakistan Development Review*, 43(3):211-238.

https://doi.org/10.30541/v43i3pp.211-238

CIP, Population Welfare Department & Government of Sindh. (2015). Costed Implementation Plan on Family Planning for SINDH, 2015-2020. Available from: https://scorecard.prb.org/wp-content/uploads/2018/04/costed-implementation-plan-on-family-planning-for-sindh-2015.pdf [Last accessed on 2024 Aug 05].

Cochrane, S.H. (1986). The Effects of Education on Fertility and Mortality.The World Bank. Available from: https://rb.gy/7y9ks9 [Last accessed on 2024 Aug 05].

Federal SDGs Support Unit. (n.d.). Available from: https://www.sdgpakistan.pk [Last accessed on 2023 Dec 22].

Folsom, M., & Tamar, A. (2022). Costed Implementation Plan Resource Kit: What we Heard. Washington, DC: USAID, Momentum Project.

Moradhvaj, & Samir, K.C. (2023). Differential impact of maternal education on under-five mortality in rural and urban India. *Health & Place*, 80:102987.

https://doi.org/10.1016/j.healthplace.2023.102987

Moreland, S., Smith, E., & Sharma, S. (2010). World Population Prospects and Unmet Need For Family Planning. Washington, DC: Futures Group. Available from: https://rb.gy/qmtugs [Last accessed on 2024 Aug 05].

National Institute of Population Studies (NIPS) & ICF. (2017). Pakistan Demographic and Health Survey, 2017-18. Islamabad: NIPS, ICF. Available from: https://dhsprogram.com/pubs/pdf/FR354/FR354.pdf [Last accessed on 2024 Aug 05].

National Institute of Population Studies (NIPS) & M. International Inc. (n.d.). PDHS - Pakistan Demographic & Health Survey, 2006-07. Islamabad: National Institute of Population Studies. Available from: https://dhsprogram.com/pubs/pdf/fr200/fr200.pdf [Last accessed on 2024 Aug 05].

National Institute of Population Studies (NIPS). (2006). Pakistan Demographic and Health Survey, 2006-07. Islamabad: National Institute of Population Studies.

National Institute of Population Studies (NIPS) [Pakistan], and Macro International Inc. (2008). Pakistan Demographic and Health Survey 2006-07. Islamabad, Pakistan: National Institute of Population Studies and Macro International Inc.

National Institute of Population Studies (NIPS) [Pakistan] and ICF. (2019). Pakistan Demographic and Health Survey 2017-18. Islamabad, Pakistan, and Rockville, Maryland, USA: NIPS and ICF.

NIPS. (2019). Maternal Mortality Survey Summary Report Pakistan, 2019. Islamabad: National Institute of Population Studies (NIPS). Available from: https://dhsprogram.com/pubs/pdf/SR267/SR267.pdf [Last accessed on 2023 Dec 22].

Pakistan Bureau of Statistics. (2023). Pakistan Census, 2023. Available from: https://www.pbs.gov.pk [Last accessed on 2023 Dec 22].

PMNCH. (n.d.). PMNCH 20121-2025 Strategy. PMNCH - Partnership for Maternal, Newborn and Child Health. Available from: https://pmnch.who.int/about-pmnch/strategy-and-workplans/pmnch-2021-2025-strategy [Last accessed on 2023 Dec 23].

Robinson, W.C. (1978). Family Planning in Pakistan 1955-1977: A Review, 1978. Islamabad: Pakistan Institute of Development Economics. Available from: https://file.pide.org.pk/pdf/PDR/1978/Volume2/233-247.pdf [Last accessed on 2024 Aug 05].

The World Bank. (2020). The Human Capital Index 2020 Update. Washington, DC: The World Bank.

https://doi.org/10.1596/978-1-4648-1552-2

World Bank. (n.d.). Pakistan Human Capital Review: Building Capabilities Throughout Life. Washington, DC: The World Bank.

ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

"Push out" and "pull in" factors of institutional delivery among rural women in central Myanmar

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Abstract

Myanmar continues to face the burden of maternal mortality, with most maternal deaths occurring during or immediately after childbirth. Many women, particularly those in rural areas, do not deliver in health institutions offering comprehensive obstetric care. Despite the importance of institutional delivery, few studies have examined its determinants among rural women in Myanmar. This community-based cross-sectional study was conducted in selected villages in the Magway region, located in central Myanmar, and exhibited a maternal mortality ratio higher than the national average. A total of 500 married women who had delivered in the two years before the survey were selected using multistage sampling and interviewed with a semi-structured questionnaire. Independent determinants were identified using a generalized linear mixed model under a logistic regression framework. Approximately one-third (35.6%; 95% confidence interval [CI]: 31.5 – 39.9%) of the respondents delivered their last child at a health institution. The "pull in" factors of institutional delivery included being aged 25 – 35 years (adjusted odds ratio [AOR] = 2.96; 95% CI: 1.21 – 7.22), having a secondary or higher education (AOR = 2.83; 95% CI: 1.50 – 5.32), receiving information from health-care providers (AOR = 2.01; 95% CI: 1.11 – 3.83), recognizing high-risk pregnancies (AOR = 5.47; 95% CI: 1.42 – 21.11), and completely taking up antenatal care (AOR = 3.04; 95% CI: 1.42 – 6.49). The "push out" factors that deterred institutional delivery included a lack of women's autonomy (AOR = 0.26; 95% CI: 0.14 – 0.50) and inadequate birth preparedness (AOR = 0.37; 95% CI: 0.19 – 0.72). The institutional delivery rate among rural women was considerably low. To improve it, it is crucial to provide information about high-risk pregnancies and the importance of institutional delivery during antenatal visits, empower women, and encourage birth preparedness in rural Myanmar.

Keywords: Institutional delivery; Health facility delivery; Rural women; Myanmar

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1. Introduction

Ending preventable maternal mortality is one of the most significant public health challenges in the developing world. The World Health Organization (WHO) estimates that 303,000 women worldwide die from pregnancy- or childbirth-related complications each year, with 99% of these deaths occurring in developing regions

and under-resourced settings (WHO, 2015). Myanmar, a developing country, ranks high in maternal mortality compared with its neighboring countries in Southeast Asia. The 2014 Myanmar census reported a maternal mortality ratio (MMR) of 282/100,000 live births (LBs), higher than the regional average of 140/100,000 LBs (Department of Population, 2016). More than 70% of maternal deaths in Myanmar occur among rural women (MOHS, 2018).

Despite the occurrence of millions of uncomplicated childbirths, the majority of adverse pregnancy outcomes occur around the time of delivery, with most intrapartum complications being unpredictable. More than 70% of maternal deaths happen during or immediately after childbirth (UNICEF, 2018). This period, which includes childbirth and the first few hours postpartum, is recognized as the period with the highest risk of mortality for mothers and newborns (The Partnership for Maternal, Newborn, & Child Health, 2006; WHO, 2005). Most postpartum deaths arise from complications during childbirth (WHO, 2005). The absence of skilled care at this critical time can lead to life-threatening consequences for mothers and their newborns. Therefore, skilled attendance at birth is considered the most important factor in preventing maternal deaths. According to the WHO, a skilled attendant is a licensed health-care provider, such as a medical doctor, nurse, or midwife who is trained in managing uncomplicated pregnancies, deliveries, and postpartum care, as well as detecting, treating, and referring complications in mothers and newborns (WHO *et al*., 2004). While skilled attendants can conduct deliveries either at home, health centers, or hospitals, delivering in health facilities with referral capacity is considered the most effective strategy in low-income countries for reducing maternal and newborn mortality (Gabrysch & Campbell, 2009). It is recommended that childbirths take place in environments equipped with the necessary resources, including medicines, well-functioning health systems, and emergency referral services (The Partnership for Maternal, Newborn, & Child Health, 2006; WHO, 2005; WHO *et al.*, 2004) Therefore, delivering in a health institution under the supervision of skilled attendants promotes child survival and reduces the risk of maternal mortality (WHO *et al*., 2004; WHO, 2015; UNICEF, 2018).

In Myanmar, skilled birth attendants (SBAs) include obstetricians, doctors, nurses, lady health visitors, and midwives. Approximately 1.3 million women give birth annually, with an average of 2.3 children per woman; this rate is notably higher in rural areas (MOHS & ICF International, 2016). The lifetime risk of maternal death is 1 in 250 (Requejo *et al.*, 2015). The 2013 Myanmar Maternal Death Review revealed that more than three-quarters (77.4%) of maternal deaths in Myanmar occurred among rural women (MOH, 2013). Among rural women, nearly 80% deliver at home, with the majority attended by unskilled providers. The Myanmar Demographic and Health Survey (MDHS) reported that 52% of rural women delivered with a skilled provider, and only 28% delivered in a health facility (MOHS & ICF International, 2016). Furthermore, an estimated 15 – 20% of pregnancies encounter unpredictable complications, and most deaths from these complications occur at home or during transit (Oo *et al*., 2012). Although institutional delivery in a well-functioning health facility is critical for reducing maternal mortality, many rural women face significant barriers in deciding to seek, access, and receive skilled care in health facilities.

Internationally, a number of studies have been conducted to determine the factors associated with institutional delivery, with education of women, socioeconomic status, women's autonomy, accessibility, antenatal visits, birth order, and awareness of maternal danger signs and high-risk pregnancies identified as key determinants (Anyait *et al.*, 2012; Darega *et al.*, 2016; Gabrysch & Campbell, 2009; Gudu & Addo, 2017; Hagos *et al.*, 2014; Kamal *et al*., 2015; Khanal *et al.*, 2014). However, most studies have focused on birth attendants rather than place of delivery, and few studies explore the determinants of institutional delivery. A study conducted in Myanmar found that the main reason for home deliveries was financial difficulty (51.9%). Other factors included a desire for social support during labor (from family members, relatives, and friends), fear of the childbirth position used in health facilities (lithotomy position), and negative attitudes toward health staff (Sein, 2012). This study aims to explore the proportion of rural women who deliver in health facilities and the push and pull factors influencing institutional delivery among rural women in central Myanmar.

2. Data and methods

This community-based cross-sectional study was conducted in selected villages in the Magway region, one of the central regions of Myanmar, which has an MMR of 343.6/100,000 LBs, higher than the national average. More than three-quarters of the population in this region reside in rural areas (Department of Population, 2016). The data were collected between November 2016 and January 2017. A sample size of 500 participants was estimated using the multiple logistic regression formula (Hsieh *et al.*, 1998). Eligible participants were currently married women who had delivered children within 2 years before the survey. In Myanmar, especially in rural areas, considering cultural factors and traditional customs, the proportion of women who deliver children without being married is

infinitesimally small. Therefore, married and reproductive-aged women were considered appropriate sampling units for this study. The eligible participants were drawn from 21 selected villages using multistage cluster sampling.

The respondents were interviewed face-to-face using a semi-structured questionnaire, collecting information about their obstetric history and recent childbirth practices. Before data collection, the researcher trained ten enumerators, explaining the study's objectives and the appropriate protocol for administering the questionnaire. Subsequently, data were collected after explaining the purpose of the study to eligible participants and ensuring their confidentiality. Data quality was ensured by checking for consistency and completeness immediately after each interview.

The outcome variable was whether participants had delivered their most recent child in a health institution or facility. The independent variables included sociodemographic variables such as the respondent's age, education level, occupation of the couple and their per capita income; accessibility to maternal care, women's autonomy, awareness of high-risk pregnancies, and sources of health information. In addition, obstetric-related factors such as birth order, birth preparedness, and complete antenatal care (ANC) uptake were considered important independent variables. Several independent variables were operationalized as follows: (1) accessibility to maternal care was defined as a combination of physical and financial accessibility. This variable had two categories: "easy access to health facilities," indicating if a woman could reach the nearest health facility even during the monsoons and afford transportation and health-care costs, and "difficulty accessing health facilities" otherwise. (2) Women's autonomy was defined as their ability to make independent decisions regarding seeking maternal care, selecting care providers, and choosing the site of delivery. (3) Complete ANC uptake was defined as having at least four ANC visits, regularly taking antenatal supplements, and receiving two tetanus toxoid injections during the most recent pregnancy. The outcome variable and most independent variables, except for age, per capita income birth order, and the number of ANC visits, were assessed as categorical. To improve interpretation, all numerical independent variables were categorized.

The sociodemographic characteristics of the respondents were presented as frequencies and percentages for categorical variables and as summary statistics (mean and standard deviation) for continuous variables. The institutional delivery rate was reported with a 95% confidence interval (CI). The determinants of institutional delivery were analyzed using adjusted odds ratios (AOR) with 95% CIs, estimated through a generalized linear mixed model (GLMM) within a logistic regression framework. GLMM was applied to account for the correlation of events within the same village when estimating standard errors. Variables with $p < 0.25$ in bivariate analysis were included in the GLMM. Two-tailed tests were used for all statistical tests, and a $p < 0.05$ was considered statistically significant. Statistical analysis was performed using STATA version 13.1.

3. Results

3.1. Choice of delivery place

Among 500 rural women in Myanmar, 35.6% (95% CI: 31.5%, 39.9%) delivered at a health facility. Of the 322 women who delivered at home, only 29.5% were attended by an SBA. The most common reason for delivering at a health facility was to ensure safe delivery (84.2%), followed by the adequacy of medical resources (48.6%) and referrals due to high-risk pregnancies (31.1%) (Table 1).

Table 1. Distribution of delivery place and reasons for choice of delivery place

Characteristics	Frequency	Percentage
Place of delivery (*n*=500)		
Institutional delivery	178	35.6
Home delivery	322	64.4
Types of birth attendants for home delivery (*n*=322)		
SBA	95	29.5
Non-SBA/TBA	227	70.5
Reasons for institutional delivery* (*n*=178)		
Safe delivery	149	84.2
Availability and adequacy of medical resources	86	48.6
Referral due to high-risk pregnancy	55	31.1
Economic accessibility	34	19.2
Advice from others	29	16.4
Physical accessibility	25	14.1
Reasons for home delivery* (*n*=322)		
Perceived that pregnancy was normal	241	74.8
Others (social pressure, previous experience)	172	53.4
Family's support	150	46.6
Practice on traditional beliefs	143	44.4
Financial difficulty	108	33.5
Fear of health facility	58	18.0
Difficulty in transportation	34	10.6

*The findings were calculated as multiple responses.
Abbreviations: SBA: Skilled birth attendant; TBA: Traditional birth attendant.

3.2. Background characteristics associated with institutional delivery

Nearly half of the respondents (48.5%) were aged 25 – 35 years, with an age range of 17 – 47 years and a mean age of 29.72 ± 6.6 years. Only one-third (27.8%) of the respondents had a secondary or higher level of education. About 25% of the women earned an income from their own businesses or regular income-generating jobs. Regarding their husbands' education and occupation, 63.8% had primary or lower education, and 57.6% were manual workers. More than half the respondents (60.8%) had a low income, earning <50,000 Myanmar kyats (MMK). Regarding accessibility, including physical and financial issues, 15.6% of rural women encountered difficulty accessing skilled care at health facilities. The institutional delivery rate was higher among women aged 25 – 35 years (44.8%), those with secondary or higher education (63.3%), those engaged in their own businesses or with regular income-generating jobs (53.9%), and those with per capita income of more than 50,000 MMK (54.1%). In addition, 39.1% of rural women who could access a health facility during the rainy season and afford the cost of transportation and health care delivered at a health facility. Nearly half (48.8%) of the participants had autonomy in deciding to seek maternal care, and among these women, 57.8% delivered at a health facility (Table 2).

3.3. Obstetric factors associated with institutional delivery

On average, the participants had 2 ± 1.4 children, with 34 mothers (6.8%) having five children or more. For nearly half of the mothers (47.6%), their most recent delivery was their first child. Only 20 respondents (4%) were aware of high-risk pregnancy criteria and key danger signs during the perinatal period. Nearly half of the mothers (46.8%) received maternal health information (antenatal, intranatal, and postnatal) from skilled health-care providers, including doctors, nurses, lady health visitors, and midwives.

Regarding birth preparedness, only 179 (35.8%) mothers reported saving money for delivery, identifying a place of delivery, choosing a skilled provider, and arranging transportation in case of an obstetric emergency. Of the 500 respondents, 382 (76.4%) had at least one ANC visit whereas 118 (23.6%) had none. Among those who received ANC, 18.5% did not regularly take antenatal supplements, although almost all (96.7%) received tetanus toxoid twice. More than half the participants received complete ANC, defined as at least four antenatal visits, regular prenatal supplement intake, and two doses of tetanus toxoid (Table 2).

3.4. "Push out" and "Pull in" factors for institutional delivery

According to bivariate analysis using simple logistic regression, several factors acted as "pull-in" influence encouraging institutional delivery. These included being 25 years of age or older, having secondary or higher education, earning a regular income (both mothers and their husbands), having a monthly per capita income exceeding 50,000 MMK, a first birth, awareness of high-risk pregnancy, receiving maternal health information from skilled providers, and completing ANC. Conversely, "push-out" factors determining institutional delivery were financial and physical barriers to accessing health facilities, a lack of women's autonomy, and inadequate birth preparedness (Table 2).

Figure 1 presents the results of a multivariable analysis, reporting AOR and 95% CI for the determinants of institutional delivery. After adjusting for other variables, the likelihood of institutional delivery was higher among rural mothers aged 25 – 35 (AOR = 2.96; 95% CI: 1.21 – 7.22) and those aged over 35 (AOR = 2.10; 95% CI: 1.10 – 4.18) compared with mothers ages <25. Mothers with secondary or higher education (AOR = 2.83; 95% CI: 1.50 – 5.32), those receiving maternal health information from health-care providers (AOR = 2.01; 95% CI: 1.11 – 3.83), those knowledgeable about high-risk pregnancies and perinatal danger signs (AOR = 5.48; 95% CI: 1.42 – 21.11), and those who completed antenatal uptake (AOR = 3.04; 95% CI: 1.42 – 6.49) were more likely to deliver at a health institution.

In contrast, mothers lacking autonomy in making decisions regarding maternal health care and choosing the delivery location or attendant (AOR = 0.26; 95% CI: 0.14 – 0.50), as well as those without birth preparedness (AOR = 0.37; 95% CI: 0.19 – 0.72), were significantly less likely to opt for institutional delivery.

4. Discussion

Institutional delivery is a key strategy for reducing maternal mortality given the unpredictable obstetric complications arising during home delivery; it can also prevent maternal deaths resulting from delays in receiving treatment due to late referral and prolonged transit. This community-based study aimed to explore the extent and determinants influencing institutional delivery among rural women in central Myanmar. The findings highlighted a considerably low institutional delivery rate, with only one-third of rural mothers delivering their most recent children at a health facility. The 2015 – 2016 MDHS reported a 28% institutional delivery rate in rural areas, 7% lower than the rate observed in this study. This discrepancy may be due to differences in the study periods and the recall period for

Table 2. Factors associated with institutional delivery in bivariate analysis

Characteristics	Total (*n*=500) number (%)	Institutional delivery number (%)	Crude OR (95% CI)	*p*-value
Age (years)				0.0002
<25 years	125 (25.0)	32 (25.6)	1	
25 – 35 years	241 (48.2)	108 (44.8)	2.36 (1.47 – 3.80)	
>35 years	134 (26.8)	38 (28.4)	1.15 (0.66 – 1.19)	
Level of education				<0.001
Primary or below	361 (72.2)	90 (24.9)	1	
Secondary or higher	139 (27.8)	88 (63.3)	5.2 (3.42 – 7.9)	
Types of occupation				<0.001
Dependent or odd jobs	372 (74.4)	109 (29.3)	1	
Own a business or income-generating job	128 (25.6)	69 (53.9)	2.82 (1.87 – 4.27)	
Husband's educational attainment				<0.001
Primary or below	319 (63.8)	79 (24.8)	1	
Secondary or higher	181 (36.2)	99 (54.7)	3.67 (2.49 – 5.4)	
Types of husband's occupation				<0.001
Odd jobs/manual worker	288 (57.6)	57 (19.8)	1	
Own a business or income-generating job	212 (42.4)	121 (57.8)	5.39 (3.62 – 8.02)	
Per capita income (MMK)*				<0.001
<50,000	304 (60.8)	72 (23.7)	1	
≥50,000	196 (39.2)	106 (54.1)	3.8 (2.58 – 5.58)	
Accessibility				<0.001
Could easily access	422 (84.4)	165 (39.1)	1	
Could not easily access	78 (15.6)	13 (16.7)	0.31 (0.17 – 0.58)	
Woman's autonomy				<0.001
Present	244 (48.8)	141 (57.8)	1	
Absent	256 (51.2)	37 (14.5)	0.12 (0.08 – 0.19)	
Birth order				0.022
Second and above	262 (52.4)	81 (30.9)	1	
First	238 (47.6)	97 (40.8)	1.54 (1.06 – 2.22)	
Awareness of high-risk pregnancy				0.001
No	480 (96.0)	163 (34.0)	1	
Yes	20 (4.0)	15 (75.0)	5.83 (2.08 – 16.34)	
Source of health information				<0.001
Non-skilled provider	266 (53.2)	41 (15.4)	1	
Skilled provider	234 (46.8)	137 (58.6)	7.75 (5.08 – 11.82)	
Birth preparedness				<0.001
Yes	179 (35.8)	125 (69.8)	1	
No	321 (64.2)	53 (16.5)	0.09 (0.06 – 0.13)	
Complete antenatal uptake				<0.001
Not received	238 (47.6)	22 (9.2)	1	
Received	262 (52.4)	156 (59.5)	14.45 (8.74 – 23.9)	

Notes: *MMK: Myanmar Kyats (exchange rate at the time of data collection; 1 USD=1,350 MMK).
Abbreviations: OR: Odds ratio; CI: Confidence interval.

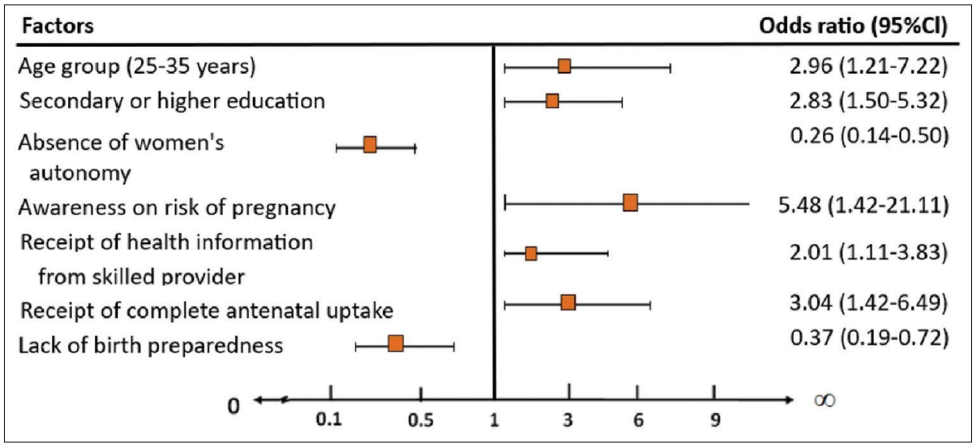


Figure 1. Factors associated with institutional delivery in multivariable analysis
Abbreviation: CI: Confidence interval.

obstetric history (5 years preceding the MDHS). In addition, the MDHS may have been affected by extremely low rates in some regions (MOHS & ICF International, 2016).

Mothers aged 25 – 35 years were approximately 3 times more likely than those under 25 years to deliver at a health institution. Older women may have stronger decision-making power when choosing maternal care providers and delivery locations and may be less influenced by older female relatives in making decisions about their maternal health care compared with younger women. Although women over 35 years had a lower proportion of institutional deliveries than those aged 25 – 35, the difference was not statistically significant. Women in this age group may have previous delivery experience and feel more confident, perceiving less need for health facility deliveries. In addition, older women may be more inclined to follow traditional beliefs, making them less likely to utilize institutional delivery than young women (Gabrysch & Campbell, 2009). Unlike other studies, this research found that physical accessibility to health facilities was not related to the choice of delivery location. In many rural areas, despite them being near health centers, the unavailability of health staff outside office hours often leads women to deliver at home. A perception of pregnancy as normal, social pressure (advice from older female relatives, husbands, and peers), previous home delivery experience, and a desire for family support during labor was identified as the most common reasons for home delivery. These factors explain the discrepancies between the findings of this study and those of others.

Furthermore, the likelihood of institutional delivery increased with education levels and awareness of high-risk pregnancies and perinatal danger signs. Mothers who received maternal health education from skilled providers, including through media, were more likely to choose institutional delivery. These results aligned with the findings of two literature reviews (Gabrysch & Campbell, 2009; Tey & Lai, 2013). Studies conducted in Ethiopia and Myanmar further support the significant association between maternal education and institutional delivery (Berelie *et al.*, 2020; Lwin & Punpuing, 2022). Similarly, another Ethiopian study found that good maternal health knowledge influenced facility-based deliveries (Zenbaba *et al.*, 2021). Education level, knowledge, awareness of pregnancy risks, and access to health information were intertwined determinants of the utilization of health facilities for delivery. Mothers with higher education attainment are more likely to seek maternal health information about safe motherhood and the availability and accessibility of health-care services from reliable sources.

As expected, institutional delivery was significantly influenced by the frequency and receipt of ANC services. Complete antenatal uptake tripled the odds of institutional delivery, consistent with international studies conducted in Ethiopia, Bangladesh, Timor-Leste, and rural Ghana (Berelie *et al.*, 2020; Gudu & Addo, 2017; Kamal *et al.*, 2015; Khanal *et al.*, 2014; Zenbaba *et al.*, 2021). Frequent antenatal visits can lead to the timely detection of obstetric abnormalities, encouraging institutional delivery. In addition, repeated exposure to skilled health personnel and valuable maternal health information may positively influence the choice of delivery location.

In this study, a lack of women's autonomy in deciding on birth location and attendant was identified as a deterrent to health facility delivery, as previously documented in a study in Bangladesh (Kamal *et al.*, 2015), although this finding contradicts results from Uganda (Anyait *et al.*, 2012). A possible explanation is that women with higher autonomy are less influenced by older female family members, such as mothers-in-law or mothers,

who may prefer traditional practices. Women's education may also empower them to make independent decisions about seeking and receiving skilled maternal health-care services. Previous studies in Myanmar and Vietnam have documented that women living in extended families were less likely to opt for institutional delivery (Duong *et al.*, 2004; Sein, 2012). Moreover, a lack of birth preparedness contributed to a low institutional delivery rate. Women without birth preparedness were 63% less likely to use health facilities compared with those with a birth plan. This finding aligns with a prospective cohort study conducted in Nepal, which showed that increased birth preparedness correlated with higher health facility delivery rates (Karkee e*t al.*, 2013). Similarly, a study conducted in semi-urban Ethiopia identified birth preparedness as a significant predictor of institutional delivery (Rosado *et al.*, 2019).

5. Conclusion

The provision of information about high-risk pregnancies, the importance of birth preparedness, and the benefits of institutional delivery should be intensified among rural reproductive-aged women, especially those in high-risk age groups and those with lower levels of education. Health-care providers should receive training and resources to support maternal health education, ensuring that the information delivered to rural communities is valid, precise, and easily understood. Given that skilled and adequate ANC is a key factor in ensuring quality maternal health, every pregnant woman should be informed at every antenatal visit about safe motherhood, including the importance of institutional delivery.

The study had some limitations. As the participants reported their past experiences and practices, recall bias may have occurred. To minimize this bias, a 2-year recall period was selected. In addition, this study did not account for the quality of services or satisfaction of rural women with the services they received, which are crucial factors for increasing institutional deliveries in rural settings. Further studies are recommended to focus on the quality of care and satisfaction with institutional delivery among rural women in Myanmar.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Aye Sandar Mon
Methodology: All authors
Formal analysis: Aye Sandar Mon
Writing – original draft: Aye Sandar Mon
Writing – review & editing: All authors

Ethics approval and consent to participate

This study protocol and the final version of written informed consent were approved by the Khon Kaen University Ethics Committee for Human Research with reference number [HE592256] and the Ethical Committee of the University of Public Health, Yangon, Myanmar (Ethical[6/2016]). Permission to conduct this study was attained from local responsible persons and health authorities. Participation in this study was entirely voluntary and informed consent was taken from all participants before the interview. For participants younger than 18 years, consent was obtained from their respective guardians. All the authors made essential contributions and agreed with the present submission.

Consent for publication

Written informed consent was obtained from each study participant. The following statement was included in the information sheet of the informed consent form and communicated to every study participant: "We will publish the results so that other interested people may learn from the research after deidentification, ensuring your privacy and confidentiality."

Availability of data

The data underlying the results presented in the study are available from the corresponding author upon reasonable request.

References

Anyait, A., Mukanga, D., Oundo, G.B., & Nuwaha, F. (2012). Predictors for health facility delivery in Busia district of Uganda: A cross sectional study. *BMC Pregnancy and Childbirth*, 12(1):1-9.

https://doi.org/10.1186/1471-2393-12-132

Berelie, Y., Yeshiwas, D., Yismaw, L., & Alene, M. (2020). Determinants of institutional delivery service utilization in Ethiopia: A population based cross sectional study. *BMC Public Health*, 20(1):1077.

https://doi.org/10.1186/s12889-020-09125-2

Darega, B., Dida, N., Tafese, F., & Ololo, S. (2016). Institutional delivery and postnatal care services utilizations in Abuna Gindeberet District, West Shewa, Oromiya Region, Central Ethiopia: A Community-based cross sectional study. *BMC Pregnancy Childbirth*, 16:149.

https://doi.org/10.1186/s12884-016-0940-x

Department of Population, Ministry of Labour, Immigration and Population. (2016). The 2014 Myanmar Population and Housing Census: Thematic Report on Maternal Mortality. Vol. 4-C.

Duong, D.V., Binns, C.W., & Lee, A.H. (2004). Utilization of delivery services at the primary health care level in rural Vietnam. *Social Science and Medicine*, 59(12):2585-2595.

https://doi.org/10.1016/j.socscimed.2004.04.007

Gabrysch, S., & Campbell, O.M.R. (2009). Still too far to walk: Literature review of the determinants of delivery service use. *BMC Pregnancy and Childbirth*, 9:34.

https://doi.org/10.1186/1471-2393-9-34

Gudu, W., & Addo, B. (2017). Factors associated with utilization of skilled service delivery among women in rural Northern Ghana: A cross sectional study. *BMC Pregnancy Childbirth,* 17(1):159.

https://doi.org/10.1186/s12884-017-1344-2

Hagos, S., Shaweno, D., Assegid, M., Mekonnen, A., Afework, M.F., & Ahmed, S. (2014). Utilization of institutional delivery service at Wukro and Butajera districts in the Northern and South Central Ethiopia. *BMC Pregnancy and Childbirth*, 14(1):178.

https://doi.org/10.1186/1471-2393-14-178

Hsieh, F.Y., Bloch, D.A., & Larsen, M.D. (1998). A simple method of sample size calculation for linear and logistic regression. *Statistics in Medicine*, 17:1623-1634.

https://doi.org/10.1002/(sici)1097-0258(19980730)17:14<1623:aid-sim871>3.0.co;2-s

Kamal, S.M., Hassan, C.H., & Alam, G.M. (2015). Determinants of institutional delivery among women in Bangladesh. *Asia-Pacific Journal of Public Health*, 27(2):NP1372-NP1388.

https://doi.org/10.1177/1010539513486178

Karkee, R., Lee, A.H., & Binns, C.W. (2013). Birth preparedness and skilled attendance at birth in Nepal: Implications for achieving millennium development goal 5. *Midwifery*, 29:1206-1210.

https://doi.org/10.1016/j.midw.2013.05.002

Khanal, V., Lee, A.H., da Cruz, J.L., & Karkee, R. (2014). Factors associated with non-utilisation of health service for childbirth in Timor-Leste: Evidence from the 2009-2010 Demographic and Health Survey. *BMC International Health and Human Rights*, 14:14.

https://doi.org/10.1186/1472-698X-14-14

Lwin, K.Z., & Punpuing, S. (2022). Determinants of institutional maternity services utilization in Myanmar. *PLoS One*, 17(4):e0266185.

https://doi.org/10.1371/journal.pone.0266185

MOH. (2013). Maternal Death Review . Vol. 3. Nay Pyi Taw, Myanmar: Ministry of Health.

MOHS. (2018). National Maternal Death Surviellance and Response: 2017 Report. Nay Pyi Taw, Myanmar: Maternal and Reproductive Health Division, Department of Public Health, Ministry of Health and Sports.

MOHS., & ICF International. (2016). Myanmar Demographic and Health Survey 2015-16: Key Indicators Report. Nay Pyi Taw, Myanmar, and Rockville, Maryland, USA: Ministry of Health and Sports and ICF International.

Oo, K., Win, L., Saw, S., Mon, M., Oo, Y., & Maung, T. (2012). Challenges faced by skilled birth attendants in providing antenatal and intrapartum care in selected rural areas of Myanmar. *WHO South-East Asia J Public Health*, 1:467-476.

Requejo, J., Victora, C., & Bryce, J. (2015). A Decade of Tracking Progress for Maternal, Newborn and Child Survival: The 2015 Report, Geneva.

Rosado, C., Callaghan-Koru, J.A., Estifanos, A., Sheferaw, E., Shay, T., de Graft-Johnson, J., *et al*. (2019). Effect of birth preparedness on institutional delivery in Semiurban Ethiopia: A cross-sectional study. *Annals of Global Health*, 85(1):44.

https://doi.org/10.5334/aogh.920

Sein, K.K. (2012). Maternal health care utilization among ever married youths in Kyimyindaing Township, Myanmar. *Maternal and Child Health Journal*, 16(5):1021-1030.

https://doi.org/10.1007/s10995-011-0815-8

Tey, N.P., & Lai, S.L. (2013). Correlates of and barriers to the utilization of health services for delivery in South Asia and Sub-Saharan Africa. *ScientificWorldJournal*, 2013:423403.

https://doi.org/10.1155/2013/423403

The Partnership for Maternal, Newborn, & Child Health. (2006). Opportunities for Africa's Newborns: Practical Data, Policy and Programmatic Support for Newborn Care in Africa. Geneva: WHO on Behalf of the Partnership for Maternal Newborn and Child Health.

UNICEF. (2018). UNICEF Data: Monitoring the Situation of Children and Women: Maternal Health: Delivery Care [Web log post]. Available from: https://data.unicef.org/topic/maternal-health/maternal-mortality [Last accessed on 2018 Aug 06].

WHO, ICM, & FIGO. (2004). Making Pregnancy Safer: The Critical Role of the Skilled Attendant. Geneva: World Health Organization.

WHO. (2005). The World Health Report 2005: Make Every Mother and Child Count. Geneva: World Health Organization.

WHO. (2015). Health in 2015 from MDG to SDG. Geneva: World Health Organization.

Zenbaba, D., Sahiledengle, B., Dibaba, D., & Bonsa, M. (2021). Utilization of health facility-based delivery service among mothers in Gindhir District, Southeast Ethiopia: A community-based cross-sectional study. *Inquiry*, 58:00469580211056061.

https://doi.org/10.1177/00469580211056061

ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

Income inequalities in maternal health-care service utilization in India: Applying the Blinder–Oaxaca decomposition method

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Abstract

Maternal health-care service (MHCS) utilization is a crucial indicator of a country's progress in protecting the health and well-being of its women and children. This paper examines trends, patterns, determinants, and disparities in MHCS utilization between the poorest and richest women in India's Empowered Action Group. The study used data from the second (1998 – 1999), third (2005 – 2006), fourth (2015 – 2016), and fifth (2019 – 2021) rounds of the National Family Health Survey. A logistic regression model was applied to assess MHCS utilization, and the Blinder–Oaxaca decomposition method (BODM) was used to explain inequalities in utilization between the poorest and richest women. The findings indicate that MHCS utilization has increased over the years among both groups. However, the utilization rate is higher among the poorest women. Furthermore, rural women are less likely to utilize MHCS compared to urban women. Key determinants include women's education, their partners' education, mass media exposure (MME), and women's empowerment. The BODM results show that although MHCS utilization has increased among both groups, inequalities persist, largely explained by coefficient effects. A trend analysis reveals a reduction in discrimination between the poorest and richest women over time. Women's education, MME, and autonomy are the key factors driving the reduction of inequalities. There is a need for comprehensive strategies to enhance education among disadvantaged women, increase MME, and promote health awareness. The government should empower women through incentives, such as cash benefits, to ensure higher MHCS utilization among poorer women.

Keywords: Antenatal care; Skilled birth attendance; Postnatal care; Blinder–Oaxaca decomposition method; Empower action group states

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1. Introduction

Maternal mortality, a persistent issue globally, particularly in poor countries, refers to deaths from complications during pregnancy or childbirth. According to the United Nations inter-agency projections, the global maternal mortality ratio (MMR)

declined by 34% between 2000 and 2020 (Khalil *et al.*, 2023). However, a divide exists between rich and poor countries regarding maternal mortalities due to differences in economic conditions, geographical locations, and educational levels (Yadav & Jena, 2021). The Sustainable Development Goals (SDG) emphasize the goal of expediting the decline of MMR by 2030 (Ogu *et al.*, 2016). The ambitious goal of SDG 3.1 is to reduce the global MMR to fewer than 70/100,000 births by 2030, with no country having a maternal death rate higher than twice the world average (Bhowmik *et al.*, 2020; the World Health Organization [WHO], 2023). To meet this target, an annual rate of decline of up to 11.6% is required, a rate that has rarely been achieved at the national level (WHO, 2023). This also underscores the connections between maternal health and development. An increase in MMR leads to an unfavorable environment for child development, ultimately hindering national development (Bhatta & Aryal, 2015). To meet these goals, it is essential to understand the degree of inequality affecting maternal outcomes, and this study is an effort in that direction. Empowered Action Group (EAG) states in India have the highest rates of MMR and the greatest health disparities compared to non-EAG states (Kumar & Paswan, 2021). EAG states, which comprise 48% of India's population, are more vulnerable due to severe health inequalities (Yadav & Jena, 2020). With only 6 years remaining to achieve the SDGs, coordinated efforts must be intensified and commitments renewed to eliminate preventable maternal mortality at the global, regional, national, and local levels. Tracking maternal mortality in developing countries remains challenging due to a lack of reliable health data and inadequate vital registration systems.

The WHO estimates that approximately 287,000 women died in 2020 due to complications during pregnancy and childbirth (WHO, 2023). It is further estimated that over 95% of all maternal deaths in 2020 occurred in low- and lower-middle-income countries. Most of these deaths could have been prevented with optimal use of prenatal care, skilled birth attendance (SBA), and postnatal care (PNC) (Kumar, 2010). In 2020, approximately 87% (253,000) of global maternal deaths occurred in sub-Saharan Africa and Southern Asia (Do *et al.*, 2018). Sub-Saharan Africa alone accounted for around 70% (202,000) of these deaths, and Southern Asia accounted for approximately 16% (47,000) (Alam *et al.*, 2015). In 2005, India's MMR was 16 times higher than Russia's, 10 times higher than China's, and 4 times higher than Brazil's (Lozano *et al.*, 2011). In 2017, Pakistan's MMR was 186/100,000 live births (WHO, 2023) and Afghanistan's was the highest at 638/100,000 live births (UNICEF, 2024). India's MMR dropped from 556 per 100,000 live births in 1990 to 145 in 2017 (WHO, UNICEF, WORLD BANK GROUP, 2020).

Countries such as Finland, Greece, and Poland have the lowest MMR, MMR for these countries were reported 8, 8, and 2/1,00,000 live births, respectively, in 2020 (WHO, 2021), whereas India's MMR was reported as 97/100,000 live births as per sample registration system (SRS, 2020) < 60% of pregnant women globally receive at least four antenatal services (ANC4+). Even fewer women access ANC4+ services in regions with the highest maternal mortality rates, such as 53% in Western and Central Africa and 49% in South Asia (Chauhan *et al.*, 2021). Several factors contribute to this, including direct obstetric causes such as hemorrhage, infection, embolism, hypertensive disorders, uterine ruptures, hepatitis, and anemia, which are responsible for approximately 50 – 98% of maternal deaths (Totade *et al.*, 2023). About 50% of deaths due to sepsis are linked to illegal abortions, and these factors are common among women globally (Totade *et al.*, 2023). There are also indirect causes, such as under-reporting and misclassification of maternal deaths due to HIV/AIDS (Say *et al.*, 2014). Literacy levels, awareness, and regional backwardness also influence maternal health-care service (MHCS) utilization, thereby impacting MMR (Yadav *et al.*, 2021). As mothers' education levels increase, so does PNC utilization (Yadav *et al.*, 2021). One of the major challenges facing public health systems is the disparity in maternal health among medical professionals (Yadav & Jena, 2022). The correlation between maternal death, child health, and maternal health inequality raises significant concerns (Yadav & Jena, 2020). Economic growth and inequality are often negatively impacted when urbanization outpaces infrastructural development (Liddle & Messinis, 2015). Rapid urbanization is likely linked to suboptimal access to basic health-care services (Blumenberg *et al.*, 2023). According to the Central Bureau of Health Intelligence, India's overall literacy rate was 73% in 2011, with urban areas reporting a 16% higher rate (84%) than rural areas (68%).

In the past few decades, several scientific studies and intervention programs have identified that prior planning, SBA for all deliveries, and access to emergency care for women with life-threatening complications are the three essential components to reducing maternal mortality and improving neonatal health (Donnay, 2000). Pre-independence India's earliest initiatives to improve maternal health focused primarily on developing safe midwifery practices and providing support during childbirth. The founding of a "Dai's" (midwifery) school in Amritsar in 1880 (Kumar, 2010) indicates that with an emphasis on slowing population growth, India became the first country

in the world to officially introduce the Family Planning Program (FPP) in 1951. After incorporating maternal and child health and recognizing the correlation between increased newborn and child survival and declining birth rates, the FPP was eventually renamed the Family Welfare Program in 1977. In 1992, India restructured the Maternal and Child Health program, in line with the 1987 Kenyan International Safe Motherhood Conference – a global effort to reduce MMR, to become the Child Survival and Safe Motherhood (CSSM) program. Later, in 1997, the CSSM program was merged into the Reproductive and Child Health program to address the needs of family planning services, particularly for the impoverished and disadvantaged, and improve maternal and child health. Similar in scope is the central Indian government's recently established National Rural Health Mission (NRHM, 2005), a flagship initiative aimed at improving access to quality healthcare for rural residents across the nation, with a focus on 18 states with inadequate public health infrastructure (Pathak *et al.*, 2010).

Economic status (Bhanderi & Srinivasan, 2015), caste (Bhanderi & Srinivasan, 2015; Yadav & Jena, 2020), maternal education (Kumar & Paswan, 2021; Yadav *et al.*, 2021), partner's education (Kumar & Paswan, 2021; Yadav *et al.*, 2021), religion (Chauhan *et al.*, 2021; Jeffery & Jeffery, 2010), place of residence (Kumar & Paswan, 2021; Yadav *et al.*, 2021), women's age (Yadav *et al.*, 2022), mass media exposure (MME) (Yadav *et al.*, 2022), and women's autonomy (Yadav *et al.*, 2022) are key factors associated with MHCS utilization.

This paper aims (i) to study the trends and patterns of MHCS utilization between the poorest and richest women in the EAG states of India over three decades, (ii) to examine the determinants of MHCS utilization among women in EAG states, and (iii) to explore the disparities in MHCS utilization between the poorest and richest women in the EAG states and identify factors responsible for these disparities.

2. Data and methods

2.1. Data

The data used in this study were taken from the National Family Health Survey (NFHS), conducted in four rounds during 1998 – 1999, 2005 – 2006, 2015 – 2016, and 2019 – 2021. These surveys cover approximately 99% of the Indian population and are nationally representative. This survey is equivalent to the demographic health survey and provides reliable and consistent estimates of many health-related variables at both the national and state levels, including family planning, mortality, fertility, and use of maternal and child health-care services. In most rural areas, the survey employed a two-stage sample design, whereas in most urban areas, a three-stage sample design was used. In rural regions, the first stage of village selection was conducted using the probability proportional to size sampling scheme. In the second stage, the required number of households was selected through systematic sampling. In urban areas, blocks were chosen in the first stage, followed by census enumeration blocks in the second stage, with approximately 150 – 200 families selected, and the required number of households was then chosen in the third stage using systematic sampling. This study applied sample weights [iw = wt] for the data analysis, and all analyses were performed using STATA Version 17.

2.2. Methods

The maternal health outcome variables in this study are antenatal care (ANC), PNC, and SBA. A binary logistic regression model was used to examine the demographic and socioeconomic determinants of MHCS utilization in India. To analyze income inequalities in maternal health outcomes, this study employs the decomposition method developed by Blinder (1973) and Oaxaca (1973), and generalized by Neumark (1988), in the subsequent literature on health outcomes (Oaxaca & Ransom, 1988).

2.3. Outcome variables

Three outcome variables were included to evaluate the sociodemographic and economic factors influencing mothers' use of healthcare: ANC coverage (at least four visits [ANC4+]), SBA, and PNC.

2.4. Explanatory variables

The explanatory variables used in this study include age, weight, place of residence, education level of the women, partners' education level, religion, caste, MME, wealth index, women's autonomy, and states.

3. Results

3.1. Utilization of MHCS between poorest and richest women in India

Findings from Table 1 suggest that about 10.8% of the poorest women in 1998 in the EAG states had access to ANC visits (ANC4+), compared to 67.26% of the richest women. From 1998 to 2021, this increased by an average of 31% with ANC4+ for the poorest rising to 41.8%, whereas access for the richest women increased by 4.56% to 71.82%. SBA also varied significantly. For the poorest women, SBA increased from 13.74% in 1998 to 77.6% in 2021, reflecting a rise of 63.86%. For the richest women, SBA access increased by 25.13% over the same period. PNC for the poorest women was unavailable in 1998. However, by 2021, 82.13% of the poorest women had access to PNC,

whereas for the richest, access increased from 61.65% in 1998 to 75.47% in 2021.

3.2. MHCS utilization between poorest and richest women in India by sector

Regional imbalances play a crucial role in MHCS utilization. The rural population faces more hurdles in accessing MHCSs than the urban population. Findings from Table 2 suggest that ANC4+ coverage in rural areas increased by 31.29% from 1998 to 2021 (from 10.31% in 1998 to 41.6% in 2021), whereas the increase in urban areas was 26.05% (from 19.72% in 1998 to 45.77% in 2021), indicating a relatively larger improvement in rural areas. There has been an improvement in ANC4+ for the richest women in both rural and urban areas, with a bi-directional trend. In rural areas, for the richest women, ANC4+ improved by 12.46% (from 54.71% in 1998 to 67.17% in 2021), whereas in urban areas, ANC4+ declined by 2.52% during the same period. For SBA, the findings suggest that the richest women, in both rural and urban areas, have shown a greater percentage improvement and are in a favorable state as of 2021. For the poorest women, SBA increased by 64.95% in rural areas (from 12.58% in 1998 to 77.5% in 2021) and 44.83% in urban areas (from 34.76% in 1998 to 79.59% in 2021). PNC has most significantly improved for the poorest women in both rural and urban areas.

Table 1. MHCS utilization between the poorest and richest women in India

Year	ANC4+		SBA		PNC	
	Poorest	Richest	Poorest	Richest	Poorest	Richest
1998	10.8	67.26	13.74	71.7	0.00	61.65
2005	12.15	77.36	13.2	85.57	32.66	45.85
2015	32.66	45.85	61.48	96.25	53.27	83.07
2021	41.8	71.82	77.6	96.83	82.13	75.47

Source: Authors' estimation based on NFHS data from different rounds.
Abbreviations: ANC4+: Antenatal care; PNC: Postnatal care; SBA: Skilled birth assistance; MHCS: Maternal health-care service.

Table 2. MHCS between poorest and richest women in India by sector

Year	ANC4+		SBA		PNC	
	Poorest	Richest	Poorest	Richest	Poorest	Richest
Rural						
1998	10.31	54.71	12.58	56.77	0.00	42.64
2005	11.62	69.68	12.58	78.5	32.26	46.5
2015	24.44	68.4	61.37	95.57	53.15	84.74
2021	41.6	67.17	77.5	96.69	82.24	78.6
Urban						
1998	19.72	76.52	34.76	82.7	0.00	73.2
2005	23.25	80.39	25.9	88.37	38.66	45.62
2015	35.79	74.97	63.59	96.53	55.54	82.39
2021	45.77	74	79.59	96.89	79.35	73.83

Source: Authors' estimation based on NFHS data from different rounds.
Abbreviations: ANC4+: Antenatal care; PNC: Postnatal care; SBA: Skilled birth assistance; MHCS: Maternal health-care service.

3.3. MHCS utilization between poorest and richest women in the EAG states of India

Table 3 indicates that the utilization of ANC4+ among women in India increased by an average of 31% from 1998 to 2021, largely due to significant improvements among the poorest mothers. ANC4+ utilization was highest in Bihar for both the poorest (66.67%) and richest (87.77%) mothers. Conversely, it was lowest in Madhya Pradesh, with 24.44% for the poorest and 61.95% for the richest women in 2021, showing significant fluctuations before 2021. SBA utilization varied: for the poorest women and was highest in Uttar Pradesh in 2021 at 84.75% and lowest in Bihar at 33.33%. For the richest women, Bihar achieved 100 percent SBA utilization, with almost all the EAG states performing well. PNC utilization was highest in Bihar for the poorest mothers at 100%. In Odisha, PNC utilization peaked in 2015 but declined to 73.11%. For the richest mothers, the highest PNC utilization was in Rajasthan at 77.09%, whereas the lowest was 66.89% in Uttar Pradesh.

3.4. Determinants of MHCS utilization among the EAG states of India

The results of the determinants of MHCS utilization are presented in Table 4, which shows that ANC4+ and SBA were statistically significant in 2005 – 2006. However, there were no significant differences in the utilization of ANC4+, SBA, and PNC in 2015 – 2016 and 2019 – 2021. Women over 25 years of age were less likely to use MHCS than women aged 15 – 24 years. Women's education has a strong impact on MHCS utilization in EAG states. Women with primary, secondary, and higher levels of education were more likely to utilize MHCSs than women with no education. Women belonging to the Muslim and other communities were less likely to use MHCS than their Hindu counterparts. Poorer, middle, richer, and richest women were less likely to use MHCSs than the poorest women. High degrees of MME and autonomy among women were positively associated with higher utilization of MHCSs. There are mixed results regarding regional differences in MHCS utilization. Regional differences also play a crucial role in MHCS utilization. Results show that women from Uttarakhand, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Odisha, and Madhya Pradesh were less likely to visit health centers for ANC compared to women from Chhattisgarh in all periods.

Table 3. MHCS utilization between poorest and richest women in the EAG states of India

Year	ANC4+		SBA		PNC	
	Poorest	Richest	Poorest	Richest	Poorest	Richest
India						
1998	10.80	67.26	13.74	71.70	0.00	61.65
2005	12.15	77.36	13.20	85.57	32.66	45.85
2015	24.99	73.04	61.48	96.25	53.27	83.07
2021	41.80	71.82	77.60	96.83	82.13	75.47
Rajasthan						
1998	3.57	43.00	8.22	52.32	0.00	54.05
2005	5.92	77.96	6.13	91.69	34.51	31.22
2015	55.70	78.41	69.06	99.10	72.57	87.03
2021	30.45	62.29	66.06	96.10	84.37	77.09
Uttar Pradesh						
1998	0.98	39.78	6.42	52.26	0.00	60.39
2005	16.98	83.01	21.00	86.68	51.25	47.51
2015	0.52	56.96	10.36	76.13	9.75	58.06
2021	65.51	84.64	84.75	97.88	76.75	66.89
Bihar						
1998	2.27	52.92	7.14	56.71	0.00	38.98
2005	0.00	0.00	0.00	0.00	0.00	0.00
2015	32.26	75.34	52.22	98.73	52.44	87.34
2021	66.67	87.77	33.33	100.00	100.00	64.86
Madhya Pradesh						
1998	5.13	46.13	7.61	55.90	0.00	43.27
2005	6.69	59.10	7.44	77.81	50.88	48.42
2015	12.65	55.27	38.90	92.88	41.82	80.87
2021	24.44	54.33	61.95	99.38	76.53	76.26
Odisha						
1998	15.13	69.58	11.50	64.88	0.00	43.82
2005	4.22	74.19	4.60	85.95	10.82	45.91
2015	100.00	81.78	100.00	99.00	100.00	94.88
2021	42.52	73.47	76.13	94.97	73.11	67.99

Source: Authors' estimation based on NFHS data from different rounds.
Abbreviations: ANC4+: Antenatal care; PNC: Postnatal care;
SBA: Skilled birth assistance; MHCS: Maternal health-care service;
EAG: Empowered action group.

3.5. Blinder–Oaxaca decomposition method (BODM) results

The study employed the threefold BODM to examine the discrimination in MHCS utilization between the poorest and richest women in the EAG states of India. The results show a significant difference in ANC4+, SBA, and PNC utilization between the two groups, with the maximum differences explained by endowment effects. The findings reveal that if the poorest women use ANC4+ services according to their features (D = 0), they would still face discrimination (26.4% during 2019 – 2021). However, if the characteristics of the richest women prevailed (i.e., D = 1), the poorest women would experience even greater discrimination (37.4%). If the average characteristics prevailed (D = 0.5), the poorest would experience slightly less inequality (31.9%). Moreover, pooled data reveal that the poorest women could reduce inequalities to 27.3%. Similar results are observed regarding SBA and PNC.

4. Discussion

This paper examined trends, patterns, determinants, inequalities, and regional differences in MHCS utilization in the EAG states. Findings reveal that MHCS utilization has been increasing over the years among both poor and rich women. Women living in rural areas were less likely to use MHCS compared to their urban counterparts. Rural–urban differences have also been observed in other studies (Singh *et al.*, 2012; Yadav & Jena, 2021). The lower utilization of MHCSs in rural areas may be due to asymmetric information, lack of infrastructure, inadequate medicine and health personnel, and transport facilities. Women's education significantly influences MHCS utilization as higher levels of education among women were associated with a greater likelihood of accessing MHCSs than uneducated women. These findings align with other studies conducted in developing countries (Kumar, 2012; Singh *et al.*, 2012; Yadav *et al.*, 2022). Educated women are more capable of making informed decisions regarding their health-care needs compared to uneducated women.

Muslims and women belonging to other religions were less likely to use MHCSs than Hindu women, which is consistent with the previous studies (Paul & Chouhan, 2020; Singh *et al.*, 2012; Yadav *et al.*, 2022). Further, Scheduled Caste women were less likely to use MHCSs compared to Scheduled Tribe women. Income, MME, and women's autonomy also play significant roles in MHCS utilization. Income has a strong and positive impact on MHCS, with women with higher income quintiles being more likely to use MHCSs than the poorest women, which is consistent with other studies (Chouhan, 2020; Singh *et al.*, 2012; Yadav & Jena, 2020). Wealthier women can afford health-care services more easily as the richest household can spend a higher proportion of their income on health-care needs than the poorest women.

High MME positively influences MHCS utilization (Fatema & Lariscy, 2020), as does women's autonomy. These findings are similar to those of studies conducted in developing countries in Southeast Asia (Sohn & Jung, 2019). Regional differences also impact MHCS utilization

Table 4. Determinants of MHCS utilization among the EAG states of India

Variables	ANC			SBA			PNC		
	2005 – 2006	2015 – 2016	2019 – 2021	2005 – 2006	2015 – 2016	2019 – 2021	2005 – 2006	2015 – 2016	2019 – 2021
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Sector: Ref-Urban									
Rural	0.69***	1 .00	0.86	0.54***	1.01	0.78	0.93	1.16	0.56**
Age group: Ref-15 – 24 years									
25 – 34 years	0.94	0.9	1.05	0.85**	0.85*	0.76	0.98	0.97	1.07
35 – 49 years	0.84*	0.85	1.21	0.99	0.75**	0.71	0.94	0.88	1.01
Women's education: Ref-Illiterate									
Primary	1.53***	1.31***	1.24	1.44***	1.29**	1.28	0.91	1.14	0.66
Secondary	2.12***	1.6***	1.47**	2.2***	1.73***	2.45***	1.18	1.24**	0.8
Higher	4.15***	2.03***	1.44**	6.02***	3.34***	2.09***	1.29	1.97***	0.93
Partner's education: Ref-Illiterate									
Primary	1.19**	1.12	1.14	1.34***	1.13	1.18	1.02	1.15	1.34
Secondary	1.22**	1.18*	1.24	1.18**	1.41***	1.49**	0.98	1.23**	1.08
Higher	1.17	1.47**	1.5**	1.41**	1.22	3.05***	1.07	1.07	1.05
Religion: Ref-Hindu									
Muslim	0.72***	1.08	0.82	0.66***	0.57***	0.64*	0.97	0.88	1.23
Others	0.5***	0.5***	0.5***	0.64***	0.57***	0.26***	0.97	0.72***	1.66**
Caste: Ref-ST									
SC	0.59***	0.9	1.03	0.44***	0.45***	0.64*	0.78*	0.78**	0.8
OBC	1.27***	0.95	1.12	1.16*	0.9	1.01	1.04	0.96	1.25
Others	0.9	1.06	1.11	1.01	0.81	0.79	1.79**	1.13	1.12
Wealth index: Ref-Poorest									
Poorer	1.49***	1.63***	1.51***	1.49***	1.65***	2.15***	1.13	1.37***	0.92***
Middle	2.35***	2.49***	2.15***	2.38***	2.36***	3.94***	1.3*	1.82***	0.83***
Richer	3.32***	3.07***	2.76***	3.53***	4.55***	6.42***	1.57***	2.37***	0.8***
Richest	6.67***	3.45***	3.38***	9.36***	11***	10.28***	1.61***	3.68***	0.7***
MME: Low degree									
High degree	1.58***	1.24*	1.37***	1.44***	1.22	1.68***	0.86	1.4**	0.77
Women's autonomy: Ref-Low degree autonomy									
High degree	1.17**	1.21***	0.93	1.08	0.98	0.89	1.03	1.1	1.28*
State: Ref-Chhattisgarh									
Uttarakhand	0.48***	0.15***	0.45*	0.26***	0.24***	0.08***	0.81	0.34***	1.22
Rajasthan	0.29***	0.42***	0.44***	0.49***	1.91***	0.67	0.74	0.81	1.5
Uttar Pradesh	0.11***	0.19***	0.28***	0.19***	0.56***	0.4***	0.48***	0.73***	0.64***
Bihar	0.12***	0.1***	0.17***	0.29***	0.68**	0.29***	0.35**	0.53***	1.46
Jharkhand	0.27***	0.29***	0.31***	0.26***	0.75**	0.49**	0.72	0.72**	1.54
Odisha	0.95	2.2***	1.42	0.71	2.62***	1.33	0.99	3.05***	1.39
Madhya Pradesh	0.39***	0.37***	0.67*	0.48***	1.3**	0.89	0.75**	0.61***	1.33
Constant	0.38***	0.62***	1.31	0.44***	1.82***	9.05***	0.62***	1.27	2.69**

Note: *,** and *** Indicate 1%, 5%, and 10% levels of significance, respectively.
Source: Authors' estimation based on NFHS data from various rounds.
Abbreviations: ANC4+: Antenatal care; Coef: Coefficient of explanatory variables; PNC: Postnatal care; SBA: Skilled birth assistance; SC: Scheduled Caste; ST: Scheduled Tribe; OBC: Other backward class; MHCS: Maternal health-care service; EAG: Empowered action group.

Table 5. BODM results

Summary of decomposition results	ANC4+				SBA				PNC			
	1998 – 1999	2005 – 2006	2015 – 2016	2019 – 2021	1998 – 1999	2005 – 2006	2015 – 2016	2019 – 2021	1998 – 1999	2005 – 2006	2015 – 2016	2019 – 2021
High group (mean)	0.667	0.509	0.776	0.718	0.669	0.519	0.97	0.971	0.636	0.5	0.897	0.786
Low group (mean)	0.082	0.481	0.691	0.672	0.073	0.467	0.903	0.951	0.000	0.2	0.811	0.78
Raw differential	0.585	0.028	0.085	0.046	0.596	0.052	0.067	0.02	0.636	0.3	0.086	0.006
Endowment effects	0.175	−0.168	0.067	0.034	0.291	0.022	0.047	0.012	0.000	−0.175	0.045	0.024
Coefficient effects	0.27	0.095	0.004	0.017	0.098	0.197	0.038	0.008	0.302	0.323	0.045	0.005
Interaction effects	0.139	0.100	0.014	−0.005	0.207	−0.167	−0.018	0	0.335	0.152	−0.004	−0.023
Oaxaca (1973) and Blinder (1973) D = 0												
Unexplained difference	0.409	0.195	0.018	0.012	0.31	0.03	0.02	0.008	0.636	0.475	0.041	−0.018
Explained difference	0.175	−0.168	0.067	0.034	0.29	0.022	0.047	0.012	0.000	−0.175	0.045	0.024
% Unexplained	70.00	707.600	20.8	26.4	51.2	57.9	29.8	40.1	100	158.3	48	−297.1
% Explained	30.00	−607.6	79.2	73.6	48.8	42.1	70.2	59.9	0	−58.3	52	397.1
Oaxaca (1973) and Blinder (1973) D = 1												
Unexplained difference	0.270	0.095	0.004	0.017	0.10	0.197	0.038	0.008	0.302	0.323	0.045	0.005
Explained difference	0.315	−0.067	0.081	0.029	0.50	−0.145	0.029	0.012	0.335	−0.023	0.041	0.001
% Unexplained	46.10	344	4.8	37.4	16.5	380	56.6	42	47.4	107.6	52.4	76.6
% Explained	53.90	−244	95.2	62.6	83.5	−280	43.4	58	52.6	−7.6	47.6	23.4
Reimers (1983) D = 0.5												
Unexplained difference	0.340	0.145	0.011	0.015	0.202	0.114	0.029	0.008	0.469	0.399	0.043	−0.007
Explained difference	0.245	−0.118	0.074	0.031	0.395	−0.062	0.038	0.012	0.167	−0.099	0.043	0.013
% Unexplained	58.10	525.8	12.8	31.9	33.8	219	43.2	41.1	73.7	133	50.2	−110.2
% Explained	41.90	−425.8	87.2	68.1	66.2	−119	56.8	58.9	26.3	−33	49.8	210.2
Cotton (1988) D = Sample proportions												
Unexplained difference	0.391	0.109	0.011	0.014	0.278	0.054	0.028	0.008	0.546	0.347	0.043	−0.006
Explained difference	0.194	−0.081	0.073	0.032	0.318	−0.002	0.039	0.012	0.09	−0.047	0.043	0.012
% Unexplained	66.90	395.1	13.3	31.4	46.7	103.2	42.3	41	85.8	115.8	50	−100.4
% Explained	33.10	−295.1	86.7	68.6	53.3	−3.2	57.7	59	14.2	−15.8	50	200.4
Neumark (1988) D = Pooled												
Unexplained difference	0.103	0.097	0.011	0.013	0.064	0.048	0.021	0.007	0.119	0.326	0.034	−0.006
Explained difference	0.482	−0.07	0.074	0.033	0.532	0.004	0.046	0.013	0.517	−0.026	0.052	0.012
% Unexplained	17.60	352.5	12.5	27.3	10.8	91.7	30.8	37	18.8	108.7	39.7	−99
% Explained	82.40	−252.5	87.5	72.7	89.2	8.3	69.2	63	81.2	−8.7	60.3	199

Abbreviations: ANC4+: Antenatal care; BODM: Blinder–Oaxaca decomposition method; PNC: Postnatal care; SBA: Skilled birth assistance.

(Bango & Ghosh, 2022). Women living in Uttarakhand, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, and Madhya Pradesh were less likely to use MHCSs (Yadav *et al.*, 2022). Differences in MHCS utilization across the EAG states may be due to state-specific variations in education levels, women's autonomy, economic status, and health infrastructure.

This study employed the threefold BODM to examine the inequalities between the poorest and richest women. It quantifies and identifies the factors contributing to these inequalities, supporting targeted interventions. This method considers structural gaps and allows a comparative analysis between the two groups. Understanding the explained and unexplained components aids policy evaluation and design, enhancing evidence-based decision-making and leading to more effective and inclusive maternal health interventions. Furthermore, the results of the BODM indicate that inequalities between the poor and rich have been narrowing over the years (Table 5). The findings suggest that women's education, their partners'

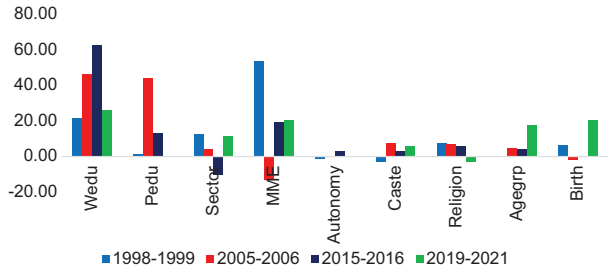


Figure 1. Percentage contribution of each predictor in ANC4+ visits (authors' estimation based on the BODM)
Abbreviations: Wedu: Women's education; Pedu: Partner's education, MME: Mass media exposure; BODM: Blinder–Oaxaca decomposition method.

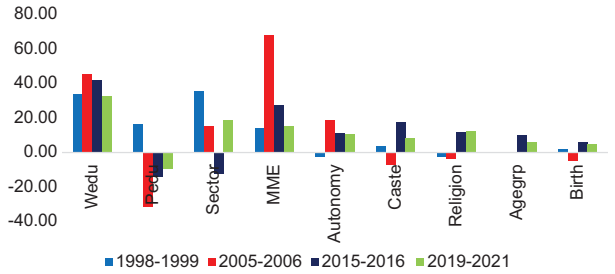


Figure 2. Percentage contribution of each predictor in SBA (authors estimation based on the BODM)
Abbreviations: Wedu: Women's education; Pedu: Partner's education, MME: Mass media exposure; BODM: Blinder–Oaxaca decomposition method.

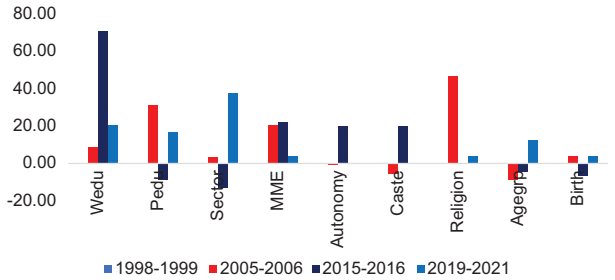


Figure 3. Percentage contribution of each predictor in PNC (authors' estimation based on the BODM)
Abbreviations: Wedu: Women's education; Pedu: Partner's education, MME: Mass media exposure; BODM: Blinder–Oaxaca decomposition method.

education, and MME are major contributing factors to the increasing inequality in MHCS utilization (Figure 1).

Moreover, partner education is reducing inequalities in the case of SBA (Figure 2). However, the education of women and their partners, as well as sectorial differences, are increasing inequalities between the poorest and richest women in the case of PNC (Figure 3). This finding is similar to a current study conducted in Nepal, which observed that women's education and MME are the highest contributors to MHCS utilization between the richest and poorest women (Bhusal, 2021). Overall, this study observes that the utilization of MHCS has been improving over the years. The findings also indicate that inequality in MHCS utilization between the poorest and richest women in India is decreasing.

5. Conclusions

Despite improvements in MMR since 1998, there are still challenges that need to be overcome. Bridging the gap between the poorest and richest mothers could be achieved by uplifting the poor. The government has introduced schemes to promote MHCS utilization. The National Health Mission aims to ensure universal access to affordable and quality health-care services. Initiatives such as the Labor Room and Quality Improvement Initiative and Surakshit Matritva Anushasan strive to provide expectant mothers with a positive childbirth experience and ensure the delivery of quality health-care services at no cost.

The Janani Suraksha Yojana (JSY) initiative, introduced by the Indian government in 2005, aims to encourage low-income mothers to give birth in public health facilities by offering a cash transfer on their release. The JSY program provides conditional cash transfers to incentivize women to give birth in medical facilities. However, the government's intense focus on institutional deliveries and SBA has led to a decreased emphasis on ANC. Schemes addressing maternal mortality will only be successful if they significantly address ANC services. The Pradhan Mantri Surakshit Matritva Abhiyan aims to increase the accessibility and standard of ANC, including counseling and diagnostic services. In addition, an initiative has been introduced to improve the quality of care in maternity operation theaters and labor rooms.

The success of programs such as Janani Shishu Suraksha Karyakram and JSY is evident. However, reducing MMR requires further enhancing female health, literacy, and prenatal care, as well as providing high-quality emergency obstetric care with trained delivery attendants.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Arvind Kumar Yadav, Bhavna Sahni
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Methodology: Arvind Kumar Yadav
Writing – original draft: Madhurima Ghosh
Writing – review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

The data source is publicly available at the following URL: https://www.dhsprogram.com

References

Alam, N., Hajizadeh, M., Dumont, A., & Fournier, P. (2015). Inequalities in maternal health care utilization in sub-Saharan African countries: A multiyear and multi-country analysis. *PLoS One*, 10(4):e0120922.

https://doi.org/10.1371/journal.pone.0120922

Bango, M., & Ghosh, S. (2022). Social and regional disparities in utilization of maternal and child healthcare services in India: A study of the post-national health mission period. *Frontiers in Pediatrics*, 10:895033.

https://doi.org/10.3389/fped.2022.895033

Bhanderi, M.N., & Srinivasan, K. (2015). Utilization of maternal health services and determinants of skilled care during delivery in slums of Gujarat, India. *Obstetrics and Gynecology International Journal*, 2015(1):1-9.

https://doi.org/10.5171/2015.293492

Bhatta, D.N., & Aryal, U.R. (2015). Paternal factors and inequity associated with access to maternal health care service utilization in Nepal: A community based cross-sectional study. *PLoS One*, 10(6):e0130380.

https://doi.org/10.1371/journal.pone.0130380

Bhowmik, J., Biswas, R.K., & Ananna, N. (2020). Women's education and coverage of skilled birth attendance: An assessment of sustainable development Goal 3.1 in the south and Southeast Asian Region. *PLoS One*, 15(4):e0231489.

https://doi.org/10.1371/journal.pone.0231489

Bhusal, U.P. (2021). Predictors of wealth-related inequality in institutional delivery: A decomposition analysis using Nepal multiple Indicator cluster survey (MICS) 2019. *BMC Public Health*, 21(1):2246.

https://doi.org/10.1186/s12889-021-12287-2

Blinder, A.S. (1973). Wage discrimination: Reduced form and structural estimates. *Journal of Human Resources,* 8:436-455.

https://doi.org/10.2307/144855

Blumenberg, C., Costa, J.C., Ricardo, L.I., Jacobs, C., Ferreira, L.Z., Vidaletti, L.P., *et al*. (2023). Coverage, trends, and inequalities of maternal, newborn, and child health indicators among the poor and non-poor in the most populous cities from 38 Sub-Saharan African countries. *Journal of Urban Health*, 1-14.

https://doi.org/10.1007/s11524-023-00806-y

Chauhan, B.G., Sivanandan, V., Singh, M.N., & Ojha, D.K. (2021). Inequalities and trends in maternal health care services utilization in India, 1992-2016: Strategies in the Search for Improvements. *Demography India*, 50:65-87.

Do, N., Tran, H.T.G., Phonvisay, A., & Oh, J. (2018). Trends of socioeconomic inequality in using maternal health care services in Lao People's democratic republic from year 2000 to 2012. *BMC Public Health*, 18:875.

https://doi.org/10.1186/s12889-018-5811-0

Donnay, F. (2000). Maternal survival in developing countries: What has been done, what can be achieved in the next decade. *International Journal of Gynecology and Obstetrics*, 70(1):89-97.

https://doi.org/10.1016/S0020-7292(00)00236-8

Fatema, K., & Lariscy, J.T. (2020). Mass media exposure and maternal healthcare utilization in South Asia. *SSM-Population Health*, 11:100614.

https://doi.org/10.1016/j.ssmph.2020.100614

Jeffery, P., & Jeffery, R. (2010). Only when the boat has started sinking: A maternal death in rural north India. *Social Science and Medicine*, 71(10):1711-1718.

https://doi.org/10.1016/j.socscimed.2010.05.002

Khalil, A., Samara, A., O'Brien, P., Coutinho, C.M., Quintana, S.M., & Ladhani, S.N. (2023). A call to action: The global failure to effectively tackle maternal mortality rates. *The Lancet Global Health*, 11(8):e1165-e1167.

https://doi.org/10.1016/S2214-109X(23)00247-4

Kumar, R., & Paswan, B. (2021). Changes in socio-economic inequality in nutritional status among children in EAG states, India. *Public Health Nutrition*, 24(6):1304-1317.

https://doi.org/10.1017/S1368980021000343

Kumar, S. (2010). Reducing maternal mortality in India: Policy, equity, and quality issues. *Indian Journal of Public Health*, 54(2):57-64.

https://doi.org/10.4103/0019-557X.73271

Liddle, B., & Messinis, G. (2015). Which comes first-urbanization or economic growth? Evidence from heterogeneous panel causality tests. *Applied Economics Letters*, 22(5):349-355.

https://doi.org/10.1080/13504851.2014.943877

Lozano, R., Wang, H., Foreman, K.J., Rajaratnam, J.K., Naghavi, M., Marcus, J.R., *et al*. (2011). Progress towards Millennium Development Goals 4 and 5 on maternal and

child mortality: An updated systematic analysis. *The Lancet*, 378(9797):1139-1165.

https://doi.org/10.1016/S0140-6736(11)61337-8

Mehta, B.S., Alambusha, R., Misra, A., Mehta, N., & Madan, A. (2023). Assessment of utilisation of government programmes and services by pregnant women in India. *PLoS One*, 18(10):e0285715.

https://doi.org/10.1371/journal.pone.0285715

Neumark, D. (1988). "Employers" discriminatory behavior and estimation of wage discrimination. *Journal of Human Resource*, 23(3):279-295.

https://doi.org/10.2307/145830

Oaxaca, R. (1973). Male-female wage differentials in urban labor markets. *International Economic Review*, 14:693-709.

https://doi.org/10.2307/2525981

Oaxaca, R.L., & Ransom, M.R. (1988). Searching for the effect of unionism on the wages of union. Journal of Labor Research, 9(2):139.

Ogu, R.N., Agholor, K.N., & Okonofua, F.E. (2016). Engendering the attainment of the SDG-3 in Africa: overcoming the socio-cultural factors contributing to maternal mortality. *African Journal of Reproductive Health*, 20(3):62-74.

https://doi.org/10.29063/ajrh2016/v20i3.11

Pathak, P.K., Singh, A., & Subramanian, S.V. (2010). Economic inequalities in maternal health care: Prenatal care and skilled birth attendance in India, 1992-2006. *PLoS One*, 5(10):e13593.

https://doi.org/10.1371/journal.pone.0013593

Paul, P., & Chouhan, P. (2020). Socio-demographic factors influencing utilization of maternal health care services in India. *Clinical Epidemiology and Global Health*, 8(3):666-670.

https://doi.org/10.1016/j.cegh.2019.12.023

Say, L., Chou, D., Gemmill, A., Tunçalp, Ö., Moller, A.B., Daniels, J., Gülmezoglu, A.M., *et al.* (2014). Global causes of maternal death: A WHO systematic analysis. *The Lancet Global Health*, 2(6):e323-e333.

https://doi.org/10.1016/S2214-109X(14)70227-X

Singh, L., Rai, R.K., & Singh, P.K. (2012). Assessing the utilization of maternal and child health care among married adolescent women: Evidence from India. *Journal of Biosocial Science*, 44(1):1-26.

https://doi.org/10.1017/S0021932011000472

Sohn, M., & Jung, M. (2020). Effects of empowerment and media use by women of childbearing age on maternal health care utilization in developing countries of Southeast Asia. *International Journal of Health Services*, 50(1):32-43.

https://doi.org/10.1177/0020731419867532

SRS. (2020). Special Bulletin on Maternal Mortality in India 2018-20. Available from: https://censusindia.gov.in/nada/index.php/catalog/44379 [Last accessed on 2024 Sep 26].

Totade, M., Gaidhane, A., & Sahu, P. (2023). Interventions in maternal anaemia to reduce maternal mortality rate across India. *Cureus*, 15(10):1-10.

https://doi.org/10.7759/cureus.46617

UNICEF. (2024). Available from: https://www.unicef.org/afghanistan/health [Last accessed on 2024 Sep 19].

WHO, UNICEF, & World Bank Group. (2020). Trends in Maternal Mortality 2000 to 2017. file:///C:/Users/DELL/Downloads/9789241516488-eng.pdf [Last accessed on 2024 Sep 19].

WHO. (2021). Available from: https://data.worldbank.org/indicator/SH.STA.MMRT?locations=PL [Last accessed on 2024 Sep 26].

WHO. (2023). Available from: https://data.who.int/indicators/i/C071DCB/AC597B1 [Last accessed on 2024 Sep 19].

Yadav, A.K., & Jena, P.K. (2020). Maternal health outcomes of socially marginalized groups in India. *International Journal of Health Care Quality Assurance*, 33(2):172-188.

https://doi.org/10.1108/IJHCQA-08-2018-0212

Yadav, A.K., & Jena, P.K. (2022). Explaining changing patterns and inequalities in maternal healthcare services utilization in India. *Journal of Public Affairs*, 22(3):e2570.

https://doi.org/10.1002/pa.2570

Yadav, A.K., Jena, P.K., Sahni, B., & Mukhopadhyay, D. (2021). Comparative study on maternal healthcare services utilisation in selected empowered action group states of India. *Health and Social Care in the Community*, 29(6):1948-1959.

https://doi.org/10.1111/hsc.13309

Yadav, A.K., Sahni, B., & Jena, P.K. (2021). Education, employment, economic status and empowerment: Implications for maternal health care services utilization in India. *Journal of Public Affairs*, 21(3):e2259.

https://doi.org/10.1002/pa.2259

Yadav, A.K., Sahni, B., Kumar, D., Bala, K., & Kalotra, A. (2021). Effect of women's and partners' education on maternal health-care services utilization in five empowered action group States of India: An analysis of 13,443 women of reproductive age. *International Journal of Applied and Basic Medical Research*, 11(4):231.

https://doi.org/10.4103/ijabmr.ijabmr_121_21

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

ORIGINAL RESEARCH ARTICLE

Human trafficking victims in Portugal: Perceptions of service providers

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Abstract

This study aims to explore the perceptions of service providers in Portugal, specifically regarding (i) how victims of human trafficking are aided; (ii) the victims' needs and their understanding of the "condition of special vulnerability"; and (iii) the opinions of service providers on the obstacles victims face in seeking and receiving assistance. According to our research, most organizations offered assistance, ranging from legal aid to food and lodging, to victims of all ages, genders, and forms of exploitation. Participants recognized that the needs of human trafficking victims differ from those of victims of other crimes, such as domestic abuse survivors, particularly in terms of the unique challenges they face in rebuilding trust. They also identified challenges in delivering assistance, including insufficient financial resources, inadequate interinstitutional cooperation, and the victims' lack of cooperation. Fear of traffickers along with feelings of humiliation, embarrassment, and fear of reprisal against themselves or their families were cited as major reasons why victims refuse assistance.

Keywords: Human trafficking; Victims; Service providers; Perceptions

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1. Introduction

The first international definition of human trafficking (HT) by the United Nations was presented in the 2000 Protocol to Prevent, Suppress, and Punish Trafficking in Persons, especially Women and Children, commonly referred to as the Palermo Protocol. Over the years, the European Commission has issued several directives requiring member states to enact laws to detect and combat HT. Among the most significant is Directive 2011/36/EU of the European Parliament and of the Council of 5 April 2011 (p.6), which focuses on preventing and combating HT and protecting victims' human rights by implementing protection and assistance mechanisms for crime prevention and repression. This legal instrument aims to harmonize the substantive criminal legislation and procedural standards of the Member States. The Palermo Protocol's acknowledgment of diverse forms of exploitation and evolving concepts of victims has led to recent normative developments across various spheres in Europe, including the social, political, legislative, and legal domains.

Human trafficking is defined in the Palermo Protocol as "the recruitment, transportation, transfer, harboring or receptions of persons, by means of the threat or use of force or other forms of coercion, of abduction, of fraud, of deception, of the abuse of power, or of a position of vulnerability or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purpose of exploitation. Exploitation shall include, at a minimum, the exploitation of the prostitution of others or other forms of sexual exploitation, forced labor or services, slavery or practices similar to slavery, servitude, or the removal of organs" for exploitation.

The crime of HT invariably involves the exploitation of a vulnerable individual. According to Article 2 of Directive 2011/36/EU, "a position of vulnerability means a situation, in which the person concerned has no real or acceptable alternative but to submit to the abuse involved." In the context of HT, "vulnerability" refers to the innate, contextual, or environmental factors that render an individual or group more susceptible to trafficking (Couto, 2012; UNODC, 2016). As noted by UNODC (2016), vulnerability to trafficking is not fixed, predetermined, or fully "known," but certain factors shape vulnerability and disproportionately affect marginalized groups, including women, children, migrants, and refugees, in varying ways and degrees. Multiple factors contribute to the conditions under which HT occurs and determine an individual's capacity to respond (Arhin, 2016; Weitzer, 2015). A situation-specific analysis is often required to fully understand the complexities of vulnerability in HT.

According to this interpretation, vulnerability is not physical but depends on who is harmed and at risk (Walklate, 2011). Vulnerability is best measured on a case-by-case basis, considering personal (e.g., physical and/or mental disabilities), situational (e.g., a person irregularly residing in a foreign country where they are socially or linguistically isolated), and circumstantial (e.g., unemployment or economic destitution) vulnerabilities of the alleged victim (UNODC, 2016). These vulnerabilities may be pre-existing or created by the trafficker (Ioannou & Oostinga, 2015; Zimmerman *et al.*, 2011). While a victim's vulnerability may be an indicator of HT, it alone does not constitute a method of human trafficking unless it has been exploited to the extent that the victim's consent is deemed invalid (UNODC, 2016).

The scope of trafficking in persons is difficult to access due to the nature and characteristics of the crime. According to the Global Report on Trafficking in Persons, no country is immune to this crime (UNODC, 2019). Victims are trafficked in various ways, both within and across borders, sometimes spanning continents, which complicates victim identification and detection within the EU. Human exploitation often goes unreported, overshadowed by other crimes such as prostitution, unauthorized immigration, property crimes, and labor disputes (UNODC, 2016).

Since 2003, UNODC has collected data on approximately 225,000 trafficking victims detected globally (UNODC, 2019). The detection of trafficking cases within a country's borders has also increased significantly over the past 15 years (UNODC, 2019). Between 2012 and 2014, 42% of detected victims were trafficked domestically (UNODC, 2016). Over the past decade, national authorities have enhanced their capacity to monitor and analyze HT patterns and flows in many regions (UNODC, 2019). These findings indicate a shift in the general perception of trafficking-related crimes. The increase in numbers may often reflect improved understanding within the criminal justice system and governments about the diversity of offenders, victims, forms of exploitation, and trafficking routes. This rise in the number of HT victims could signal both positive and negative developments in the fight against HT. On the one hand, it may point to a stronger victim identification effort by law enforcement; on the other hand, it could suggest a more serious and widespread trafficking problem (UNODC, 2019). Whether more victims are being identified because of legislative efforts, such as legal amendments, action plan implementation, victim protection, and national referral systems that have improved victim identification and the effectiveness of criminal justice responses, remains uncertain (UNODC, 2019).

1.1. Victims' needs

Being a victim of HT typically involves enduring extreme physical and psychological violence in highly precarious situations. Consequently, interventions must take multiple forms and address various needs (Couto, 2012; Couto & Fernandes, 2014; Fernandes, 2019; Fernandes *et al.*, 2021; Reichert & Sylwestrzak, 2013; UNODC, 2016; Zimmerman, 2003). These needs may include housing (providing shelter in secure specialized facilities and ensuring protection); subsistence (access to basic living conditions, such as food, hygiene, and clothing); health (medical care, including evaluation and treatment of physical and psychiatric issues); psychological support for emotional recovery and improvements in cognitive, behavioral, and interpersonal functioning; legal assistance with regularizing immigration status, navigating the criminal process, and asserting victims' rights (e.g., requesting a reflection period, obtaining a special residence permit, or securing witness protection); social support (economic aid and access to essential resources, support for educational reintegration,

vocational training, or assistance in finding employment and housing); cultural support (access to translation services and facilitation of religious practices); and assisted return (access to programs that support reintegration into the community of origin or another chosen by the victim).

Once identified, victims often have complex needs that require substantial, long-term care. This care is provided through a continuum of services, ranging from short-term to long-term assistance (Davy, 2015; Hossain *et al.*, 2010; Reichert & Sylwestrzak, 2013). Providers conceptualize this continuum of care in three phases: assessment and intervention, comprehensive case management, and social reintegration (Couto & Fernandes, 2014; Hodge, 2014; Fernandes, 2020). The goal during the initial phase of assessment and intervention is to address the victim's immediate needs and help them progress along the continuum – from crisis to a stable, secure situation. Over time, victims experience increased stability and can eventually reintegrate into society (Clawson *et al.*, 2009; Fernandes *et al.*, 2021b; Reichert & Sylwestrzak, 2013).

Social reintegration is closely linked to the concept of social inclusion, which emphasizes restoring all rights that were violated during the trafficking cycle. Recovery is the first step in this process (Fernandes, 2019). Social inclusion improves the conditions under which marginalized individuals participate in society by increasing opportunities, access to resources, voice, and respect for their rights. It is the opposite of social exclusion, one of the root causes of HT, and focuses on empowering survivors, ensuring their active participation in all decisions affecting them (Fernandes *et al.*, 2021).

This perspective reinforces that the experience of trafficking is not a permanent condition and that survivors can overcome it. Moreover, it calls for eliminating the term "trafficked persons," as survivors should not be permanently defined by their past experience (Human Rights Council, 2019).

The victims of HT must be the focal point of any response when providing support. Establishing an environment of trust and respect is crucial to help victims regain control of their lives and move toward independence and self-sufficiency (Pascual-Leone *et al.*, 2017; Sandhu *et al.*, 2013). Ensuring victims feel supported and safe should always be the first priority. When this is achieved, victims are more likely to offer valuable testimony and evidence during prosecutions, aiding law enforcement in meeting key justice restitution goals (Farrell *et al.*, 2012; Greenbaum, 2016; and Kiss *et al.*, 2015). For victims to believe that service providers are interested in helping them overcome their exploitation and achieve independence, rather than solely focusing on the crime, it is essential that they receive comprehensive support (Fernandes *et al.*, 2021).

Thus, intervention requires a comprehensive and culturally sensitive approach, which includes ongoing political and community awareness campaigns, alongside health care, legal aid, social support, and educational or vocational training for victims (Ramnauth *et al.*, 2018; Reichert & Sylwestrzak, 2013; and Sandhu *et al.*, 2013).

1.2. The Portuguese context

The National Trafficking Victims Support and Protection Network (NTVSPN) was established in Portugal in 2013, reflecting concerns over the adequacy of assistance provided to HT victims. This network brings together 23 governmental and non-governmental organizations across the country, including prosecutor's offices, public institutes, inspectorate authorities, law enforcement agencies, non-governmental organizations, and international organizations. These are organized into five regional multidisciplinary teams. Through comprehensive and specialized treatments – legal, psychological, and social assistance – the network aims to prevent trafficking, protect victims, and facilitate their reintegration. It also ensures that victims are referred to appropriate support agencies.

Currently, Portugal operates five makeshift shelters: two for women and children, two for adults, and one for juveniles. When law enforcement officers encounter a potential victim, they conduct a preliminary, standardized risk assessment. If a person is found to be vulnerable or at risk, they are referred to as one of five regional multidisciplinary NGO teams for specialized care and support, which includes the involvement of social workers and psychologists.

While only law enforcement officers have the formal authority to confirm that an individual is a victim of HT, frontline responders, such as police and non-governmental organizations, can identify potential victims and direct them to the appropriate resources. In the process of confirming a victim, police, judges, and prosecutors review the evidence and access for indicators of HT.

Nevertheless, the number of reported cases each year is far below the likely reality. One problem contributing to the misconceptions spread by social media is the lack of reliable, official, and comparative data (Cunha *et al.*, 2018). As a country of origin, transit, and destination for HT, Portugal registered 1,630 potential victims – both national and foreign – between 2010 and 2019, but judicial authorities confirmed only 330 cases (OTSH, 2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018).

Portuguese nationals with low levels of education and poverty are particularly vulnerable to forced labor

networks originating in Spain and extending throughout Northern and Eastern Europe (OTSH, 2017). In 2018, authorities identified 203 potential victims and confirmed 49, compared to 171 potential victims and 4 confirmed victims in 2017. Of the confirmed victims in 2018, 10 were children, 17 were women, and 32 were men, with the majority being Moldovans coerced into forced labor (OTSH, 2019). In 2019, there was a sharp decline in the numbers, with 33 potential victims and 45 confirmed victims. Of the confirmed victims, 36 were from Moldova, 4 from Pakistan, 15 were women, 30 were men, and 1 was a child, all these individuals were exploited in forced labor. Notably, no confirmed cases of sex trafficking were reported in 2019, though 10 suspects were identified as potential victims. None of the confirmed victims were Portuguese nationals. Among the presumed victims were eight children, eight Portuguese nationals, and four individuals exploited through forced begging (OTSH, 2020).

Victims' rights, including those of their minor children, encompassed access to housing, medical care, psychosocial support, legal assistance, translation and interpretation, education, and job training. However, due to the absence of reliable and comparable official data, it is unclear how many victims accessed these services. Despite significant investments to improve victim identification, referrals, and support, Portugal appears to have a low rate of victim recognition assistance (Fernandes, 2019; Matos *et al.*, 2017; 2019). Moreover, despite the guidelines of the National Plans against Trafficking in Human Beings, no studies have been identified that evaluate the effectiveness of victim identification and support interventions. Consequently, it remains difficult to assess the quality, impact, and effectiveness of the support provided or the system's capacity to recognize, identify, and assist victims.

This study aims to enhance our current understanding of these services by identifying the types of support available to HT victims. Do the service providers foresee obstacles for victims seeking help? What do care providers consider to be the victims' primary needs? Are the needs of HT victims distinct from those of other victims? What challenges or barriers exist in providing these services? What do the service providers mean when they refer to the victims' "condition of special vulnerability"?

2. Data and methods

2.1. Theoretical framework

As outlined by Fernandes (2019), this study is grounded in the framework of applied victimology, which is rooted in critical victimology. From a human rights standpoint, we aim to explore the social context, in which victimology-related issues intersect with concerns about policy responses and the provision of services to crime victims (Walklate, 2011).

2.2. Measures

We followed the data collection method detailed by Fernandes (2019), and the technique used was an electronic survey. This approach enabled us to reach all relevant organizations, including the police, social workers, and NGOs, whereas ensuring the privacy and anonymity of participants, particularly for shelters whose locations are confidential.

The instrument was specifically developed for this study based on a literature review of the subject. The questionnaire was divided into five sections:

(i) Characterization of the participant
(ii) Characterization of the assisted victim (type of victim, type of exploitation)
(iii) Services provided by the institution, along with 22 Likert-type scale questions regarding the work performed at the institution
(iv) Perceptions of the victims' barriers in the help-seeking process (17 questions with *Yes*, *No*, or *Do not know* responses)
(v) Three open-ended questions on 1) intervention dilemmas with HT victims, 2) differences between HT victims and victims of other crimes (e.g., domestic violence), and 3) the definition of the victim's "special vulnerability." In addition, participants were asked to rank the needs of HT victims from a prearranged list of 13 based on their work experience.

2.3. Procedure

This study was approved by the Ethics Subcommittee for Social and Human Sciences under the code SECSH 038/2016. A total of 23 NTVSPN agencies were contacted electronically through email. Since 2008, Portugal has had a National Rapporteur, whose primary duties include liaising with international organizations to combat human trafficking, fostering national and international information networks, and proposing new laws to protect victims and address HT.

Participation in the study was voluntary, and the National Rapporteur only shared the study with the network after receiving proper authorization to collect data. Their involvement did not influence the participants' power dynamics. Data collection took place from December 2016 to May 2017.

The inclusion criteria were that participants must be service providers employed by the network, who had assisted at least one presumed victim of HT, regardless

of the victim's gender or the nature of exploitation (e.g., sexual, labor, organ extraction, illegal adoption, begging, slavery, or other criminal activities). Participants had to be at least 18 years old, with no upper age limit. No monetary compensation was offered to participants, and they were informed that their participation incurred no financial cost and that they could withdraw from the study at any time.

2.4. Data analysis

The information collected for the study included both quantitative and qualitative information. Descriptive statistical analyses were conducted on the data from the first part of the survey (parts I–IV) using IBM SPSS 22 software. For the open-ended questions, a qualitative methodology was employed, using thematic analysis (Braun & Clarke, 2012) with QSR International NVivo 10 Software. Since each response could be categorized under more than one theme, an inclusive criterion was used for analysis, based on the emergent themes. The initial coding was guided by a preliminary coding grid, which was later refined into core categories and further divided into secondary, more specific categories in the final coding grid.

The data revealed themes and a range of strategies, such as detailed explanations of the data's meanings and continuous comparative analysis were employed to ensure the validity and reliability of the findings. To further ensure data trustworthiness, an additional independent coder (the second author) reviewed 40% of the randomly selected responses. After this independent review by a co-coder, the fidelity rate was calculated using Vala's (1986) formula, F = 2(C1, 2)/(C1 + C2), where the number of agreements between the coders was divided by the total number of categorizations made by each coder. The resulting calculation was 2(81)/82 + 87 = 0.96, indicating an excellent agreement level (Martins & Machado, 2006), thus providing confidence in the results. Coders discussed and reached a consensus on any coding discrepancies. In addition, the coding procedure was reviewed by a senior researcher.

Five of the participants who did not have direct contact with victims were excluded from the second part of the analysis, which focused on the characterization of the assisted victims, as the study aimed to capture the service providers' perceptions regarding the support provided to HT victims. Only the data of participants who completed every survey segment were analyzed to ensure the accuracy of the findings.

2.5. Participants

The sample consisted of 27 participants (17 females and 10 males), ranging in age from 25 to 71 years (M = 39.93, SD = 10.85). The participants' levels of education were as follows: graduate (n = 16), master's degree (n = 7), and secondary education (n = 4). The participants belonged to the fields of social sciences (n = 12), psychology (n = 7), law (n = 2), and nursing (n = 1), as well as other areas (n = 5), which included technical studies and police sciences.

Participants had worked as service providers for an average of 7.30 years (SD = 8.17) and had provided specific support to HT victims for an average of 5.42 years (SD = 6.54).

3. Results

3.1. How did the service providers acquire knowledge of human trafficking?

Almost half of the participants (n = 13) reported acquiring knowledge about HT exclusively through formal means. Their contact with the subject occurred through reporting, classes, direct engagement with victims, and professional practice. A small number of participants (n = 2) reported gaining knowledge exclusively through informal and self-directed methods (e.g., through personal knowledge and interaction with co-workers). A total of 12 participants indicated that they had learned about HT through both formal and informal channels.

3.2. Characterization of the assisted victims

The participants reported assisting an average of 32.77 victims (DP = 34.01) throughout their careers. In the year preceding this study, they supported an average of 13.36 victims (SD = 8.18). Participants stated that they had worked with victims of all types: 8 service providers worked with male, female, and juvenile victims; 11 exclusively dealt with adult male victims; and 3 worked exclusively with adult female victims. Most service providers (n = 17) supported victims of more than one form of exploitation, while 5 professionals worked with only one type of exploitation. The forms of exploitation reported by the professionals included sexual exploitation (n = 13), labor exploitation (n = 19), forced begging (n = 10), and slavery (n = 8).

3.3. Professionals' perceptions of services provided

The duration of institutional support provided to victims ranged from 0–16 months, with an average support period of 5.76 months (SD = 5.52). The types of support provided by the institutions are detailed in Table 1.

As shown in Table 2, the participants generally had positive perceptions of the services provided by their institutions. They expressed satisfaction with the types of services offered, the existence and usefulness of intervention protocols, the involvement of the victims

Table 1. Types of services provided by the institutions

Services provided	Total (*n*=21)
Meals	18
Legal support	18
Reintegration in the community	18
Professional reintegration	18
Essentials	17
Physical health (nurse and doctor)	17
Mental health (psychologist/psychiatrist)	17
Educational support	17
Accommodation	16
Translator	16
Assisted return	15
Nursery	8

in their assistance process, the clarity of the assistance procedures, and the interdisciplinary collaboration with other organizations (e.g., courts and employment centers).

3.4. Barriers to help-seeking

Nineteen service providers stated that the primary reasons victims are often unable to seek help are the fear of the trafficker and reprisals against themselves or their families. The lack of social support and confidence in the support system were identified as the least significant barriers by service providers. Figure 1 depicts the obstacles to victims seeking aid.

3.5. Victims' needs

Service providers ranked the victims' primary needs as follows: first, a sense of security (including economic independence and a place to stay); second, access to physical health care; and third, knowing their rights as immigrants. The least recognized needs were access to information/prevention campaigns, followed by educational support and access to education. Figure 2 graphically illustrates the prioritization of these needs in a pyramid.

The frequently identified theme when analyzing component (v) of the instrument was "barriers to providing support," followed by "similarities and differences in providing support to HT victims versus victims of other crimes." The "condition of special vulnerability" theme, which focuses primarily on the structural and individual vulnerabilities of the victims, appeared more tangential in the discussions. These themes are presented in Table 3.

3.6. Barriers to providing support

In analyzing the barriers to providing services, aside from those related to differences in treatment, the most frequently reported obstacle was a lack of economic resources. As Participant 25 explained, "[The] lack of economic resources" prevents institutions from offering necessary support because of insufficient resources. Some participants also highlighted that a key barrier is the absence of coordination between service providers and other organizations essential for establishing the support victims require. In addition, there is a lack of cooperation from the victims, compounding these challenges. As Participant 26 noted, there is a "lack of interinstitutional connections to allow rapid process execution. Closer associations with training and employment entities that allow a quick resolution of the life project," while Participant 6 remarked on the "lack of cooperation of the victim."

Participants also pointed out the absence of, or inadequate planning for, housing, shelter, and accommodation for victims. There was a concern about the safety of both the victims and service providers, as well as the ability to provide adequate responses despite the existence of a nationwide network to assist male and female victims of HT. As Participant 6 explained, "the difficulty of addressing basic needs and providing safe accommodation" remains a significant challenge.

Cultural aspects were also identified as barriers to providing support to HT victims. These could manifest at both linguistic and deeper spiritual or social levels. Participant 9 highlighted "language and cultural barriers and the bureaucracy of certain processes that delay their integration into society." The participants identified several challenges that substantially affect the delivery of support, including language and cultural barriers, concerns about victims' safety, a lack of confidence in the police, and ignorance among the general public and service providers. As previously mentioned, the victim's lack of security inhibits cooperation with organizations and institutions, whether judicial or support-related. As Participant 12 noted, there is a need "to transmit security and help overcome the fear that victims feel during the whole process," while Participant 10 pointed to the "lack of information on the part of the population in general, and the service providers and criminal police bodies themselves." Working with victims of this crime is made more challenging by the victims' ignorance of their rights, the general public's, and even the police's lack of information.

3.7. Similarities and differences between trafficking victims and victims of other crimes)

Participants noted some similarities between the issues faced by victims of domestic violence and those of HT. However, they also identified several key distinctions. One major difference is that victims of trafficking may be

Table 2. Perceptions of the service provided

Perceptions about the service provided	Disagree/ Completely disagree	Neither agree nor disagree	Agree/Completely agree
	(*n*=17)	(*n*=17)	(*n*=17)
The institution where I work can meet the needs of (presumed) victims.	2	-	15
The institution where I work has specific intervention protocols for (presumed) victims of human trafficking.	1	2	14
Specific intervention protocols for (presumed) victims of human trafficking are helpful.	-	1	16
The problems of (presumed) victims of human trafficking are different from those of victims of other crimes.	-	3	14
The needs of (presumed) victims of human trafficking are different from those of victims of other crimes.	-	2	15
Human trafficking victim support services are responsive to victims' needs.	1	1	15
Human trafficking victim support services are tailored to victims' needs.	2	-	15
In the institution where I work, the (presumed) victim is involved in its support process (e.g., the support and the various phases of the process are explained to the victim).	-	1	16
In the institution where I work, the (presumed) victim participates in decision-making (e.g., the victim is allowed to choose and decide on specific aspects of the support process, such as training area or professional reintegration).	2	1	14
There is coordination with governmental institutions in the institution where I work (e.g., Border Patrol and Employment Center).	-	-	17
In the institution where I work, there is coordination with judicial forces.	2	-	15
There are internal rules/procedures on the intervention with victims of trafficking persons in the institution where I work.	2	1	14
In the institution where I work, there is training on human trafficking.	-	3	14
In the institution where I work, there is multidisciplinary coordination.	3	1	13
In the institution where I work, there is technical supervision.	2	4	11
In the institution where I work, translators/interpreters have specialized training in attending to victims of human trafficking.	5	6	4
The institution usually informs the (presumed) victim about their rights.	1	-	17
The institution provides the (presumed) victim with a period of reflection (up to 60 days).	1	5	11
The (presumed) victim is informed that the support/protection process does not depend on an obligation to collaborate with judicial processes.	1	2	14
The (presumed) victim is informed that the support/protection process does not depend on an obligation to provide evidence.	-	2	15
The (presumed) victim is informed about the possibility of assisted return.	-	2	15
The victim is informed of the possibility of compensation.	2	1	14

fleeing an entire network of organized crime, sometimes transnational, and fearing reprisals against their families, whereas victims of domestic abuse are usually fleeing from a single offender. This makes providing safety more complex, as Participant 16 observed, there is "greater complexity in protecting the victim and his/her family [considering] the factor of transnationality and sometimes organized crime."

Another distinction is the impact on victims of HT, which may be more severe than that experienced by victims of domestic abuse. This leads to a longer and more challenging process of support and reintegration. As Participant 26 explained, "although all victims, regardless of type, have emotional and psychological wounds, in the case of HT victims, these wounds are even deeper. That is why the work takes time; it takes the victim time to adapt to the new reality and to believe that we are a way of helping them start a new life."

In addition, participants noted that foreign trafficking victims often lack citizenship, making it more difficult to meet their needs compared to Portuguese victims of domestic abuse. Participant 3 emphasized this: "The

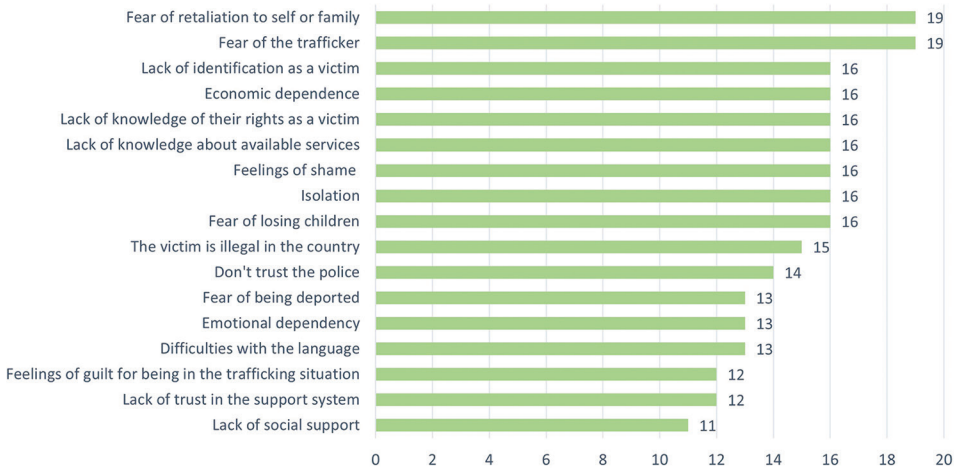


Figure 1. Barriers to help-seeking of the victim (n =19)

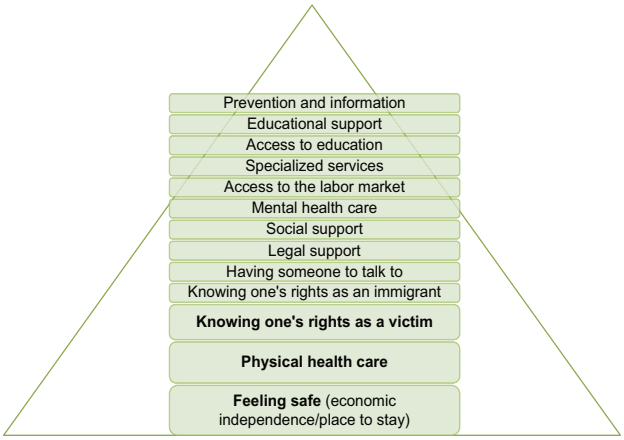


Figure 2. Pyramid of the perceived needs of trafficked people (n = 14)

absence or partial existence of documentation delays the beginning of their life project, so reintegration into society is more complex and combined with post-traumatic stress makes the work of the teams difficult."

There are also ongoing challenges with the courts and the length of legal procedures, even with the available assistance network for trafficking victims. Given the global nature of these crimes, trafficking victims sometimes disappear from the care providers after returning to their home countries. Participant 4 remarked on this issue: "In the area of justice: delay in the face of legal obstacles and responses by the authorities in the countries of origin." They, further, noted "the difficulty in locating them in later moments for procedural steps essential to produce the proof."

Building a trustworthy relationship with victims of HT is another key distinction. Participants disclosed that establishing a positive relationship with trafficking victims is more challenging than with victims of domestic abuse, which can hinder their healing and integration. As Participant 1 explained, "in our intervention, we assume that all cases are different, so all must be analyzed from an individual perspective and also be based on the needs of each situation. One of the great differences has to do with trust; in our experience, it is more difficult to establish a relationship of trust with a victim of trafficking than in other situations."

The focus of the intervention is also altered because of trafficking victims' heightened safety concerns, vulnerability, and lack of awareness of their rights as victims—or even the fact that they were victims of HT. As Participant 15 noted, "these victims have specific characteristics that differentiate them in most situations from other victims of crime, are in a situation of greater vulnerability, rarely seek support, and do not identify themselves as victims of crime. The focus of intervention is different from that for victims of domestic violence."

3.8. Condition of special vulnerability

One of the three open-ended questions of the e-survey was related to defining the "special vulnerability of the victim." When it was mentioned, it became clear that participants understand these unique vulnerabilities as either personal/individual and/or structural factors that put the victim at risk of HT exploitation. However, these vulnerabilities may not always be identifiable or quantifiable, and they do not necessarily apply to every victim. They are defined by a variety of personal, contextual, and situational particularities (physical, cognitive, and social), which differ in origin and characteristics and are not mutually exclusive. As Participant 3 noted, "victims who, on account of their age, mental or physical illness, or lack of knowledge of the language and customs of the place where they are

Table 3. Main Themes and Sub-themes

Theme	Sub-theme	Participants[a]	References[b]
Barriers to providing support		13	37
	Logistics	10	12
	Lack of information	6	8
	Lack of coordination	5	5
	Cultural aspects	3	5
	Lack of identification as a victim	2	2
	Individual characteristics of the victim	2	2
Similarities and differences (trafficking victims/victims of other crimes)		13	28
	Trust	7	8
	Transnationality of crime	6	6
	Multilevel impact	4	7
Condition of special vulnerability		12	17
	Individual vulnerability	11	12
	Structural vulnerability	3	3

Notes: [a]Number of participants who mentioned the theme and sub-theme; [b]Total number of references that integrated the theme and sub-theme.

considered liable without being able to exercise their basic rights." Participant 12 described this as "the very precarious socioeconomic and psychological conditions of the victims."

Service providers pointed out that victims in such conditions require special protection as their victimization continues. They emphasized that vulnerabilities vary based on the specifics of the crime, outlining the particular care needed, which includes paying attention to the victims' physical, mental, and safety needs, as well as those of their family members. In addition, they raised concerns about the potential for secondary victimization. This is reflected in the following statement by Participant 7: "The condition of the special vulnerability of the victim is that all victims who have special needs of protection (depending on their characteristics, the type or nature of the crime suffered and/or the circumstances) are particularly vulnerable to the continuation of victimization, suffer from secondary victimization, intimidation, etc., requiring special care, especially in terms of care and protection."

4. Discussion

This is the first study to address this research gap and evaluate the services offered to victims of HT in Portugal, focusing on the professionals who provide such services. Few participants reported having undergone educational courses; instead, they gained knowledge about HT primarily through their direct experiences with victims, rather than through proper academic training. Consequently, the information they acquire is experience-based rather than grounded in scientific knowledge or planned, certified instruction. In addition to impairing one's ability to treat patients or make appropriate (trauma-specific) referrals, inadequate training can also result in retraumatization through routine clinical procedures or inadvertently bringing up traumatic memories (Butler *et al.*, 2011; Hopper, 2017).

An essential aspect of victim support is shifting focus from the victim's status to their personhood, helping them move beyond self-blame and the identity of a victim/survivor to seeing themselves as individuals who are more than just the sum of their adverse life experiences (Hopper, 2017; Kiss *et al.*, 2015; Nguyen *et al.*, 2017; and Salami *et al.*, 2018). The victims are empowered by emphasizing their resilience and strengths and exploring past personal coping mechanisms (Bonanno, 2004 and Hopper, 2017). Victims' resources for overcoming the challenges they face can be organized with the assistance of service providers (Bonanno, 2004; Butler *et al.*, 2011; and Hopper, 2017). This raises concerns regarding the efficacy and recognition of the institutions' training programs in the absence of appropriate instruction and training. All care providers—medical, mental health, and social professionals and those in the legal and judicial systems—must be trained in the fundamentals of dealing with individuals who have undergone trauma. To ensure that every encounter is compatible with the recovery process and lessens the chance of retraumatization, all members of an organization's staff or those in direct contact with the victim must understand the impact that violence has on the lives of the people they serve (Butler *et al.*, 2011 and Wilson and Butler, 2014).

To prevent victim retraumatization, enhance safety, and improve the efficacy and efficiency of contact with victims, service providers must receive proper training and education (Farrell *et al.*, 2010, 2012; Ahn *et al.*, 2013; Beck *et al.*, 2015; and Renzetti *et al.*, 2015). Adequate training enables care providers to develop trusting relationships with victims, which is often challenging in the absence of proper knowledge and skills (Hemmings *et al.*, 2016; Pascual-Leone *et al.*, 2017; and Reichert and Sylwestrzak, 2013).

Portugal has five temporary shelters: two for women and children, two for men, and one for minors. Although these shelters cater to specific demographics, the broader support network assists men, women, and children who have been victims of various forms of exploitation. Given that the literature suggests that the needs of victims may vary depending on the type of exploitation they have endured, it would be valuable to understand the strategies employed to address these differing needs.

Working clinically with HT victims presents unique challenges. Every victim and every form of abuse has complexities that can create difficulties (Hemmings *et al.*, 2016; Pascual-Leone *et al.*, 2017; and Reichert and Sylwestrzak, 2013). These challenges may stem from external factors, the client's problems, the professional's limitations, or the dynamics of their relationship (Clawson *et al.*, 2009). A range of factors, including language barriers, cultural differences, and varying forms of exploitation, can act as obstacles to providing services. When these barriers work against the victim, they can cause alienation and even reinforce the helplessness that may have been instilled during the victim's exploitation. Targets that are heterogeneous and diversified, along with a lack of specialized knowledge and training, could make offering services inadequate. For this reason, to provide proper support and move past obstacles, professional training is essential (Pascual-Leone *et al.*, 2017 and Reichert & Sylwestrzak, 2013). To meet the needs of HT victims, professionals are now required to possess cultural understanding, knowledge, and skills. Therefore, it is essential to provide professionals with a foundation for delivering culturally competent and inclusive services (APA Multicultural Guidelines: Ecological Approach to Context, Identity, and Intersectionality; APA, 2017).

Identifying the victims' needs is also critical for law enforcement and service providers (Pascual-Leone *et al.*, 2017; and Reichert & Sylwestrzak, 2013). Participants specified key needs such as feelings of security and safety, which include financial independence and safe housing. Establishing a sense of safety and building trust with the victim takes time (Freemire, 2017). A comprehensive treatment plan includes screening, outreach, and treatments like crisis intervention and life skills training (Freemire, 2017; Hemmings *et al.*, 2016; and Westwood *et al.*, 2016). Short-term programs are generally insufficient for providing the necessary rehabilitation (Hemmings *et al.*, 2016 and Sandhu *et al.*, 2013). Therefore, the typical duration of support is often inadequate for developing a tailored and effective treatment plan.

HT victims have varying needs at different stages of their recovery (Stanley *et al.*, 2016 and Zimmerman, 2003). In addition to psychological support, victims often require professional reintegration, legal assistance, accurate language interpreters, and logistical support (transportation to treatment facilities) (Hemmings *et al.*, 2016; Pascual-Leone *et al.*, 2017; and Stanley *et al.*, 2016). Long-term support may include help with education, family reunification, mental health therapy, job training, employment placement, and even repatriation (Clawson *et al.*, 2009; Clawson *et al.*, 2003; and Pascual-Leone *et al.*, 2017). Participants noted that the services provided to HT victims include short- and long-term support, including legal aid, medical care, mental health services, education, financial assistance, job training, childcare, and reunification or repatriation, as well as emergency services, such as safety, housing, food/clothing, and translation. The literature demonstrates that HT victims require a variety of services (Clawson *et al.*, 2009; Clawson *et al.*, 2003; Freemire, 2017; and Hemmings *et al.*, 2016). Thus, providing support does not mean that a single institution must deliver all services. Through pre-existing networks of collaborations, institutions can address a wide range of needs, including those related to physical health (nurses and doctors, among other services), education, assisted return, reintegration into the community, and professional reintegration.

Participants highlighted the differences between victims of other crimes and those of HT. While victims' needs were not influenced by age or gender, some victims were said to have different levels of need than others, according to the participants. Participants also noted that HT victims experience higher levels of trauma and greater difficulty in trusting others compared to victims of other crimes. This underscores the importance of supporting HT victims with a trauma-informed approach, as emphasized in numerous studies (Ghafoori & Taylor, 2017; Hemmings *et al.*, 2016; and Salami *et al.*, 2018).

Trauma-informed care begins with an understanding of the physical, social, and emotional impact of the victim's trauma (Dell *et al.*, 2017; Freemire, 2017; Salami *et al.*, 2018). This approach consists of three key components: first, recognizing the prevalence of trauma; second,

identifying how the victim participating in the program, organization, or system, including the program's personnel, is impacted by the trauma; and third, integrating this understanding into practice (Butler *et al.*, 2011). This approach acknowledges the potential effects of several traumatic incidents throughout a person's life and involves a dedication to victim protection and empowerment (Hemmings *et al.*, 2016 and Salami *et al.*, 2018). It highlights how important it is to prevent retraumatization by ensuring that victims are not pressured to discuss the specifics of their victimization until they are ready (Hemmings *et al.*, 2016). However, more research is needed in this area, especially given that the average duration of support in this study was only 5.76 months. It is particularly important to ensure that time, pressure, and victim empowerment—three essential components of trauma-informed care—are addressed without bias (Fernandes *et al.*, 2020; 2021).

Participants also discussed the distinctions between victims of domestic abuse and victims of HT in terms of the impact of their victimization and the challenges HT victims face in building relationships based on trust. Roe-Sepowitz *et al.* (2014) highlighted the similarities in the support demands of victims of sex trafficking and domestic abuse. However, it is crucial to consider additional treatments that address the unique characteristics of sex trafficking, which require mutual respect, communication, teamwork, and an awareness of each team member's responsibilities to help the victim receive effective therapy.

Considering the range of services needed to meet the victims' complicated demands, it is not surprising that participants mentioned several difficulties in assisting victims. One of the most common challenges was victims' lack of information and understanding about crime, which also extends to care providers and law enforcement. When initiating the assistance process, it can be difficult to overcome the victims' frequent lack of awareness or recognition that they have been victims of a crime (Fernandes *et al.*, 2021). Another significant issue was the lack of cooperation between institutions. While partnerships may function at a service-provision level (shelter, clothing, food), due to pre-existing networks, sometimes these partnerships—such as those involving law enforcement or other institutions—create barriers that delay the victim's access to timely support. It can be challenging for some victims to receive certain services where identification documents are necessary because they lack documentation. In addition, the legal system often operates slowly, and victims frequently cooperate without properly communicating their needs to the organizations that offer assistance.

The works of Matos *et al.* (2017; 2019) and Fernandes *et al.* (2021) highlight the risks of relying heavily on the victim's testimony as the central piece of evidence in the criminal justice process (e.g., the police investigation and trial), highlighting the risks associated with the centralization of proof based solely on the victim's testimony. Therefore, to establish effective cooperation between the various law enforcement agencies at the national and international levels, it is imperative to increase the participation of all the institutions that assist victims of HT.

Participants mentioned a lack of interinstitutional support; however, when we assess the type of support provided using a Likert-type scale, it becomes evident that they effectively coordinate with other institutions to offer medical care, educational courses, and even job placements. Participants in the open-response question indicated obstacles that seemed inconsistent with the impressions gathered from the initial phase (Likert questions), where they primarily offered favorable judgments of good practices at an institutional level. This discrepancy may be explained by social desirability bias, as participants likely provided more positive responses in structured formats, only to reveal their specific challenges in open-ended questions, where they felt freer to express difficulties. These challenges often pertain to collaboration across institutions, particularly the lack of cooperation with judicial entities. Participants explained how this lack of cooperation frequently acts as a barrier to the delivery of services, causing the victim to withdraw and making it more challenging to win their trust.

Participants also indicated that victims are aware of the compensation fund and/or their rights; however, responses to compensation claims have not yet been processed. This suggests that victims may not fully understand their rights (OTSH, 2018).

When asked what prevents victims from coming forward and seeking help, the most common response was fear of facing reprisals against themselves or their families. Due to corruption in their home countries or threats from traffickers, victims were often afraid of law enforcement, believing they would face arrest and deportation if discovered (Clawson *et al.*, 2009; Ioannou & Oostinga, 2015; and UNODC, 2016). Service providers are well aware of this barrier. How can we overcome it? Fear of the trafficker, lack of self-identification as victims, and lack of knowledge of rights are barriers that can be addressed through information campaigns, as well as preventive and interventive measures in countries of origin, transit, and destination (Bishop *et al.*, 2013; Fernandes *et al.*, 2020; and Robinson, 2011).

Regarding the concept of "special vulnerability of the victim," participants divided vulnerability into two aspects: pre- and post-victimization. They acknowledged that victims may be targeted by HT exploitation because

of personal, individual, and/or structural vulnerabilities. As previously noted, several social and economic factors affect the behavior of both the victim and the trafficker, making HT more visible. Push factors, such as social and economic conditions in the nations of origin, affect both victims and exploiters, and make it easier for the crime of HT to be committed (Couto & Fernandes, 2014 and Fernandes *et al.*, 2020, 2021). Service providers also highlighted vulnerabilities that arise after a victim has been trafficked when additional protection is needed to prevent re-victimization. While HT often leaves individuals more vulnerable, some victims use their experience to make more informed decisions, particularly in the case of international victims who may attempt a second migration. A few may become recruiters themselves (Siegel & Blank, 2010). From a health perspective, re-trafficking is consistent with research showing that prior abuse experiences heighten the likelihood of engaging in future risky behaviors (UNODC, 2014; 2016).

5. Conclusions and practical implications

This study faced several obstacles, particularly the low participation and difficult access to the network's participating institutions. Some establishments remained insular and made no effort to participate in the inquiry, despite the involvement of the National Rapporteur for HT.

In Portugal, access to trauma-informed care training, as well as its quality and outcomes, remains essential. This paper highlights the scarcity of both training and research in this field. The government, beyond its role as legislator, plays a pivotal part by providing resources to all organizations – both governmental and non-governmental – to tackle the issue from multiple angles, including prevention, intervention, training, assessment, and enforcement. As the academic community is a component of the political and social spheres, addressing the issue effectively requires collaboration among all three sectors.

There is an immediate need for further research into treatment modalities (including type, duration, and efficacy) and how professional training influences the quality of support provided. Focus groups with key stakeholders, including social workers, attorneys, nurses, police officers, judges, and victims, would offer valuable insights into the challenges of delivering assistance. These studies can also enhance cooperation among partner agencies that support victims of HT. To improve training and service outcomes, the government and non-governmental organizations should establish a collaborative partnership with the academic community.

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Conflict of interest

The authors declare they have no competing interests.

Author contributions

Conceptualization: Ângela Fernandes
Investigation: Ângela Fernandes
Methodology: Ângela Fernandes, Marlene Matos
Formal analysis: Ângela Fernandes, Marlene Matos
Writing—original draft: Ângela Fernandes
Writing—review & editing: Ângela Fernandes, Marlene Matos

Ethics approval and consent to participate

This dissertation was approved by the Ethics Subcommittee for Social and Human Sciences under the code SECSH 038/2016. Its job is to supervise and uphold the development of moral behavior and to guarantee the honesty, decency, integrity, and morality of experiments and research in the social and human sciences carried out in the University of Minho research units. The human participants' consent was obtained in writing digitally, and all participants consented to participate in this study.

Consent for publication

Not applicable.

Availability of data

Not applicable.

Further disclosure

The paper has been uploaded to or deposited in a preprint server (RepositoriUM: https://hdl.handle.net/1822/75963).

References

Ahn, R., Alpert, E.J., Purcell, G., Konstantopoulos, W.M.I., McGahan, A., Cafferty, E., *et al.* (2013). Human trafficking: Review of educational resources for health professionals. *American Journal of Preventive Medicine*, 44(3):283-289.

https://doi.org/10.1016/j.amepre.2012.10.025

American Psychological Association. (2017). Multicultural Guidelines: An Ecological Approach to Context, Identity,

and Intersectionality. Available from: http://www.apa.org/about/policy/multicultural-guidelines.pdf [Last accessed on 2024 Mar 19].

Arhin, A. (2016). A diaspora approach to understanding human trafficking for labor exploitation. *Journal of Human Trafficking*, 2(1):78-98.

https://doi.org/10.1080/23322705.2016.1136538

Beck, M.E., Lineer, M.M., Melzer-Lange, M., Simpson, P., Nugent, M., & Rabbitt, A. (2015). Medical providers' understanding of sex trafficking and their experience with at-risk patients. *Pediatrics*, 135(4):e895-e902.

https://doi.org/10.1542/peds.2014-2814

Bishop, R.A., Morgan, C.V., & Erickson, L. (2013). Public awareness of human trafficking in Europe: How concerned are European citizens? *Journal of Immigrant and Refugee Studies,* 11(2):113-135.

https://doi.org/10.1080/15562948.2013.759047

Bonanno, G.A. (2004). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? *American Psychologist*, 59(1):20-28.

https://doi.org/10.1037/0003-066X.59.1.20

Braun, V., & Clarke, V. (2012). Thematic analysis. APA Handbook of Research Methods in Psychology. Vol 2. Research designs: Quantitative, qualitative, neuropsychological, and biological. United States: American Psychological Association, p57-71.

https://doi.org/10.1037/13620-004

Butler, L.D., Critelli, F.M., & Rinfrette, E.S. (2011). Trauma-Informed Care and Mental Health. *Directions in Psychiatry*, 31:197-210.

https://doi.org/10.1093/acrefore/9780199975839.013.1063

Clawson, H., Small, K., Go, E., & Myles, B. (2003). Needs Assessment for Service Providers and Trafficking Victims. Fairfax, VA: Caliber.

https://doi.org/10.1024/0301-1526.32.1.54

Clawson, H.J., Dutch, N.M., Salomon, A., & Grace, L.G. (2009). Study of HHS Programs Serving Human Trafficking Victims: Final Report, p1-14.

Couto, D. (2012). Tráfico de Seres Humanos: Perceções Sociais, Percursos de Vitimização e de Sobrevivência [Trafficking in Human Beings: Social Perceptions, Pathways of Victimization and Survival]. PhD Thesis. Braga: Universidade do Minho.

Couto, D., & Fernandes, Â. (2014). Tráfico de seres humanos: Dimensões da intervenção e medidas de proteção [Trafficking in human beings: Dimensions of intervention and protective measures]. In: Matos, M., (ed). *Vítimas de Crime e Violência: Práticas de Intervenção* [Victims of Crime and Violence: Intervention Practices]. Braga: Psiquilibrios Edições, p87-102.

Couto, D., Machado, C., Martins, C., & Gonçalves, R.A. (2012). A construção mediática do tráfico de seres humanos na imprensa escrita Portuguesa. *Analise Psicologica*, 30(1-2):231-246.

Cunha, A., Gonçalves, M., & Matos, M. (2018). Knowledge of trafficking in human beings among Portuguese social services and justice professionals. *European Journal on Criminal Policy and Research*, 25:1-20.

https://doi.org/10.1007/s10610-018-9394-1

Davy, D. (2015). Understanding the support needs of human-trafficking victims: A review of three human-trafficking program evaluations. *Journal of Human Trafficking*, 1:318-337.

https://doi.org/10.1080/23322705.2015.1090865

Dell, N.A., Maynard, B.R., Born, K.R., Wagner, E., Atkins, B., & House, W. (2017). Helping survivors of human trafficking. *Trauma, Violence, and Abuse*, 20(2):183-196.

https://doi.org/10.1177/1524838017692553

Farrell, A, McDevitt, J., & Fahy, S. (2010). Where are all the victims? Understanding the determinants of official identification of human trafficking incidents. *Criminology and Public Policy,* 9(2):201-233.

https://doi.org/10.1111/j.1745-9133.2010.00621

Farrell, A., Mcdevitt, J., Pfeffer, R., Fahy, S., Owens, C., Dank, M., *et al.* (2012). Identifying Challenges to Improve the Investigation and Prosecution of State and Local Human Trafficking Cases Executive Summary, p1-321. Available from: https://www.ncjrs.gov/pdffiles1/nij/grants/238795.pdf [Last accessed on 2024 Mar 19].

Fernandes, Â. (2019). Human Trafficking in Portugal: From Perceptions to Victims Support [Doctoral Dissertation]. Available from: https://hdl.handle.net/1822/75963 [Last accessed on 2024 Mar 19].

Fernandes, Â., Gonçalves, M., & Matos, M. (2020). "Who are the victims, who are the traffickers?" University students' portrayals on human trafficking. *Victims and Offenders*, 15(2):243-266.

https://doi.org/10.1080/15564886.2019.1711276

Fernandes, A., Gonçalves, M., & Matos, M. (2021) Exploring human trafficking victimization experiences in Portugal. *Victims and Offenders*, 16(5):746-769.

https://doi.org/10.1080/15564886.2021.1880509

Fernandes, Â., Gonçalves, M., & Matos, M. (2021b). Labor trafficking in Portugal: Victims perceptions of formal support, post-victimization and impact. *Journal of Forensic Psychology Research and Practice*, 21:438-467.

https://doi.org/10.1080/24732850.2021.1945831

Freemire, K.E. (2017). Mental health rehabilitation in victims of sex-trafficking. *Journal of Personality and Social Psychology*.

Ghafoori, B., & Taylor, R. (2017). Age-related differences in trauma experiences, mental-health needs, and mental-health-service use in victims of human trafficking: A pilot investigation of transition-aged youth compared to older adults. *Journal of Human Trafficking*, 3(4):259-270.

https://doi.org/10.1080/23322705.2016.1219840

Greenbaum, J. (2016). Identifying victims of human trafficking in the emergency department. *Clinical Pediatric Emergency Medicine*, 17(4):241-248.

https://doi.org/10.1016/j.cpem.2016.09.006

Hemmings, S., Jakobowitz, S., Abas, M., Bick, D., Howard, L.M., Stanley, N., *et al.* (2016). Responding to the health needs of survivors of human trafficking: A systematic review. *BMC Health Services Research*, 16(1):320.

https://doi.org/10.1186/s12913-016-1538-8

Hodge, D.R. (2014). Assisting victims of human trafficking: Strategies to facilitate identification, exit from trafficking, and the restoration of wellness. Social Work (United States), 59(2):111-118.

https://doi.org/10.1093/sw/swu002

Hopper, E.K. (2017). Trauma-informed psychological assessment of human trafficking survivors. Women and Therapy, 40(1-2):12-30.

https://doi.org/10.1080/02703149.2016.1205905

Hossain, M., Zimmerman, C., Abas, M., Light, M., & Watts, C. (2010). The relationship of trauma to mental disorders among trafficked and sexually exploited girls and women. *American Journal of Public Health*, 100(12):2442-2449.

https://doi.org/10.2105/AJPH.2009.173229

Human Rights Council. (2019). Report of the Special Rapporteur on Trafficking in Persons, Especially Women and Children. Vol. 06537. Available from: https://undocs.org/A/HRC/41/46 [Last accessed on 2024 Mar 19].

Ioannou, M., & Oostinga, M.S.D. (2015). An empirical framework of control methods of victims of human trafficking for sexual exploitation. *Global Crime*, 16(1):34-49.

https://doi.org/10.1080/17440572.2014.979915

Kiss, L., Pocock, N.S., Naisanguansri, V., Suos, S., Dickson, B., Thuy, D., *et al.* (2015). Health of men, women, and children in post-trafficking services in Cambodia, Thailand, and Vietnam: An observational cross-sectional study. *The Lancet Global Health*, 3(3):e154-e161.

https://doi.org/10.1016/S2214-109X(15)70016-1

Martins, C., & Machado, C. (2006). Observações da interação humana: Considerações metodológicas [Observation of human interaction: Methodological considerations]. Psicologia: Teoria, Investigação e Prática, 2:159-176.

Matos, M., Gonçalves, M., & Maia, Â. (2017). Human trafficking and criminal proceedings in Portugal: Discourses of professionals in the justice system. *Trends in Organized Crime,* 21, 370-400.

https://doi.org/10.1007/s12117-017-9317-4

Matos, M., Gonçalves, M., & Maia, Â. (2019). Understanding the criminal justice process in human trafficking cases in Portugal: Factors associated with successful prosecutions. Crime, Law and Social Change, 72:501-525.

https://doi.org/10.1007/s10611-019-09834-9

Nguyen, P.T., Coverdale, J.H., & Gordon, M.R. (2017). Identifying, treating, and advocating for human trafficking victims: A key role for psychiatric inpatient units. *General Hospital Psychiatry,* 46:41-43.

https://doi.org/10.1016/j.genhosppsych.2017.02.006

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2011). Relatório Anual Sobre Tráfico de Seres Humanos 2010 [Annual Report on Trafficking in Human Beings 2010]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2012). Relatório Anual Sobre Tráfico de Seres Humanos 2011 [Annual Report on Trafficking in Human Beings 2011]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2013). Relatório anual sobre Tráfico de Seres Humanos 2012 [Annual Report on Trafficking in Human Beings 2012]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2014). Relatório Anual Sobre Tráfico de Seres Humanos 2013 [Annual Report on Trafficking in Human Beings 2013]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2015). Relatório anual sobre Tráfico de Seres Humanos 2014 [Annual Report on Trafficking in Human Beings 2014]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2016). Relatório Anual Sobre Tráfico de Seres Humanos

2015 [Annual Report on Trafficking in Human Beings 2015]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2017). Relatório anual sobre Tráfico de Seres Humanos 2016 [Annual Report on Trafficking in Human Beings 2016]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2018). Relatório Anual Sobre Tráfico de Seres Humanos 2017 [Annual Report on Trafficking in Human Beings 2017]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2019). Relatório Anual Sobre Tráfico de Seres Humanos 2018 [Annual Report on Trafficking in Human Beings 2017]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Observatório do Tráfico de Seres Humanos, Ministério da Administração Interna, [Observatory of Trafficking in Human Beings, Ministry of Internal Administration]. (2020). Relatório Anual Sobre Tráfico de Seres Humanos 2019 [Annual Report on Trafficking in Human Beings 2019]. Available from: http://www.OTSH.mai.gov.pt [Last accessed on 2024 Mar 19].

Pascual-Leone, A., Kim, J., & Morrison, O.P. (2017). Working with victims of human trafficking. *Journal of Contemporary Psychotherapy,* 47(1):51-59.

https://doi.org/10.1007/s10879-016-9338-3

Ramnauth, T., Benitez, M., Logan, B., Abraham, S.P., & Gillum, D. (2018). Nurses' awareness regarding human trafficking. *International Journal of Studies in Nursing,* 3(2):76.

https://doi.org/10.20849/ijsn.v3i2.389

Reichert, J., & Sylwestrak, A. (2013). National Survey of Residential Programs for Victims of Sex Trafficking. Chicago, IL: The Illinois Criminal Justice Information Authority.

Renzetti, C.M., Bush, A., Castellanos, M., & Hunt, G. (2015). Does training make a difference? An evaluation of a specialised human trafficking training module for law enforcement officers. *Journal of Crime and Justice*, 38(3):334-350.

https://doi.org/10.1080/0735648X.2014.997913

Robinson, J. (2011). Public perceptions of human trafficking in moldova * percepciones públicas del tráfico ilegal de personas en Moldavia. Psychosocial Intervention, 20(3):269-279.

https://doi.org/10.5093/in2011v20n3a4

Roe-Sepowitz, D.E., Hickle, K.E., Dahlstedt, J., & Gallagher, J. (2014). Victim or whore: The similarities and differences between victim's experiences of domestic violence and sex trafficking. *Journal of Human Behavior in the Social Environment,* 24(8):883-898.

https://doi.org/10.1080/10911359.2013.840552

Salami, T., Gordon, M., Coverdale, J., & NGuyen, P. (2018). What therapies are favored in the treatment of the psychological sequelae of trauma in human trafficking victims? *Journal of Psychiatric Practice,* 24(2):87-96.

https://doi.org/10.1097/PRA.0000000000000288

Sandhu, S., Bjerre, N.V., Dauvrin, M., Dias, S., Gaddini, A., Greacen, T., *et al.* (2013). Experiences with treating immigrants: A qualitative study in mental health services across 16 European countries. *Social Psychiatry and Psychiatric Epidemiology*, 48(1):105-116.

https://doi.org/10.1007/s00127-012-0528-3

Siegel, D., & Blank, S. (2010). Women who traffic women: The role of women in human trafficking networks - Dutch cases. *Global Crime,* 11(4):436-447.

https://doi.org/10.1080/17440572.2010.519528

Stanley, N., Oram, S., Jakobowitz, S., Westwood, J., Borschmann, R., Zimmerman, C., *et al.* (2016). The health needs and healthcare experiences of young people trafficked into the UK. Child Abuse and Neglect, 59:100-110.

https://doi.org/10.1016/j.chiabu.2016.08.001

United Nations Office on Drugs and Crime (UNODC). (2016). Global Report on Trafficking in Persons Country Profiles: Western and Central Europe, 87. Available from: https://www.unodc.org/documents/data-and-analysis/glotip/2016_Global_Report_on_Trafficking_in_Persons.pdf [Last accessed on 2024 Sep 30].

United Nations Office on Drugs and Crime (UNODC). (2019). Global Report on Trafficking in Persons 2018. Vienna: UNODC.

https://doi.org/10.18356/9805f543-en

Vala, J. (1986). A análise de conteúdo. In: Silva, A.S., Pinto, J.M. (Orgs). Metodologia das Ciências Sociais. Porto: EdiçõesAfrontamento, p101-128.

Walklate, S. (2011). Reframing criminal victimisation: Finding a place for vulnerability and resilience. *Theoretical Criminology*, 15(2):179-194.

https://doi.org/10.1177/1362480610383452

Weitzer, R. (2015). Human trafficking and contemporary slavery. *Annual Review of Sociology,* 41(1):223-242.

https://doi.org/10.1146/annurev-soc-073014-112506

Westwood, J., Howard, L.M., Stanley, N., Zimmerman, C.,

Gerada, C., & Oram, S. (2016). Access to, and experiences of, healthcare services by trafficked people: Findings from a mixed-methods study in England. *British Journal of General Practice,* 66(652):e794-e801.

https://doi.org/10.3399/bjgp16X687073

Wilson, B., & Butler, L.D. (2014). Running a gauntlet: A review of victimisation and violence in the pre-entry, post-entry, and peri-/post-exit periods of commercial sexual exploitation. *Psychological Trauma: Theory, Research, Practice, and Policy,* 6(5):494-504.

https://doi.org/10.1037/a0032977

Zimmerman, C. (2003). The Health Risks and Consequences of Trafficking in Women and Adolescents Trafficking in Women and Adolescents: Findings from a European Study. London: London School of Hygiene and Tropical Medicine, p1-130.

Zimmerman, C., & Kiss, L. (2017). Human trafficking and exploitation: A global health concern. *PLoS Medicine,* 14(11):1-11.

https://doi.org/10.1371/journal.pmed.1002437

Zimmerman, C., Hossain, M., & Watts, C. (2011). Human trafficking and health: A conceptual model to inform policy, intervention and research. *Social Science and Medicine,* 73(2):327-335.

https://doi.org/10.1016/j.socscimed.2011.05.028

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Factors influencing adherence to antiretroviral treatment among people living with HIV aged 15 – 60 years at Cité des Palmiers District Hospital, Cameroon

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Abstract

Antiretroviral therapy (ART), essential for halting the progression of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) infection and restoring immunity, should be taken regularly to be effective. This study aimed to assess the factors that may affect adherence to ART among people living with HIV (PLHIV) aged between 15 and 60 years at the Cité des Palmiers District Hospital. Thus, we conducted a descriptive and analytical cross-sectional study using a non-probabilistic, convenience survey. Data were collected using a questionnaire administered to PLHIV aged between 15 and 65 years ($n = 309$). These factors affecting adherence were established by determining relative and absolute frequencies, and associations were estimated by calculating the odds ratios, confidence intervals, and P-values. Subsequently, 48.5% of participants were found to comply with ART and 51.5% were not. The independent predictors of poor adherence to ART were missed appointments at the HIV unit, occasional use of excitants/cigarettes, fear of disclosing HIV status, perceived limited opening hours of HIV-related services, discomfort with medication, recent initiation of treatment, and use of therapy reminders. Our study results are essential to orient public health policies and measures toward PLHIV non-adherents to ART treatment and mitigate the social, economic, and health impact of HIV threats on developing countries by focusing on good adherence.

Keywords: HIV; Antiretroviral therapy; Influencing factors; Therapeutic adherence; Cité des Palmiers

1. Introduction

More than 39 million people have died since the onset of the human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) epidemic (UNAIDS, 2022a).

Although many strategies are needed to end the HIV/AIDS epidemic, we are certain that the epidemic will not end without the effective use of antiretroviral treatment by those requiring it. Before antiretroviral drugs were discovered, active medicines against HIV were unavailable. The introduction of this highly active combination therapy in 1996 dramatically altered the natural course of this infection, effectively reducing morbidity (Centers for Disease Control and Prevention, 1996). However, difficulties linked to the cumbersome nature of the treatment, multiple side effects, and compliance problems emerged, compromising the success associated with antiretroviral therapy (ART).

Adherence, which measures patient compliance with medical prescriptions, plays an essential role in the effectiveness of ART (Ankri *et al.*, 2015). It is also the main factor determining the success of ART and a fundamental element in the response to HIV infection (Moing *et al.*, 2001). However, a 95% therapeutic compliance rate is necessary (Mouala *et al.*, 2006) to achieve the following therapeutic objectives: prolong life, reduce the frequency of opportunistic infections, rapidly and durably stop or slow down viral replication, and restore or improve the immunity of infected individuals (Delfraissy, 2002).

In 2021, there were an estimated 38.4 million people living with HIV (PLHIV) worldwide (World Health Organization, 2022), of which 29.8 million had access to ART (UNAIDS, 2022b) and approximately 38% had poor adherence to ART as prescribed (World Health Organization, 2016). Africa remains the most affected region, with the total number of PLHIV estimated at approximately 25.6 million in 2021 (World Health Organization, 2022) and the ART coverage estimated at 80% (World Health Organization, 2023). In Cameroon, 15,000 people were newly diagnosed with HIV in 2021, and only 78% of them were on ART (UNAIDS, 2022). Moreover, the frequency of poor adherence to treatment varies between 35% and 40%. (Mbopi-Kéou *et al.*, 2012; Buh *et al.*, 2023).

To be effective, ART must be taken throughout life with 100% compliance, as clinical and immunological improvement and viral suppression are only possible with treatment adherence (Mbopi-Kéou *et al.*, 2012). Consequently, poor adherence to treatment can lead to drug resistance and therapeutic failure (Saag *et al.*, 2020). This study aimed to assess the factors affecting adherence to ART among PLHIV aged 15 – 60 years at the Cité des Palmiers District Hospital. We aim to raise awareness among PLHIV about the importance of adherence to HIV prevention through health education initiatives and promoting better self-management practices. Moreover, the results will help improve the educational program not only for newly diagnosed PLHIV but also for health-care staff and patients' relatives throughout the HIV care continuum.

2. Methods

2.1. Setting and study period

We conducted this study between January and April 2024 at the Cité des Palmiers District Hospital in Cameroon. The Cité des Palmiers District Hospital, located in the Littoral region, Wouri department, and Douala V arrondissement, was established in 1990 as a dispensary and upgraded to a district hospital in 1993, following a presidential decree creating the health districts of Cameroon. The facility boasts modern, well-equipped infrastructure, enabling the provision of advanced and emergency medical services. The medical team comprises highly qualified and experienced professionals who are committed to offering personalized, quality care to every patient. They follow rigorous treatment protocols adapted to international standards, ensuring effective management of the various health conditions encountered. As a focal point for HIV/AIDS management, the Cité des Palmiers District Hospital plays a crucial role in HIV prevention, screening, and treatment programs as well as hosts research and education initiatives aimed at improving public health knowledge and practices.

2.2. Study design and population

This is a quantitative, cross-sectional, descriptive, and analytical study that included PLHIV aged 15 – 60 years who visited the HIV care unit of the Cité des Palmiers District Hospital during the study period and signed an informed consent form for adults and an assent form for minors. We selected this age group because it represents a period of active and productive life, during which effective management of HIV/AIDS is crucial for maintaining health and productivity and preventing the transmission of the virus.

2.3. Sample size and procedure

The Lorenz formula was used to calculate the minimum sample size, assuming a precision of 5%, a 95% confidence interval (CI), and a prevalence value of poor adherence to ART of 27.1% from previous studies (Heestermans *et al.*, 2016), yielding a sample size of 304. Non-probability convenience sampling was used as the sampling technique.

2.4. Data collection techniques and tools

Data were collected through a hospital-based survey using a semistructured questionnaire with four headings: sociodemographic characteristics, patient-related factors,

health system-related factors, and therapy-related factors. We pretested the questionnaire with 25 participants, and feedback on comprehension of the questions, clarity, and length of the interview was recorded.

2.5. Definition and operationalization of variables

Adherence to ART was assessed by asking whether "participants had missed ART 2 times in the month before the study." Those who had missed treatment on two occasions had poor adherence, and those who had not missed treatment had good adherence.

2.6. Data collection procedure

After obtaining the necessary research authorization, we requested a meeting with the head of the HIV care department, who permitted us to contact the patients. Upon contacting the patients, the investigator introduced himself, explained the reasons for his presence as well as the study's objectives and activities using an information leaflet, and answered any questions the patients had to ensure clear understanding. The patients signed the informed consent after agreeing to participate in the study. Subsequently, a questionnaire was administered face-to-face, and those who refused were considered non-respondents. The data were obtained anonymously to guarantee confidentiality, with each participant identified by a unique code assigned for this study.

The inclusion criteria were PLHIV aged 15 – 60 years who were followed up at the Cité des Palmiers District Hospital in Douala and either signed informed consent or received parental approval. The exclusion criteria included PLHIV aged ≤15 years, those aged ≥60 years, those who had relocated during the collection period, and those aged 15 – 60 years who did not provide consent.

2.7. Data processing and analysis

Data collected using the Kobo Collect application were compiled and analyzed using Rstudio software version 4.2.4. Microsoft Office Excel 2013 was used to create the tables. Descriptive statistics were calculated for all variables considered. The analysis of this study considered one dependent variable (adherence to ART) and several independent variables divided into four groups (sociodemographic characteristics, patient-related factors, health system-related factors, and therapy-related factors). The association between the dependent and independent variables was determined using binary logistic regression, and all variables with $p < 0.05$ in bivariate analysis were candidates for multivariate analysis. The various indicators were estimated with a significance level of alpha (α) = 0.05, and associations were considered significant for $p < 0.05$ using a two-tailed test.

3. Results

Data were collected between January and April 2024, during which 511 patients were recruited. Of these 511 patients, 309 consented to participate in the study, representing a 60.46% participation rate.

3.1. Description of participant characteristics

Table 1 shows the distribution of participants based on age, sex, marital status, occupation, area of residence, educational level, number of people in the household, household income, and cohabitation. The most represented age group was 45 – 60 years (50%), with an average age of 41.12 ± 12.97 years. Women slightly outnumbered men (64.1% vs. 35.9%). Most respondents were married (59.2%), worked in the private sector (32%), lived in an urban area (91.3%), had a higher educational level (64.1%), lived in a household of four to five people (53.4%), had a monthly income between 100,000 and 300,000 (37.9%), and lived with their family (94.2%).

3.2. Frequency of poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Figure 1 shows that 48.5% of participants were adherent to ART and 51.5% were not.

3.3. Sociodemographic factors associated with poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Table 2 shows that male participants (OR = 2.82 [95% CI: 1.74 – 4.63]; $p < 0.001$), those who were married (OR = 3.12 [95% CI: 1.91 – 5.18]; $p < 0.001$) or widowed (OR = 3.65 [95% CI: 1.17 – 12.62]; $p = 0.029$), and those working in the private (OR = 2.01 [95% CI: 1.06 – 3.91]; $p = 0.034$) or public sector (OR = 6.42 [95% CI: 2.65 – 16.78]; $p < 0.001$) were more likely to be less compliant with ART. In addition, participants with a higher educational level (OR = 5.74 [95% CI: 2.34 – 16.22]; $p = 0.0003$) and a monthly income of <100,000 FCFA (OR = 2.43 [95% CI: 1.30 – 4.61]; $p = 0.005$) or between 100,000 and 300,000 FCFA (OR = 2.60 [95% CI: 1.55 – 4.38]; $p = 0.0002$) also presented an increased risk of poor adherence to ART.

3.4. Patient factors associated with poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Table 3 shows that participants who had missed an appointment at the HIV management unit (OR = 4.13 [95% CI: 2.58 – 6.68]; $p < 0.001$), occasionally consumed excitants or cigarettes (OR = 9.33 [95% CI: 5.28 – 17.23]; $p < 0.001$), traveled frequently (OR = 6.38 [95% CI: 3.61 – 11.7]; $p < 0.001$), were very busy (OR = 5.22 [95% CI: 2.94 – 9.63];

Table 1. Distribution of study participants' characteristics

Variables	Absolute value	Relative frequency (%)
Age group (years)		
15 – 29	73	24
30 – 44	81	26
45 – 60	155	50
Sex		
Female	198	64.1
Male	111	35.9
Marital status		
Single	109	35.3
Married	183	59.2
Separated/divorced	3	1.0
Widow/widower	14	4.5
Profession		
Student/pupil	51	16.5
Jobless	66	21.4
Informal sector	57	18.4
Private sector	99	32.0
Public sector	36	11.7
Area of residence		
Rural	27	8.7
Urban	282	91.3
Education level		
Primary	27	8.7
Secondary	84	27.2
University	198	64.1
Number of people in your household		
1	42	13.6
2 – 3	66	21.4
4 – 5	165	53.4
>6	36	11.7
Household financial income per month (CFA Franc)		
<100,000	60	19.4
100,000 – 300,000	117	37.9
>400,000	6	1.9
I do not know	126	40.8
Who do you live with		
Friends	9	2.9
Family	291	94.2
Alone	9	2.9

$p < 0.001$), and were afraid of having their HIV status disclosed (OR = 4.75 [95% CI: 2.75 – 8.50]; $p < 0.001$) were at greater risk of poor adherence to ART. In addition, those who had consulted a pastor (OR = 2.84 [95% CI: 1.76 – 4.63]; $p < 0.001$) or used traditional treatments (OR = 12.25 [95% CI: 6.48 – 24.99]; $p < 0.001$) were more likely to have poor adherence to ART.

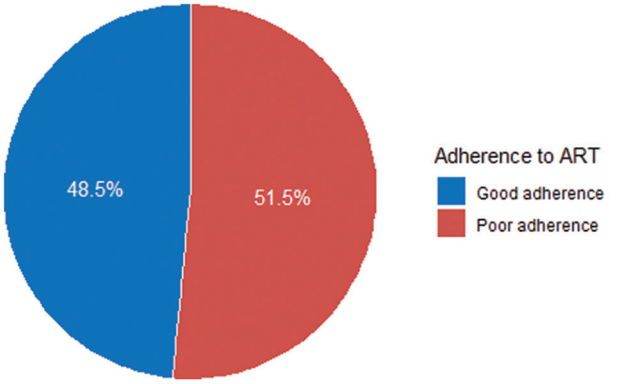


Figure 1. Frequency of poor adherence to ART
Abbreviation: ART: Antiretroviral therapy.

3.5. Health system factors associated with poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Table 4 shows that participants who felt that the opening hours of HIV-related services were insufficient (OR = 10.43 [95% CI: 5.51 – 21.29]; $p < 0.001$) and those who perceived insufficient confidentiality in these services (OR = 5.73 [95% CI: 3.43 – 9.82]; $p < 0.001$) were significantly more likely to have poor adherence to ART.

3.6. Therapy-related factors associated with poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Table 5 shows that participants who felt embarrassed when taking medication (OR = 6.09 [95% CI: 3.59 – 10.62]; $p < 0.001$), had difficulty adjusting to therapy (OR = 3.25 [95% CI: 1.98 – 5.41]; $p < 0.001$), were <1 year old (OR = 4.28 [95% CI: 2.38 – 7.99]; $p < 0.001$), had been receiving treatment for >10 years (OR = 18 [95% CI: 3.41 – 131.08]; $p < 0.001$), and those for whom taking the tablets reminded them of their unwanted HIV status (OR = 4.38 [95% CI: 2.52 – 7.83]; $p < 0.001$) were more likely to have poor adherence to ART. However, those taking treatment other than ART (OR = 2.20 [95% CI: 1.39 – 3.52]; $p = 0.008$) or using reminder tools for therapy (OR = 7.84 [95% CI: 3.85 – 17.73]; $p < 0.001$) were also at greater risk of poor adherence to ART.

3.7. Multivariate analysis of factors associated with poor adherence to ART among PLHIV at Cité des Palmiers District Hospital

Table 6 shows that failure to attend scheduled appointments at the HIV management unit (AOR = 3.93

Table 2. Sociodemographic factors associated with poor adherence to ART

Explanatory variables	Adherence to ART		OR (95% CI)	*p*-value
	Good (*n*=150)	Poor (*n*=159)		
Age group (years)				
15 – 29	35 (23)	38 (24)	1.09 (0.63 – 1.92)	0.738
30 – 44	37 (25)	44 (28)	1.20 (0.70 – 2.07)	0.498
45 – 60	78 (52)	77 (48)	1	
Sex				
Female	114 (76)	84 (52.8)	1	
Male	36 (24)	75 (47.2)	2.82 (1.74 – 4.63)	<0.001***
Marital status				
Single	73 (48.7)	36 (22.6)	1	
Married	72 (47.3)	111 (69.8)	3.12 (1.91 – 5.18)	<0.001***
Separated/divorced	1 (0.7)	3 (1.9)	1.07 (0.034 – 2.78)	0.984
Widow/widower	5 (3.3)	9 (5.7)	3.65 (1.17 – 12.62)	0.029*
Profession				
Student/pupil	15 (10)	36 (22.6)	5.14 (2.36 – 11.66)	
Jobless	45 (30)	21 (13.2)	1	
Informal sector	30 (20)	27 (17)	1.92 (0.93 – 4.05)	0.079
Private sector	51 (34)	48 (30.2)	2.01 (1.06 – 3.91)	0.034*
Public sector	9 (6)	27 (17)	6.42 (2.65 – 16.78)	<0.001***
Area of residence				
Rural	12 (8)	15 (9.4)	1.19 (0.54 – 2.69)	0.656
Urban	138 (92)	144 (90.6)	1	
Educational level				
Primary	21 (14)	6 (3.8)	1	
Secondary	54 (36)	30 (18.9)	1.94 (0.74 – 5.76)	0.197
University	75 (50)	123 (77.4)	5.74 (2.34 – 16.22)	0.0003***
Number of people in the household				
1	21 (14)	21 (13.2)	1	
2 – 3	42 (28)	24 (15.1)	0.571 (0.25 – 1.83)	0.163
4 – 5	66 (44)	99 (62.3)	1.50 (0.75 – 2.97)	0.243
>6	21 (14)	15 (9.4)	0.71 (0.28 – 1.74)	0.462
Household financial income per month (CFA Franc)				
<100,000	24 (16)	36 (22.6)	2.43 (1.30 – 4.61)	0.005**
100,000 – 300,000	45 (30)	72 (54.3)	2.60 (1.55 – 4.38)	0.0002***
>400,000	3 (2)	3 (2)	1.62 (0.29 – 9.08)	0.561
I do not know	78 (52)	48 (30)	1	
Who do you live with				
Friends	9 (6)	0	1	
Family	132 (88)	158 (99)	1.7 (0.21 – 3.31)	0.983
Alone	9 (6)	1 (1)	1.0 (0.06 – 1.75)	1.0

Notes: *p<0.05; **p<0.01; ***p<0.001.
Abbreviations: OR: Odds ratio; CI: Confidence interval; ART: Antiretroviral therapy.

[95% CI: 1.80 – 8.88]; p = 0.0007), occasional consumption of excitants/cigarettes (AOR = 9.86 [95% CI: 0.9 – 25.7]; p = 0.001), fear of HIV status disclosure (AOR = 8.14 [95% CI: 1.42 – 75.2]; p = 0.035), perception of limited opening hours

Table 3. Patient-related factors associated with poor adherence to ART

Explanatory variables	Adherence to ART		OR (95% CI)	*p*-value
	Good (*n*=150)	Poor (*n*=159)		
Missed an appointment at the HIV care unit				
No	102 (68)	54 (34)	1	
Yes	48 (32)	105 (66)	4.13 (2.58 – 6.68)	<0.001***
Excitants/cigarette consumption				
No	83 (55.3)	18 (11)	1	
Occasionally	66 (44)	132 (83)	9.33 (5.28 – 17.23)	<0.001***
Yes	1 (0.7)	9 (6)	0.77 (0.02 – 2.3)	0.982
Alcohol consumption				
No	57 (38)	66 (42)	1	
Yes	93 (62)	93 (58)	0.86 (0.54 – 1.36)	0.529
Support from family or friends in your therapy				
No	93 (62)	96 (60)	0.93 (0.59 – 1.47)	0.77
Yes	57 (38)	63 (40)	1	
Stress or depression attacks				
No	75 (50)	84 (53)	1	
Yes	75 (50)	75 (47)	0.89 (0.57 – 1.39)	0.619
Frequent traveler				
No	69 (46)	18 (11)	1	
Yes	81 (54)	141 (89)	6.38 [3.61 – 11.7]	<0.001***
Forget a lot				
No	96 (64)	108 (68)	1	
Yes	54 (36)	51 (32)	0.83 (0.52 – 1.34)	0.467
Very busy				
No	60 (40)	18 (11)	1	
Yes	90 (60)	141 (89)	5.22 (2.94 – 9.63)	<0.001***
Number of meals per day				
1	9 (6)	9 (6)	1	
2	39 (26)	54 (34)	1.38 (0.49 – 3.85)	0.528
>3	102 (68)	96 (60)	0.94 (0.35 – 2.50)	0.902
Fear of disclosure of HIV status				
No	63 (42)	21 (13)	1	
Yes	87 (58)	138 (87)	4.75 (2.75 – 8.50)	<0.001***
Disease other than HIV				
No	105 (70)	105 (66)	1	
Yes	45 (30)	54 (34)	1.2 (0.74 – 1.94)	0.456
Turn to a pastor for healing				
No	72 (48)	39 (25)	1	
Yes	78 (52)	120 (75)	2.84 (1.76 – 4.63)	<0.001***
Recourse to traditional treatment for recovery				
No	75 (50)	12 (8)	1	
Yes	75 (50)	147 (8)	12.25 (6.48 – 24.99)	<0.001***

Notes: *p<0.05; **p<0.01; ***p<0.001.
Abbreviations: OR: Odds ratio; CI: Confidence interval; HIV: Human immunodeficiency virus; ART: Antiretroviral therapy.

Table 4. Health system factors associated with poor adherence to ART

Explanatory variables	Adherence to ART		OR (95% CI)	*P*-value
	Good (*n*=150)	Poor (*n*=159)		
Present medication after recovering in the hospital				
Fixed dose	144 (96)	150 (94)		
Variable dose	6 (4)	9 (6)	1.44 (0.50 – 4.39)	0.499
Time taken to reach the hospital by foot (h)				
<1	126 (84)	143 (90)	1	
1 – 2	21 (14)	15 (9)	0.62 (0.30 – 1.25)	0.191
>2	3 (2)	1 (1)	1.07 (0.06 – 2.4)	0.985
Difficulty obtaining medication				
No	123 (82)	147 (92)	1	
Yes	27 (18)	12 (8)	0.37 (0.17 – 0.74)	0.207
Victim of stigmatization by healthcare providers				
No	120 (80)	126 (79)	1	
Yes	30 (20)	33 (21)	1.04 (0.60 – 1.82)	0.869
Insufficient confidentiality of HIV-related services				
No	81 (54)	27 (17)	1	
Yes	69 (46)	132 (83)	5.73 (3.43 – 9.82)	<0.001***
Limited opening hours for HIV-related services				
No	69 (46)	12 (8)	1	
Yes	81 (54)	147 (92)	10.43 (5.51 – 21.29)	<0.001***

Notes: *p<0.05; **p<0.01; ***p<0.001.
Abbreviations: OR: Odds ratio; CI: Confidence interval; HIV: Human immunodeficiency virus; ART: Antiretroviral therapy.

of HIV-related services (AOR = 9.27 [95% CI: 1.05 – 15.09]; p=0.0002), discomfort when taking medication (AOR=2.17 [95% CI: 0.19 – 8.1]; p = 0.002), recent treatment initiation (AOR = 2.68 [95% CI: 1.54 – 4.48]; p = 0.0047), and the use of therapy reminders (AOR = 2.01 [95% CI: 1.67 – 9.24]; p = 0.019) significantly increased the odds of being less compliant with ART.

4. Discussion

At the end of our investigation, we found that the overall prevalence of self-reported poor adherence to ART was 51.5%, which was lower than that reported by Collinet (2019) in Gabon (66%) and Addo *et al.* (2022) in Ghana (55.1%) but higher than that reported by Isika *et al.* (2022) in Nigeria (39.9%) and Do *et al.* (2010) in Botswana (18.3%). This discrepancy can be attributed to differences in study settings, geographical locations, and age groups of participants. In addition, variations in sample size and study period may result in different estimates.

Furthermore, multivariate analysis indicated that failure to attend scheduled appointments, use of stimulants/cigarettes, fear of HIV status disclosure, limited opening hours of HIV-related services, discomfort when taking medication, recent initiation of treatment, and use of reminder tools for therapy were all independent predictors of poor adherence to ART.

Failure to attend scheduled appointments at the HIV ward was significantly associated with poor ART adherence, consistent with the result obtained by Kim *et al.* (2018) in Asia, where not visiting a hospital increased the risk of poor ART adherence. This result may be attributed to the inability of medical staff to ensure correct treatment adherence if patients miss appointments, which also prevents the identification of any difficulties the patients might be experiencing. Therefore, this discontinuity in follow-up can undermine the relationship of trust between the patient and the health-care team, which is essential in promoting good compliance. Moreover, failure to attend scheduled appointments may be a sign of personal, social, or psychological difficulties, which may compromise compliance. Thus, identifying these signals is crucial for providing appropriate support and assisting patients in overcoming obstacles to consistent treatment.

The consumption of stimulants/cigarettes significantly increases the risk of poor ART adherence. This finding aligns with the results reported by Isika *et al.* (2022)

Table 5. Therapy-related factors associated with poor adherence to ART

Explanatory variables	Adherence to ART		OR (95% CI)	*P*-value
	Good (*n*=150)	Poor (*n*=159)		
Discomfort when taking medication				
No	78 (52)	24 (15)	1	
Yes	72 (48)	135 (85)	6.09 (3.59 – 10.62)	<0.001***
Difficulty getting used to therapy				
No	69 (46)	33 (21)	1	
Yes	81 (54)	126 (79)	3.25 (1.98 – 5.41)	<0.001***
Duration of ART (years)				
>10	3 (2)	18 (11)	18 (3.41 – 131.08)	<0.001***
1 – 5	54 (36)	18 (11)	1	
6 – 10	9 (6)	3 (2)	1 (0.20 – 3.78)	1
<1	84 (56)	120 (75)	4.28 (2.38 – 7.99)	<0.001***
Fear that ART will no longer work in the future				
No	90 (60)	93 (58)	1	
Yes	60 (40)	66 (42)	1.06 (0.67 – 1.67)	0.787
Taking the tablets is a reminder of unwanted HIV status				
No	60 (40)	21 (13)	1	
Yes	90 (60)	138 (87)	4.38 (2.52 – 7.83)	<0.001***
Side effects of this therapy				
No	120 (80)	132 (83)	1	
Yes	30 (20)	27 (17)	0.81 (0.45 – 1.45)	0.494
Taking treatment other than ART				
No	102 (68)	78 (49)	1	
Yes	48 (32)	81 (51)	2.20 (1.39 – 3.52)	0.008 ***
Reminder to take the medication				
Family	6 (4)	15 (9)	1	
Myself	144 (96)	144 (91)	0.4 (0.13 – 1.01)	0.065
ART regimen				
First-line	150 (100)	153 (96)	1	
Second-line	0	6 (4)	1.02 (8.e-01 – 1.27)	0.979
Using reminder tools for therapy				
No	48 (32)	9 (6)	1	
Yes	102 (68)	150 (94)	7.84 (3.85 – 17.73)	<0.001***
Last viral load result				
Detectable	24 (16)	27 (17)	0.93 (0.50 – 1.69)	0.816
Undetectable	126 (84)	132 (83)	1	

Notes: *p<0.05; **p<0.01; ***p<0.001.
Abbreviations: OR: Odds ratio; CI: Confidence interval; HIV: Human immunodeficiency virus; ART: Antiretroviral therapy.

in Nigeria and can be explained by the potential for stimulants, such as cocaine or amphetamines, to disrupt the regularity of treatment intake. These substances often have a disinhibiting effect and can lead patients to forget or neglect their medication, particularly when their effects wear off. Moreover, the periods of descent and withdrawal associated with drug use can divert patients' attention from their treatment, preventing them from proper compliance. In addition, certain drug interactions between excitants and antiretroviral drugs can compromise treatment efficacy, undermining the patient's motivation to continue treatment.

Table 6. Multivariate analysis of factors associated with poor adherence to ART

Explanatory variables	AOR (95% CI)	*p*-value
Sex		
Female	1	
Male	0.44 (0.16 – 1.16)	0.104
Marital status		
Single	1	
Married	0.2 (0.03 – 0.9)	0.147
Separated/divorced	1.07 (0.21 – 3.21)	0.996
Widow/widower	0.4 (0.11 – 3.77)	0.989
Profession		
Student/pupil	1.75 (0.38 – 7.84)	0.460
Jobless	1	
Informal sector	0.6 (0.09 – 3.41)	0.570
Private sector	0.8 (0.11 – 4.77)	0.854
Public sector	3.82 (0.58 – 28.08)	0.168
Educational level		
Primary	1	
Secondary	1.50 (0.16 – 15.4)	0.714
University	2.08 (0.2 – 21.1)	0.521
Household financial income per month (CFA Franc)		
<100,000	1.73 (0.44 – 7.21)	0.433
100,000 – 300,000	4.31 (0.82 – 22.3)	0.078
>400,000	2.67 (0.65 – 15.3)	0.607
I do not know	1	
Missed an appointment at the HIV care unit last month		
No	1	
Yes	3.93 (1.80 – 8.88)	0.0007 ***
Excitant/cigarette consumption		
No	1	
Occasionally	9.86 (0.9 – 25.7)	0.001 **
Yes	3.85 (0.33 – 29.7)	0.992
Frequent traveler		
No	1	
Yes	2.33 (0.75 – 7.03)	0.131
Very busy		
No	1	
Yes	1.38 (0.29 – 6.73)	0.680
Fear of disclosure of HIV status		
No	1	
Yes	8.14 (1.42 – 75.2)	0.035 *
Turn to a pastor for healing		
No	1	
Yes	0.25 (0.04 – 1.07)	0.075
Recourse to traditional treatment for recovery		
No	1	
Yes	1.23 (0.22 – 7.53)	0.806
Limited opening hours for HIV-related services		
No	1	
Yes	9.27 (1.05 – 15.09)	0.0002 ***
Discomfort when taking medication		
No	1	
Yes	2.17 (0.19 – 8.1)	0.002 **
Difficulties getting used to therapy		
No	1	
Yes	0.37 (0.05 – 1.98)	0.271
Duration of ART (years)		
>10	4.71 (1.17 – 12.26)	0.991
1 – 5	1	
6 – 10	0.55 (0.01 – 1.18)	0.455
<1	2.68 (1.54 – 4.48)	0.0047 **
Taking the tablets is a reminder of unwanted HIV status		
No	1	
Yes	2.74 (0.55 – 14.5)	0.222
Taking treatment other than ART		
No	1	
Yes	1.66 (0.41 – 7.49)	0.485
Using reminder tools for therapy		
No	1	
Yes	2.01 (1.67 – 9.24)	0.019 *

Notes: *p<0.05; **p<0.01; ***p<0.001.
Abbreviations: AOR: Odds ratio adjusted; CI: Confidence interval; HIV: Human immunodeficiency virus; ART: Antiretroviral therapy.

In addition, fear of HIV status disclosure was significantly associated with poor adherence to ART, similar to findings reported by Sánchez Peña *et al.* (2021) in Spain, Do *et al.* (2010) in Botswana, and Villiera *et al.* (2022) in Malawiet. This fear may be attributed to social isolation and a sense of shame among PLHIV. This can lead to a deterioration in self-esteem and self-confidence, which can compromise motivation to follow treatment regularly. The fear of being judged or rejected by others can also create an additional barrier to treatment adherence because patients may fear being stigmatized if they are seen taking their medication or if they have to visit specialized care centers. Fear of disclosure may also influence patients' behavior regarding treatment management. Some individuals may be reluctant to carry their medications in public, for fear of being identified as a PLHIV, leading to missed doses

or interruptions in treatment, which compromises its effectiveness.

Conversely, the perception that the opening hours of HIV-related services were limited significantly increased the chance of poor adherence to ART. This perception can undermine trust between patients and medical staff, making patients less inclined to share their concerns, difficulties, or questions about treatment. In addition, inaccessible HIV-related services can lead to practical barriers to treatment adherence. Incompatible schedules, long travel distances, or high costs can discourage patients from regularly visiting medical facilities or pharmacies to obtain their medication, leading to treatment interruptions or delays in taking medication, compromising its effectiveness.

Discomfort when taking medication significantly increases the risk of poor adherence to ART, a finding consistent with results from Isika *et al.* (2022) in Nigeria and Arrieta-Martínez *et al.* (2022) in Colombia. This discomfort may be due to undesirable side effects caused by some antiretroviral drugs, such as nausea, headaches, fatigue, or gastrointestinal disorders. These side effects can be unpleasant and uncomfortable, discouraging patients from taking their medication regularly as prescribed. Moreover, ART often requires daily dosing at specific times, which can be restrictive for some people. The constraints of taking medication regularly can be difficult to reconcile with the demands of daily life, particularly for those with jobs or family responsibilities, can be challenging. Patients may feel constrained by the strict rhythm of treatment, leading to feelings of embarrassment and frustration.

However, recent treatment initiation significantly increased the possibility of poor adherence to ART, a finding consistent with results from Mbopi-Kéou *et al.* (2012) in Cameroon, Do *et al.* (2010) in Botswana, and Lantche *et al.* (2021) in Cameroon, which indicate that adherence to ART improves with longer treatment duration. This result may be due to the undesirable side effects accompanying the initiation of a new treatment, such as nausea, headaches, or fatigue, which may reduce the patient's motivation to continue treatment rigorously. These side effects can also lead to anxiety and concern about the long-term tolerability of treatment. In addition, starting a new treatment can lead to upheavals in the patient's daily routine, making it difficult to adapt to the new medication demands. Constraints such as busy schedules, frequent travel, or family obligations can interfere with the regular intake of the patient's medication. In addition, psychosocial factors such as stress, depression, or lack of support can negatively influence compliance.

Furthermore, this study revealed that using reminder tools for therapy significantly increased the likelihood of being less compliant with ART. This finding differs with the results from Mbuagbaw *et al.* (2012) in Cameroon, where multiple reminder methods were associated with better adherence. The discrepancy may arise because over-reliance on these tools can reduce the ability to remember to take medication without reminders, leading to neglect when reminders are unavailable. In addition, over time, psychological resistance or indifference to reminders may develop, causing them to be ignored or deactivated. However, using reminder tools can create a false sense of security, leading to complacency about taking the medication. Thus, we should recognize that reminder tools can be useful, but they should be used with other adherence strategies and tailored to individual needs to promote optimal adherence to ART.

Notably, only 60.64% of individuals agreed to participate in the study, which could introduce a significant self-selection bias. This relatively low participation rate indicates that those who chose to participate may have distinct characteristics from those who declined. In particular, these participants may be more motivated to follow ART rigorously or more committed to their medical follow-up. Consequently, the frequency of poor adherence to ART could be underestimated. Individuals who agreed to participate could be those with better adherence to treatment or who are more aware of ART-related issues, which may not necessarily reflect the behaviors of the general PLHIV population. This self-selection bias may thus limit the generalizability of the study results and mask the true extent of the ART non-adherence problem in the wider population.

4.1. Study limitations

Our study's limitations lie mainly in its methodology and the population studied. First, using a non-probabilistic convenience method for participant selection could introduce a selection bias, limiting the generalizability of the results. In addition, data collection from a single hospital may restrict the representativeness of the findings. Furthermore, the cross-sectional nature of the study does not allow the establishment of causal relationships between the factors studied and ART adherence. Moreover, this study is based on self-reported data, which may be subject to recall bias and social desirability bias.

5. Conclusions

This study highlights several factors associated with non-adherence to ART among PLHIV. The results underline the importance of considering various aspects such as the management of medical appointments, consumption habits, concerns about confidentiality of HIV status, and

accessibility and comfort when taking medication. By directing public health policies to consider these factors, treatment adherence may improve, and consequently, the social, economic, and health impact of HIV in developing countries can be reduced. Targeted interventions aimed at strengthening psychosocial support, widening access to health services, and improving the use of reminder tools for therapy can help promote better adherence to ART and improve the quality of life of PLHIV.

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Conflict of interest

The authors declare they have no competing interests.

Author contributions

Conceptualization: All authors
Formal analysis: All authors
Investigation: Godfroy Rostant Pokam Djoko, Eric Martin Nomo
Methodology: Godfroy Rostant Pokam Djoko, Eric Martin Nomo
Writing – original draft: All authors
Writing – review & editing: All authors

Ethics approval and consent to participate

For this study, we obtained ethical clearance from the Institutional Ethics Committee for Human Health Research of the School of Health Sciences of the Catholic University of Central Africa [N°2024/020699/CEIRSH/ESS/MSP]. In addition, an agreement was obtained from the Director of the District Hospital of Cité des Palmiers. Informed consent was obtained from adult participants and an assent from a guardian was obtained for justifying the voluntary participation of their minors in this research. Confidentiality and anonymity were maintained during data collection.

Consent for publication

Not applicable.

Availability of data

All data used and/or analyzed for this study are available from the corresponding author upon reasonable request.

References

Addo, M.K., Aboagye, R.G., & Tarkang, E.E. (2022). Factors influencing adherence to antiretroviral therapy among HIV/AIDS patients in the Ga West Municipality, Ghana. *IJID Regions*, 3:218-225.

https://doi.org/10.1016/j.ijregi.2022.04.009

Ankri, J., Le disert, D., & Henrard, J.C. (2015). Individual behavior regarding medications: From therapeutic compliance to the experience of illness, analysis of the literature. *Public Health* (*Vandoeuvre-lès-Nancy*), 7(4):427-441.

Arrieta-Martínez, J.A., Estrada-Acevedo, J.I., Gómez, C.A., Madrigal-Cadavid, J., Serna, J.A., Giraldo, P.A., *et al*. (2022). Related factors to non-adherence to antiretroviral therapy in HIV/AIDS patients. *Farmacia Hospitalaria*, 46(6):319-326.

https://doi.org/10.7399/fh.11793

Buh, A., Deonandan, R., Gomes, J., Krentel, A., Oladimeji, O., & Yaya, S. (2023). Prevalence and factors associated with HIV treatment non-adherence among people living with HIV in three regions of Cameroon: A cross-sectional study. *PLoS One*, 18(4):e0283991.

https://doi.org/10.1371/journal.pone.0283991

Centers for Disease Control and Prevention (CDC). (2010). Update: Trends in AIDS incidence, deaths, and prevalence--United States, 1996. *MMWR Morbidity and Mortality Weekly Report*, 46(8):165-173.

Collinet, O. (2019). Factors *Associated with Poor Therapeutic Adherence among Patients Living with HIV at the Albert Schweitzer Hospital in Gabon in 2019*, p.54. Available from: https://dumas.ccsd.cnrs.fr/dumas-02401977 [Last accessed on 2024 Feb 18].

Delfraissy, J.F. (2002). *Management of People Infected with HIV: Recommendations from the Expert Group*. Paris: Flammarion Médecine-Sciences, p.384.

Do, N.T., Phiri, K., Bussmann, H., Gaolathe, T., Marlink, R.G., & Wester, C.W. (2010). Psychosocial factors affecting medication adherence among HIV-1 infected adults receiving combination antiretroviral Therapy (cART) in Botswana. *AIDS Research and Human Retroviruses*, 26(6):685-691.

https://doi.org/10.1089/aid.2009.0222

Heestermans, T., Browne, J.L., Aitken, S.C., Vervoort, S.C., & Klipstein-Grobusch, K. (2016). Determinants of adherence to antiretroviral therapy among HIV-positive adults in sub-Saharan Africa: A systematic review. *BMJ Global Health*, 1(4):e000125.

https://doi.org/10.1136/bmjgh-2016-000125

Isika, A.I., Shehu, A., Dahiru, T., Obi, I.F., Oku, A.O., Balogun, M.S., *et al.* (2022). Factors influencing adherence to antiretroviral therapy among HIV-infected adults in Cross River State, Nigeria: A cross-sectional study. *The Pan African Medical Journal*, 43:187.

https://doi.org/10.11604/pamj.2022.43.187.37172

Kim, J., Lee, E., Park, B.J., Bang, J.H., & Lee, J.Y. (2018). Adherence to antiretroviral therapy and factors affecting low medication adherence among incident HIV-infected individuals during 2009-2016: A nationwide study. *Scientific Reports*, 8(1):3133.

https://doi.org/10.1038/s41598-018-21081-x

Lantche, M.W., Fokam, J., Cheudjui, A.J.N., Tchatchueng, J.B.M., Noumsi, T.S.J., Ateba, F.N., *et al.* (2021). Factors associated with non-adherence to antiretroviral therapy among HIV-infected adolescents aged 15-19 years: A snapshot from the Mother and Child Center in Yaounde, Cameroon. *The Pan African Medical Journal*, 39(154):154.

https://doi.org/10.11604/pamj.2021.39.154.27623

Mbopi-Kéou, F.X., Dempouo Djomassi, L., & Monebenimp, F. (2012). Study of factors related to adherence to antiretroviral therapy among patients followed at HIV/AIDS Unit in the District Hospital of Dschang, Cameroon. *The Pan African Medical Journal*, 12:55.

Mbuagbaw, L., Thabane, L., Ongolo-Zogo, P., Yondo, D., Noorduyn, S., Smieja, M., *et al.* (2012). Trends and determining factors associated with adherence to antiretroviral therapy (ART) in Cameroon: A systematic review and analysis of the CAMPS trial. *AIDS Research and Therapy*, 9(1):37.

https://doi.org/10.1186/1742-6405-9-37

Moing, V.L., Chêne, G., Patrizia Carrieri, M., Besnier, J.M., Masquelier, B., Salamon, R., *et al.* (2001). Clinical, biologic, and behavioral predictors of early immunologic and virologic response in HIV-infected patients initiating protease inhibitors. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, 27(4):372-376.

https://doi.org/10.1097/00126334-200108010-00007

Mouala, C., Roux, P., Okome, M., Sentenac, S., Okome, F., Nziengui, U., *et al.* (2006). Assessment of compliance with ARV treatment in Africa. *Medicine Tropical* (*Mars*), 66(6):610-614.

Saag, M.S., Gandhi, R.T., Hoy, J.F., Landovitz, J., Thompson, M.A., Sax, P.E., *et al.* (2020). Antiretroviral drugs for treatment and prevention of HIV infection in adults: 2020 Recommendations of the international antiviral society-USA panel. *JAMA*, 324(16):1651-1669.

https://doi.org/10.1001/jama.2020.17025

Sánchez Peña, S., Pastor Bravo, M.D.M., Cánovas Tomás, M.Á., Almansa-Martínez, P., Peñalver Guillen, C., & Jiménez-Ruiz, I. (2021). Factors related to adherence to antiretroviral treatment in women with HIV: A mixed study with sequential design. *Enfermería Global*, 20(2):1-34.

https://doi.org/10.6018/eglobal.437711

UNAIDS. (2021). *Cameroon*. UNAIDS. Available from: https://www.unaids.org/en/regionscountries/countries/cameroon [Last accessed on 2024 Mar 07].

UNAIDS. (2022a). *Fact Sheet--Latest Statistics on the Status of the AIDS Epidemic*. Available from: https://www.unaids.org/fr/resources/fact-sheet [Last accessed on 2024 Mar 12].

UNAIDS. (2022b). *Fact Sheet--Latest Statistics on the Status of the AIDS Epidemic*. Available from: https://www.unaids.org/fr/resources/fact-sheet [Last accessed on 2024 Jan 22].

Villiera, J.B., Katsabola, H., Bvumbwe, M., Mhango, J., Khosa, J., Silverstein, A., *et al.* (2022). Factors associated with antiretroviral therapy adherence among adolescents living with HIV in the era of isoniazid preventive therapy as part of HIV care. *PLOS Global Public Health*, 2(6):e0000418.

https://doi.org/10.1371/journal.pgph.0000418

World Health Organization. (2016). Clinical guidelines: Antiretroviral therapy. In *Consolidated Guidelines on the Use of Antiretroviral Drugs for Treating and Preventing HIV Infection: Recommendations for a Public Health Approach*. 2nd ed. Geneva: World Health Organization. Available from: https://www.ncbi.nlm.nih.gov/books/NBK374316 [Last accessed on 2024 Jan 14].

World Health Organization. (2022). *GHO by Category People (All Ages) Living with HIV -Estimates by WHO Region*. Geneva: WHO; Available from: https://apps.who.int/gho/data/view.main.22100who [Last accessed on 2024 Feb 17].

World Health Organization. (2023). *GHO by Category Antiretroviral Therapy Coverage--Estimates by WHO Region*. Available from: https://apps.who.int/gho/data/view.main.23300region?lang=en [Last accessed on 2024 Jan 08].

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

ORIGINAL RESEARCH ARTICLE

Effectiveness of a digital single-session cognitive behavioral psychoeducational intervention in reducing public stigma associated with psychosis: A randomized controlled trial

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Abstract

Psychosis is a severe mental health condition that is highly stigmatized, significantly increasing the costs of mental healthcare and reducing the productivity of those affected. Due to public stigma, individuals with psychosis often delay seeking professional help, exacerbating the socioeconomic burden of their ill-health. Psychoeducation, delivered in a structured and systematic manner, has been a key part of evidence-based psychological treatments and has been gradually adopted in stigma reduction efforts. This study evaluated the effectiveness of a digital single-session cognitive behavioral psychoeducation intervention in reducing public stigma toward people with psychosis in a collectivist society through a randomized controlled trial. Stigma was assessed using standardized self-report tools at pre-intervention, post-intervention, and 1-month follow-up. A significant reduction was observed in stereotyping, prejudice, and discrimination on seven out of 10 public stigma components post-intervention. However, the desired effects were maintained for only two components at the 1-month follow-up. No significant changes were found in negative emotions, tolerance, and support from pre-intervention to post-intervention. Attribution of responsibility significantly increased after the intervention, contrary to predictions. The findings of this study provide empirical support for the short-term effectiveness of a brief cognitive behavioral psychoeducation intervention in reducing public stigma toward individuals with psychosis while highlighting the potential benefits of delivering this intervention digitally. At the same time, the limitations of individual-level interventions in sustaining long-term effects are discussed from a sociocultural perspective. This study also examined the relevance of these findings in the context of health economics.

Keywords: Mental ill-health; Psychosis; Public stigma; Psychoeducation; Economic burden; Cognitive behavioral therapy; Randomized controlled trial

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1. Introduction

1.1. Psychosis and health economics

Mental ill-health encompasses a range of cognitive, emotional, and behavioral difficulties that disrupt individuals' lives, productivity, and interpersonal relationships (Johnstone, 2001, p. 203). People with mental ill-health (PMIH) not only face the distress of their condition but also the stigma associated with it (Waqas *et al.*, 2020). This stigma leads to negative outcomes, including reduced help-seeking behavior, diminished social integration, higher unemployment rates, and increased psychological distress (Clement *et al.*, 2015; Yang *et al.*, 2008).

Psychosis is a severe form of mental ill-health characterized by hallucinations, delusions, and disorganized speech or behavior (Arciniegas, 2015). It is a complex emotional and behavioral response to distressing interpretations of unusual experiences, such as hearing voices or seeing things that are not there (Mankiewicz, 2013). Psychosis is not only worsened by public stigma and discrimination (Vass *et al.*, 2015) but is also often cited in academic and clinical literature as one of the most misunderstood and stigmatized psychological conditions (Henderson *et al.*, 2013; Morgan *et al.*, 2018; Pingani *et al.*, 2011; Wood *et al.*, 2014). Recent studies have shown that individuals with psychosis are often unfairly labeled as dangerous and unpredictable (Crisp *et al.*, 2000; Read *et al.*, 2013; Stuart & Arboleda-Flórez, 2012), which traps them in a cycle of suffering and socioeconomic disadvantage (Vass *et al.*, 2015). Misconceptions fueled by cultural stigma are frequently internalized by those with psychosis, leading to social isolation, long-term unemployment, and decreased economic productivity (Mankiewicz & Tan, 2024). Public discrimination exacerbates these issues, causing delays in seeking mental health services, which hinders recovery and perpetuates the cycle of socioeconomic disadvantage (Clement *et al.*, 2015; Schomerus *et al.*, 2019).

The impact of psychosis on health economics is well-documented in epidemiological literature. Psychosis is identified as one of the top 25 global causes of disability, imposing a significant economic burden on gross domestic product (Chong *et al.*, 2016). Several studies have highlighted the significant health expenditures associated with psychosis worldwide. In the US, these costs have been estimated to be $343.2 billion, including $259.1 billion in indirect costs, $62.3 billion in direct health-care costs, and $35.0 billion in direct non-health-care costs, with premature mortality and unemployment adding $77.9 billion and $54.2 billion, respectively (Kadakia *et al.*, 2022). In addition, the economic burden of psychosis is notable in Europe. For example, in the UK, direct and indirect costs per diagnosed individual reach up to $94,229 annually (Kotzeva, 2023), while total societal costs in Norway are estimated to be $890 million/year (Evensen *et al.*, 2016). In China, the average annual cost per individual with psychosis is $2586.21, with lost working days comprising the majority of indirect costs (Zhai, 2013).

Although clinical literature indicates that individuals with psychosis have the potential for functional psychosocial recovery (Mankiewicz, 2015), social isolation and unemployment are commonly noted as factors exacerbating the socioeconomic impact of the condition (Evensen *et al.*, 2016). In addition, the internalization of widespread public stigma is believed to hinder individuals from seeking professional help, thereby delaying their overall recovery (Mankiewicz & Tan, 2024).

1.2. Understanding the public stigma of mental ill-health

Stigma can be categorized into three main types: public, structural, and self-stigma (Corrigan & Bink, 2016). The present study focuses on public stigma, which was conceptualized by Zvonkovic & Lucas-Thompson (2015). They labeled a person or group as different, assigning them undesirable traits and subjecting them to discrimination, leading to negative outcomes. According to this definition, public stigma can be broken down into cognitive (stereotyping), affective (prejudice), and behavioral (discrimination) components (Corrigan & Watson, 2002b; Madianos *et al.*, 2012).

Stereotyping involves holding beliefs about the characteristics, attributes, and behaviors of individuals categorized as members of a specific social group (Corrigan & Shapiro, 2010, pp. 908-909). These beliefs are often inaccurate, resulting in oversimplified or false labels that reinforce misperceptions about stigmatized groups and foster prejudice (Bodenhausen & Richeson, 2010; Corrigan & Watson, 2002a; Cox *et al.*, 2012). For example, people with psychosis are often labeled as unpredictable, dangerous, and violent (Angermeyer & Dietrich, 2006; Benbow, 2007; Zvonkovic & Lucas-Thompson, 2015). Prejudice involves adopting these stereotypes (Corrigan *et al.*, 2003; Rüsch *et al.*, 2005) and having negative emotional responses toward the affected group (Dovidio *et al.*, 2010). Individuals who hold such prejudices may agree with the stereotypes that PMIH are unpredictable and violent, leading to fear (Corrigan & Shapiro, 2010; Devine, 1989). Discrimination is the behavioral manifestation of prejudice, resulting in differential treatment based on group membership (Bodenhausen & Richeson, 2010; Corrigan & Shapiro, 2010). Such behavior, driven by negative evaluations and

emotions, harms or brings disadvantages to those who are stigmatized (Corrigan *et al.*, 2003; Dovidio *et al.*, 2010). The belief that individuals with psychosis are dangerous fosters aversion and fear, leading to discriminatory actions such as avoidance and coercive interventions (Corrigan & Bink, 2016), which in turn perpetuate a cycle of disadvantage and stigma (Corrigan *et al.*, 2003; Corrigan & Shapiro, 2010).

To fully understand stigma within health and societal contexts, it is important to recognize how public stigma is interconnected with self-stigma and structural stigma (Livingston, 2013). Self-stigma occurs when individuals internalize the negative views and discrimination they face, leading to feelings of "shame, blame, hopelessness, guilt, and fear of discrimination associated with mental [ill-health]" (Brohan *et al.*, 2010, p. 2). This internalization, combined with emotional distress, worsens the loss of self-esteem and self-efficacy, creating a cycle of ongoing psychosocial decline and disempowerment (Lucksted & Drapalski, 2015; Stuart *et al.*, 2005; Corrigan *et al.*, 2003; Corrigan & Watson, 2002b). Structural stigma refers to "societal-level conditions, cultural norms, and institutional policies that constrain the opportunities, resources, and well-being of the stigmatized" (Hatzenbuehler & Link, 2014, p. 2). These restrictions support public stigma (Hatzenbuehler & Link, 2014; Livingston, 2013) and result in systematic disadvantages across various life areas for PMIH, particularly individuals with psychosis (Dovidio *et al.*, 2010; Hinshaw & Stier, 2008; Corrigan *et al.*, 2004). In occupational settings, individuals may need to disclose their history of mental ill-health, which can lead to fewer job opportunities, exclusion from community activities (Ong *et al.*, 2020; Sheehan *et al.*, 2016; Suto, 2012), and higher rates of unemployment, thereby limiting their career advancement (Stuart, 2006) and leading to disruptions in educational progress (Mojtabai *et al.*, 2015) and social marginalization (Kapadia, 2023).

1.3. Sociocognitive aspects of stigma

Attribution theory is a sociocognitive framework that explains how cognitive processes contribute to the development of public stigma (Corrigan, 2006; Weiner *et al.*, 1988). It suggests that people seek to understand behaviors and events by making attributions (Corrigan, 2006; Heider, 1958). These attributions can involve assigning responsibility and assessing potential danger (Corrigan *et al.*, 2015; Corrigan *et al.*, 2003; Pingani *et al.*, 2011). According to the attribution of responsibility model, people make judgments about the causes and controllability of an individual's mental health issues, which then leads to assigning responsibility for the condition (Corrigan *et al.*, 2003). When responsibility is attributed to PMIH, it often results in anger and a tendency to enforce punishment or deny assistance (Corrigan, 2006; Corrigan *et al.*, 2015; Muñoz *et al.*, 2015; Pingani *et al.*, 2011). Fear and apprehension arise when dangerous behaviors are linked to an individual, leading to avoidance or fearful reactions (Corrigan *et al.*, 2002; Muñoz *et al.*, 2015). In contrast, if the behavior is attributed to external, uncontrollable factors, the individual is less likely to be blamed (Corrigan, 2006; Corrigan *et al.*, 2003; Sousa *et al.*, 2012) and may instead receive sympathy and support (Corrigan *et al.*, 2003; Weiner, 1995).

Although stigma against PMIH is widespread, it is also influenced by differences in sociocultural norms and beliefs (Angermeyer & Dietrich, 2006; Cheon & Chiao, 2012; Yang *et al.*, 2007). Emotional reactions are shaped by culturally specific beliefs about mental ill-health, and behaviors related to these beliefs vary depending on what is socially acceptable (Cheon & Chiao, 2012, p. 1059). Since local values are closely linked to the development of stigmatizing attitudes (Abdullah & Brown, 2011), cultural beliefs should be considered when developing interventions tailored to specific contexts (Dalky, 2011; Kutcher *et al.*, 2016).

Given the social context of our study, Singapore is a multiethnic nation with strong Asian cultural influences (Singapore Department of Statistics, 2021). In this setting, behaviors and meanings related to mental health issues may be viewed as contrary to Asian values of conformity and emotional self-control (Abdullah & Brown, 2011). Psychological difficulties are often perceived as deviations from social norms (Abdullah & Brown, 2011) and are associated with dangerousness, unpredictability, and mental instability, which contribute to misconceptions about individuals' ability to manage their emotions (Ong *et al.*, 2020; Lai *et al.*, 2000). These misconceptions lead to prejudicial attitudes, such as fear and mistrust, toward PMIH (Ong *et al.*, 2020).

Research indicates that stigma toward PMIH is more pronounced in Asian countries than in European countries (Shamblaw *et al.*, 2015). In Singapore, an epidemiological study by Subramaniam *et al.* (2017) found that individuals with psychological difficulties are often viewed as weak, dangerous, and unpredictable. A nationwide survey revealed that 44.5% of participants used derogatory terms like "crazy" to describe PMIH (Pang *et al.*, 2017). In Singapore's collectivistic culture, shared societal goals are emphasized over individual ones (Shamblaw *et al.*, 2015). This trend may lead to discrimination against those with mental ill-health (Tan *et al.*, 2020). Psychological issues are frequently attributed to family dynamics, suggesting that they reflect familial flaws or moral shortcomings (Subramaniam *et al.*, 2017; Yang, 2007). Consequently,

mental ill-health often causes family members to experience shame, contributing significantly to public stigma (Shamblaw *et al.*, 2015). Furthermore, Singapore's elitist mindset, which values success in all aspects of life, leads to viewing mental ill-health as incompatible with societal functioning and deserving of disparagement (Tan *et al.*, 2020). According to Subramaniam *et al.* (2017), these restrictive cultural norms can result in a sense of "loss of face," disappointment, and heightened feelings of failure among PMIH and their families.

1.4. Stigma associated with psychosis

Individuals with psychosis are often perceived as unpredictable, dangerous, violent, and incompetent by the public (Angermeyer & Matschinger, 2004; Henderson *et al.*, 2013; Zvonkovic & Lucas-Thompson, 2015). For example, a large survey by Crisp *et al.* (2000) revealed that 70% of the general population viewed people with psychosis as dangerous. They are also seen as responsible for their condition and unlikely to recover (Corrigan & Kleinlein, 2005; Crisp *et al.*, 2000), which can hinder access to evidence-based treatments for psychosis (Mankiewicz & Turner, 2012). These negative attitudes may arise from the disruptive and unusual behavior of individuals with psychosis and a lack of understanding about the condition (Angermeyer & Matschinger, 2004; Corrigan *et al.*, 2001). Historically, psychosis was associated with schizophrenia, a disease paradigm that implied inherited brain abnormalities and led to ineffective medical treatments (Mankiewicz, 2013; Villafana, 2017). This historical stigma continues to influence structural systems, perpetuating continued discrimination against individuals with psychosis (Lee *et al.*, 2006; Vass *et al.*, 2015) and underscoring the need for inclusive, multidisciplinary approaches in clinical services for PMIH (Mankiewicz *et al.*, 2015).

Misconception about psychosis is often pronounced in Asian societies, where cultural beliefs reinforce viewing individuals with psychosis as highly dangerous and aggressive (Zhang *et al.*, 2019). In Singapore, the lack of awareness about psychosis leads to widespread misunderstandings, with those experiencing psychosis being seen as exhibiting abnormal behavior and being labeled as bizarre or unstable (Lai *et al.*, 2000). Such individuals face discrimination due to the belief that psychosis results in permanent debilitation, and even those who fully recover continue to experience stigma and discriminatory behavior from their communities and society (Lai *et al.*, 2000).

Stigmatization of PMIH is a significant issue in Southeast Asia (Subu *et al.*, 2021; Tan *et al.*, 2020). A recent qualitative study involving participants aged 19 – 24 years found that even among young and educated Singaporeans, strong stigmatizing misconceptions persist. Individuals with psychosis are often labeled as abnormal, neurologically disordered, mentally ill, dangerous to themselves and others, and crazy (Mankiewicz & Kam, 2024). These persistent misperceptions contribute to the ongoing nature of stigma in Singapore, with historical data showing that 73% of people with psychosis have had trouble finding employment (Lai *et al.*, 2000). The internalization of stigma is also evident, with 52% of individuals with psychosis reporting low self-esteem, 47% feeling shame, and 51% believing that people who know about their condition would avoid them (Lai *et al.*, 2000). Recent statistics further highlight the issue: a study by Ang *et al.* (2020) demonstrated that only 46.01% of community-based Singaporean outpatients with psychosis were employed, with 51.15% working full time. Another study by Chua *et al.* (2019) reported an unemployment rate of 63.5% among participants in the Singapore Early Psychosis Intervention Programme. Furthermore, only 13.3% of young Singaporeans with psychotic and affective disorders have managed to secure senior-level jobs (Subramaniam *et al.,* 2022).

1.5. Role of psychoeducation in reducing mental health stigma

Given the public's limited understanding of psychosis (Zvonkovic & Lucas-Thompson, 2015), interventions to address these misperceptions are necessary. Structured psychoeducation is an effective method for correcting stigma-related misunderstandings, as it has shown promise in reducing stigma and is relatively straightforward to implement in mental health services (Zvonkovic & Lucas-Thompson, 2015). Commonly integrated into cognitive behavioral interventions (Kellett *et al.*, 2007; Sijbrandij *et al.*, 2016), psychoeducation involves "any structured group or individual program that addresses a [difficulty] from a multidimensional viewpoint, including familial, social, biological and pharmacological perspectives" (Economou, 2015, p. 259). It is systematically used in treatments for complex mental health needs, such as cognitive behavioral therapy for psychosis (CBTp) (Mankiewicz & Turner, 2014; Mankiewicz, 2019), behavioral family therapy (Lucksted *et al.*, 2012; O'Hanlon *et al.*, 2018), and family intervention for psychosis (FIp) (Onwumere *et al.*, 2018).

Recognizing the benefits of psychoeducation, researchers have increasingly included it in stigma reduction programs, with some focusing specifically on improving psychotic experiences (Alonso *et al.*, 2019; Blair Irvine *et al.*, 2012; Kimmerle & Cress, 2013; Li *et al.*, 2015; Tan & Mankiewicz, 2024). Meta-analyses have consistently shown that psychoeducation is effective in reducing stigma

toward PMIH, with significant small-to-medium effect sizes (Corrigan *et al.*, 2012; Morgan *et al.*, 2018; Na *et al.*, 2022). These effects span cognitive (beliefs), emotional (responses), and behavioral (intended actions) components of stigma, with lasting improvements in beliefs and intended actions observed during follow-ups. However, existing interventions, while successful in enhancing knowledge and reducing discriminatory behavior, are less effective in addressing emotional responses (Na *et al.*, 2022). The impact of educational approaches on mental health stigma has been confirmed across various cultures (Corrigan *et al.*, 2012). Similarly, educational interventions focused on understanding psychosis have led to notable improvements in stigmatizing attitudes and social distancing, with long-term maintenance of changes in social distancing but not in attitudes (Morgan *et al.*, 2018).

Psychoeducational interventions vary widely in content, duration, and delivery methods (Morgan *et al.*, 2018). Na *et al.* (2022) found that neither the length nor the medium of delivery significantly affected the effectiveness of psychoeducation in reducing stigma. Several experts recommend that interventions should use a balanced, multidimensional approach, incorporating psychosocial perspectives on mental health issues (Jorm & Griffiths, 2008; Lincoln *et al.*, 2008; Yamaguchi *et al.*, 2011). There is also consensus on the need to include evidence-based information to directly counteract stereotypes about mental health issues (Corrigan *et al.*, 2012; Corrigan *et al.*, 2000; Lincoln *et al.*, 2008), share personal testimonies of those with psychological difficulties (Knaak *et al.*, 2017), and highlight their potential for recovery (Knaak *et al.*, 2014). Despite this, current interventions still primarily focus on explanatory models and factual information addressing myths (Corrigan *et al.*, 2012; Morgan *et al.*, 2018), often overlooking personal testimonies and examples of recovery (Knaak *et al.*, 2014; Na *et al.*, 2022).

1.6. Current study

Building on the increasing empirical evidence supporting the effectiveness of brief psychoeducation (Corrigan *et al.*, 2004; Na *et al.*, 2022), this study aimed to evaluate the effectiveness of a digital single-session cognitive behavioral psychoeducation program in reducing public stigma associated with psychosis in a randomized controlled trial. A 1-month follow-up was included to evaluate the sustainability of the stigma reduction effects.

The study hypothesized that psychoeducation would significantly (1) reduce social distancing, (2) increase tolerance and support for community care, (3) decrease social restrictiveness, (4) lessen prejudice and misconceptions, (5) reduce fear and perceived dangerousness, (6) enhance willingness to help and interact, (7) lower perceived responsibility, (8) decrease coercive treatment, (9) improve empathy, and (10) reduce negative emotions toward individuals with psychosis, compared with a control group, and that these effects would be maintained at 1-month follow-up.

Ethical approval was obtained from the Departmental Ethics Review Committee (DERC) at the National University of Singapore (NUS) and endorsed by the NUS Institutional Review Board (IRB), reference code 2022-September-10. The study adhered to the Declaration of Helsinki.

2. Data and methods

2.1. Participants

The sample size of 118 participants was calculated using G*Power 3.1 software, with an effect size of 0.2, alpha level of 0.05, and power of 0.8 for a repeated-measures, between-factors analysis of variance (ANOVA). Due to the absence of effect sizes from similar studies, a small-to-medium effect size was anticipated. According to Cohen's (1988) guidelines, a small effect size is 0.10, a medium effect size is 0.25, and a large effect size is 0.40.

Figure 1 shows the CONSORT diagram of participant flow throughout the study. A total of 148 participants who were Singaporean and over 18 years old were initially included. With 15 participants not completing the follow-up, list-wise deletion reduced the final sample to 133. Participants, recruited through online advertisements targeting university students and the general public, ranged in age from 19 to 58 years (M = 22.07, SD = 5.38), with 62% being females. The demographic characteristics of participants in the intervention and control groups are detailed in Table 1 and showed no significant differences at pre-intervention.

2.2. Standardized measures

2.2.1. Attitudes to Mental Illness-Singapore (AMI-SG) version

The AMI-SG is a 20-item, 4-factor self-report questionnaire developed by Yuan *et al.* (2016) to assess public attitudes toward mental ill-health. Confirmatory factor analysis indicated that the model fits well, with a comparative fit index of 0.933 and a Tucker–Lewis index of 0.955 (Yuan *et al.*, 2016). The items are rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The four subscales are (1) social distancing, (2) tolerance and support for community care, (3) social restrictiveness, and (4) prejudice and misconception. These subscales have good internal consistency, with Cronbach's alpha values

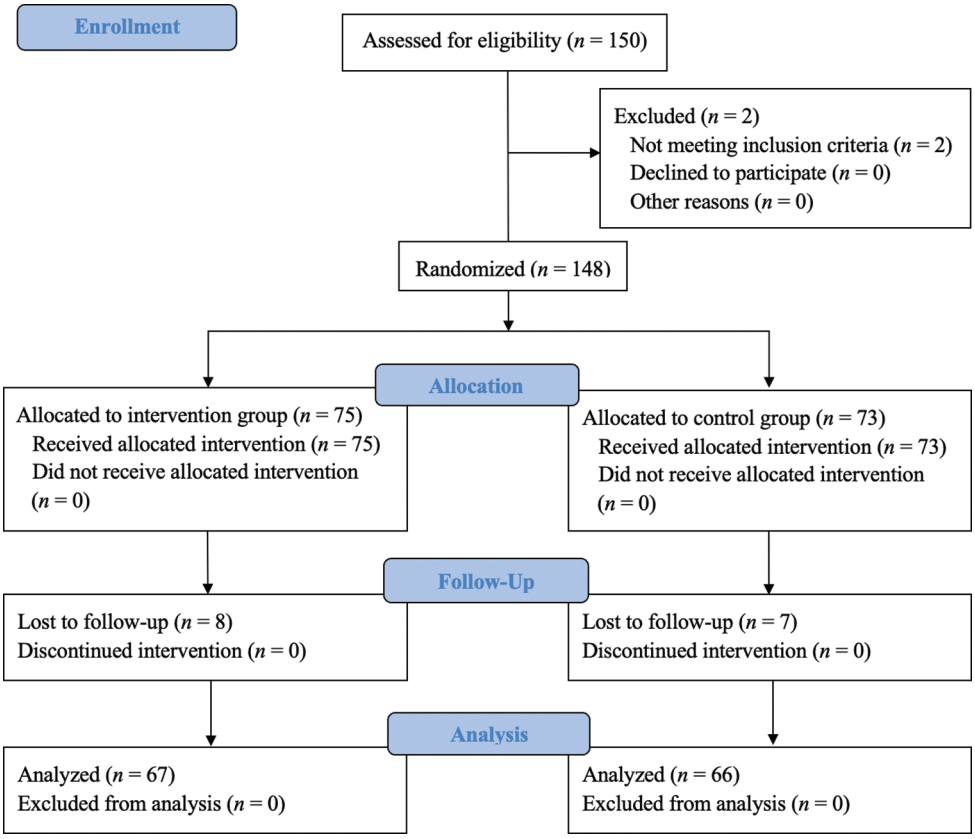


Figure 1. CONSORT flowchart showing recruitment and study process

Table 1. Descriptive statistics for the intervention and control groups

	Intervention (*n*=67)		Control (*n*=66)		*t*/χ2	*p*
Age	*M*=22	*SD*=4.56	*M*=22.14	*SD*=6.14	0.15	0.89
Gender (female)	64.18%		60.61%		0.18	0.67

of 0.707, 0.696, 0.709, and 0.665, respectively (Yuan *et al.*, 2016). The AMI-SG also demonstrates strong construct validity for assessing attitudes toward PMIH (Yuan *et al.*, 2017).

2.2.2. Attribution questionnaire (AQ)

The AQ (Brown, 2008) is a self-report tool designed to measure public stigma regarding PMIH, focusing on stereotyping, prejudice, and discrimination. It includes 26 items rated on a 9-point Likert scale from 1 (not at all) to 9 (very much). The questionnaire comprises six subscales: (1) Fear/dangerousness, (2) help/interact, (3) responsibility, (4) forcing treatment, (5) empathy, and (6) negative emotions. Internal consistency is high for five subscales and moderate for the responsibility factor, with Cronbach's alpha values of 0.93, 0.82, 0.60, 0.79, 0.77, and 0.81, respectively (Brown, 2008). The AQ demonstrates adequate test-retest reliability and convergent validity with other stigma measures (Brown, 2008). It has been adapted for adolescents, showing validity in its factor structure and internal consistency (Pinto *et al.*, 2012), and has been used to assess public stigma toward various psychological disorders (Johnson-Kwochka *et al.* 2021a).

2.3. Procedure

Participants were recruited through convenience sampling and took part either in person (laboratory-based) or remotely (online). After reviewing an information sheet and providing informed consent, they were randomly assigned to either the intervention group (n = 67) or the active control group (n = 66). Both groups completed the AMI-SG and AQ questionnaires at pre-intervention (Time 1), post-intervention (Time 2), and 1-month follow-up (Time 3). Following pre-intervention measurement, the intervention group viewed a digitally delivered psychoeducational session on psychosis, whereas the active control group watched an educational video on obesity, which was unrelated to mental health. Both groups completed the post-intervention questionnaire and returned for the

1-month follow-up. The procedures were standardized through online delivery through Qualtrics. Regardless of the setting, all participants used the same software and followed identical prerecorded instructions. No additional information was provided by the experimenter in the lab. All research activities, including reviewing the information sheet, providing written consent, completing questionnaires, and participating in the intervention, were conducted electronically. Double-blinding of allocation outcomes was maintained throughout the data collection period.

2.4. Intervention

The psychoeducational intervention video used in this study included several sections: an introduction to psychosis, its incidence and prevalence, anomalous experiences and paranoid ideation in the general population, a psychosocial understanding of psychosis, cognitive-behavioral formulation and interventions for psychosis, and a case vignette featuring a client's recovery story from a CBTp. The active control video followed a similar format but covered obesity: an introduction to obesity, its prevalence, experiences of obesity, its development and maintenance, health implications, lifestyle interventions, and a case vignette with a recovery story. Both videos were 30 min long and featured a slideshow with a voiceover by the same narrator. Although the topics differed between the intervention and active control groups, the format, structure, delivery method, narration, and duration were kept consistent. The researchers chose a health-related topic for the control group to ensure that any observed effects were specifically due to the psychoeducation on psychosis, rather than just exposure to general health information.

2.5. Data analyses

An independent samples *t*-test was used to verify that the intervention and control groups were equivalent before the intervention and to compare the change scores from pre-intervention to post-intervention for each subscale. A mixed ANOVA with a 3 (time: Pre-intervention, post-intervention, follow-up) × 2 (group: intervention, control) design, including repeated measures for time, was conducted to assess the interaction effect between time and group for subscales showing significant differences in the *t*-test. *Post hoc* analyses were conducted to determine if significant changes were maintained at follow-up. The AMI-SG and AQ subscales were analyzed separately, as each subscale measures a distinct aspect of public stigma. All subscales have been individually validated and have demonstrated strong psychometric properties (Brown, 2008; Yuan *et al.*; 2016).

3. Results

3.1. Effects of psychoeducation on public stigma

No significant differences were found between the intervention and control groups at pre-intervention for any subscales ($p > 0.05$), as shown in Table 2. The mean scores for each subscale at pretest, post-test, and follow-up for both groups are detailed in Table 3.

As shown in Table 4, the independent samples *t*-test revealed that the intervention group had significantly greater changes in scores from pre-intervention to post-intervention than the control group for eight subscales: fear/dangerousness, help/interact, responsibility, forcing treatment, empathy, social distancing, social restrictiveness, and prejudice/misconception ($p < 0.05$). However, the changes in scores for the negative emotions and tolerance/support subscales from pre-intervention to post-intervention were not significantly different between the two groups ($p > 0.05$).

A two-way mixed ANOVA revealed significant interactions between time and group for the following subscales: fear/dangerousness [$F(1.76, 230.58) = 4.89$, $p = 0.01$, $\eta_p^2 = .036$], help/interact [$F(2, 262) = 10.76$, $p < 0.001$, $\eta_p^2 = 0.076$], responsibility [$F(2, 262) = 3.71$, $p = 0.03$, $\eta_p^2 = 0.028$], and social distancing [$F(1.91, 250.11) = 3.56$, $p = 0.03$, $\eta_p^2 = 0.026$]. *Post hoc* analyses revealed that the intervention group maintained a significant reduction in fear/dangerousness ($p = 0.26$) and a significant increase in help/interact ($p = 0.09$) at follow-up, with these scores

Table 2. Independent samples *t*-test comparing the baseline scores of the intervention and control groups for AQ and AMI-SG subscales

Subscale	Intervention		Control		*t* (131)	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
FD	22.45	9.76	22.89	11.21	0.25	0.81	0.042
HI	33.36	8.23	34.97	10.49	0.99	0.33	0.171
R	8.66	3.37	8.79	3.84	0.21	0.83	0.036
FT	13.58	4.79	12.86	4.96	−0.85	0.40	−0.147
E	20.79	3.56	21.09	3.69	0.48	0.63	0.083
NE	7.72	3.58	8.27	3.92	0.85	0.39	0.148
SD	5.55	2.36	5.56	2.46	0.02	0.98	0.003
TS	39.81	3.24	39.11	4.55	−1.02	0.31	−0.177
SR	5.34	2.04	5.15	2.07	−0.54	0.59	−0.093
PM	9.99	2.92	9.38	2.78	−1.23	0.22	−0.212

Abbreviations: FD: Fear/dangerousness; HI: Help/interact; R: Responsibility; FT: Forcing treatment; E: Empathy; NE: Negative emotions; SD: Social distancing; TS: Tolerance/support; SR: Social restrictiveness; PM: Prejudice/misconception.

Table 3. AMI-SG and AQ subscale scores at pre-intervention, post-intervention, and follow-up for the intervention and control groups

Subscale	Group	Pre-intervention		Post-intervention		Follow-up	
		M	*SD*	*M*	*SD*	*M*	*SD*
FD	Intervention	22.45	9.76	15.19	9.38	17.49	8.87
	Control	22.89	11.21	19.61	10.27	20.38	9.34
HI	Intervention	33.36	8.23	40.22	8.43	37.78	8.61
	Control	34.97	10.49	37.23	9.46	35.02	8.77
R	Intervention	8.66	3.37	10.25	3.96	9.13	4.00
	Control	8.79	3.84	8.70	4.37	8.32	4.28
FT	Intervention	13.58	4.79	10.94	5.10	11.64	5.51
	Control	12.86	4.96	11.67	5.18	11.77	5.51
E	Intervention	20.79	3.56	21.45	3.49	20.31	3.58
	Control	21.09	3.69	20.74	4.10	20.46	4.50
NE	Intervention	7.72	3.58	6.61	3.47	7.02	3.41
	Control	8.27	3.92	7.24	4.37	7.70	3.97
SD	Intervention	5.55	2.36	4.63	1.95	5.08	2.08
	Control	5.56	2.46	5.39	2.33	5.26	1.92
TS	Intervention	39.81	3.24	40.96	3.46	40.52	3.38
	Control	39.11	4.55	39.96	3.96	39.71	3.73
SR	Intervention	5.34	2.04	4.66	1.75	5.13	1.95
	Control	5.15	2.07	5.08	2.19	5.14	1.81
PM	Intervention	9.99	2.92	9.19	3.09	9.61	2.92
	Control	9.38	2.78	9.46	3.14	9.53	2.57

Abbreviations: FD: Fear/dangerousness; HI: Help/interact; R: Responsibility; FT: Forcing treatment; E: Empathy; NE: Negative emotions; SD: Social distancing; TS: Tolerance/support; SR: Social restrictiveness; PM: Prejudice/misconception.

Table 4. Results of independent samples *t*-test comparing the changes in scores from pre-intervention to post-intervention for AQ and AMI-SG subscales between the intervention and control groups

Subscale	Intervention		Control		*df*	*t*	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*				
FD	−7.25	6.49	−3.29	6.06	131	−3.64	<0.001	−0.63
HI	6.87	6.76	2.26	5.86	128.96	4.20	<0.001	0.73
R	1.60	4.37	−0.09	2.61	108.03	2.71	0.008	0.47
FT	−2.64	3.72	−1.20	2.96	131	−2.48	0.015	−0.43
E	0.66	2.51	−0.35	2.42	131	2.35	0.020	0.41
NE	−1.10	3.25	−1.03	2.94	131	−0.14	0.890	−0.02
SD	−0.93	1.69	−0.17	1.51	131	−2.73	0.007	−0.47
TS	1.15	2.25	0.85	2.60	131	0.71	0.477	0.12
SR	−0.69	1.53	−0.08	1.06	117.47	−2.68	0.008	−0.47
PM	−0.79	1.90	0.08	2.00	131	−2.57	0.011	−0.45

Abbreviations: FD: Fear/dangerousness; HI: Help/interact; R: Responsibility; FT: Forcing treatment; E: Empathy; NE: Negative emotions; SD: Social distancing; TS: Tolerance/support; SR: Social restrictiveness; PM: Prejudice/misconception.

remaining significantly different from those at pre-intervention ($p < 0.001$). However, the significant effects of responsibility and social distancing in the intervention group were not sustained at follow-up, as indicated by nonsignificant differences between pre-intervention and follow-up scores for these factors ($p > 0.05$).

The ANOVA results for forcing treatment, empathy, social restrictiveness, and prejudice/misconception indicated no significant interaction between time and group ($p > 0.05$). Therefore, the notable effects observed from pretest to post-test for these factors were not maintained at follow-up, and no *post hoc* analyses were performed. Figure 2 shows the changes in subscale scores over time for both the intervention and control groups.

Internal consistencies for each AMI-SG subscale were calculated based on item scores in this study, with Cronbach's alpha values of 0.74 for the 3-item social distancing subscale, 0.75 for the 9-item tolerance and support subscale, 0.66 for the 3-item social restrictiveness subscale, and 0.54 for the 5-item prejudice and misconception subscale. For the AQ, the fear/dangerousness subscale had 7 items ($\alpha = 0.93$), the help and interact subscale had 6 items ($\alpha = 0.86$), the responsibility subscale had 3 items ($\alpha = 0.67$), the forcing treatment subscale had 4 items ($\alpha = 0.62$), the empathy subscale had 3 items ($\alpha = 0.73$), and the negative emotions subscale had 3 items ($\alpha = 0.75$). Cronbach's alpha assesses internal consistency, with higher values indicating that items within a subscale are closely related and reliably measure a specific construct (Hajjar, 2018). In general, a Cronbach's alpha value of 0.7 or above suggests adequate internal consistency (Hajjar, 2018). However, alpha values can be affected by the number of items, and a small number may lead to an underestimation of reliability (Hajjar, 2018; Tavakol & Dennick, 2011). In addition, significant results often require a large sample size, typically over 200 (Hajjar, 2018). Given that subscales with lower Cronbach's alpha values had fewer items and the current study's sample size was 133, the internal consistency reliability might be underestimated. Therefore, all subscales were included in the present study.

4. Discussion

The results of the present study demonstrate that a digital single-session cognitive behavioral psychoeducation intervention effectively reduced several aspects of public stigma related to psychosis in the short term. These aspects include fear and perceived dangerousness, coercive treatment, social distancing, social restrictiveness, and prejudice and misconception about PMIH, compared with active control. The intervention also led to significant improvements in the help and interact and empathy components of stigma. However, at the 1-month follow-up, significant effects were only maintained for fear and perceived dangerousness and help and interact. There were no significant changes in negative emotions and tolerance and support from pre-intervention to post-intervention compared with the control group. In addition, the responsibility subscale showed a significant increase post-intervention relative to the control, contrary to our initial hypothesis.

Our findings of significant changes from pre-intervention to post-intervention align with existing literature on the effectiveness of cognitive behavioral psychoeducation in reducing public stigma (Alonso *et al.*, 2019; Kimmerle & Cress, 2013; Li *et al.*, 2015). Consistent with recommendations emphasizing the importance of

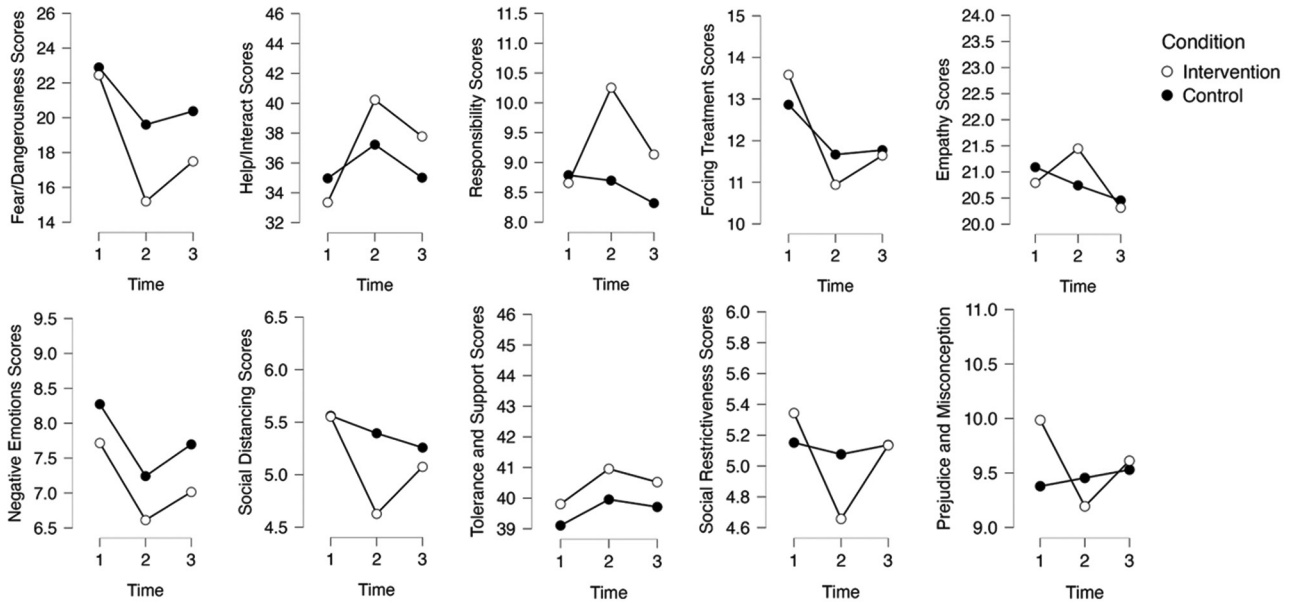


Figure 2. Changes in scores for each subscale over time for the intervention and control groups

addressing misconceptions about PMIH, sharing lived experiences, and highlighting recovery potential (Corrigan *et al.*, 2012; Knaak *et al.*, 2014), this study shows that a brief, cost-effective, 30-min digital psychoeducational session incorporating these elements effectively reduces public stigma across multiple dimensions.

However, significant effects did not persist from post-intervention to follow-up for five stigma-related factors: coercive treatment, empathy, social distancing, social restrictiveness, and prejudice and misconception. This lack of sustained impact may be due to participants' continued exposure to societal stigma about PMIH during the 1 month period after the intervention, which diminished the benefits of psychoeducation on a broader, community level (Na *et al.*, 2022). Previous studies have highlighted the strong influence of sociocultural norms and beliefs on maintaining public stigma (Angermeyer & Dietrich, 2006; Cheon & Chiao, 2012; Yang *et al.*, 2007). In Singapore's collectivistic society, stigmatizing and discriminatory beliefs are common, with PMIH often linked to negative traits (Lai *et al.*, 2000; Mankiewicz & Kam, 2024; Ong *et al.*, 2020). These cultural norms may reinforce misconceptions and hinder long-term change. For example, societal pressure to conform can perpetuate views of mental ill-health as abnormal and deviant from accepted norms (Abdullah & Brown, 2011). Thus, while the psychoeducational intervention was effective in reducing stigma on an individual level immediately after the intervention, it was less effective in maintaining these changes over time due to the strong cultural influences encountered by participants between the post-intervention and follow-up measurements.

However, significant effects were maintained at follow-up for the dimensions of fear and dangerousness. Several studies have highlighted the importance of including factual information that directly addresses and corrects misconceptions about mental ill-health and psychosis in psychoeducational interventions (Corrigan *et al.*, 2000; Corrigan *et al.*, 2012; Lincoln *et al.*, 2008; Tan & Mankiewicz, 2024). This suggests that providing relevant information is crucial for achieving and maintaining a long-term reduction in stigma. The sustained reduction in fear and perceived dangerousness at follow-up may be attributed to the intervention's focus on directly countering the myth that people with psychosis are dangerous, consistent with existing evidence (Schrack *et al.*, 2021).

The continued increase in willingness to help and interact at follow-up might be influenced by collectivistic values. Research indicates that people with collectivistic values are more likely to engage with, cooperate with, and support others than those with individualistic values (Grusec *et al.*, 2002; Lampridis & Papastylianou, 2014; Markus & Kitayama, 1991; Martí-Vilar *et al.*, 2019). Singaporeans often value maintaining harmony and showing kindness, which aligns with collectivistic values (Chang *et al.*, 2003). Therefore, the sustained increase in participants' willingness to help and interact with PMIH may reflect these local collectivistic values.

Interestingly, there were no significant changes in negative emotions from pre-intervention to post-intervention compared with the control group. As the only factor measuring affective responses, its lack of significant change might be due to affective reactions toward mental ill-health being more resistant to change than cognitive and behavioral aspects of stigma (Na *et al.*, 2022). Psychoeducational interventions focus on providing knowledge to challenge incorrect stereotypes, which likely impacts cognitive rather than affective responses (Na *et al.*, 2022). This may explain why our findings did not align with the original hypothesis.

The lack of significant increase in tolerance and support from pre-intervention to post-intervention may be due to this factor encompassing all three dimensions of public stigma: stereotyping, prejudice, and discrimination. The complex nature of public stigma, influenced by cultural factors as noted by Abdullah & Brown (2011), may have limited the effectiveness of the psychoeducational intervention in significantly boosting tolerance and support. Some researchers suggest that educational materials alone might have limited impact on reducing public stigma, particularly if interventions focus solely on individual mechanisms (Corrigan *et al.*, 2000; Rao *et al.*, 2019).

Therefore, psychoeducational interventions may need to go beyond individual-level delivery and include strategies targeting stigma at a systemic level, such as within families and communities, to achieve substantial and lasting change across all aspects of stigma (Hinshaw & Stier, 2008). Multilevel interventions should also integrate evidence-based strategies to address public stigma effectively (Rao *et al.*, 2019). For example, FIp, which is evidence-based and used in clinical settings, has demonstrated positive effects in reducing negative caregiver evaluations and enhancing empathy toward family members with psychosis (Girón *et al.*, 2014; Lowenstein *et al.*, 2010). Since psychoeducation is a key component of FIp and contributes to these outcomes (Onwumere *et al.*, 2018), it suggests its potential as a systemic intervention for addressing misperceptions about psychosis. Thus, psychoeducational interventions may also need to be implemented at a systemic level to effectively improve and sustain changes in the multidimensional aspects of stigma, especially

in collectivistic cultures. Previous research supports the effectiveness of family-based psychoeducational interventions for complex mental health conditions in such societies. For example, Ran *et al.* (2015) found that systemic psychoeducation involving families of individuals with psychosis in China was beneficial and its effects were maintained over a 14-year follow-up. This outcome has not yet been replicated in individualistic Western societies. In addition, recent research by Mankiewicz *et al.* (2021) has demonstrated the cross-cultural acceptability of FIp, including among Asian families.

An unexpected finding of the present study was that personal responsibility for difficulties related to PMIH significantly increased after the intervention. According to the responsibility model of attribution theory, if individuals are seen as responsible for their own difficulties and if these difficulties are perceived as controllable, they may be held personally responsible, which can influence negative emotional responses and discriminatory behavior (Corrigan *et al.*, 2003; Hinshaw & Stier, 2008). Therefore, psychoeducation was anticipated to reduce attributions of personal responsibility, leading to decreased prejudicial attitudes and discrimination. Although this finding appears to contradict established literature, a recent study by Johnson-Kwochka *et al.* (2021b) found a strong positive association between higher responsibility attribution and increased willingness to help or interact.

Johnson-Kwochka *et al.* (2021b) suggested that attributing personal responsibility to PMIH may not imply blame but rather indicate a belief that individuals have control over their recovery and can benefit from assistance. Our findings support this view, as they show a significant increase in participants' willingness to help and interact with individuals experiencing psychosis following psychoeducation. Considering the reduction in stigma observed on most subscales post-intervention, our results challenge the assumption that higher responsibility attribution necessarily leads to more stigmatizing attitudes and behaviors. Furthermore, rather than reinforcing the disease paradigm of schizophrenia, which portrays individuals as disabled and unable to recover (Mankiewicz, 2013), our psychoeducational intervention was based on a cognitive behavioral model of psychosis, which views unhelpful delusional thoughts and safety behaviors as controllable and subject to change (Mander & Kingdon, 2015). Therefore, the observed increase in perceived controllability may represent a positive shift in how individuals with psychosis are viewed, from being seen as severely ill and needing separation from society to being capable of managing their well-being and having the potential for recovery (Mankiewicz, 2015).

The need to use existing research to enhance health spending has been emphasized in recent literature (Idris *et al.*, 2024). Leviton (2017) suggested that empirical studies on evidence-based public health interventions should address common clinical challenges and provide practical knowledge for solving these issues. Research shows that public stigma associated with severe mental health conditions, such as psychosis, exacerbates social isolation and economic inactivity among affected individuals, hindering their ability to seek professional help and access health-care services, which in turn extends the duration of untreated psychosis (Clement *et al.*, 2015; Schomerus *et al.*, 2019). As noted earlier, the global socioeconomic impact of this situation is substantial, involving both direct health-care costs and indirect costs related to prolonged unemployment (Chong *et al.*, 2016). This is true for both Western and Asian societies (Zhai, 2013), with mental health professionals in Asia identifying public stigma as a significant barrier to accessing and engaging with health-care services for individuals with psychosis (Wen & Mankiewicz, 2024). Our study provides preliminary evidence supporting a structured, theory-based, and evidence-informed intervention to address this widespread stigma. Such an approach can help individuals seek help, access professional services, support their recovery, return to work, and contribute economically to their community and society. The psychoeducational intervention, being brief and delivered digitally, is highly cost-effective and can be easily distributed through online platforms, social media, or mental health service websites. It is ideally suitable as part of larger systemic campaigns addressing this issue. This aligns with the digital global health-care model currently promoted by G20 (Ramaprasad *et al.*, 2023).

This study had several limitations. Although the psychoeducational intervention included relevant information to counter general misconceptions about psychosis, it did not address specific societal myths and stigmas prevalent in Singapore, such as increased aggression or self-harm tendencies, as highlighted by Mankiewicz & Kam (2024). Given that culture strongly influences stereotypical views and prejudicial beliefs (Cheon & Chiao, 2012), there is a need for culturally tailored interventions. Future research should compare the effectiveness of psychoeducational content that addresses general misconceptions with content customized for specific cultural contexts. In addition, we could not conclusively determine the effectiveness of psychoeducation as a systemic intervention, as it was applied individually. As Mankiewicz and Tan (2024) have recently suggested, exploring psychoeducation in community and health-care settings could provide insights into its effectiveness as a

multilevel intervention, especially in collectivistic cultures. Furthermore, implementing such interventions at an organizational level within mental health services might be beneficial for individuals receiving multidisciplinary support (Mankiewicz & Tan, 2024).

5. Conclusion

Our study showed that a brief, structured, digitalized, single-session cognitive behavioral psychoeducational intervention delivered individually can effectively reduce public stigma related to psychosis, as indicated by significant decreases in several components post-intervention. However, the lack of sustained effects at follow-up suggests that individual interventions alone may not be sufficient for long-term stigma reduction, especially in collectivistic societies. Therefore, there is a need to develop and test psychoeducational interventions that address stigma and discrimination on a systemic, community-wide level.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Data curation: Pawel D. Mankiewicz
Formal analysis: Jaye J.Y. Wong
Investigation: Jaye J.Y. Wong
Methodology: All authors
Project administration: All authors
Resources: Pawel D. Mankiewicz
Supervision: Pawel D. Mankiewicz
Writing – original draft: All authors
Writing – review & editing: Pawel D. Mankiewicz

Ethics approval and consent to participate

Ethical approval was granted by the DERC at the NUS and was subsequently endorsed by the NUS IRB, reference code 2022-September-10. This research was conducted in conformance with the Declaration of Helsinki.

Consent for publication

All participants provided informed written consent to take part in the study and for the results to be published. The questionnaires were completed anonymously by the participants, and their personal data were securely discarded following their participation in the study. Thus, no individually identifiable data were utilized in this publication.

Availability of data

In accordance with the received ethical approval, the de-identified and anonymized data pertinent to this study are being stored securely at the NUS for duration of 10 years following the conclusion of the study. However, it will be made available to other researchers upon a reasonable request from the corresponding author.

References

Abdullah, T., & Brown, T.L. (2011). Mental illness stigma and ethnocultural beliefs, values, and norms: An integrative review. *Clinical Psychology Review*, 31(6):934-948.

https://doi.org/10.1016/j.cpr.2011.05.003

Alonso, M., Guillén, A.I., & Muñoz, M. (2019). Interventions to reduce internalized stigma in individuals with mental illness: A systematic review. *The Spanish Journal of Psychology*, 22:e27.

https://doi.org/10.1017/sjp.2019.9

Ang, M.S., Rekhi, G., & Lee, J. (2020). Vocational profile and correlates of employment in people with schizophrenia: The role of avolition. *Frontiers in Psychiatry*, 11:856.

https://doi.org/10.3389/fpsyt.2020.00856

Angermeyer, M.C., & Dietrich, S. (2006). Public beliefs about and attitudes towards people with mental illness: A review of population studies. *Acta Psychiatrica Scandinavica*, 113(3):163-179.

https://doi.org/10.1111/j.1600-0447.2005.00699.x

Angermeyer, M.C., & Matschinger, H. (2004). The stereotype of schizophrenia and its impact on discrimination against people with schizophrenia: Results from a representative survey in Germany. *Schizophrenia Bulletin*, 30(4): 1049-1061.

https://doi.org/10.1093/oxfordjournals.schbul.a007120

Arciniegas, D.B. (2015). Psychosis. *Continuum (Minneap Minn)*, 21(3):715-736.

https://doi.org/10.1212/01.con.0000466662.89908.e7

Benbow, A. (2007). Mental illness, stigma, and the media. *The Journal of Clinical Psychiatry*, 68 Suppl 2:31-35.

Blair Irvine, A., Billow, M.B., Eberhage, M.G., Seeley, J.R., McMahon, E., & Bourgeois, M. (2012). Mental illness training for licensed staff in long-term care. *Issues in Mental Health Nursing*, 33(3):181-194.

https://doi.org/10.3109/01612840.2011.639482

Bodenhausen, G.V., & Richeson, J.A. (2010). Prejudice, stereotyping, and discrimination. In: Baumeister, R.F., & Finkel, E.J. (eds). Advanced Social Psychology: The State of the Science. Oxford: Oxford University Press, p.341-383.

Brohan, E., Slade, M., Clement, S., & Thornicroft, G. (2010). Experiences of mental illness stigma, prejudice and discrimination: A review of measures. *BMC Health Services Research*, 10(1):80.

https://doi.org/10.1186/1472-6963-10-80

Brown, S.A. (2008). Factors and measurement of mental illness stigma: A psychometric examination of the attribution questionnaire. *Psychiatric Rehabilitation Journal*, 32(2):89-94.

https://doi.org/10.2975/32.2.2008.89.94

Chang, W.C., Wong, W.K., & Koh, J.B.K. (2003). Chinese values in Singapore: Traditional and modern. *Asian Journal of Social Psychology*, 6(1):5-29.

https://doi.org/10.1111/1467-839x.t01-1-00007

Cheon, B.K., & Chiao, J.Y. (2012). Cultural variation in implicit mental illness stigma. *Journal of Cross-Cultural Psychology*, 43(7):1058-1062.

https://doi.org/10.1177/0022022112455457

Chong, H.Y., Teoh, S.L., Wu, D.B.C., Kotirum, S., Chiou, C.F., & Chaiyakunapruk, N. (2016). Global economic burden of schizophrenia: A systematic review. *Neuropsychiatric Disease and Treatment*, 12:357-373.

https://doi.org/10.2147/NDT.S96649

Chua, Y.C., Abdin, E., Tang, C., Subramaniam, M., & Verma, S. (2019). First-episode psychosis and vocational outcomes: A predictive model. *Schizophrenia Research,* 211:63-68.

https://doi.org/10.1016/j.schres.2019.07.009

Clement, S., Schauman, O., Graham, T., Maggioni, F., Evans-Lacko, S., Bezborodovs, N., *et al.* (2015). What is the impact of mental health-related stigma on help-seeking? A systematic review of quantitative and qualitative studies. *Psychological Medicine*, 45(1):11-27.

https://doi.org/10.1017/s0033291714000129

Cohen, J. (1988). Statistical Power Analysis for the Behavioural Sciences. 2nd ed. Oxfordshire: Routledge.

https://doi.org/10.4324/9780203771587

Corrigan, P.W. (2006). Mental health stigma as social attribution: Implications for research methods and attitude change. *Clinical Psychology: Science and Practice*, 7(1):48-67.

https://doi.org/10.1093/clipsy.7.1.48

Corrigan, P.W., & Bink, A.B. (2016). The stigma of mental illness. In: Encyclopedia of Mental Health. Netherlands: Elsevier Inc., p.230-234.

https://doi.org/10.1016/b978-0-12-397045-9.00170-1

Corrigan, P.W., & Kleinlein, P. (2005). The impact of mental illness stigma. In: Corrigan, P.W. (eds). On the Stigma of Mental illness: Practical Strategies for Research and Social Change. American Psychological Association, p.11-44.

https://doi.org/10.1037/10887-001

Corrigan, P.W., & Shapiro, J.R. (2010). Measuring the impact of programs that challenge the public stigma of mental illness. *Clinical Psychology Review*, 30(8):907-922.

https://doi.org/10.1016/j.cpr.2010.06.004

Corrigan, P.W., & Watson, A.C. (2002a). Understanding the impact of stigma on people with mental illness. *World Psychiatry: Official Journal of the World Psychiatric Association (WPA)*, 1(1):16-20.

Corrigan, P.W., & Watson, A.C. (2002b). The paradox of self-stigma and mental illness. *Clinical Psychology: Science and Practice*, 9(1):35-53.

https://doi.org/10.1093/clipsy.9.1.35

Corrigan, P.W., Bink, A.B., Fokuo, J.K., & Schmidt, A. (2015). The public stigma of mental illness means a difference between you and me. *Psychiatry Research*, 226(1):186-191.

https://doi.org/10.1016/j.psychres.2014.12.047

Corrigan, P.W., Green, A., Lundin, R., Kubiak, M.A., & Penn, D.L. (2001). Familiarity with and social distance from people who have serious mental illness. *Psychiatric Services*, 52(7):953-958.

https://doi.org/10.1176/appi.ps.52.7.953

Corrigan, P.W., Markowitz, F.E., & Watson, A.C. (2004). Structural levels of mental illness stigma and discrimination. *Schizophrenia Bulletin*, 30(3):481-491.

https://doi.org/10.1093/oxfordjournals.schbul.a007096

Corrigan, P.W., Markowitz, F.E., Watson, A., Rowan, D., & Kubiak, M.A. (2003). An attribution model of public discrimination towards persons with mental illness. *Journal of Health and Social Behavior*, 44(2):162-179.

https://doi.org/10.2307/1519806

Corrigan, P.W., Morris, S.B., Michaels, P.J., Rafacz, J.D., & Rüsch, N. (2012). Challenging the public stigma of mental illness: A meta-analysis of outcome studies. *Psychiatric Services*, 63(10):963-973.

https://doi.org/10.1176/appi.ps.201100529

Corrigan, P.W., River, L.P., Lundin, R.K., Uphoff Wasowski, K., Campion, J., Mathisen, J., *et al.* (2000). Stigmatizing attributions about mental illness. Journal of Community Psychology, 28(1):91-102.

https://doi.org/10.1002/(SICI)1520-6629(200001)28:1<91:AID-JCOP9>3.0.CO;2-M

Corrigan, P.W., Rowan, D., Green, A., Lundin, R., River, P.,

Uphoff-Wasowski, K., *et al*. (2002). Challenging two mental illness stigmas: Personal responsibility and dangerousness. *Schizophrenia Bulletin*, 28(2):293-309.

https://doi.org/10.1093/oxfordjournals.schbul.a006939

Corrigan, P.W., Watson, A.C., Heyrman, M.L., Warpinski, A., Gracia, G., Slopen, N., *et al*. (2005). Structural stigma in state legislation. *Psychiatric Services*, 56(5):557-563.

https://doi.org/10.1176/appi.ps.56.5.557

Cox, W.T.L., Abramson, L.Y., Devine, P.G., & Hollon, S.D. (2012). Stereotypes, prejudice, and depression. The integrated perspective. *Perspectives on Psychological Science*, 7(5):427-449.

https://doi.org/10.1177/1745691612455204

Crisp, A.H., Gelder, M.G., Rix, S., Meltzer, H.I., & Rowlands, O.J. (2000). Stigmatisation of people with mental illnesses. *British Journal of Psychiatry*, 177(1):4-7.

https://doi.org/10.1192/bjp.177.1.4

Dalky, H.F. (2011). Mental illness stigma reduction interventions. Review of intervention trials. *Western Journal of Nursing Research*, 34(4):520-547.

https://doi.org/10.1177/0193945911400638

Devine, P.G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology*, 56(1):5-18.

https://doi.org/10.1037/0022-3514.56.1.5

Dovidio, J., Hewstone, M., Glick, P., & Esses, V. (2010). Prejudice, Stereotyping and Discrimination: Theoretical and Empirical Overview. United States: Sage Publications Ltd., p.3-28.

Economou, M.P. (2015). Psychoeducation: A multifaceted intervention. *International Journal of Mental Health*, 44(4):259-262.

https://doi.org/10.1080/00207411.2015.1076288

Evensen, S., Wisløff, T., Lystad, J.U., Bull, H., Ueland, T., & Falkum E. (2016). Prevalence, employment rate, and cost of schizophrenia in a high-income welfare society: A population-based study using comprehensive health and welfare registers. *Schizophrenia Bulletin*, 42(2):476-483.

https://doi.org/10.1093/schbul/sbv141

Girón, M., Nova-Fernández, F., Mañá-Alvarenga, S., Nolasco, A., Molina-Habas, A., Fernández-Yañez, A., *et al*. (2014). How does family intervention improve the outcome of people with schizophrenia? *Social Psychiatry and Psychiatric Epidemiology*, 50(3):379-387.

https://doi.org/10.1007/s00127-014-0942-9

Grusec, J.E., Davidov, M., & Lundell, L. (2002). Prosocial and helping behavior. In: Smith, P.K., & Hart, C.H. (eds.). Blackwell Handbook of Childhood Social Development. United States: Blackwell Publishing, p.457-474.

Hajjar, S.T. (2018). Statistical analysis: Internal-consistency reliability and construct validity. *International Journal of Quantitative and Qualitative Research Methods*, 6(1):27-38.

Hatzenbuehler, M.L., & Link, B.G. (2014). Introduction to the special issue on structural stigma and health. *Social Science and Medicine*, 103:1-6.

https://doi.org/10.1016/j.socscimed.2013.12.017

Heider, F. (1958). The Psychology of Interpersonal Relations. United States: John Wiley and Sons Inc.

https://doi.org/10.1037/10628-000

Henderson, C., Evans-Lacko, S., & Thornicroft, G. (2013). Mental illness stigma, help seeking, and public health programs. *American Journal of Public Health*, 103(5):777-780.

https://doi.org/10.2105/AJPH.2012.301056

Hinshaw, S.P., & Stier, A. (2008). Stigma as related to mental disorders. *Annual Review of Clinical Psychology*, 4(4):367-393.

https://doi.org/10.1146/annurev.clinpsy.4.022007.141245

Idris, F.M., Seraj, M., & Ozdeser, H. (2024). Impact of health expenditure on poverty in low- and middle-income countries: An autoregressive distributed lag bounds approach. *Global Health Economics and Sustainability*, 2(1):2383.

https://doi.org/10.36922/ghes.2383

Johnson-Kwochka, A., Aalsma, M.C., Monahan, P.O., & Salyers, M.P. (2021a). Development and examination of the attribution questionnaire-substance use disorder (AQ-SUD) to measure public stigma towards adolescents experiencing substance use disorders. *Drug and Alcohol Dependence*, 221:108600.

https://doi.org/10.1016/j.drugalcdep.2021.108600

Johnson-Kwochka, A., Minor, K.S., Ashburn-Nardo, L., Wu, W., Stull, L.G., & Salyers, M.P. (2021b). A new look at the attribution model: Considerations for the measurement of public mental illness stigma. *Stigma and Health*, 9(1):1-8.

https://doi.org/10.1037/sah0000288

Johnstone, M.J. (2001). Stigma, social justice and the rights of the mentally ill: Challenging the status quo. *Australian and New Zealand Journal of Mental Health Nursing*, 10(4):200-209.

https://doi.org/10.1046/j.1440-0979.2001.00212.x

Jorm, A.F., & Griffiths, K.M. (2008). The public's stigmatizing attitudes towards people with mental disorders: How important are biomedical conceptualizations? *Acta Psychiatrica Scandinavica*, 118(4):315-321.

https://doi.org/10.1111/j.1600-0447.2008.01251.x

Kadakia, A., Catillon, M., Fan, Q., Williams, R., Marden, J., Anderson, A., *et al*. (2022). The economic burden of schizophrenia in the United States. Journal of Clinical Psychiatry, 83(6):22m14458.

https://doi.org/10.4088/JCP.22m14458

Kapadia, D. (2023). Stigma, mental illness and ethnicity: Time to centre racism and structural stigma. *Sociology of Health and Illness*, 45(4):855-871.

https://doi.org/10.1111/1467-9566.13615

Kellett, S., Clarke, S., & Matthews, L. (2007). Delivering group psychoeducational CBT in primary care: Comparing outcomes with individual CBT and individual psychodynamic-interpersonal psychotherapy. *British Journal of Clinical Psychology*, 46(2):211-222.

https://doi.org/10.1348/014466506x146188

Kimmerle, J., & Cress, U. (2013). The effects of TV and film exposure on knowledge about and attitudes toward mental disorders. *Journal of Community Psychology*, 41(8):931-943.

https://doi.org/10.1002/jcop.21581

Knaak, S., Mantler, E., & Szeto, A. (2017). Mental illness-related stigma in healthcare: Barriers to access and care and evidence-based solutions. *Healthcare Management Forum*, 30(2):111-116.

https://doi.org/10.1177/0840470416679413

Knaak, S., Modgill, G., & Patten, S.B. (2014). Key ingredients of anti-stigma programs for health care providers: A data synthesis of evaluative studies. *Canadian Journal of Psychiatry*, 59(10 Suppl 1):S19-S26.

https://doi.org/10.1177/070674371405901s06

Kotzeva, A., Mittal, D., Desai, S., Judge, D., & Samanta, K. (2023). Socioeconomic burden of schizophrenia: A targeted literature review of types of costs and associated drivers across 10 countries. *Journal of Medical Economics*, 26(1):70-83.

https://doi.org/10.1080/13696998.2022.2157596

Kutcher, S., Wei, Y., & Coniglio, C. (2016). Mental health literacy: Past, present, and future. *The Canadian Journal of Psychiatry*, 61(3):154-158.

https://doi.org/10.1177/0706743715616609

Lai, Y., Hong, P., Chee, Y., & Yew, L. (2000). Stigma of mental illness. *Singapore Medical Journal*, 42(3):111-114.

Lampridis, E., & Papastylianou, D. (2014). Prosocial behavioural tendencies and orientation towards individualism-collectivism of Greek young adults. *International Journal of Adolescence and Youth*, 22(3):268-282.

https://doi.org/10.1080/02673843.2014.890114

Lee, S., Chiu, M.Y.L., Tsang, A., Chui, H., & Kleinman, A. (2006). Stigmatizing experience and structural discrimination associated with the treatment of schizophrenia in Hong Kong. *Social Science and Medicine*, 62(7):1685-1696.

https://doi.org/10.1016/j.socscimed.2005.08.016

Leviton, L.C. (2017). Generalizing about public health interventions: A mixed-methods approach to external validity. *Annual Review of Public Health,* 38:371-391.

https://doi.org/10.1146/annurev-publhealth-031816-044509

Li, J., Li, J., Thornicroft, G., Yang, H., Chen, W., & Huang, Y. (2015). Training community mental health staff in Guangzhou, China: Evaluation of the effect of a new training model. *BMC Psychiatry*, 15(1):263.

https://doi.org/10.1186/s12888-015-0660-1

Lincoln, T.M., Arens, E., Berger, C., & Rief, W. (2008). Can antistigma campaigns be improved? A test of the impact of biogenetic vs psychosocial causal explanations on implicit and explicit attitudes to schizophrenia. *Schizophrenia Bulletin*, 34(5):984-994.

https://doi.org/10.1093/schbul/sbm131

Livingston, J.D. (2013). Mental Illness-Related Structural Stigma: The Downward Spiral of Systemic Exclusion Final Report. Ontario: Mental Health Commission of Canada. Available from: https://mentalhealthcommission.ca/resource/mental-illness-related-structural-stigma-the-downward-spiral-of-systemic-exclusion-final-report [Last accessed on 2024 Apr 04].

Lowenstein, J.A., Butler, D.W., & Ashcroft, K. (2010). The efficacy of a cognitively orientated carers group in an early intervention in psychosis service--a pilot study. *Journal of Psychiatric and Mental Health Nursing*, 17(7):628-635.

https://doi.org/10.1111/j.1365-2850.2010.01564.x

Lucksted, A., & Drapalski, A.L. (2015). Self-stigma regarding mental illness: Definition, impact, and relationship to societal stigma. *Psychiatric Rehabilitation Journal*, 38(2):99-102.

https://doi.org/10.1037/prj0000152

Lucksted, A., McFarlane, W., Downing, D., & Dixon, L. (2012). Recent developments in family psychoeducation as an evidence-based practice. *Journal of Marital and Family Therapy*, 38(1):101-121.

https://doi.org/10.1111/j.1752-0606.2011.00256.x

Madianos, M., Economou, M., Peppou, L.E., Kallergis, G., Rogakou, E., & Alevizopoulos, G. (2012). Measuring public attitudes to severe mental illness in Greece: Development of a new scale. *The European Journal of Psychiatry*, 26(1):55-67.

https://doi.org/10.4321/s0213-61632012000100006

Mander, H., & Kingdon, D. (2015). The evolution of cognitive-behavioural therapy for psychosis. *Psychology Research and Behaviour Management*, 8:63-69.

Mankiewicz, P.D. (2013). Cognitive behavioural symptom-oriented understanding of psychosis: Abandoning the disease paradigm of schizophrenia. *Counselling Psychology Review*, 28(1):53-63.

https://doi.org/10.53841/bpscpr.2013.28.1.53

Mankiewicz, P.D. (2015). Toward positive psychosocial practice in psychosis: In pursuit of subjective wellbeing in severe mental ill-health. *International Journal of Wellbeing*, 5(4):120-134.

https://doi.org/10.5502/ijw.v5i4.346

Mankiewicz, P.D. (2019). Cognitive restructuring and graded behavioural exposure for persecutory paranoia and agoraphobic anxiety in complex psychosis. *Clinical Case Studies*, 18(2):143-158.

https://doi.org/10.1177/1534650119826713

Mankiewicz, P.D., & Kam, W.S. (2024). The perception of psychosis among young adults in Southeast Asia: A Singaporean perspective. *Journal of Asia Pacific Counseling*, 14(1):1-26.

https://doi.org/10.18401/2024.14.1.1

Mankiewicz, P.D., & Tan, A.S.Y. (2024). Reducing discrimination against service users with psychosis through brief contact-based video interventions: A randomised control trial. *British Journal of Healthcare Management*, 30(1):14-24.

https://doi.org/10.12968/bjhc.2023.0074

Mankiewicz, P.D., & Turner, C. (2012). Do assertive outreach clients with experiences of psychosis receive the NICE recommended cognitive behavioural interventions? An audit. *Clinical Psychology Forum*, 240:32-37.

https://doi.org/10.53841/bpscpf.2012.1.240.32

Mankiewicz, P.D., & Turner, C. (2014). Cognitive restructuring and graded behavioural exposure for delusional appraisals of auditory hallucinations and comorbid anxiety in paranoid schizophrenia. *Case Reports in Psychiatry,* 14:124564.

https://doi.org/10.1155/2014/124564

Mankiewicz, P.D., Reid, J., Hughes, E.A., & Attard, A. (2021). Management of demographic equality of access to family intervention for psychosis in specialist community mental healthcare teams. *British Journal of Healthcare Management*, 27(8):1-11.

https://doi.org/10.12968/bjhc.2020.0136

Markus, H.R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, 98(2):224-253.

https://doi.org/10.1037/0033-295X.98.2.224

Martí-Vilar, M., Serrano-Pastor, L., & Sala, F.G. (2019). Emotional, cultural and cognitive variables of prosocial behaviour. *Current Psychology*, 38(4):912-919.

https://doi.org/10.1007/s12144-019-0168-9

Mojtabai, R., Stuart, E.A., Hwang, I., Eaton, W.W., Sampson, N., & Kessler, R.C. (2015). Long-term effects of mental disorders on educational attainment in the national comorbidity survey ten-year follow-up. *Social Psychiatry and Psychiatric Epidemiology*, 50(10):1577-1591.

https://doi.org/10.1007/s00127-015-1083-5

Morgan, A.J., Reavley, N.J., Ross, A., Too, L.S., & Jorm, A.F. (2018). Interventions to reduce stigma towards people with severe mental illness: Systematic review and meta-analysis. *Journal of Psychiatric Research*, 103(1):120-133.

https://doi.org/10.1016/j.jpsychires.2018.05.017

Muñoz, M., Guillén, A.I., Pérez-Santos, E., & Corrigan, P.W. (2015). A structural equation modeling study of the Spanish mental illness stigma attribution questionnaire (AQ-27-E). *American Journal of Orthopsychiatry*, 85(3):243-249.

https://doi.org/10.1037/ort0000059

Na, J.J., Park, J.L., LKhagva, T., & Mikami, A.Y. (2022). The efficacy of interventions on cognitive, behavioral, and affective public stigma around mental illness: A systematic meta-analytic review. *Stigma and Health*, 7(2):127-141.

https://doi.org/10.1037/sah0000372

O'Hanlon, B., Hayes, L., Perlesz, A., & Harvey, C. (2018). Understanding the complex family experiences of Behavioural Family Therapy. *Journal of Family Therapy*, 40(1):45-62.

https://doi.org/10.1111/1467-6427.12139

Ong, W.J., Shahwan, S., Goh, C.M.J., Tan, G.T.H., Chong, S.A., & Subramaniam, M. (2020). Daily encounters of mental illness stigma and individual strategies to reduce stigma-perspectives of people with mental illness. *Frontiers in Psychology*, 11:590844.

https://doi.org/10.3389/fpsyg.2020.590844

Onwumere, J., Jansen, J.E., & Kuipers, E. (2018). Editorial: Family interventions in psychosis change outcomes in early intervention settings-how much does the evidence support this? *Frontiers in Psychology*, 9:406.

https://doi.org/10.3389/fpsyg.2018.00406

Pang, S., Liu, J., Mahesh, M., Chua, B.Y., Shahwan, S., Lee, S.P., *et al.* (2017). Stigma among Singaporean youth: A cross-sectional study on adolescent attitudes towards serious mental illness and social tolerance in a multiethnic population. *British Medical Journal Open,* 7(10):1-11.

https://doi.org/10.1136/bmjopen-2017-016432

Pingani, L., Forghieri, M., Ferrari, S., Ben-Zeev, D., Artoni, P., Mazzi, F., *et al.* (2011). Stigma and discrimination toward mental illness: Translation and validation of the Italian version of the attribution questionnaire-27 (AQ-27-I). *Social Psychiatry and Psychiatric Epidemiology*, 47(6):993-999.

https://doi.org/10.1007/s00127-011-0407-3

Pinto, M.D., Hickman, R., Logsdon, M.C., & Burant, C. (2012). Psychometric evaluation of the revised attribution questionnaire (r-AQ) to measure mental illness stigma in adolescents. *Journal of Nursing Measurement,* 20(1):47-58.

https://doi.org/10.1891%2F1061-3749.20.1.47

Ramaprasad, A., Martinez, V., Nunez, A., & Sreeganga, S.D. (2023). Pathways to Universal Digital Access to Inclusive Healthcare in the G20. Think20. Available from: https://t20ind.org/wp-content/uploads/2023/05/t20_policybrief_

tf6_6154.pdf [Last accessed on 2024 Apr 04].

Ran, M.S., Chan, C.L.W., Ng, S.M., Guo, L.T., & Xiang, M.Z. (2015). The effectiveness of psychoeducational family intervention for patients with schizophrenia in a 14-year follow-up study in a Chinese rural area. *Psychological Medicine*, 45(10):2197-2204.

https://doi.org/10.1017/S0033291715000197

Rao, D., Elshafei, A., Nguyen, M., Hatzenbuehler, M.L., Frey, S., & Go, V.F. (2019). A systematic review of multi-level stigma interventions: State of the science and future directions. *BMC Medicine*, 17(1):41.

https://doi.org/10.1186/s12916-018-1244-y

Read, J., Haslam, N., & Magliano, L. (2013). Prejudice, stigma and 'schizophrenia': The role of bio-genetic ideology. In: Read, J., & Dillon, J. (eds.). Models of Madness: Psychological, Social and Biological *Approaches* to Psychosis. Oxfordshire: Routledge, p.157-177.

Rüsch, N., Angermeyer, M.C., & Corrigan, P.W. (2005). Mental illness stigma: Concepts, consequences, and initiatives to reduce stigma. *European Psychiatry*, 20(8):529-539.

https://doi.org/10.1016/j.eurpsy.2005.04.004

Schomerus, G., Stolzenburg, S., Freitag, S., Speerforck, S., Janowitz, D., Evans-Lacko, S., *et al.* (2019). Stigma as a barrier to recognizing personal mental illness and seeking help: A prospective study among untreated persons with mental illness. *European Archives of Psychiatry and Clinical Neuroscience*, 269(4):469-479.

https://doi.org/10.1007/s00406-018-0896-0

Schrack, A., Romaker, E., Joyce-Beaulieu, D., & Zaboski, B.A. (2021). Psychoeducation, relaxation training, and mindfulness. In: Joyce-Beaulieu, D., & Zaboski, B.A. (eds.). Applied Cognitive Behavioral Therapy in Schools. Oxford: Oxford University Press, p.83-100.

https://doi.org/10.1093/med-psych/9780197581384.001.0001

Shamblaw, A.L., Botha, F.B., & Dozois, D.J.A. (2015). Accounting for differences in depression stigma between Canadian Asians and Europeans. *Journal of Cross-Cultural Psychology,* 46(4):597-611.

https://doi.org/10.1177/0022022115575076

Sheehan, L., Nieweglowski, K., & Corrigan, P.W. (2016). Structures and types of stigma. In: Gaebel, W., Rössler, W., & Sartorius, N. (eds.). The Stigma of Mental Illness: End of the Story? Cham: Springer, p.43-66.

https://doi.org/10.1007/978-3-319-27839-1_3

Sijbrandij, M., Kunovski, I., & Cuijpers, P. (2016). Effectiveness of internet-delivered cognitive behavioral therapy for posttraumatic stress disorder: A systematic review and meta-analysis. *Depression and Anxiety*, 33(9):783-791.

https://doi.org/10.1002/da.22533

Singapore Department of Statistics. (2021). Census of Population 2020 Statistical Release 1: Demographic Characteristics, Education, Language and Religion. Singapore Department of Statistics. Available from: https://www.parliament.gov.sg/docs/default-source/default-document-library/cop2020sr1.pdf [Last accessed on 2024 Apr 04].

Sousa, S.D., Marques, A., Rosário, C., & Queirós, C. (2012). Stigmatizing attitudes in relatives of people with schizophrenia: A study using the attribution questionnaire AQ-27. *Trends in Psychiatry and Psychotherapy*, 34(4): 186-197.

https://doi.org/10.1590/s2237-60892012000400004

Stuart, H. (2006). Mental illness and employment discrimination. *Current Opinion in Psychiatry*, 19(5):522-526.

https://doi.org/10.1097/01.yco.0000238482.27270.5d

Stuart, H., & Arboleda-Flórez, J. (2012). A public health perspective on the stigmatization of mental illnesses. *Public Health Reviews*, 34(2):12.

https://doi.org/10.1007/bf03391680

Stuart, H., Milev, R., & Koller, M. (2005). The inventory of stigmatizing experiences: Its development and reliability. *World Psychiatry*, 4(Suppl 1):33-37.

Subramaniam, M., Abdin, E., Picco, L., Pang, S., Shafie, S., Vaingankar, J.A., *et al.* (2017). Stigma towards people with mental disorders and its components: A perspective from multi-ethnic Singapore. *Epidemiology and Psychiatric Sciences*, 26(4):371-382.

https://doi.org/10.1017/S2045796016000159

Subramaniam, M., Zhang, Y., Shahwan, S., Vaingankar, J.A., Satghare, P., Teh, W.L., *et al.* (2022). Employment of young people with mental health conditions: Making it work. *Disability and Rehabilitation,* 44(10):2033-2043.

https://doi.org/10.1080/09638288.2020.1822932

Subu M.A., Wati D.F., Netrida N., Priscilla, V., Dias, J.M., Abraham, M.S., *et al.* (2021). Types of stigma experienced by patients with mental illness and mental health nurses in Indonesia: A qualitative content analysis. *International Journal of Mental Health Systems*, 15(1):77.

https://doi.org/10.1186/s13033-021-00502-x

Suto, M. (2012). Stigma shrinks my bubble: A qualitative study of understandings and experiences of stigma and bipolar disorder. *Stigma Research and Action*, 2(2):85-92.

Tan, A.S.Y., & Mankiewicz, P.D. (2024). Does a brief contact-based video intervention reduce public mental health stigma associated with psychosis in a collectivistic society? A randomised control trial. *Journal of Mental Health Education, Training and Practice,* 19(1): 21-35.

https://doi.org/10.1108/jmhtep-05-2023-0053

Tan, G.T.H., Shahwan, S., Goh, C.M.J., Ong, W.J., Wei, K.C., Verma, S.K., *et al.* (2020). Mental illness stigma's reasons and determinants (MISReaD) among Singapore's lay public: A qualitative inquiry. *BMC Psychiatry*, 20(422):1-13.

https://doi.org/10.1186/s12888-020-02823-6

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, 2:53-55.

https://doi.org/10.5116/ijme.4dfb.8dfd

Vass, V., Morrison, A.P., Law, H., Dudley, J., Taylor, P., Bennett, K.M., *et al.* (2015). How stigma impacts on people with psychosis: The mediating effect of self-esteem and hopelessness on subjective recovery and psychotic experiences. *Psychiatry Research*, 230(2):487-495.

https://doi.org/10.1016/j.psychres.2015.09.042

Villafana, F. (2017). Coercion as Cure: A Critical History of Psychiatry. Oxfordshire: Routledge.

https://doi.org/10.4324/9781315080994

Waqas, A., Malik, S., Fida, A., Abbas, N., Mian, N., Miryala, S., *et al.* (2020). Interventions to reduce stigma related to mental illnesses in educational institutes: A systematic review. *Psychiatric Quarterly*, 91(3):887-903.

https://doi.org/10.1007/s11126-020-09751-4

Weiner, B. (1995). Judgments of Responsibility: A Foundation for a Theory of Social Conduct. New York: Guilford Press.

Weiner, B., Perry, R.P., & Magnusson, J. (1988). An attributional analysis of reactions to stigmas. *Journal of Personality and Social Psychology*, 55(5):738-748.

https://doi.org/10.1037/0022-3514.55.5.738

Wen, S., & Mankiewicz, P.D. (2024). Practitioner psychologists' perspectives on working with clients with psychosis in a South-East Asian city-state: A qualitative investigation. *Counselling and Psychotherapy Research,* 1-14.

https://doi.org/10.1002/capr.12739

Wood, L., Birtel, M., Alsawy, S., Pyle, M., & Morrison, A. (2014). Public perceptions of stigma towards people with schizophrenia, depression, and anxiety. *Psychiatry Research*, 220(1-2):604-608.

https://doi.org/10.1016/j.psychres.2014.07.012

Yamaguchi, S., Mino, Y., & Uddin, S. (2011). Strategies and future attempts to reduce stigmatization and increase awareness of mental health problems among young people: A narrative review of educational interventions. *Psychiatry and Clinical Neurosciences*, 65(5):405-415.

https://doi.org/10.1111/j.1440-1819.2011.02239.x

Yang, L.H. (2007). Application of mental illness stigma theory to Chinese societies: Synthesis and new directions. *Singapore Medical Journal*, 48(11):977-985.

Yang, L.H., Cho, S.H., & Kleinman, A. (2008). Stigma of mental illness. International Encyclopedia of Public Health. Netherlands: Elsevier, p.219-230.

https://doi.org/10.1016/b978-012373960-5.00047-2

Yang, L.H., Kleinman, A., Link, B.G., Phelan, J.C., Lee, S., & Good, B. (2007). Culture and stigma: Adding moral experience to stigma theory. *Social Science and Medicine*, 64(7):1524-1535.

https://doi.org/10.1016/j.socscimed.2006.11.013

Yuan, Q., Abdin, E., Picco, L., Vaingankar, J.A., Shahwan, S., Jeyagurunathan, A., *et al.* (2016). Attitudes to mental illness and its demographic correlates among general population in Singapore. *PLoS One*, 11(11):e0167297.

https://doi.org/10.1371/journal.pone.0167297

Yuan, Q., Picco, L., Chang, S., Abdin, E., Chua, B.Y., Ong, S., *et al.* (2017). Attitudes to mental illness among mental health professionals in Singapore and comparisons with the general population. *PLoS One*, 12(11):e0187593.

https://doi.org/10.1371/journal.pone.0187593

Zhai, J., Guo, X., Chen, M., Zhao, J., & Su, Z. (2013). An investigation of economic costs of schizophrenia in two areas of China. *International Journal of Mental Health Systems,* 7(26):26.

https://doi.org/10.1186/1752-4458-7-26

Zhang, Z., Sun, K., Jatchavala, C., Koh, J., Chia, Y., Bose, J., *et al.* (2019). Overview of stigma against psychiatric illnesses and advancements of anti-stigma activities in six Asian societies. *International Journal of Environmental Research and Public Health,* 17(1):280.

https://doi.org/10.3390/ijerph17010280

Zvonkovic, A., & Lucas-Thompson, R.G. (2015). Refuting the myth of the "violent schizophrenic": Assessing an educational intervention to reduce schizophrenia stigmatization using self-report and an implicit association test. *Social Work in Mental Health*, 13(3):201-215.

https://doi.org/10.1080/15332985.2014.924463

ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

Affect heuristics and peer effect on substance use among adolescents in Brazil

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Abstract

Significant changes are observed during adolescence with respect to health-related habits and risky behaviors. Among the behavioral changes, the consumption of substances such as alcoholic beverages, cigarettes, and illicit drugs, and social interactions are relevant factors for the intake of such substances. This study aims to analyze the relationship between the joint decisions of substance use by adolescents and their peers from the perspective of the affect heuristics. To this end, a multivariate probit model was estimated, based on microdata from the 2019 National School Health Survey. The results showed that substance use by adolescents was positively related to substance use by their peers; therefore, having friends who consume alcohol, illicit drugs, and cigarettes or having parents who consume alcohol or cigarettes increases the likelihood of an adolescent consuming these substances. The study also identified that the substance consumption decision was governed by an unobserved common factor compatible with the affect heuristic.

Keywords: Affect heuristic; Substance use; Adolescents; Peer effect

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1. Introduction

Health risk behaviors, such as smoking, drinking alcohol, using drugs, having unprotected sex, following a poor diet, and being sedentary are among the main causes of deaths from preventable causes (Cawley & Rhum, 2011). This information has attracted attention toward studying health risk behaviors in adolescents.

Risk perception is related to Loewenstein *et al.*'s (2001) hypothesis of risk as a sensation, according to which individuals' risk-related behavior is associated with their feelings about specific risk situations. These feelings can be positive or negative depending on how vividly the individual imagines the consequences and personal exposure or experiences with outcomes.

Slovic *et al.* (2002; 2005) emphasized the role of the affect heuristic in risk decision-making, stating that individuals' emotional responses to a decision significantly influence their perceptions of risk. Affect is defined as the immediate positive or negative feeling associated with a stimulus; this feeling shapes how individuals assess the relationship between risk and benefit. Typically, higher risk correlates with higher returns; however, the affect heuristic can reverse this perception; for instance, individuals could underestimate risks if they view an activity as highly beneficial. This effect is evident

in behaviors, such as smoking, which cause individuals to downplay health risks due to the short-term pleasure associated with smoking.

According to van Ryzin *et al.* (2012) the proportion of the population that consumes alcoholic beverages, cigarettes, and illicit drugs increases during the adolescent years. This finding indicates that individuals change their exposure and risk behaviors related to using these substances throughout adolescence. The decisions of adolescents, to smoke, consume alcohol, or take illicit drugs are related to the affective impulse of the moment—to experience positive feelings, socialize with friends, belong to a group, and avoid loneliness (Slovic, 2000; Oliveira & Pucci, 2021; Sousa *et al.*, 2024), highlighting the importance of social interactions and the affect heuristic in the consumption of such substances.

According to Manski (2000), the effects of social interaction are observed when the decisions of agents are influenced by those of others. Manski identified three channels through which such effects could occur: Restrictions, expectations, and preferences. Interactions through restrictions occur when constraints on individual choices are affected by the decisions of other individuals. Meanwhile, interactions through expectations occur when individual expectations are shaped by information obtained by observing the choices made by other individuals and the outcomes of those decisions. Finally, interactions through preferences occur when an agent prioritizes their preferred alternatives based on the options selected by other agents (Manski, 2000). According to Kaplan *et al.* (1984), individuals whose peers share favorable preferences for a certain activity are more likely to engage in these activities, including activities such as excessive consumption of alcohol, cigarettes, and illicit drugs. For the authors, the effect of peers on the use of substances by adolescents, such as illicit drugs, for example, can occur both through involvement with peers who use drugs after the adolescent begins using drugs, and also through increased general susceptibility to adopting drug use influenced by peers who already use drugs.

Needle *et al.* (1986) based their analysis of the influence of friends and parents on adolescent behaviors concerning substance use on the importance of social interactions and peer influence. Manski (2000) pointed out the difficulties of defining peers for certain groups of individuals. In this context, several empirical studies have sought to analyze this correlation based on data from various countries and socioeconomic contexts.

Studies by scholars such as (Graham *et al.*, 1991; Biglan *et al.*, 1995; Norton *et al.*, 1998; Sutherland & Shepherd, 2001; Guo *et al.*, 2002; Lundborg, 2006; Trucco *et al.*, 2011; Allen *et al.*, 2012; Van Ryzin *et al.*, 2012; Zimmerman & Farrel, 2016; and Chan *et al.*, 2017) have indicated positive and significant correlations between substance use by adolescents and interactions with other individuals using these substances. These findings reinforce the importance of socialization in substance consumption. In particular, studies by researchers such as (Malta *et al.*, 2011; Malta *et al.*, 2014; Horta *et al.*, 2014; Barreto *et al.*, 2014; and Figueiredo *et al.*, 2016) have also identified this trend in Brazil.

Benchaya *et al.* (2019) explored the link between family dynamics and substance abuse, finding that healthy parent-child relationships protect against drug abuse; meanwhile, the absence of a father figure increases the risks of drug abuse. In addition, they noted that adolescents often consume alcohol in the presence of their parents. Arcadepani & Fidalgo (2023) examined the relationship between substance use and violent behavior among Brazilian adolescents, revealing that recent use of alcohol, tobacco, and illicit drugs contributed significantly to violent behavior, as per data acquired from the 2015 National School Health Survey (NSHS).

Fernandes *et al.* (2022) also used data from the 2015 NSHS, reporting that sleep difficulties and feelings of loneliness are linked to higher frequencies of alcohol and cigarette use among adolescents. Arruda *et al.* (2022) investigated factors affecting alcohol consumption among adolescents and found that public school students and girls were more likely to consume alcohol than private school students and boys. They highlighted that substance use by friends and parental smoking contributed to such behavior. Notably, students attending schools involved in the Health at School Program did not exhibit reduced alcohol consumption.

Sousa *et al.* (2024) analyzed the combined use of alcohol, tobacco, and illicit drugs among Brazilian adolescents. They identified mental health issues, early substance use, peer pressure, parental substance use, and lack of monitoring as significant factors influencing such behavior.

Oliveira & Pucci (2021) conducted a systematic review of adolescent substance use in Brazil. They detected key biological, psychological, social, and religious factors including poor nutrition, lack of physical activity, sleep issues, family alcoholism, bullying, and social vulnerability.

In general, these studies addressing the relationship between substance use by adolescents and substance use by friends and family have treated substance use separately, even when they have investigated the use of different substances. However, as Slovic (2000) and Slovic *et al.* (2002; 2005) have discussed, from the perspective of the affect heuristic, the affective impulse that results in consuming a type of substance is the same for other types of substance use because the same affect is related to the consumption of different types of substances.

Given the importance of social interactions in adolescent decision-making regarding the consumption of alcohol, cigarettes, and illicit drugs, this study aims to analyze the relationship between adolescent consumption and the use of these substances by their peers from the perspective of the affect heuristic. The multivariate probit model was used to achieve this objective because it allows for analysis of the determinants of joint decisions to use substances. This study contributes to the literature by considering a possible common affective impulse in substance consumption. It thus advances the literature by modeling joint use of substances (i.e., alcohol, illicit drugs, and cigarettes) by considering common unobservable factors in adolescents' decision to consume these substances.

2. Materials and methods

2.1. Data

Microdata obtained from the NSHS[1] and made available by the Brazilian Institute of Geography and Statistics (IBGE) were used to conduct this study. The NSHS contains a questionnaire administered to students from public and private schools and aims to collect information on risks and protective factors that can impact adolescent health.

The NSHS encompasses elementary- and high-school students enrolled in the 2019 school year. This study used a sample of high school students who attended school regularly. The NSHS questionnaire contains information such as sociodemographic and economic circumstances, family contexts, health-related behaviors, and other risk factors for adolescents. This study focuses on the relationship between the consumption of alcohol, cigarettes, and illicit drugs among adolescents and their peers; therefore, the following variables were selected for the analysis.

Three binary variables were defined as dependent variables, which assumed a value of 1 if the adolescent had consumed the respective substance (alcohol, illicit drug, or cigarette), and a value of 0 if otherwise.

In this study, peers are the people reported by the respondents consist of those who are part of the adolescents' coexistence friends, and parents. Thus, those representing the behavior of peers were considered as explanatory variables of greatest interest and defined as binary variables. A value of 1 was assigned to affirmative answers for each of the following scenarios: A friend consumes alcoholic beverages, a friend consumes any illicit drug, a parent smokes, and a parent consumes alcoholic beverages.

The study constructed indices to analyze adolescents' standard of living and degree of exposure to various risks based on multiple correspondence analysis (MCA)[2], the standard of living index (SLI)[2], and the risk behavior index (RBI)[2]. A separate MCA was applied for constructing each index. Table 1 presents the variables included in the MCA.

The indices were obtained from the lines of the first dimension of each MCA for the results of the composition of each of the constructed indices. Table A1 displays these results for the SLI and Table A2 presents the outcomes obtained for the RBI. The indices are described by the following equations:

$$SLI = \frac{\left[SL_{row} - \min\left(SL_{row}\right)\right]}{\left[\max\left(SL_{row}\right) - \min\left(SL_{row}\right)\right]} \quad (1)$$

$$RBI = \frac{\left[RB_{row} - \min\left(RB_{row}\right)\right]}{\left[\max\left(RB_{row}\right) - \min\left(RB_{row}\right)\right]} \quad (2)$$

Both indices assumed values between 0 and 1; values closer to 1 on the SLI indicated a worse standard of living, and values closer to 1 on the RBI indicated greater exposure to risk.

Variables were defined to indicate the plans of adolescents after finishing school and were constituted as binary variables: The value 1 was assumed if the adolescent intended to continue studying and working after high school and 0 if not, the value 1 was assigned if an adolescent intended only to study and 0 if not; the value 1 was allocated if the adolescent respondent intended only to work and 0 if not; the value 1 was ascribed if the adolescent mentioned plans other than the previously mentioned facets and 0 if not. These binary variables were compared against adolescent respondents who did not declare any defined plans for their futures after completing high school.

The mother's education level was also included: A value of 1 was ascribed for no education, 2 for incomplete primary education, 3 for complete primary education, 4 for incomplete high school, 5 for complete secondary education, 6 for incomplete higher education, and 7 for complete higher education.

Other individual characteristics such as the gender, race, age, school type, and residential locations of the adolescents were also controlled: for instance, the value of 1 was ascribed for males, whites, adolescents attending private school, urban residents, and respondents aged 11 – 19. Table 2 elucidates how the variables used in the study were defined.

1. The NSHS microdata are public and were obtained directly from the official IBGE website at the following link: https://www.ibge.gov.br/estatisticas/downloads-estatisticas.html?caminho=pense/2019/microdados/

2. For a detailed explanation of multiple correspondence analysis see Hair et. al. (2009)

Table 1. Selected Variables in the SLI and RBI

Index	Variables constituting the index	Descriptions of variables
SLI	Adolescent has a cell phone (*cel*); the household has a computer (*comp*); the household has Internet (*internet*); the household has a housemaid (*maid*); the household has a car (*car*); the number of bathrooms with showers in the household (*bath*).	The variables *cel*; *comp*; *internet*; *maid* and *car* assumed a value of 1 if the adolescent responded in the affirmative and 0 if not. The variable *bath* assumed values from 0 to 5.
RBI	Frequency of seat belt use in the front seat (*belt_front*); frequency of seat belt use in the back seat (*belt_back*); frequency of motorcycle helmet use (*helmet*); frequency of riding in a car with a drunk driver (*drunk_drive*); became involved in a fight (*fight*); used a condom during first sexual intercourse (*condom*).	The variables belt_front; *belt_back; helmet* assumed the value 0 if the adolescent did not report riding a car/motorcycle during the reference period; otherwise, the value 1 was assigned if the adolescent always wore a seat belt/helmet, 2 if used most of the time, 3 if sometimes, 4 if rarely, and 5 if never. The variable *drunk_drive* assumed the value 0 if the adolescent did not ride in a car with a drunk driver during the reference period; otherwise, the value 1 was assigned for once, 2 for 2 or 3 times, 3 for 4 or 5 times, and 4 for 6 times or more. The variable *fight* assumed a value of 1 if the adolescent became involved in a fight and 0 if not. The variable *condom* assumed a value of 0 if the adolescent had never engaged in sexual intercourse, 1 if they used a condom during the first sexual intercourse, and 2 if a condom was not used.

Source: Author's elaboration based on NSHS 2019 data.
Abbreviations: SLI: Standard of living index; RBI: Risk behavior index.

The initial sample comprised 165,838 respondents. Elementary School students and respondents with missing information that appeared as "I do not know" for any of the selected variables were excluded from the sample. Answers in the "I do not know" category were considered only for the intended education variable because this answer could be interpreted as the absence of aspiration in adolescents about their future after high school. Thus, the final sample for analysis comprised 55,883 respondents.

2.2. Multivariate probit model

According to Greene (2012), the multivariate probit model is adequate when the interest is in the joint determination of multiple binary variables. In the present study, the interest is in the joint determination of substance use by adolescents. The multivariate probit model presented by Cappellari & Jenkins (2003) is given by the following system with M equations:

$$y_{im}^{*} = \beta_{m}^{'} x_{im} + \dot{o}_{im}, m = 1,\ldots M \tag{3}$$

$$y_{im} \begin{cases} = 1 if\ y_{im}^{*} > 0 \\ = 0 otherwise \end{cases} \tag{4}$$

Where ϵ_{im} denotes the error term with multivariate normal distribution, with zero mean and variance-covariance matrix $\boldsymbol{V}$. Matrix V has elements of value equal to 1 on its main diagonal and elements off the main diagonal equal to the correlations $p_{jm} = p_{mj}\ p_{mj}$ represents the correlation between the error terms of the equations m and j. The multivariate probit model is an interesting choice model because it allows a flexible correlation structure for the unobserved factors.

The simulation methods required to estimate this type of model are computationally demanding (Hair *et al.*, 2009). However, simulated maximum likelihood methods such as the Geweke-Hajivassiliou-Keane (GHK) simulator have become popular with the advancement of modern computers, allowing the estimation of models with multiple equations (Cappellari & Jenkins, 2003; Greene, 2012).

Model estimation was effected using the GHK simulation method, which displays desirable properties for simulated maximum likelihood methods applied in multivariate models of limited dependent variables (Cappellari & Jenkins, 2013).

Cappellari & Jenkins (2003) presented the simulated maximum likelihood method for the case of a multivariate probit model with $M = 3$. This case applies to the present study, which analyzes the joint determination of the consumption of alcoholic beverages, cigarettes, and illicit drugs by adolescents. The log-likelihood function proposed by Cappellari & Jenkins (2003) for a multivariate probit model with 3 equations is denoted as follows:

$$L = \sum_{i=1}^{N} w_i \log \phi_3 (\mu_i; \Omega) \tag{5}$$

Where w_j is the sampling weight of the observation, $i = 1,\ldots, N$, e ϕ_3 (.) is a trivariate standard normal distribution whose arguments μ_i e Ω are defined as follows:

$$\mu_i = \left(K_{i1} \beta_1^{'} x_{i1}, K_{i2} \beta_2^{'} x_{i2}, K_{i3} \beta_3^{'} x_{i3} \right) \tag{6}$$

Table 2. Description of selected variables: NSHS, Brazil 2019

Variable	Description
Alcohol	Have you ever consumed any alcoholic beverages?
Drugs	Have you ever consumed any illicit drugs?
Cigarette	Have you ever smoked a cigarette?
Friend_alcohol	Do any of your friends drink alcohol?
Friend_drugs	Do any of your friends use illegal drugs?
Friend_smoke	Do any of your friends smoke cigarettes?
Parent_alcohol	Does either of your parents or any guardian drink alcohol?
Parent_smoke	Does either of your parents or any guardian smoke cigarettes?
SLI	Standard of Living Index (values closer to 1 indicate a worse standard of living)
RBI	Risk Behavior Index (values closer to 1 denote risker behavior)
Work	After high school, you intend only to work (base variable: no plans)
Study	After high school, you intend only to study (base variable: no plans)
Study_work	After high school, you intend to study and work (base variable: no plans)
Another_plan	After high school, you have another plan (base variable: no plans)
Male	Male sex
Age	Age
School_mom	Mother's education level
n_people	Number of people living in the household
White	White ethnicity
Priv	Attending private school
Urb	Households located in an urban area

Source: Author's elaboration based on NSHS 2019 data.

Where $K_{im} = 2y_{im} - 1$, for each i, $m = 1,2,3$, The matrix Ω has the following elements:

$$\Omega mm = 1, m = 1,2,3 \quad (7)$$

$$\Omega_{21} = \Omega_{12} = K_{i1} K_{i2} \rho_{21}$$

$$\Omega_{31} = \Omega_{13} = K_{i3} K_{i1} \rho_{31}$$

$$\Omega_{32} = \Omega_{23} = K_{i3} K_{i3} \rho_{32}$$

According to Cappellari & Jenkins (2003), the GHK simulator takes advantage of the fact that the multivariate normal distribution can be defined as the product of sequentially conditioned univariate normal distributions. Eight joint probabilities corresponding to eight combinations of $y_{im} = 1$ e $y_{im} = 0$ exist for a trivariate case. Given the probability of all outcomes being $y_{im} = 1$,

$$\begin{aligned}
&\Pr\left(y_{i1} = 1, y_{i2} = 1, y_{i3} = 1\right) \\
&= \Pr\left(\dot{o}_{i1} \le \beta_1' x_{i1}, \dot{o}_{i2} \le \beta_2' x_{i2}, \dot{o}_{i3} \le \beta_3' x_{i3}\right) \\
&= \Pr\left(\dot{o}_{i3} \le \beta_3' x_{i3} | \dot{o}_{i2} < \beta_2' x_{i2}, \dot{o}_{i1} < \beta_1' x_{i1}\right) \\
&\times \Pr\left(\dot{o}_{i2} \le \beta_3' x_{i2} | \dot{o}_{i1} < \beta_1' x_{i1}\right) \times \Pr\left(\dot{o}_{i1} < \beta_1' x_{i1}\right) \quad (8)
\end{aligned}$$

The probability expressed in (8) involves conditioning on unobserved variables that are correlated with each other. The GHK simulator performs an approximation of these conditional distributions (Cappellari & Jenkins, 2003).

Börsch-Supan & Hajivassiliou (1993) stated that the desirable properties for simulated maximum likelihood methods are generating unbiased simulated choice probabilities that are bounded within the range of 0 and 1 and that represent continuous and differentiable functions of the model parameters. According to Cappellari & Jenkins (2003), the simulation bias is reduced to tiny levels in the GHK simulator as the number of random drawings increases with the sample size. They recommended that the number of random drawings in sufficiently large samples should approximate the closest integer to the square root of the number of respondents in the sample. In the present study, the analyzed sample comprised 55,883 respondents. Therefore, the number of 243 random draws was defined for the model estimation.

3. Results and discussion

First, a descriptive analysis was conducted on the data on substance use among high school students in Brazil. Figure 1 presents the relative frequency of use for each substance (alcohol, illicit drugs, and cigarettes).

It was observed that alcoholic beverages were the most commonly used substance among adolescents, probably because of their greater social acceptance and easier access notwithstanding the prohibition of alcohol sales to minors in Brazil. A significant proportion of adolescents also used cigarettes and illicit drugs even though this percentage was much lower than the proportion of alcohol users, which probably reflected greater difficulty of access and lower social acceptance, particularly in the case of illicit drugs. Figure 2 illustrates the relative frequency of substance use by sex.

Notably, the examination of the relative frequency of substance use by gender revealed that alcohol consumption was higher among female adolescents, while the use of cigarettes and illicit drugs was more prevalent among male adolescents. Figure 3 displays the relative frequency of substance use by age.

The evaluation of substance use trends by age disclosed that the youngest high school students (11 and 12 years

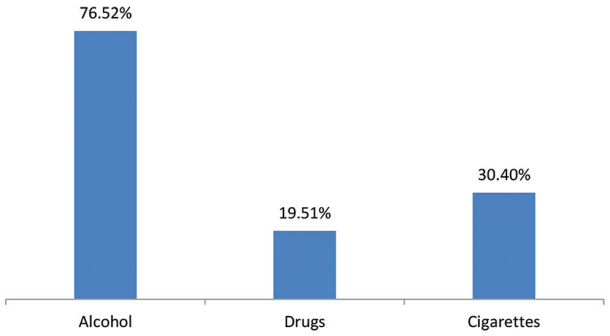


Figure 1. Relative frequency (%) of substance use (alcohol, illicit drugs, and cigarettes) by adolescents; Brazil 2019
Source: Author's elaboration based on National School Health Survey 2019 data.

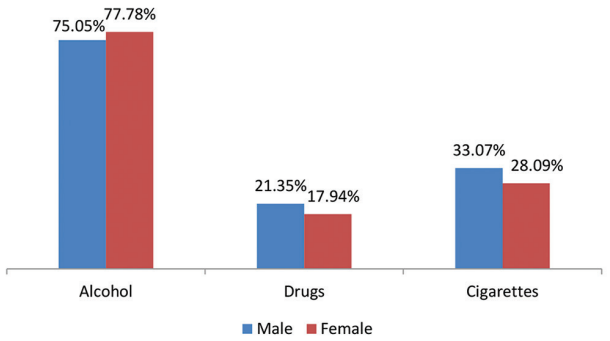


Figure 2. Relative frequency (%) of substance use (alcohol, illicit drugs, and cigarettes) by adolescents by sex; Brazil 2019
Source: Author's elaboration based on National School Health Survey 2019 data.

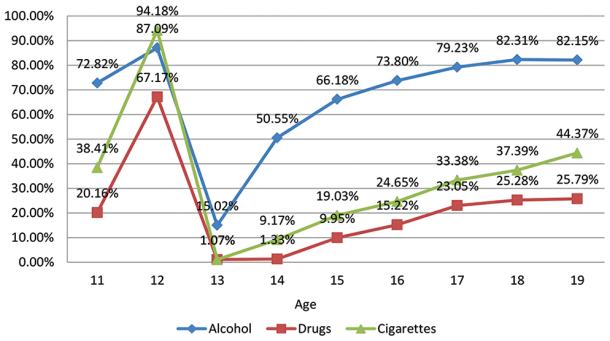


Figure 3. Relative frequency (%) of substance use (alcohol, illicit drugs, and cigarettes) by adolescents by age; Brazil 2019
Source: Author's elaboration based on National School Health Survey 2019 data.

old) exhibited a particularly high relative frequency of use. Subsequently, a decline in consumption was noted among 13-year-old students, after which a general trend of increasing substance use was observed as students became older. Noteworthily, the number of 12- and 13-year-old students in the sample was small, which could account

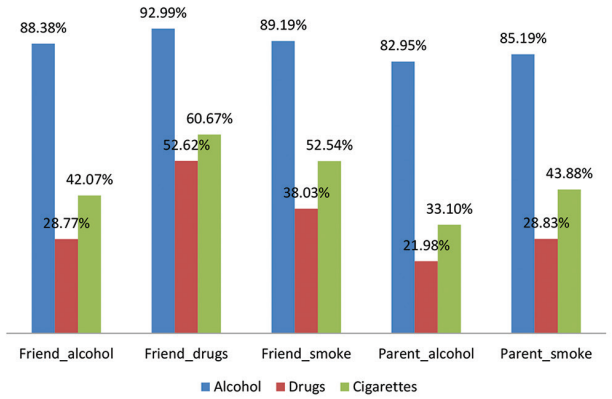


Figure 4. Relative frequency (%) of substance use (alcohol, illicit drugs, and cigarettes) by adolescents who reported having friends who drink alcohol, take illicit drugs, or smoke cigarettes and adolescents who reported having a parent who drinks alcohol or smokes cigarettes; Brazil 2019
Source: Author's elaboration based on National School Health Survey 2019 data.

for these more extreme behaviors compared to the total sample, for instance, the very high prevalence among 12-year-olds and the very low prevalence among 13-year-olds. Figure 4 illustrates the relative frequency of substance use among adolescents who reported having friends who drink alcohol, use illicit drugs, or smoke cigarettes, and adolescents who reported having a parent who drinks alcohol or smokes cigarettes.

Figure 4 evidences that proximity to individuals who use substances is associated with a higher prevalence of substance use among adolescents. This relationship is particularly pronounced for adolescents with friends who use illicit drugs. Adolescents who reported having friends who use illicit drugs exhibited a much higher prevalence of substance use compared to the overall sample, with a notable increase in illicit drug use. The prevalence of illicit drug use among all adolescents was below 20% but it surpassed 50% among adolescents who had friends using illicit drugs. This finding highlights the strong correlation between drug use and proximity to others who use drugs.

The relationship between substance use (alcohol, cigarettes, and illicit drugs) by adolescents and substance use by their peers was examined by estimating binary response models in which the dependent variables indicated whether the adolescent had already consumed any of the substances. First, separate probit models were estimated for each substance; then, a multivariate probit model was estimated by incorporating a joint decision to use all substances in the estimation.

Table 3 presents the results of probit models estimated individually for each substance (alcoholic beverages,

Table 3. Results of the probit models estimated separately for the consumption of each substance by adolescents; Brazil 2019

Variables	*Alcohol*		*Drugs*		*Cigarettes*	
	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)
Friend_alcohol	0.5997***	0.5356***	0.2423***	0.1661***	0.3262***	0.2561***
Friend_drugs	0.4632***	0.4055***	1.0111***	0.9728***	0.6239***	0.5950***
Friend_smoke	0.2558***	0.2555***	0.4399***	0.4190***	0.5421***	0.5001***
Parent_alcohol	0.4163***	0.3986***	0.0789**	0.0597	0.0249	0.0551*
Parent_smoke	0.2484***	0.2623***	0.2993***	0.3121***	0.4035***	0.3820***
SLI		−0.8922***		−0.5978***		−0.2122**
RBI		1.0566***		0.9413***		0.8974***
Work		0.1229		−0.1304		0.0503
Study		−0.0692		−0.2890***		−0.1859***
Study_work		0.1681***		−0.1329**		0.0050
Another_plan		0.0464		−0.1001		0.0007
Male		−0.1563***		0.0142		0.0744***
Age		0.1271***		0.1373***		0.1272***
School_mom		0.0121**		0.0324***		0.0094
n_people		−0.0469***		−0.0569***		−0.327***
White		0.0799***		0.1104***		0.0634*
Priv		−0.1545***		−0.1001**		−0.1633***
Urb		0.1369**		0.2339***		−0.1444**
Intercept	0.0178	−2.0803***	−1.6495***	−4.0252***	−1.1938***	−3.2829***
Respondents	58837		58837		58837	
Wald Test	2222.36***	17644.15***	4472.77***	11912.14***	1495.42***	9071.81***
Pseudo R^2	0.1284	0.1656	0.2102	0.2407	0.1522	0.1783

Source: Author's elaboration based on NSHS 2019 data. Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

cigarettes, and illicit drugs). Models (1a), (1b), and (1c) in Table 3 present only the variables of substance use by peers as explanatory variables. Models (2a), (2b), and (2c) add to the other previously described control variables. All models displayed in this table are statistically significant at the 1% level. The Wald test was utilized to determine the global significance of the model.

Of the models with the consumption of alcoholic beverages as their dependent variable, model (1a) was estimated by including only the variables that represented the consumption of substances by peers. In this model, having a friend who consumes alcohol, having a parent who consumes alcohol, having a parent who smokes, having a friend who smokes, or having a friend who consumes illicit drugs increased the probability that an adolescent had already consumed an alcoholic beverage. In model (2a), the values of the coefficients of these variables did not show many changes when the other control variables were included, and the statistical significance remained the same. Thus, the positive effect of peer consumption on alcohol consumption among adolescents remained when socioeconomic and demographic variables and risk behaviors were controlled.

Among models with the consumption of illicit drugs among adolescents as their dependent variable, all variables in the model (1b) that indicated the consumption of substances by peers exerted a positive effect on the probability that an adolescent had already consumed illicit drugs. However, the consumption of alcoholic beverages by parents ceased to exercise a statistically significant effect when other control variables were included in the model (2b). The coefficients of illicit drug, alcohol, and cigarette consumption by friends and cigarette consumption by a parent remained positive and statistically significant after the inclusion of the control variables.

Of models with cigarette consumption by adolescents as the dependent variable, the coefficient of the alcohol consumption by a parent was not statistically significant in model (1c) but variables that indicated substance use by

peers revealed a positive relationship in model (2c). Thus, the consumption of all substances by peers increases the probability of cigarette consumption among adolescents even after controlling for socioeconomic and demographic characteristics and other risk behaviors. However, the consumption of alcohol by a parent was statistically significant only at the 10% level.

The results displayed in Table 3 considered independent probit models for the consumption of alcohol, illicit drugs, and cigarettes by adolescents. Norton *et al.* (1998) asserted that a possible endogeneity in peer substance use did not constitute a problem in expressing the positive relationship between substance use by adolescents and consumption by peers. However, the present study identified a possible correlation between factors that remain unobserved in the decision to consume these substances. It also noted a significant correlation between the error terms of the models estimated in Table 3, which made the parameters obtained by these models biased.

A multivariate probit model was estimated for the joint decision to use substances, alcohol, illicit drugs, and cigarettes to account for this possible correlation between factors that remain unobserved in decisions to use the relevant substances. Table 4 presents the results of the multivariate probit model. First, the results of the p_{mj} parameters representing the correlations between the error terms of the dependent variables must be highlighted. It was observed that the correlations between the error terms of substance use decisions were positive and statistically significant, revealing that these correlations must be taken into account.

Table 4. Results of multivariate probit models on the joint decision of substance use by adolescents; Brazil 2019

Variables	*Alcohol*		*Drugs*		*Cigarettes*	
	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)
Friend_alcohol	0.5950***	0.5299***	0.2599***	0.1804***	0.3358***	0.2651***
Friend_drugs	0.4564***	0.3984***	1.0086***	0.9747***	0.6272***	0.5988***
Friend_smoke	0.2507***	0.2547***	0.4387***	0.4114***	0.5386***	0.4970***
Parent_alcohol	0.4128***	0.3949***	0.0883**	0.0697	0.0325	0.0640**
Parent_smoke	0.2399***	0.2536***	0.3128***	0.3244***	0.4053***	0.3837***
SLI		−0.8849***		−0.6143***		−0.2074**
RBI		1.041***		0.9526***		0.9068***
Work		0.1265*		−0.1462		0.0489
Study		−0.0745*		−0.3033***		−0.1859***
Study_work		0.1569***		−0.1348**		0.0087
Another_plan		0.0394		−0.1089		−0.0009
Male		−0.1680***		0.0284		0.0765***
Age		0.1260***		0.1343***		0.1281***
School_mom		0.0117**		0.0330***		0.0086
n_people		−0.0470***		−0.0576***		−0.0346***
White		0.0837***		0.1020***		0.0625**
Priv		−0.1513***		−0.1133***		−0.1683***
Urb		0.1417**		0.2174***		−0.1388**
Intercept	0.0239	−2.0442***	−1.6699***	−3.9714***	−1.2060***	−3.3201***
Respondents	58837		58837		58837	
Wald Test	8946.44***	5611029.47***				
p_{21}	0.5538***	0.5260***				
P_{31}	0.6058***	0.5983***				
P_{32}	0.7388***	0.7307***				
LR test	15000000***	14000000***				

Source: Author's elaboration based on NSHS 2019 data. Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Abbreviation: LR: Likelihood ratio.

The likelihood ration test was also performed to verify the joint significance of the correlation parameters between the error terms. The statistically significant result of this test must be underscored: it revealed that the estimation of a multivariate probit model that considers jointly taken decisions to consume the studied substances is more adequate than the estimation of independent probit models for the consumption of each substance.

The results of these tests elucidate the relevance of common unobservable factors in the decision-making of Brazilian adolescents to use substances. This finding suggests that the choice of using these discrete substances could evoke the same sensation in adolescents, which can be interpreted as the influence of the affect heuristic in the decision to consume alcohol, cigarettes, and illicit drugs, as Slovic (2000) and Slovic *et al.* (2002; 2005) have described.

The examination of the effects of the variables representing the consumption of substances by peers on the probability of consumption of these substances by adolescents resulted in the observation that having a friend who consumes alcohol increased the probability of the consumption of alcohol, illicit drugs, and cigarettes by adolescents. The presence of a friend who consumed illicit drugs increased the probability of adolescent consuming illicit drugs and heightened the probability of the adolescent consuming alcohol and cigarettes. The existence of a friend who smoked cigarettes also amplified the probability that the adolescent would consume all the studied substances. These results were statistically significant at the 1% level.

The probability that an adolescent had already consumed alcohol, cigarettes, and illicit drugs also statistically significantly increased by the existence of a parent who smoked. However, the presence of a parent who consumed alcohol did not affect the intake of illicit drugs by adolescents in the model (2b) and did not influence the consumption of cigarettes in model (1c). The consumption of alcohol by a parent significantly heightened the probability of alcohol consumption by adolescents in both models.

These results show that contact with other individuals who use substances exerts a vital impact on substance use by adolescents. Barreto *et al.* (2014) and Figueiredo *et al.* (2016) have previously highlighted this impact on adolescent cigarette consumption by adolescents in Brazil. The affect heuristic could function as a channel in this relationship: adolescents may observe the good experiences of close people using substances and may want to share these experiences. This desire could create a positive affect regarding substance use, which could lead adolescents to underestimate the risks and overestimate the benefits of consuming the studied substances.

Zimmerman & Farrell (2016) found that substance use by friends was a more relevant factor than consumption by parents in influencing the perceptions of adolescents about the negative consequences of substance use. This finding reinforces the idea of the affect heuristic associated with peer impact on substance use. Chan *et al.* (2017) highlighted that substance use by peers represented the most relevant factor in increasing the likelihood of multiple substance use by adolescents. Needle *et al.* (1986) asserted that substance use by friends exerted a relatively stronger influence on adolescent decisions to use substances than substance use by parents. According to Guo *et al.* (2002) and Van Ryzin *et al.* (2012), the influence of friends surges in mid-adolescence, namely, in adolescents who are 14 – 15 years old.

Lundborg's (2006) study results exhibited that the influence of peers was stronger for the most common behavior of consuming alcoholic beverages and weaker for the least common behavior of illicit drug use. This result differed from the findings of the present study that the effects of the consumption of the less common and socially unaccepted substances (illicit drugs) by friends were generally stronger for all substances. Thus, the effects of social interactions on substance use by adolescents in Brazil are more significant for less socially accepted substances. This finding can be explained by the desire of adolescents to attain a sense of belonging and their discomfort with loneliness. Substance use can foster a sense of belonging, particularly when it occurs in a group context. Studies conducted by (Oliveira & Pucci, 2021; Fernandes *et al.*, 2022; Arruda *et al.*, 2022; and Sousa *et al.*, 2024) have highlighted this phenomenon.

Tables 4 and 3 present generally similar results vis-à-vis socioeconomic and demographic variables. As Malta *et al.* (2014) indicated from their study on the 2012 NSHS, female adolescents were more likely to have already consumed some type of alcoholic beverage. This finding indicates that the sex-related pattern of alcohol consumption among adolescents remained identical between 2012 and 2019. Male and female adolescents evinced no differences in the consumption of illicit drugs, in alignment with the trends reported by other studies conducted by researchers such as (Guo *et al.*, 2002; Malta *et al.*, 2011; Van Ryzin *et al.*, 2012; and Chan *et al.*, 2017). These scholars also indicated the absence of any differences in substance use patterns between male and female adolescents. However, male adolescents were more likely than female adolescents to have already smoked cigarettes.

White adolescents were more likely to have already consumed the three substances. These results differ from the findings reported by (Guo *et al.*, 2002 and Van

Ryzin *et al*., 2012), who did not detect racial differences in substance use among adolescents. However, white adolescents in Brazil are generally more likely to consume some substance.

Greater age increases the likelihood of consuming all substances similarly. This positive relationship between age and substance use among adolescents has also been shown in other studies, such as (Sutherland & Shepherd, 2001; Guo *et al*., 2002; Horta *et al*., 2014; Barreto *et al*., 2014; Figueiredo *et al*., 2016; Chan *et al*., 2017), pointing out that older adolescents are at greater risk of exposure to substance use. However, (Sutherland & Shepherd, 2001 and Chan *et al*., 2017) also highlighted the perception of poor school performance as a relevant factor for substance use among adolescents.

As higher SLI values indicate a worse standard of living, the negative sign of the model coefficients shows that a better standard of living increases the probability of substance use among adolescents, this result is consistent with that identified by Horta *et al*. (2014), who found an association between income level and illicit drug use based on the NSHS 2012 data. However, they identified that this relationship lost relevance in the NSHS 2015. However, it was observed that this relationship was once again relevant to NSHS 2019. This relationship between standard of living and substance use can be explained by the greater accessibility to the consumption of these products, mainly alcohol and illicit drugs, provided by a higher standard of living.

Malta *et al*. (2014) reported no differences in alcohol consumption between public and private school students in their study based on the NSHS 2012 data. Conversely, the present investigation found that studying at a private school in Brazil reduced the probability of substance use in a statistically significant manner. This outcome is congruent with the findings reported by Figueiredo *et al*. (2016) on cigarette consumption. Living in urban areas increased the probability of consuming all the studied substances because they were more accessible in urban environments.

In terms of the plans adolescents articulated for their lives after completing high school, aspirations that involved continuing their studies were generally associated with a lower likelihood of substance use, notwithstanding whether they aspired to continue their studies and work or to just continue studying. However, aspirants who planned to just work after their high school qualification or registered another plan did not evince the probability of reduced substance use vis-à-vis adolescents who reported no plans.

The education level of mothers revealed a positive association with the probability of consumption of alcohol and illicit drugs. Cigarette consumption was not statistically significantly related to the education of mothers, and this result aligns with Figueiredo *et al*.'s (2016) study, which used a different database but reported no differences in cigarette consumption by Brazilian adolescents vis-à-vis the educational level of their parents.

In terms of the relationship between substance use and other risk behaviors, RBI values indicate greater exposure to risk. Therefore, a strong correlation was observed between risk behaviors and substance use among adolescents. Biglan *et al*. (1995) also observed a positive relationship between tobacco consumption and other risk behaviors. These results align with the opinion of Hersch & Viscusi (1998) that risky behavior about health and risky behavior are generally associated.

4. Conclusion

The results of this study indicated that the estimation of the multivariate probit model for the consumption of alcohol, cigarettes, and illicit drugs was preferable to the estimation of individual probit models for the consumption of each substance. The analysis of the joint decision-making to use these different types of substances proved more appropriate and was justified by the correlation found between unobservable factors in the decision to consume alcohol, cigarettes, and illicit drugs. These factors could be related to the application of the affect heuristic in this consumption decision. As Slovic *et al*. (2005) exemplify, the use of different types of substances can generate similar experiences and sensations for adolescents, such as the thrill of trying something new or having fun with friends.

A positive relationship was found between substance use by peers and the decisions of adolescents to use the studied substances. Thus, in congruence with the trends reported in the existing literature, the presence of friends who consume alcohol, illicit drugs, or cigarettes, or the existence of a parent who consumes cigarettes or alcohol generally increases the probability of an adolescent choosing to consume these substances. Contact with other individuals who consume alcohol, cigarettes, or illicit drugs can make adolescents positively perceive the use of these substances, underestimate their risks, and overestimate their benefits. Such effects could also relate to the affect heuristic and to the desire to belong to a group.

This study also noted that social interactions exert a greater influence on the use of illicit drugs, which denote substances that are less commonly consumed and less socially accepted. The presence of friends who consume illicit drugs exercises a positive and strongly statistically

significant relationship with the consumption of all the studied substances. Thus, adolescents could perceive that friends who consume illicit drugs are more accepting of the consumption of any substance.

Cigarette consumption by a parent was also found to be a relevant factor that positively affects the consumption of all substances by adolescents. However, alcohol consumption by a parent only influences the consumption of alcohol by adolescents in a relevant manner and does not exert a relevant effect on the use of cigarettes or illicit drugs.

The multivariate probit regression revealed that the coefficients associated with the variable that indicates exposure to risk in other activities were statistically significant in explaining the greater probability of the use of the studied substances. This strong relationship found between substance use and other risk behaviors reinforces that efforts to design prevention policies regarding substance use must crucially attend to exposure to other types of risk in addition to the social interactions of adolescents. Future research endeavors could find it valuable to analyze the factors associated with the frequency of substance use and also with the age at which adolescents in Brazil begin substance use.

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Conflict of interest

The author declares that no competing interests exist.

Author contributions

This is a single-authored article.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

This study utilized public data made available by the IBGE.

Further disclosure

The manuscript is derived from a yet-unpublished PhD thesis. The complete thesis is available in the university repository at https://acervodigital.ufpr.br/handle/1884/67435.

References

Allen, J.P., Chango, J., Szwedo, D., Schad, M., & Marston, E. (2012). Predictors of susceptibility to peer influence regarding substance use in adolescence. *Child Development*, 83(1):337-350.

https://doi.org/10.1111/j.1467-8624.2011.01682.x

Arcadepani, F.B., & Fidalgo, T.M. (2023). Violent behavior and substance use among adolescents-results from the national adolescent school-based health survey (PeNSE). *International Journal of Mental Health and Addiction*, 21(1):484-491.

https://doi.org/10.1007/s11469-022-00840-4

Arruda, P.S.M., Silva, A.N., Rinaldi, A.E.M., Silva, L.S.D., & Azeredo, C.M. (2022). Individual and contextual characteristics associated with alcohol use among Brazilian adolescents. *International Journal of Public Health*, 67:e1604397.

https://doi.org/10.3389/ijph.2022.1604397

Barreto, S.M., Giatti, L., Oliveira-Campos, M., Andreazzi, M.A., & Malta, D.C. (2014). Experimentation and use of cigarette and other tobacco products among adolescents in the Brazilian state capitals (NSHS 2012). *Revista Brasileira de Epidemiologia*, 17:62-76.

https://doi.org/10.1590/1809-4503201400050006

Benchaya, M.C., Moreira, T.D.C., Constant, H.M.R.M., Pereira, N.M., Freese, L., Ferigolo, M., *et al.* (2019). Role of parenting styles in adolescent substance use cessation: Results from a Brazilian prospective study. *International Journal of Environmental Research and Public Health*, 16(18):e3432.

https://doi.org/10.3390/ijerph16183432

Biglan, A., Duncan, T.E., Ary, D.V., & Smolkowski, K. (1995), Peer and parental influences on adolescent tobacco use. *Journal of Behavioral Medicine*, 18(4):315-330.

https://doi.org/10.1007/BF01857783

Börsch-Supan, A., & Hajivassiliou, V.A. (1993). Smooth unbiased multivariate probability simulators for maximum likelihood estimation of limited dependent variable models. *Journal of Econometrics*, 58(3):347-368.

https://doi.org/10.1016/0304-4076(93)90085-Y

Cappellari, L., & Jenkins, S.P. (2003). Multivariate probit regression using simulated maximum likelihood. *The Stata Journal*, 3(3):278-294.

https://doi.org/10.1177/1536867X0300300305

Cawley, J., & Ruhm, C.J. (2011). The economics of risky health behaviors. In: Handbook of Health Economics. Vol. 2. Netherlands: Elsevier. pp. 95-199.

https://doi.org/10.1016/B978-0-444-53592-4.00003-7

Chan, G.C., Kelly, A.B., Carroll, A., & Williams, J.W. (2017). Peer drug use and adolescent polysubstance use: Do parenting and school factors moderate this association? *Addictive Behaviors*, 64:78-81.

https://doi.org/10.1016/j.addbeh.2016.08.008

Fernandes, B.F., Russo, L.X., & Bondezan, K.L. (2022). Relationship between mental health and use of psychoactive substances in schoolchildren. *Revista Brasileira de Estudos de População*, 39:e0228.

https://doi.org/10.20947/s0102-3098a0228

Figueiredo, V.C., Szklo, A.S., Costa, L.C., Kuschnir, M.C.C., Da Silva, T.L.N., Bloch, K.V., *et al*. (2016). Smoking prevalence in Brazilian adolescents. Revista de Saúde Pública, 50:1S-12S.

https://doi.org/10.1590/S01518-8787.2016050006741

Graham, J.W., Marks, G., & Hansen, W.B. (1991). Social influence processes affecting adolescent substance use. *Journal of Applied Psychology*, 76(2):291.

https://doi.org/10.1037/0021-9010.76.2.291

Greene, W.H. (2012). Econometric Analysis. 7th ed. Upper Saddle River, NJ: Prentice-Hall.

Guo, J.I.E., Hill, K.G., Hawkins, J.D., Catalano, R.F., & Abbott, R.D. (2002). A developmental analysis of sociodemographic, family, and peer effects on adolescent illicit drug initiation. *Journal of the American Academy of Child and Adolescent Psychiatry*, 41(7):838-845.

https://doi.org/10.1097/00004583-200207000-00017

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2009). Multivariate Data Analysis. 7th ed. New Jersey: Pearson Prentice Hall.

Hersch, J., & Viscusi, W.K. (1998). Smoking and other risky behaviors. *Journal of Drug Issues*, 28(3):645-661.

https://doi.org/10.1177/002204269802800304

Horta, R.L., Horta, B.L., Costa, A.W.N., Prado, R.R., Oliveira-Campos, M., & Malta, D.C. (2014). Lifetime use of illicit drugs and associated factors among Brazilian schoolchildren, National Adolescent School-based Health Survey (PeNSE 2012. *Revista Brasileira de Epidemiologia*, 17(1S):31-45.

https://doi.org/10.1590/1809-4503201400050004

Kaplan, H.B., Martin, S.S., & Robbins, C. (1984). Pathways to adolescent drug use: Self-derogation, peer influence, weakening of social controls, and early substance use. *Journal of Health and Social Behavior*, 25(3):270-289.

https://doi.org/10.2307/2136494

Loewenstein, G.F., Weber, E.U., Hsee, C.K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, 127(2):267.

https://doi.org/10.1037/0033-2909.127.2.267

Lundborg, P. (2006). Having the wrong friends? Peer effects in adolescent substance use. *Journal of Health Economics*, 25(2):214-233.

https://doi.org/10.1016/j.jhealeco.2005.02.001

Malta, D.C., Machado, I.E., Porto, D.L., Silva, M.M.A.D., Freitas, P.C.D., Costa, A.W.N.D., *et al.* (2014). Consumo de álcool entre adolescentes brasileiros segundo a Pesquisa Nacional de Saúde Escolar (PeNSE 2012). *Revista Brasileira de Epidemiologi*a, 17(1S):203-214.

https://doi.org/10.1590/1809-4503201400050004

Malta, D.C., Mascarenhas, M.D.M., Porto, D.L., Duarte, E.A., Sardinha, L.M., Barreto, S.M., *et al*. (2011). Prevalence of alcohol and drug consumption among adolescents: data analysis of the National Survey of School Health. Revista Brasileira de Epidemiologia, 14:136-146.

https://doi.org/10.1590/S1415-790X2011000500014

Manski, C.F. (2000). Economic analysis of social interactions. *Journal of Economic Perspectives*, 14(3):115-136.

https://doi.org/10.1257/jep.14.3.115

Needle, R., Mccubbin, H., Wilson, M., Reineck, R., Lazar, A., & Mederer, H. (1986). Interpersonal influences in adolescent drug use-the role of older siblings, parents, and peers. *The International Journal of the Addictions*, 21(7):739-766.

https://doi.org/10.3109/10826088609058920

Norton, E.C., Lindrooth, R.C., & Ennett, S.T. (1998). Controlling for the endogeneity of peer substance use on adolescent alcohol and tobacco use. *Health Economics*, 7(5):439-453.

https://doi.org/10.1002/(sici)1099-1050(199808)7:5<439:aid-hec362>3.0.co;2-9

Oliveira, K.C., & Pucci, S.H.M. (2021). Factors associated with experimentation, use, abuse and dependence on psychoactive substances in adolescence. Revista Ibero-Americana de Humanidades, *Ciências e Educação*, 7(7):1331-1351.

https://doi.org/10.51891/rease.v7i7.4424

Slovic, P. (2000). What does it mean to know a cumulative risk? Adolescents' perceptions of short-term and long-term consequences of smoking. *Journal of Behavioral Decision Making*, 13(2):259-266.

https://doi.org/10.1002/(SICI)1099-0771(200004/06)13:2<259:AID-BDM342>3.0.CO;2-R

Slovic, P., Peters, E., Finucane, M.L., & Macgregor, D.G. (2002). Rational actors or rational fools: Implications of the affect heuristic for behavioral economics. *The Journal of Socio-Economics*, 31(4):329-342.

https://doi.org/10.1016/S1053-5357(02)00174-9

Slovic, P., Peters, E., Finucane, M.L., & Macgregor, D.G. (2005). Affect, risk, and decision making. *Health Psychology*, 24(4S):S35.

https://doi.org/10.1037/0278-6133.24.4.S35

Sousa, M.D.G.D.M., Castro, L.D.C., Malta, D.C., Gonçalves, A.M.D.S., Silva Júnior, F.J.G.D., & Lima, L.H.D.O. (2024). Factors associated with concurrent alcohol, tobacco and illicit drug use: 2019 National School-Based Health Survey. *Ciência and Saúde Coletiva*, 29:e06882023.

https://doi.org/10.1590/1413-81232024296.08822023

Sutherland, I., & Shepherd, J.P. (2001). Social dimensions of adolescent substance use. *Addiction*, 96(3):445-458.

https://doi.org/10.1080/09652140020054491

Trucco, E.M., Colder, C.R., & Wieczorek, W.F. (2011). Vulnerability to peer influence: A moderated mediation study of early adolescent alcohol use initiation. *Addictive Behaviors*, 36(7):729-736.

https://doi.org/10.1016/j.addbeh.2011.02.008

Van Ryzin, M.J., Fosco, G.M., & Dishion, T.J. (2012). Family and peer predictors of substance use from early adolescence to early adulthood: An 11-year prospective analysis. *Addictive Behaviors*, 37(12):1314-1324.

https://doi.org/10.1016/j.addbeh.2012.06.020

Zimmerman, G.M., & Farrell, C. (2017). Parents, peers, perceived risk of harm, and the neighborhood: Contextualizing key influences on adolescent substance use. *Journal of Youth and Adolescence*, 46(1):228-247.

https://doi.org/10.1007/s10964-016-0475-9

Appendices

Table A1. Results of multiple correspondence analysis employed in the creation of the standard of living index

Categories	Coordinated	Contribution
cel		
No	2.478	0.080
Yes	−0.211	0.007
Comp		
No	1.755	0.149
Yes	−0.718	0.061
Internet		
No	3.258	0.141
Yes	−0.281	0.012
Car		
No	1.584	0.140
Yes	−0.795	0.070
Maid		
No	0.357	0.018
Yes	−1.793	0.089
Bath		
0	4.396	0.053
1	0.992	0.073
2	−0.538	0.016
3	−1.363	0.041
4	−1.961	0.051

Source: Author's elaboration based on National School Health Survey 2019 data.

Table A2. Results of multiple correspondence analysis employed in the creation of the risk behavior index

Categories	Coordinated	Contribution
belt_front		
Not ridden	0.836	0.016
Always	−1.364	0.149
Most of time	0.362	0.004
Sometimes	1.633	0.041
Rarely	2.300	0.070
Never	3.623	0.089
belt_back		
Not ridden	0.818	0.013
Always	−1.924	0.170
Most of time	−0.412	0.005
Sometimes	0.691	0.011
Rarely	0.921	0.027
Never	1.924	0.075
Helmet		
Not ridden	−0.695	0.040
Always	0.013	0.000
Most of time	1.220	0.013
Sometimes	1.951	0.024
Rarely	2.361	0.035
Never	2.939	0.054
drunk_driver		
Not ridden	−0.354	0.015
1 time	0.573	0.005
2 or 3 times	0.950	0.015
4 or 5 times	1.338	0.009
6 times or more	1.332	0.015
Fight		
No	−0.103	0.002
Yes	1.445	0.023
Condom		
Never had sex	−0.566	0.029
Used condom	1.330	0.048
Did not use condom	0.319	0.005

Source: Author's elaboration based on National School Health Survey 2019 data.

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

ORIGINAL RESEARCH ARTICLE

Assessing the intersection of tourism and sustainable development: A bibliometric analysis from the perspectives of medicine, health, therapy, and wellness

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Abstract

This study employs bibliometric techniques to construct a comprehensive knowledge map encompassing medical, health, therapy, and wellness (MHTW) tourism for sustainable development. It also aims to detail collaborations between authors, institutions, and countries; analyze keywords; and identify research trends. The study is based on the Web of Science database and utilizes the Citespace software to analyze 318 relevant publications from 2014 to 2024, constructing author coauthorship networks, institutional coauthorship networks, and keyword co-occurrence networks, as well as performing prominence and cluster analyses of keywords. Findings reveal a significant growth trend since 2014 in publications on the integration of MHTW tourism and the advancement of sustainable tourism. Prominent researchers include Lin, Hsiao-Hsien, Hsu, Chin-Hsien, Ariza-Montes, Antonic, Han, and Heesup, along with several closely collaborating research teams. The United States, China, and Spain lead the research output. The National Chin-Yi University of Technology and the Australian National University are preeminently positioned in sustainable research, and new contributors such as Qingdao University are emerging and facilitating wider research efforts. Furthermore, the research agenda highlights the health concept in tourism and promotes MHTW tourism for the sustainable development of societies, economies, and the environment. Future research should emphasize international collaborations and promote knowledge sharing and resource integration to collectively address global health challenges. Moreover, scholarly attention on the application of emerging technologies in MHTW tourism can enhance service quality and sustainability to achieve a harmonious balance of economic, social, and environmental benefits.

Keywords: Sustainable tourism; Health tourism; Medical tourism; Bibliometric analysis; International collaboration

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1. Introduction

Tourism for sustainable development now represents a pivotal sector for the promotion of holistic health strategies (Sharpley, 2020). Health is emerging as a prominent

21st-century concern; therefore, the tourism industry is currently attempting to integrate wellness programs and medical services into its offerings and align with more wide-ranging sustainable development goals (Buhalis *et al*., 2023). This integration seeks to enhance the visitor experience through therapeutic and wellness-oriented services. It simultaneously contributes to local economies by diversifying tourism products and creating health-centered employment opportunities. Such initiatives underscore the potential of the tourism sector to foster environmental sustainability and concurrently address the well-being of both local populations and tourists (Higgins-Desbiolles *et al*., 2022).

Medical, health, therapy, and wellness (MHTW) and tourism have become increasingly convergent and intertwined (Milano & Koens, 2022). Numerous destinations have begun to embody these forms of tourism and exemplify this trend, for instance, wellness resorts, therapeutic landscapes, and medical tourism hubs. The relations between tourism and human health have gradually garnered the tourism industry's attention, resulting in the development of destinations that foster physical and psychosocial well-being (Xiang & Qiao, 2023). The creation of health-oriented tourism destinations has now become imperative, reflecting a shift toward sustainable and responsible tourism practices. These destinations align with global sustainability standards by offering therapeutic experiences and advocating for environmental conservation and cultural respect (Kim & Yang, 2021). Thus, the tourism industry is poised to function crucially in promoting global health and wellness, driving economic growth, and enhancing the quality of life for communities and visitors alike (Dwyer, 2023).

However, the amalgamation of MHTW has also become a trending topic in tourism research. A plethora of visual analytic studies have recently focused on these domains (Narechania *et al*., 2022). For instance, studies using geographic information systems have mapped wellness tourism flows and network analysis to explore the connections between medical tourism providers and global health networks (Xu *et al*., 2020). Researchers are focusing significantly on sustainable and eco-friendly practices, integrating green technologies, promoting environment-conserving activities, and aligning health tourism with broader sustainability goals (Souza *et al*., 2020). Moreover, the incorporation of advanced technologies such as wearable devices, mobile applications, and virtual reality is becoming increasingly prevalent to make wellness programs more personalized and efficacious (Baragash *et al*., 2022). Personalized medicine has gained traction in medical tourism, leveraging genetic testing and diagnostic tools to tailor treatments to individual health profiles. This emergent phenomenon extends into wellness tourism through customized health and wellness programs (Dillette *et al*., 2021). In addition, a revival and integration of traditional and cultural healing practices such as Ayurveda and traditional Chinese medicine are becoming increasingly evident. Such renewals enrich the wellness experience, facilitate cultural exchanges, and preserve legacy knowledge (Sujatha, 2020).

The industry has become increasingly attentive to mental health, recognizing its essential role in overall well-being and incorporating programs attending to stress reduction, mindfulness, and therapeutic interventions (Johnson *et al*., 2020). The trend of providing diagnostic assessments in wellness travel is also notable; travelers can attain profound insights into their health, which enriches their travel experiences and promotes proactive health management (de Silva *et al*., 2024). These trends collectively illustrate a move toward a more holistic, culturally enhanced, and technologically integrated approach to health and wellness tourism and signal shifts toward more sophisticated and conscientious health tourism paradigms (de Silva *et al*., 2024).

Tourism for sustainable development is no longer an unfamiliar topic. However, the literature on integrating varied tourism concepts to discuss the outcomes of sustainable development remains surprisingly scarce (Becken *et al*., 2020; Marinello *et al*., 2023). Bibliometric analyses represent a powerful tool for synthesizing the expansive and multidisciplinary domains of MHTW and integrating them into sustainable tourism development (Khanuja *et al*., 2024). Therefore, this study uses bibliometric techniques to construct a comprehensive knowledge map of this topic, detailing collaborations among authors, institutions, and countries. It also analyzes keywords and identifies research trends. Subsequently, it presents a literature review on MHTW and discusses how these domains relate to sustainable development. Section 3 introduces the applied bibliometric methods and steps undertaken for the data collection and analysis performed. Section 4 displays the knowledge maps and outlines the study findings. Finally, we discuss the research results in Section 5 and conclude the study in Section 6.

2. Literature review

2.1. Medical tourism and sustainable development

Medical tourism is defined as the practice of traveling across international borders to avail health-care services ranging from elective procedures to complex specialized surgeries (Medhekar *et al*., 2020; Nilashi *et al*., 2019). Integrating sustainability into medical tourism involves

ensuring that such travel does not adversely impact the environmental, economic, and social fabric of the destination countries (Chaulagain *et al*., 2020; Ghasemi *et al*., 2021). The medical tourism approach advocates for sustainable practices that support the long-term health of individuals as well as communities. Thus, it emphasizes environmental conservation, economic benefits, and ethical health-care practices (Monika *et al*., 2024; Shaw *et al*., 2021).

The quality and safety of health-care services are paramount in sustaining the growth and reputation of the medical tourism sector (Kundury *et al*., 2024). Sustainable medical facilities are encouraged to adopt practices that ensure high standards of medical care and patient safety while minimizing their environmental impact (White *et al*., 2022). A framework must be instituted to establish sustainable medical facilities that cogitate both operational sustainability and more wide-ranging environmental and cultural effects (Chisholm *et al*., 2021).

Studies have also focused on the regional and collaborative dimensions of medical tourism, evaluating how different regions adapt and respond to related challenges and opportunities (Virani *et al*., 2020). Lithuania can develop cooperative models to sustainably boost its medical tourism sector (Civinskas *et al*., 2023). Moreover, recent investigations provide crucial insights into consumer motivations and describe the competitive landscape of medical tourism by apprehending the behaviors and preferences of medical tourists by means such as utilizing ranking systems to evaluate destinations in Iran (Majeed *et al*., 2018).

2.2. Health tourism and sustainable development

Health tourism often encompasses medical, wellness, and spa tourism and entails travel with the intent to promote health and well-being through medical, psychological, or holistic treatments (Gkinton *et al*., 2023; Sun *et al*., 2022). Sustainable health tourism aims to protect and enhance opportunities for future generations and thus integrates these practices into frameworks that support ecological balance, economic viability, and social equity (Dembovska & Zvaigzne, 2021). This concept aligns with the more expansive objectives of sustainable development, which include promoting health alongside encouraging sustainable practices in the tourism industry.

The sustainable development of health tourism relies heavily on the ethical use and conservation of natural resources, which are intrinsic to many health tourism offerings such as thermal baths and natural spas (Favargiotti *et al*., 2022). The development of health tourism should not deplete the environments on which it depends. Further, ethical considerations must guide the development of health tourism to ensure that practices are just and benefit local communities (Jackson & Barber, 2014; Pessot *et al*., 2021).

Recent research has delved into the multifaceted effects of health tourism on local and global scales (Figueiredo *et al*., 2024). Sustainable health tourism can contribute positively to local economies by simultaneously promoting environmental stewardship and improving public health (Qureshi *et al*., 2021). Specific case studies, such as those examining health tourism in low mountain areas or the impact of religious tourism on rural health and environments, provide specific examples of how regions can sustainably develop health tourism. Such studies often highlight unique challenges and opportunities and suggest tailored approaches for integrating health tourism into local sustainable development strategies (Scheyvens & van der Watt, 2021).

The future integration of health tourism into sustainable development agendas appears promising. A growing trend exists of health-oriented tourists who prioritize sustainability, indicating a shift toward more conscious consumption patterns in tourism. Such movements are expected to drive further innovations in sustainable practices in the health tourism sector, reinforcing the role of the tourism industry in the global promotion of health and well-being (Fennell & Bowyer, 2020). Hence, the concept of health tourism for sustainable development highlights the importance of natural resources, underscores the need for ethical and economic considerations, presents practical case studies, and envisions future trends in the field.

2.3. Wellness tourism and sustainable development

Wellness tourism is defined as travel associated with the quest to maintain or enhance personal well-being. It often involves activities such as spa visits, fitness classes, mental and physical therapies, and health-oriented leisure activities (Voigt *et al*., 2011; Zhong *et al*., 2021). When integrated with sustainable development practices, wellness tourism aims to foster environments that facilitate the well-being of both locals and tourists and thus emphasizes ecological conservation, social responsibility, and economic viability(Mathew & Nimmi, 2022). This broader perspective supports the development of sustainable tourism by promoting health while ensuring the preservation of natural and cultural resources (Antunes *et al*., 2023; Esfandiari & Choobchian, 2020).

Research emphasizes that governance functions significantly in the development of sustainable wellness tourism. Effective governance frameworks ensure that wellness tourism contributes positively to local economies,

supports environmental sustainability, and enhances the social fabric of communities (Zhong *et al*., 2021). This outcome entails creating policies that support sustainable practices and encourage community participation in wellness tourism initiatives (Coghlan, 2015; Weaver *et al*., 2022). Wellness tourism can catalyze local economic development, particularly in rural or underdeveloped regions (Zhong *et al*., 2021). Wellness tourism can tap into local natural resources and cultural heritage, generate income, create jobs, and stimulate local businesses. However, this result requires careful planning to ensure that tourism development does not overburden local ecosystems or cultural practices.

Studies from Northwest Iran and Tobago have investigated how wellness tourism can align with sustainable development goals to integrate wellness activities with environmental conservation efforts and community engagement and illustrate how destinations can balance tourist needs with resource sustainability (Alexis-Thomas, 2020; Verharen *et al*., 2021). Despite its potential, wellness tourism faces challenges such as the need for consistent quality of service, sustainable supply chain management, and continued balance between tourist influx and local capacity. Future research must address these challenges by developing more robust models for sustainable wellness tourism to ensure that this strategy remains viable for promoting health, well-being, and economic development in harmony with environmental and cultural preservation. Hence, wellness tourism for sustainable development emphasizes the role of governance, economic impact, and practical models and overviews the ongoing challenges and opportunities in the field.

2.4. Therapy tourism and sustainable development

Therapy tourism is often focused on therapeutic activities linked to physical and mental health benefits and involves travel to destinations offering medical and wellness treatments such as thermal baths, forest healing, and other natural restorative environments (Ohe *et al*., 2017). When aligned with sustainable development, therapy tourism emphasizes ecologically sustainable, economically viable, and socially equitable practices and ensures that tourism activities contribute to the health of individuals as well as the environments with which they interact (Ohe *et al*., 2017). This integration aims to equally foster long-term well-being for local communities and tourists while preserving natural resources (Jabbar & Dani, 2020; Kristjánsdóttir *et al*., 2018).

Effective sustainable practices in therapy tourism require the natural and cultural environments that support therapeutic activities to be maintained and enhanced (Pessot *et al*., 2021). For example, studies have explored the sustainable development of thermal tourism and forest therapy tourism, attending to their environmental impact and their benefits to visitors and locals. These practices do not concern merely providing therapeutic benefits to tourists; they also ensure that the said benefits are delivered in a manner that can be sustained over the long term without degrading natural resources or local cultures (Shahzalal & Elgammal, 2023; Stavroula & Vasiliki, 2020).

The application of models such as strengths, weaknesses, opportunities, and threats (SWOT) analysis and analytic hierarchy process (AHP) is crucial. For instance, the SWOT-AHP combination can facilitate assessments of the sustainability of therapy tourism ventures by identifying strong facets, drawbacks, possibilities, and risks and consequently enabling stakeholders to prioritize actions based on the performed assessment (Büyüközkan *et al*., 2021). To cite one example, a study conducted in Enshi on forest therapy tourism utilized such models to strategically plan and increase the sustainability of tourism practices and assure that tourism contributes constructively to both environmental conservation and local development (Rai, 2019). Community involvement and the benefits introduced by therapy tourism to local populations are vital components of mutual sustainability. The attitudes of local communities toward therapy tourism can significantly influence the success and sustainability of such initiatives. Engaging local communities and ensuring that they benefit from therapy tourism projects can result in more sustainable and accepted practices, which are vital to the long-term success of such tourism initiatives (Zamani-Farahani, 2016).

Despite its potential, therapy tourism confronts challenges such as guaranteeing that therapeutic practices do not exploit natural resources and managing the influx of tourists in a manner that does not disrupt local lives. Future research and practices related to therapy tourism must focus on devising and implementing robust sustainable praxes that address such issues and affirm therapy tourism as a viable tool that promotes sustainable development in host communities and simultaneously delivers genuine therapeutic benefits to tourists (Jabbar & Dani, 2020; Ohe, 2021). Therapy tourism for sustainable development underlines sustainable practices, utilizes model applications, secures community engagement, and surpasses the challenges facing this sector. Table 1 presents details of the relevant studies referenced in this literature review including their authors, publication years, and titles.

3. Research methodology

Bibliometric analysis is a method of quantitative analysis based on mathematics and statistics. It is employed primarily

Table 1. Reference list for the literature review

Authors (year)	Article description
Medhekar *et al.* (2020)	This paper identifies key supply-side factors critical to enhancing the value of medical tourism in India, for instance, reduced waiting times, health-care quality, and staff expertise.
Nilashi *et al.* (2019)	This study uses a new decision-making model based on DEMATEL and Fuzzy TOPSIS techniques to pinpoint human and technological factors as the most critical for the development of medical tourism in Malaysia.
Chaulagain *et al.* (2020)	This study develops and tests a theoretical model predicting individual intentions to engage in medical tourism; it finds that attitudes, perceived behavioral control, and subjective norms positively influence such intentions and perceived severity moderates key relationships between perceived benefits, barriers, and attitudes.
Ghasemi *et al.* (2021)	The study employs a fuzzy SWARA-PROMETHEE approach to rank medical tourism destinations for Iranians, highlighting India as the top choice based on criteria such as service quality and medical equipment, noting implications for sustainable tourism development.
Monika *et al.* (2024)	The CBTD approach achieves sustainable tourism through community participation, enhancing residents' sense of belonging while protecting natural resources and cultural heritage. Successful CBTD improves community livelihoods; conversely, neglect can lead to environmental degradation and economic losses, which can be adapted to medical tourism development.
Shaw *et al.* (2021)	This Consensus Statement advocates for a transformation in health profession education to foster sustainable health-care practices and planetary health, emphasizing the need for health professionals to be equipped with the necessary skills and knowledge to address environmental challenges and achieve global sustainability goals by 2030.
Kundury *et al.* (2024)	This book chapter examines the expansion of medical tourism by discussing its driving factors, stakeholder roles, and India's regulatory strategies to improve Medical Value Travel; it encapsulates the essence of the text's focus on the development and management of medical tourism services.
White *et al.*(2022)	This summary outlines a consensus among anesthesiologists on the urgent need to adopt environmentally sustainable practices in anesthesia to mitigate climate change, emphasizing patient safety, global cooperation, and the reduction of the carbon footprint of health care through specific actionable principles.
Chisholm *et al.* (eds.) (2021)	This study reviews the challenges posed by medical waste management in Africa and proposes sustainable solutions to this issue, highlighting the need for proper policy implementation, eco-friendly technologies, and improved health-care systems to safeguard public health and environmental integrity.
Virani *et al.* (2020)	This article presents a bibliometric analysis that reveals a limited engagement with policy issues in medical tourism research; it urges the stronger integration of policy frameworks to better address and influence the sector's real-world governance and systemic challenges.
Civinskas *et al.* (2023)	This investigation probes the challenges of developing social cooperatives in Lithuania, highlighting the absence of a supportive environment, limited policy engagement, and inadequate understanding of cooperative business models, which hinder the growth of socially sustainable enterprises.
Gkinton *et al.* (2023)	This paper reviews the role of wellness tourism in improving quality of life; it highlights the benefits of wellness tourism on physical, mental, and social well-being and emphasizes the need for investment in health and wellness tourism infrastructure to yield significant socioeconomic benefits for communities.
	This study conducts a bibliometric analysis to trace the thematic evolution of health tourism research in China since 1981; it reveals how themes have diversified and are influenced by government policy, offers insights for academic research, and delivers recommendations for the strategic development of the health tourism industry.
Dembovska & Zvaigzne (2021)	This article reviews the literature on sustainable tourism, emphasizing the universal application of its principles to all tourism-dependent destinations like Cyprus; it also discusses the balance between environmental, economic, and social sustainability in tourism development.
Favargiotti *et al.* (2022)	This paper discusses the initial outcomes of the "B4R Branding4Resilience" project in Val di Sole, Italy, focusing on leveraging thermal water resources to foster sustainable development through an interdisciplinary approach that integrates ecological design with community engagement to enhance the region's natural capital and quality of life.
Jackson & Barber (2014)	This article advocates for a stakeholder-driven approach to sustainably and ethically develop health-care tourism; it provides a framework and offers suggestions to guide policy planners and practitioners in balancing economic gains with ethical considerations and sustainability.
Pessot *et al.* (2021)	This paper explores the transition of European manufacturing companies toward the Factory of the Future; it utilizes qualitative research methods to offer insights on the adoption of digital technologies, necessary organizational changes, and strategic implications for business models while highlighting challenges in skills, supply chain, and customer relations.
Figueiredo *et al.* (2024)	This study conducts a systematic literature review to consolidate knowledge on sustainable development in health tourism post-COVID-19; it identifies key research areas and proposes a future research agenda to guide further exploration and theory development in this evolving field.

(cont'd...)

Table 1. ***(Continued)***

Authors (year)	Article description
Qureshi *et al.* (2021)	This abstract reveals a significant disparity between high-income countries and LI-LMICs with respect to CVD research output versus disease burden: LI-LMICs experience the majority of CVD-related disability-adjusted life years and deaths yet contribute minimally to research. The abstract highlights the need for increased research funding and capacity building in such regions.
Scheyvens & van der Watt (2021)	This paper reviews and critiques the evolution of empowerment frameworks in tourism research; it focuses particularly on Scheyvens' 1999 model and proposes an expanded framework that includes environmental and cultural dimensions integrated into a broader sustainable development context to better assess community empowerment through tourism.
Fennell & Bowyer (2020)	This study presents a Tourism and Sustainable Transformation Framework that integrates concepts of sustainability, social-ecological systems, technology, innovation, resilience, and transitions; it applies this framework to address food waste in restaurants as an aspect of more wide-ranging sustainable development goals in tourism.
Voigt *et al.* (2011)	This paper examines the different benefits sought by three types of wellness tourists: beauty spa, lifestyle resort, and spiritual retreat visitors. To this end, it uses the development and application of a Benefits of Wellness Tourism Scale, highlighting distinct motivations and transformations sought by each group alongside demographic and travel behavior differences.
Zhong *et al.* (2021)	This study provides a comprehensive review of the literature on medical, health, and wellness tourism from 1970 to 2020; it identifies key research themes and suggests a future research agenda that emphasizes integration with broader health-care sectors and policy-making for sustainable development and quality of life improvements.
Mathew & Nimmi (2022)	This study explores how the four domains of responsible tourism (economic, social, cultural, and environmental) contribute to community life satisfaction in Kerala, India. It reveals that such responsibilities enhance life satisfaction through various aspects of community well-being. Thus, the study offers practical implications for enhancing destination attractiveness and promoting responsible tourism practices.
Antunes *et al.* (2023)	This article conducts a systematic literature review to explore the role of communication in promoting and managing thermal tourism, particularly during crises. The study identifies a gap in strategic communication models for thermal destinations and proposes a new model labeled the COSMO to enhance the resilience and promotion of these destinations.
Esfandiari & Choobchian (2020)	This study uses structural equation modeling to analyze wellness tourism in Sarab County, Iran; it finds that location and physical wellness are key factors influencing the destination choices of tourists. The results offer strategies for developing wellness tourism to enhance quality of life, particularly under the stresses of COVID-19.
Coghlan (2015)	This conceptual study explores how positive psychology can be utilized to design travel experiences that enhance well-being; it focuses on charity challenges that integrate physical activity, social connection, and meaningful engagement to promote mental health and contribute to sustainable tourism.
Weaver *et al.* (2022)	This study offers the core argument that positioning residents as citizens can foster tourism sustainability and resilience. This citizenship approach integrates rights, duties, virtues, and behaviors and offers a novel perspective for balanced tourism development while addressing the limitations of industry-centric and resident-centric models.
Alexis-Thomas (2020)	This investigation aims to explore how the tourism sector can contribute to national health and well-being in the context of sustainable development goals, as perceived by tourism providers in Tobago. The study highlights key themes such as knowledge acquisition, social vulnerability, challenges, and collective action, which link the tourism industry to health and well-being.
Verharen *et al.* (2021)	This essay presents an Africa-centric ethical solution and sustainable development model to combat rural poverty in Africa. It draws upon the moral foundations of Senegalese scholar Cheikh Anta Diop and highlights the Songhaï Centers as a practical implementation of this principle, translating ethical theories into action through advanced technologies and a holistic agroecological approach.
This study adopts the physiological, psychological, and rural business perspectives to explore the relaxation benefits of forest therapy tourism on urban office workers, highlighting the need for scientific integration to sustain such rural tourism ventures in the face of demographic challenges in Chizu, Japan.	
Jabbar and Dani (2020)	This study explores blockchain applications beyond cryptocurrency, focusing on the potential of blockchains to optimize supply chain operations through the lens of computational costs and smart contracts, using experimental methods to assess these dynamics.
Kristjánsdóttir *et al.* (2018)	Research on Integrated Sustainability Indicators for Tourism represents an evolving interdisciplinary field. Current research trends emphasize conceptualizing tourism as an interconnected system and focus on sustainable development as a dynamic process rather than a static goal. Methodologically, a preference exists for developing novel approaches over applying existing indicator frameworks.

(cont'd...)

Table 1. ***(Continued)***

Authors (year)	Article description
Pessot *et al.* (2021)	This systematic review examines the role of natural resources in health tourism; it also identifies key research themes such as resource analysis and exploitation, tourist motivations, value proposition development, and cultural considerations. The study highlights research gaps and proposes a multidisciplinary research agenda for nature-based health tourism, offering valuable insights for both academics and industry stakeholders in sustainable health tourism destination development.
Shahzalal & Elgammal (2023)	This systematic review explores the critical role of natural resources in health tourism development and sustainability. The study analyzes 52 papers and identifies key research areas including resource utilization, tourist motivations, value proposition development, and cultural factors. The study findings provide a foundation for future multidisciplinary research in nature-based health tourism and offer practical insights that can enable industry stakeholders to sustainably leverage natural resources in health tourism destinations.
Stavroula & Vasiliki (2020)	This study examines the decline of thermal tourism in Greece despite its rich resources, contrasting this fact with the thriving industry in Europe; it aims to identify causes and propose solutions for improvement and sustainability.
Büyüközkan *et al.* (2021)	This study conducts a SWOT analysis of Istanbul's health tourism using an integrated hesitant fuzzy linguistic AHP-MABAC methodology to identify and select the most effective strategy for implementation; it represents the first application of this analytical approach in health tourism strategy selection.
The need for destination evaluation has increased in the medical tourism service sector because of factors such as technological innovations, globalization, competition, and increasing customer demand. This study's use of the SWOT analysis with a particular focus on the future prospects of medical tourism in Kolkata facilitates the development of sustainable growth strategies to avoid long-term issues.	
Zamani-Farahani (2016)	This study examines the perceptions of residents apropos tourism development in Sare'in, a small tourist area in northern Iran known for its hot springs. Locals support further tourism development but express mixed feelings about its impact. The study indicates the need for expert assistance and enhanced cooperation with the National Tourism Organization to ensure sustainable tourism development.
This study utilizes data envelopment analysis to demonstrate that educational tourism can enhance the efficiency of dairy farms by fostering a broadened farmer identity, leading to improved demand creation and resource allocation.	

Abbreviations: BATD: Community-based tourism development; LI-LMICs: Low-to-lower-middle-income countries; CVD: Cardiovascular disease.

to study the external characteristics of scientific literature but can also serve as an effective quantitative analysis tool and help researchers adopting a macro perspective of a research domain present situational and developmental trends, thereby providing a scientific basis for decision-making about scientific research (Kabil *et al.*, 2021; Luo *et al.*, 2022; Zhao *et al.*, 2023). Citespace represents an important tool of bibliometric analysis, which has facilitated significant achievements in the research of news communication. This method is also an important means of constructing knowledge graphs (Trinh Thi Phuong *et al.*, 2022; Yu *et al.*, 2023).

Therefore, the present study utilized Citespace to analyze 318 important articles from the Web of Science, searching for papers related to MHTW tourism for sustainable development using the "top" retrieval mode. The retrieval formula was as follows:

(TS=(medical tourism)) AND TS=(sustainable development)
(TS=(health tourism)) AND TS=(sustainable development)
(TS=(therapy tourism)) AND TS=(sustainable development)
(TS=(wellness tourism)) AND TS=(sustainable development)

These search queries were designed to explore the relationship between varied forms of tourism and sustainable development in the Web of Science database. "Medical tourism" is defined as individuals traveling to other countries or regions to receive medical services, whereas "health tourism" encompasses travel aimed at improving health, preventing disease, and relaxation. "Therapy tourism" typically refers to travel for specific treatments, rehabilitation, or convalescence, and "wellness tourism" focuses on enhancing physical and mental well-being through travel activities. Each query integrated the theme of sustainable development, seeking literature that addressed the specific type of tourism as well as sustainable development. This approach aided researchers in understanding strategies and practices in these tourism activities that support and promote sustainability.

Citespace enabled the researchers to obtain 270 valid documents after removing duplicates to ensure that all manuscripts were academic papers in English and related to the research topic. Subsequently, an annual publication analysis was conducted on the data along with author cooperation knowledge graph analysis, organization cooperation knowledge graph analysis, keyword co-occurrence analysis, keyword prominence analysis, and keyword clustering.

4. Results

4.1. Trends discovered in the extant literature

Figure 1 illustrates the publication trends observed from 2014 to 2024 on the topic of sustainable development in MHTW tourism as indexed by the Web of Science. The data demonstrated an increase from no publications in 2014 to 46 in 2023, with 17 publications recorded up to June 2024. This trend indicates the increasing scholarly interest in this field. The significant growth observed from 2020 to 2021 reflects heightened research activity, driven possibly by the wider dissemination of sustainability concepts (Fischer *et al*., 2022). The changes in publication numbers also suggest shifts in research hotspots and focus areas. The gradual annual rise in publications from 2014 to 2018 signals the initiation of exploratory studies in this field. The steady increase in publications from 2014 to 2021 highlights the maturation of research themes and methodologies in this discipline. The number of published studies has remained relatively stable since 2022, indicating that more researchers in this domain are now focusing on mature research themes and methods.

4.2. Authors collaboration knowledge map

Table 2 and Figure 2 show the "author collaboration network" apropos the theme of tourism and sustainability. The "author collaborative knowledge atlas" represents a tool that can be utilized to demonstrate collaborations between authors. It can reveal the strengths of partnerships, display core and edge authors, and indicate the relevant research teams and collaboration models (Luo *et al*., 2022). The author collaborative contribution map displayed in Figure 2 functions primarily to demonstrate collaborations forged between authors researching the sustainable development of medical treatment, health, and recuperative and health-related tourism and reveals the intensities and patterns of cooperation between different research teams in the domain.

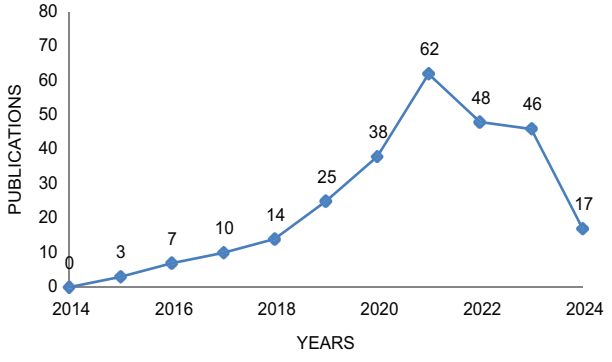


Figure 1. Research trends noted in medical, health, therapy, and wellness tourism for sustainable development (2014 – 2024)

Figure 2 indicates that Lin, Hsiao-Hsien, Hsu, Chin-Hsien, Ariza-Montes, Antonic, Han, and Heesup are centrally positioned on this map and have recorded their work for many years. Thus, they represent core members of the research field or act as opinion leaders in the field. The connecting lines between the authors indicate partnerships. Figure 2 portrays several intensive collaborative teams, indicating that strong research teams and partnerships exist in the research domain of fashion design and sustainability. Table 2 presents the top ten representative authors selected according to the number of publications. It reveals that key authors such as Hsiao-Hsien Lin, Chin-Hsien Hsu, Rosa Anaya-Aguilar, and German Gemar have significantly shaped the discourse through multiple publications over several years. The concentration of the research output in this domain has grown notably since 2015, reflecting a growing recognition of sustainability

Table 2. Authors contributing to Medical, health, therapy, and wellness tourism and sustainable development (2014 – 2024)

Count	Authors	Articles
6	Lin, Hsiao-Hsien	Oxygen- and growth rate-dependent regulation of *Escherichia coli* fumarase (FumA, FumB, and FumC) activity
4	Hsu, Chin-Hsien	How to defend COVID-19 in Taiwan? Talk about people's disease awareness, attitudes, behaviors, and the impact of physical and mental health
3	Azadi, Hossein	Organic farming and small-scale farmers: Main opportunities and challenges
3	Szromek, Adam R	Melatonin and neurotrophins NT-3, BDNF, and NGF in patients with varying levels of depression severity
3	Anaya-aguilar, Rosa	Delphi assessment of occupational hazards in the wineries of Andalusia, in southern Spain
3	Gemar, German	Measuring the eco-efficiency of wastewater treatment plants under data uncertainty
3	Anaya-Aguilar, Carmen	Challenges of spa tourism in Andalusia: Experts' proposed solutions
2	Han, Heesup	The post-coronavirus world in the international tourism industry: Application of the theory of planned behavior to safer destination choices in the case of US outbound tourism
2	Hall, C. Michael	Trends in ocean and coastal tourism: The end of the last frontier?
2	Tseng, Kuan-Chieh	PlantPAN3.0: A new and updated resource for reconstructing transcriptional regulatory networks from ChIP-seq experiments in plants



Figure 2. Analysis of author collaborative networks relating to medical, health, therapy, and wellness tourism and sustainability (2014 – 2024)

issues in medical treatment, health, and recuperative and health-related tourism. Publications have peaked in recent years, particularly in 2020 and 2021, underscoring the urgency and relevance of sustainable practices in MHTW tourism amidst global environmental challenges.

The collaborative network analysis illuminates the existence of a complex web of interactions among researchers, indicating robust and dynamic partnerships. Central figures within the network such as Hsiao-Hsien Lin and Chin-Hsien Hsu facilitate the exchange of knowledge and ideas by acting as key influencers and connectors. Emerging collaborations noted between recent contributors such as Fyall and Radovanovic highlight a trend toward interdisciplinary and cross-institutional research efforts. This evolving collaborative landscape fosters innovative solutions to sustainability challenges and simultaneously contributes to a diversified and enriched knowledge base in the fields of research related to medical treatment, health, and recuperative and health-related tourism. These author collaborations are not extensive and include only two or three researchers. Evidently, it is difficult to form stable alliances of researchers in this field that evince a robust leadership relationship. Thus, author partnerships remain fragmented. We could identify key investigators, assess the quality and intensity of research collaborations, and predict possible future research directions and opportunities for collaboration through our interpretation of the data.

4.3. Institutional collaborative knowledge maps

Institutional collaborative knowledge maps can display cooperative relationships forged between discrete institutions, reveal the cooperative network structure in a research field, and identify key research centers (Luo *et al.*, 2022). The knowledge graph constructed in this study identified the key research institutions and disclosed modes of cooperation in the fields of medical treatment, health, recuperative and health-related tourism, and sustainability research.

Figure 3 shows the distribution of institutions researching sustainable fashion design. Table 3 ranks mainstream research institutions by the number of publications and selects the top ten institutions, revealing a high level of global participation. Institutions such as the National Chin-Yi University of Technology and the Australian National University top the list with five and four publications, respectively, which underscores their pivotal contribution to the development of the field. Other notable contributors include Asia University Taiwan and Bucharest University of Economic Studies with three publications each, which demonstrates their extensive research activity and sustained interest in sustainability and MHTW tourism at varied academic centers around the world.

Figure 3 depicts the institutional collaboration network, highlighting the highly interconnected nature of research



Figure 3. Institutional cooperation network analysis for research on medical, health, therapy, and wellness tourism and sustainable development (2014 – 2024)

Table 3. List of major institutions researching medical, health, therapy, and wellness tourism and sustainability (2014 – 2024)

Count	Year	Institutions
5	2020	National Chin-Yi University of Technology
4	2018	Australian National University
3	2021	Asia University Taiwan
3	2020	Bucharest University of Economic Studies
3	2015	Islamic Azad University
3	2018	South Ural State University
3	2021	Universidad de Malaga
3	2017	Clemson University
3	2019	Silesian University of Technology
3	2021	National Kaohsiung University of Science and Technology

related to MHTW tourism and sustainable development. Central nodes such as the National Chin-Yi University of Technology and the Australian National University have facilitated extensive collaborations, acting as key influencers in the network. The presence of collaboration clusters indicates the existence of targeted partnerships between institutions with shared research interests, while the emergence of new contributors such as Qingdao University reflects the expansion of research networks and the growing recognition of MHTW tourism and sustainability issues in academia. Such interconnected networks highlight the importance of collaborations and enable institutions to leverage diverse expertise and resources. Ultimately, they promote more comprehensive and impactful research results in the field of MHTW tourism and sustainability.

Thus, Figure 3 clarifies the partnerships between different institutions, reflecting the dissemination of knowledge and research collaboration. Such connections can indicate the intensity and frequency of research collaborations and elucidate whether research alliances or joint research teams have been formed. The geographical distribution and temporal changes of publishing institutions show the regional and development trends of research in this field. For example, publications emanating from Clemson University span different years, indicating this institution's continuous activities in this research domain. Such analyses can better illuminate the roles and contributions of discrete research institutions engaged in the fields of medical treatment, health, recuperative and health-related tourism, and sustainability research and explicate how the two dimensions mutually influence and drive the literature in this domain.

4.4. Co-occurrence knowledge graph of countries

Country knowledge co-occurrence maps are commonly used in bibliometric analysis to visualize international

collaboration and knowledge exchange networks and reveal the extent of global academic efforts in specific research domains (Gu *et al.*, 2021). Table 4 portrays the co-occurrence maps specific to the field of medical treatment, health, recuperative and health-related tourism, and sustainable development. It also illuminates the global dynamics of cooperation and highlights the leading contributions of nations to the advancement of sustainable practices. Table 4 and Figure 4 offer a detailed overview of global contributions to the research on sustainable medical treatment, health, and recuperative and health-related tourism from 2014 to 2024. Table 4 quantifies publications per country, providing insights into international academic activity and geopolitical dynamics in this crucial research area.

Table 4. Major countries engaged in research on Medical, health, therapy, and wellness and sustainability (2014 – 2024)

Count	Countries
74	People's Republic of China
31	Spain
24	Taiwan
22	U.S.A
21	Italy
18	England
16	Poland
15	Portugal
15	South Korea
14	Australia

China led this research domain with 74 publications, underscoring its pivotal role in shaping sustainable tourism practices. Spain and the U.S.A. followed with 31 and 22 publications, respectively, indicating substantial interest and investment in sustainable tourism and reflecting broader economic and cultural shifts toward sustainability. Italy and the U.K. contributed 21 and 18 publications, respectively, emphasizing Europe's robust commitment to issues related to sustainability and MHTW tourism development. Contributions from Poland (16), Portugal (15), and Australia (14) further illustrate global engagement with sustainability and reflect diverse perspectives on sustainable development and MHTW tourism.

The participation of each discussed country highlights collaborative efforts in global discourses on sustainable development and MHTW tourism. Collectively, these contributions illustrate international efforts and knowledge exchanges aimed at advancing sustainability principles and synergies in tourism. Table 4 and Figure 4 reveal a vibrant global landscape in the research efforts centered on sustainable development, medical treatment, health, and recuperative and health-related tourism. This landscape underscores a collaborative global movement toward sustainable development, uniting countries at varied developmental stages and with discrete cultural backgrounds in promoting sustainable tourism. Such

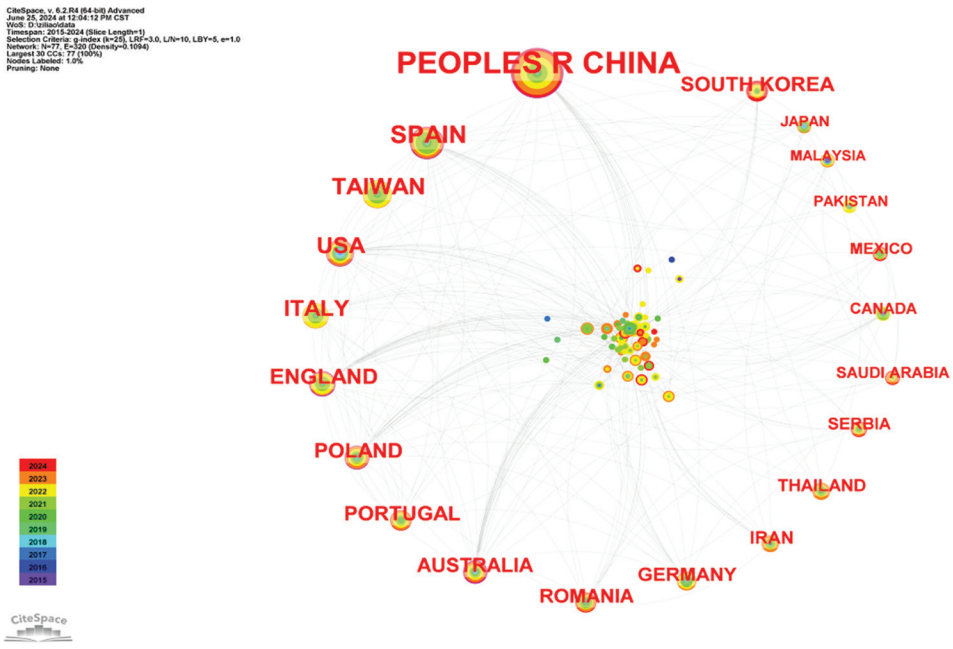


Figure 4. National co-present map for medical, health, therapy, and wellness tourism for sustainable development (2014 – 2024)

collective academic endeavors signify a global commitment to addressing environmental, ethical, and economic challenges in the field of MHTW tourism to steer the tourism industry toward a sustainable and equitable future.

4.5. Keyword co-occurrence knowledge graph

Keyword co-occurrence analysis is an important method that can reveal relationships between themes and concepts utilized in a research field (Luo *et al.*, 2022). Table 5 displays keywords with publication frequency ≥15 and notes their frequencies, centrality, and year of publication. Figure 5 shows the knowledge map of these keywords utilized in the relevant literature. Table 5 presents a detailed analysis of the high-frequency keywords from 2014 to 2024 and their centrality in the Web of Science index of research related to medical treatment, health, recuperative and health-related tourism, and sustainable development. The keyword "sustainable development" evinced the highest frequency with 46 occurrences, indicating a high centrality (0.25) and specifying its vital role and wide application in the relevant literature.

Table 5. Analysis of high-frequency keywords of medical, health, therapy, and wellness tourism and sustainable development (2014 – 2024)

Count	Centrality	Year	Keywords
46	0.25	2018	Sustainable development
37	0.26	2024	Health
34	0.08	2022	Tourism
34	0.14	2015	Management
29	0.14	2017	Sustainable tourism
28	0.17	2023	Impact
23	0.16	2016	Impacts
23	0.16	2015	Medical tourism
17	0.09	2019	Model
15	0.08	2018	Satisfaction

"Development" and "health" were also prominently positioned, reflecting the growing interest in academia to construct more sustainable economic models and practices in medical treatment, health, or recuperative and health-related tourism. "Health" represented a high-frequency keyword with a centrality of 0.26, evidencing that health was a core concern of medical or health tourism and the health industries. The keyword "tourism" evinced a lower number of occurrences with a centrality value of 0.08 but exhibited the highest number of occurrences in 2020. Thus, medical tourism denotes a new form of tourism that is receiving increasing scholarly attention. "Management" (0.14) and "impact" (0.17) were also important keywords, signaling that researchers are studying how the medical tourism and health industries can be better managed and how their impact can be evaluated.

Each node in Figure 5 represents a keyword such as "sustainable development," "health," or "tourism." The lines between the nodes represent the co-occurrence relationship between the keywords: the thicker the line, the more frequently the two keywords cooccur in the literature. Thus, thicker lines demonstrate a stronger

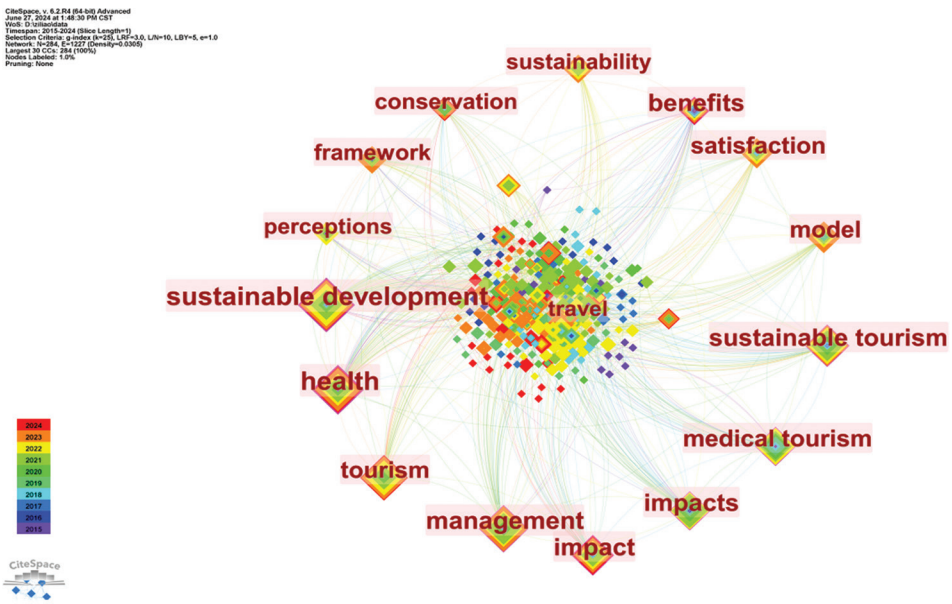


Figure 5. Keyword co-occurrence knowledge graph (2014 – 2024)

co-occurrence relationship. The colors of the lines indicate the period when the keyword co-occurrence relationship transpired: the closer the line color is to red, the earlier the co-occurrence relationship appeared; the closer the line color is to purple, the later the co-occurrence relationship emerged.

Figure 5 shows that "sustainable development" and "health" were core themes that were closely related to multiple other keywords. This finding reflects the concerns of researchers about the sustainable development of medical tourism and health industries and exhibits their scholarly interest in managing and evaluating their impact. The keywords "tourism," "management," and "impact" were also important themes that evinced significant co-occurrence relationships with "sustainable development" and "health." This outcome reveals the present research focus on how to better manage the medical tourism and health industries and evaluate their impact. In addition, emerging nodes such as "model," "satisfaction," and "benefits" divulge the increasing associations of these keywords with other keywords. Thus, researchers are currently exploring how the impact of medical tourism and the health industry can be explored through models and how they can evaluate the benefits of the intersections of these sectors.

Figure 5 elucidates the co-occurrence relationship of keywords in medical tourism, health, rehabilitation, and sustainable development research in recent years. Scholars in these fields are attending increasingly to sustainable development and impact assessment, and research in this domain is advancing steadily as new themes and directions emerge.

4.6. Keyword cluster map analysis

Keyword cluster analyses are performed to classify keywords appearing in the relevant literature by forming distinct topic-related constellations to reveal the trending topics and research directions in a research field. Keyword clustering analysis benefits bibliometric investigations by identifying blank areas of existing research, facilitating the discovery of new directions for future research, and potentially driving collaborative research across disciplines (Luo *et al*., 2022). Table 6 shows the clustering of keywords in medical treatment, health, recuperative and health-related tourism, and sustainable development research. It displays the serial number, name, and corresponding keywords of each cluster. These clusters present the different themes and foci of the research domain and indicate how these topics relate at the keyword level.

Cluster 0 comprises keywords such as "sustainable development" and "ecosystem services." It highlights

Table 6. Keyword cluster analysis for Medical, health, therapy, and wellness tourism and sustainable development: Web of Science data perspective (2014 – 2024)

Cluster ID: Name	Years	Top terms (LSI)
0: Ecosystem services	2019	sustainable development; crime reduction; community safety; secure tourism destination; community development; ecosystem services; marine protected areas; invasive alien species; capital assets; ecosystem-based fishery management
1: Mental health	2019	sustainable development; hotel industry; emotional well-being; customer behavior; importance-performance analysis; mental health; memorable experience; community well-being; causal analysis; multiphase leisure
2: Perceived vaccine efficacy	2019	life cycle; real estate market; urban farming; urban greening; plant factory; sustainable development; EU countries; EU labor market; market inequalities; health risk
3: Sustainable urban development	2019	sustainable urban development; adaptive reuse; urban transformation; regional growth; cultural heritage; design; fear; crime prevention; urban parks; health
4: Health crisis	2020	sustainable development; bibliometric analysis; science mapping; scientometric analysis; mountain tourism; rural tourism; crisis management; environment protection; IAD framework; green development
5: Spa	2020	tourism; health; survey; Andalusia; business models; health resorts; business model; spa tourism; responsible consumption; health-related service
6: Medical tourism	2017	medical tourism; sustainable tourism; health resort; tourist behavior; sunshine coast; health tourism; travel experience; tourist perception; wellness tourism; sunshine coast
7: Sustainable tourism	2019	sustainable tourism; medical tourism; hotel managers; sunshine coast; tourism industry; carrying capacity; visitor management; public health; sustainable development; risk society
8: Psychological well-being	2020	psychological well-being; perma model; explanatory style; tourism practitioners; peak experiences peak experiences; behavioral intentions; astronomical tourism; stargazing tourism; sustainable competitive advantage
9: Composite index	2017	beach quality; beach management; composite index; Emilia-Romagna

the challenges of balancing community safety and crime reduction against sustainable development goals. This cluster focuses on how ecosystem services and natural resource management can contribute to community development and secure tourism destinations, particularly in marine protected areas and fisheries management.

Terms such as "sustainable development" and "mental health" are central to Cluster 1, which explores the intersections of emotional well-being and customer behaviors in the hotel industry. The research positioned in this cluster emphasizes the importance of community well-being and memorable experiences and utilizes tools such as causal analysis and multiphase leisure to understand the impact of these factors on customer satisfaction and loyalty.

Cluster 2 incorporates keywords such as "sustainable development" and "health risk," focusing on the perceived efficacy of vaccines within the context of sustainable development. It examines implications for urban farming, urban greening, and market inequalities, particularly in the EU. The research placed in this cluster addresses the life cycle of such factors and studies their impact on health risks and market dynamics.

Cluster 3 includes keywords such as "sustainable urban development" and "urban transformation" and focuses on adaptive reuse, regional growth, and cultural heritage. The research designated to this cluster explores how design, crime prevention, and urban parks function to foster sustainable urban environments and enhance public health.

Cluster 4 centers on keywords such as "sustainable development" and "crisis management" and addresses health crises through the lens of sustainable development. It employs bibliometric and scientometric analyses to map the field, focusing on rural tourism, environmental protection, and green development. Research positioned in this cluster highlights the importance of managing health crises in a sustainable manner.

Cluster 5 encompasses keywords such as "tourism" and "health" and examines the spa and health resort industry, highlighting the significance of business models and responsible consumption in promoting health-related services. Studies in this cluster underscore the role of spa tourism in integrating sustainable development principles into business practices.

Cluster 6 features keywords such as "medical tourism" and "sustainable tourism." It focuses on tourist behaviors, travel experiences, and wellness tourism, particularly on the Sunshine Coast. The research positioned in this cluster explores how medical tourism can be made more sustainable and probes the perceptions and experiences of tourists in this sector.

Cluster 7 is focused on keywords such as "sustainable tourism" and "public health" and examines the sustainability practices followed by the tourism industry. It addresses issues such as carrying capacity and visitor management and underlines the need for sustainable development and risk management in the tourism sector. The existing research in this cluster also explores the roles of hotel managers and the Sunshine Coast as case studies.

Cluster 8 includes the keywords "psychological well-being" and "PERMA model." The research placed in this cluster focuses on the impact of tourism on psychological health, using models and theories to understand behavioral intentions and peak experiences. Thus, this cluster highlights niche areas such as astronomical tourism and investigates how they function in promoting sustainable competitive advantages.

Cluster 9 incorporates keywords such as "beach quality" and "composite index" and attends to the evaluation and management of beach destinations. It focuses on the Emilia-Romagna region, using composite indices to assess beach quality and management practices. The research in this cluster emphasizes the importance of maintaining high standards in beach destinations to support sustainable tourism.

The clusters reflect the diversity and richness of the research domain and reflect the focus and interests of the researchers on discrete topics. Such clusters can help researchers identify lacunae in the existing research, discover possible new directions for future research, and potentially drive collaborative research across disciplines.

Figure 6 displays the keyword cluster map, which reveals the intercorrelation and research hotspots of various research topics in the fields of medical treatment, health, recuperative and health-related tourism, and sustainable development. This map illuminates the relationships between the varied keyword clusters using discrete colors and connecting lines. Each cluster represents a research topic or field and the keywords placed in the cluster represent the subdivided research directions or focal points of the themes.

Different colored regions in the atlas represent different clusters of keywords, indicating clearly differentiated research topics in the research field. The size and color depth of each cluster could indicate the importance and study activities of the cluster. The density of the points in the cluster identifies the degrees of aggregation of the keywords within the cluster: dense clustering specifies more focused and specific studies on the topic. The lines



Figure 6. Keyword cluster network map for medical, health, therapy, and wellness tourism and sustainable development (2014 – 2024)

in the atlas represent the co-occurrence relationships between the different keywords. The more connected and thicker keywords indicate a higher centrality in the research field, that is, these keywords are more frequently mentioned simultaneously in the relevant literature. The interconnections and distances between clusters can reflect the evolutionary paths of the research field, for instance, the transitions from competitive advantages to related industries. Gaps in the relevant literature may be identified by observing sparse or unconnected regions between clusters in the clustering map, which indicate directions that have not been comprehensively explored by extant research.

Overall, Figure 6 provides a macro perspective on the academic dialog and knowledge structure of the fields of medical treatment, health, recuperative and health-related tourism, and sustainability. Researchers can identify research trends, discover the key concepts in the field, and study their interactions by analyzing this map. Thus, this map can guide scholars to future research directions.

4.7. Burst analysis of keywords

Table 7 provides the top 25 keywords for the citation surge (citation bursts) in the fields of medical treatment, health, recuperative and health-related tourism, and sustainability between 2014 and 2024. A citation spike is a sudden and significant increase in the number of citations to a keyword in a certain period and usually signals widespread attention to a topic or concept in the field. The spike intensity (strength) indicates the concentration of the keyword spike: the larger the value, the more significant the citation increase of the keyword in the relevant time period. It became clear during the examination of the keyword burst analysis in the domains of medical treatment, health, and recuperative and health-related tourism in the context of sustainable development that certain terms surged to prominence at specific times, reflecting shifts in research priorities and thematic interests.

For example, "health tourism" emerged as a crucial term in 2016, achieving a burst strength of 2.43 and remained focal until 2019. This finding underscores growing explorations of how tourism can be integrated with health services to promote well-being and ensure sustainable development. "Medical tourism" exhibited a substantial presence in 2017 with a high burst strength of 3.56, and its relevance continued through 2019. This discovery indicates a peak in research on cross-border health services and on the sustainable development of such practices during this period. "Sustainable tourism" also rose to prominence in 2017 with a burst strength of 1.92, remaining a significant study topic until 2018. This period marked an increased focus on integrating sustainability into tourism practices to ensure long-term benefits for both the environment and local communities.

The use of the keyword "information" rose significantly in 2021, evincing a burst strength of 2.04. The importance of this keyword was maintained through 2022, indicating the growing role of information dissemination in promoting sustainable health tourism. "Sustainability" emerged strongly in 2021 with a burst strength of 1.71 and remained relevant through 2022. "Happiness" appeared as a prominent keyword in 2022 with a burst strength of 1.88,

Table 7. Analysis of keywords used for Medical, health, therapy, and wellness tourism for sustainable development (2014 – 2024)

Keywords	Year	Strength	Begin	End	2014 – 2024
Benefits	2015	1.74	2015	2017	
Health tourism	2016	2.43	2016	2019	
Governance	2016	1.25	2016	2017	
Agriculture	2016	0.86	2016	2018	
Medical tourism	2015	3.56	2017	2019	
Travel	2017	2.36	2017	2018	
Sustainable tourism	2017	1.92	2017	2018	
Biodiversity	2018	1.23	2018	2019	
Attitudes	2018	1.22	2018	2019	
Index	2016	1.79	2019	2020	
Impacts	2016	1.72	2019	2020	
Accessibility	2020	0.99	2020	2021	
China	2018	0.95	2020	2021	
Perceptions	2015	0.83	2020	2022	
Information	2021	2.04	2021	2022	
Sustainability	2021	1.71	2021	2022	
Industry	2021	1.23	2021	2022	
Circular economy	2021	1.16	2021	2022	
Experiences	2017	0.76	2021	2022	
Happiness	2022	1.88	2022	2024	
Services	2022	1.46	2022	2024	
Destination	2021	1.17	2022	2024	
Rural tourism	2015	1.13	2022	2024	
Demand	2017	1.13	2022	2024	
Areas	2020	0.76	2022	2024	

and this keyword is expected to remain significant through 2024. This term's rise indicates a focus on well-being outcomes in sustainable health and tourism practices. "Services" also attained importance in 2022 with a burst strength of 1.46 and will probably remain relevant through 2024, highlighting the emphasis on improving service provision in sustainable health tourism. Interest in the keyword "destination" grew in 2022 with a burst strength of 1.17. This keyword is projected to remain relevant through 2024, underscoring the importance of sustainable practices at tourist destinations. "Rural tourism" became more prominent in 2022 with a burst strength of 1.13 and is expected to stay relevant through 2024. This projection indicates a focus on promoting sustainable tourism in rural areas. Finally, "demand" gained significance in 2022 with a burst strength of 1.13. This term is expected to remain important through 2024, reflecting an interest in understanding consumer demand for sustainable health and tourism services.

In summary, the analysis of keyword bursts reveals evolving research interests, moving from theoretical discussions to practical applications in sustainable health and tourism. Future studies will probably continue to focus on circular economies, sustainable business models, consumer behaviors, and technological applications and will deliver valuable insights for both scholars and practitioners on how sustainable development can be promoted.

5. Discussion

This study conducted a bibliometric analysis to investigate 318 publications on themes related to the intersection of MHWT tourism for sustainable development obtained from the Web of Science (2014 – 2024). We constructed knowledge maps to reveal collaborations between authors, institutions, and countries. We also uncovered the keyword highlights to better identify the research trends.

The author cooperation analysis conducted for this study revealed that Lin, Hsiao-Hsien, Hsu, Chin-Hsien, Ariza-Montes, Antonic, Han, and Heesup represent core authors and have established several closely collaborating research teams. The existence of core author groups in a research field indicates stable academic partnerships. The author cooperative network has evinced a trend of expansion in recent years, reflecting a rise in interdisciplinary and cross-institutional collaborations. This trend is conducive to the further advancement of this research domain. However, the existing author network is still somewhat fragmented and more future scholarly collaborations should be encouraged, especially across institutions and disciplines, to forge more intimate partnerships and promote the participation of emerging authors to instigate further research in this field.

The study's analysis of institutional knowledge graphs identified the leading research institutions including the National University of Science and Technology, the Australian National University of Economics and Research, and the Asia University of Bucharest. These core institutions have formed several closely-knit research teams, which evince stable cooperation in this research domain. Institutional cooperation networks have expanded in recent years, reflecting an increase in interdisciplinary and cross-institutional cooperation, which helps to drive the development of the discipline. However, some degree of fragmentation remains in the existing institutional network, and more interinstitutional and interdisciplinary cooperation should be encouraged in the future. In addition, closer partnerships should be forged and the participation of emerging research institutions should be encouraged to drive further research in this field. The national cooperation map indicates that countries such as the United States, China, and Spain possess abundant research output but also engage in close collaborations with other countries. Therefore, they occupy central positions in the network.

Keyword cluster analyses reveal the diversity of research themes in the domains of medical treatment, health, and recuperative and health-related tourism in the context of sustainable development. Such themes include ecological services, mental health, vaccine efficacy, urban sustainable development, and health crisis management, among others. The interconnectedness between different clusters reflects domain-specific knowledge structures and evolutionary paths. Future research initiatives should delve into the intersections of such themes and leverage cluster analyses to identify research gaps and offer future directions.

Keyword burst analyses highlight the dynamic evolution of research priorities in this field, shifting from a focus on theoretical concepts to practical applications. Recent bursts observed in keywords such as "information," "sustainability," "happiness," and "services" indicate a growing interest in the practical aspects of sustainable health tourism, including service provision, consumer demand, and well-being outcomes. Future research projects should investigate the underlying factors driving keyword bursts, track their longevity, and integrate burst analysis with cluster analysis to acquire a comprehensive understanding of the field's knowledge structures, trends, and future directions.

This study takes a more comprehensive and interdisciplinary approach to analyze MHTW tourism in the context of sustainable development and constructs a broader knowledge map. Previous studies have primarily relied on qualitative methods such as interviews and case studies (Johnson & Park, 2020; Ospina *et al*., 2018), which could offer limited research perspectives. Conversely, our investigation employed the methodology of bibliometric analysis and utilized Citespace software for data visualization. This approach enables a more visual, objective, and expansive understanding of the knowledge structure, research hotspots, and development trends in this field.

Moreover, some studies have focused on specific aspects of sustainable tourism, such as economic (Brown *et al*., 2011), social (Davis *et al*., 2021), or environmental (Lu & Nepal, 2009). However, our review delivers a more holistic view by integrating discrete tourism concepts and disclosing their intersections with sustainable development. This approach enables us to identify critical interconnections and synergies between different domains and thus contributes to a more comprehensive understanding of sustainable tourism development.

Furthermore, our study highlights several future research directions, including strengthening international collaboration, promoting knowledge sharing and resource integration, and exploring the application of emerging technologies in MHTW tourism. These recommendations align with recent calls for increased interdisciplinary and transdisciplinary research in sustainable tourism (Thompson, 2021) and address the need to leverage technological advancements to enhance service quality and sustainability (Chatterjee *et al*., 2023). Our study contributes to the ongoing discourse on sustainable tourism by providing valuable guidance for future research and development in this domain and offers actionable insights for researchers, practitioners, and policymakers.

6. Conclusion

This study employed bibliometric analysis and utilized the Citespace software to systematically analyze the

extant research on MHTW tourism in the context of sustainable development. In so doing, it constructed a more comprehensive knowledge map. The study findings revealed a significant growth trend in research on MHTW tourism in sustainable development since 2014. Future research endeavors should emphasize international collaborations, promote knowledge sharing and resource integration, and explore the application of emerging technologies in MHTW tourism.

However, this study was limited by its analysis of only literature published in English. Future research projects could expand the scope to include literature in other languages, yielding more diverse and comprehensive research results. Prospective studies could also emphasize comparative examinations of the roles and contributions of discrete tourism forms on sustainable development to further reveal their advantages and disadvantages. In addition, the relationships between sustainable development and digital transformation in the tourism industry could be explored in studies investigating the application prospects of emerging technologies (such as big data, artificial intelligence, and virtual reality) in promoting sustainable tourism development. Moreover, in-depth research could be conducted on how tourism enterprises achieve sustainable development goals, including but not limited to corporate social responsibility, green supply chain management, and low-carbon tourism. Studies conducted from the perspective of international cooperation could explore best practices and experiences in promoting sustainable tourism development in different countries and regions to facilitate cross-country knowledge sharing and resource integration. Finally, researchers should attend to the impact of sustainable tourism on local communities and cultures and probe ways to achieve sustainable tourism industry development while protecting and promoting local cultures and communities.

Due to data accessibility constraints, this study utilized only the Web of Science database. Future research initiatives could consider incorporating additional databases to enhance the comprehensiveness and representativeness of research findings. In addition, future research endeavors could complement and intensify this study by utilizing qualitative research methods such as case studies and interviews to yield a more in-depth exploration of related issues. Future research ventures could also focus on the impact of emerging technologies on the sustainable development of MHTW tourism. Further, they could probe the understanding, attitudes, and behavioral intentions of consumers from diverse cultural backgrounds toward sustainable tourism products and examine how governments, businesses, and communities can collaborate to promote the sustainable development of MHTW tourism.

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Author contributions

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Investigation: Songyu Jiang

Methodology: Shu Li

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References

Alexis-Thomas, C. (2020). An examination of issues related to tourism and health and well-being as a sustainable development goal by tourism providers in Tobago. *Worldwide Hospitality and Tourism Themes*, 12(3):293-303.

https://doi.org/10.1108/WHATT-02-2020-0006

Antunes, V., Gonçalves, G., & Estevão, C. (2023). A theoretical reflection on thermalism and communication: Future perspectives in times of crisis. *Journal of Hospitality and Tourism Insights*, 6(4):1618-1638.

https://doi.org/10.1108/JHTI-08-2021-0231

Baragash, R.S., Aldowah, H., & Ghazal, S. (2022). Virtual and augmented reality applications to improve older adults' quality of life: A systematic mapping review and future directions. *Digital Health*, 8:20552076221132099.

https://doi.org/10.1177/20552076221132099

Becken, S., Whittlesea, E., Loehr, J., & Scott, D. (2020).

Tourism and climate change: Evaluating the extent of policy integration. *Journal of Sustainable Tourism*, 28(10):1603-1624.

https://doi.org/10.1080/09669582.2020.1745217

Brown, J.H., Burnside, W.R., Davidson, A.D., DeLong, J.P., Dunn, W.C., Hamilton, M.J., *et al.* (2011). Energetic limits to economic growth. *BioScience*, 61(1):19-26.

https://doi.org/10.1525/bio.2011.61.1.7

Buhalis, D., Leung, X.Y., Fan, D., Darcy, S., Chen, G., Xu, F., *et al.* (2023). Editorial: Tourism 2030 and the contribution to the sustainable development goals: The tourism review viewpoint. *Tourism Review*, 78(2):293-313.

https://doi.org/10.1108/TR-04-2023-620

Büyüközkan, G., Mukul, E., & Kongar, E. (2021). Health tourism strategy selection via SWOT analysis and integrated hesitant fuzzy linguistic AHP-MABAC approach. *Socio-Economic Planning Sciences*, 74:100929.

https://doi.org/10.1016/j.seps.2020.100929

Chatterjee, S., Chaudhuri, R., Kamble, S., Gupta, S., & Sivarajah, U. (2023). Adoption of artificial intelligence and cutting-edge technologies for production system sustainability: A moderator-mediation analysis. *Information Systems Frontiers*, 25(5):1779-1794.

https://doi.org/10.1007/s10796-022-10317-x

Chaulagain, S., Pizam, A., & Wang, Y. (2020). An integrated behavioral model for medical tourism: An American perspective. *Journal of Travel Research*, 60(4):761-778.

https://doi.org/10.1177/0047287520907681

Chisholm, J.M., Zamani, R., Negm, A.M., Said, N., Abdel daiem, M.M., Dibaj, M., *et al.* (2021). Sustainable waste management of medical waste in African developing countries: A narrative review. *Waste Management and Research*, 39(9):1149-1163.

https://doi.org/10.1177/0734242X211029175

Civinskas, R., Stašys, R., Pancerovienė, A., & Anužienė, A. (2023). Social cooperative model choices in the socially unsustainable environment: Evidence from Lithuania. *Sustainability*, 15(15):11566.

https://doi.org/10.3390/su151511566

Coghlan, A. (2015). Tourism and health: Using positive psychology principles to maximise participants' well-being outcomes-a design concept for charity challenge tourism. *Journal of Sustainable Tourism*, 23(3):382-400.

https://doi.org/10.1080/09669582.2014.986489

Davis, R.E., Trickey, A.W., Abrahamse, P., Kato, I., Ward, K., & Morris, A.M. (2021). Association of cumulative social risk and social support with receipt of chemotherapy among patients with advanced colorectal cancer. *JAMA Network Open*, 4(6):e2113533.

https://doi.org/10.1001/jamanetworkopen.2021.13533

De Silva, R., Gayathri, P., Ganeshan, K., & Silva, S.D.A.C. (2024). Wellness tourism after the pandemic: Real experience of wellness tourism after the pandemic in Sri Lankan context. In: Tanrisever, C, Pamukçu, H., & Sharma, A. (eds.). Future Tourism Trends. Vol. 1. United Kingdom: Emerald Publishing Limited, p.299-307.

https://doi.org/10.1108/978-1-83753-244-520241020

Dembovska, I., & Zvaigzne, A. (2021). Sustainability and its challenges in destinations that highly depend on tourism: A thematic literature review. *Worldwide Hospitality and Tourism Themes*, 13(6):697-708.

https://doi.org/10.1108/WHATT-07-2021-0098

Dillette, A.K., Douglas, A.C., & Andrzejewski, C. (2021). Dimensions of holistic wellness as a result of international wellness tourism experiences. *Current Issues in Tourism*, 24(6):794-810.

https://doi.org/10.1080/13683500.2020.1746247

Dwyer, L. (2023). Tourism development and sustainable well-being: A beyond GDP perspective. *Journal of Sustainable Tourism*, 31(10):2399-2416.

https://doi.org/10.1080/09669582.2020.1825457

Esfandiari, H., & Choobchian, S. (2020). Designing a Wellness-based Tourism Model for Sustainable Rural Development. North Carolina: Research Square.

Favargiotti, S., Pasquali, M., Chioni, C., & Pianegonda, A. (2022). Water Resources and health tourism in Val di Sole: Key elements for innovating with nature in the Italian inner territories. *Sustainability*, 14(18):11294.

https://doi.org/10.3390/su141811294

Fennell, D.A., & Bowyer, E. (2020). Tourism and sustainable transformation: A discussion and application to tourism food consumption. *Tourism Recreation Research*, 45(1):119-131.

https://doi.org/10.1080/02508281.2019.1694757

Figueiredo, N., Abrantes, J.L., & Costa, S. (2024). Mapping the sustainable development in health tourism: A systematic literature review. *Sustainability*, 16(5):1901.

https://doi.org/10.3390/su16051901

Fischer, D., King, J., Rieckmann, M., Barth, M., Büssing, A., Hemmer, I., *et al.* (2022). Teacher education for sustainable development: A review of an emerging research field. *Journal of Teacher Education*, 73(5):509-524.

https://doi.org/10.1177/00224871221105784

Ghasemi, P., Mehdiabadi, A., Spulbar, C., & Birau, R. (2021). Ranking of sustainable medical tourism destinations in Iran: An integrated approach using fuzzy swara-promethee. *Sustainability*, 13(2):683.

https://doi.org/10.3390/su13020683

Gkinton, E., Telonis, G., Halkiopoulos, C., & Boutsinas, B. (2023). Quality of life and health tourism: A conceptual roadmap of enhancing cognition and well-being. In: Tourism, Travel, and Hospitality in a Smart and Sustainable World. Cham: Springer.

Gu, Z., Meng, F., & Farrukh, M. (2021). Mapping the research on knowledge transfer: A scientometrics approach. *IEEE Access*, 9:34647-34659.

https://doi.org/10.1109/ACCESS.2021.3061576

Higgins-Desbiolles, F., Blanchard, L.A., & Urbain, Y. (2022). Peace through tourism: Critical reflections on the intersections between peace, justice, sustainable development and tourism. *Journal of Sustainable Tourism*, 30(2-3):335-351.

https://doi.org/10.1080/09669582.2021.1952420

Jabbar, A., & Dani, S. (2020). Investigating the link between transaction and computational costs in a blockchain environment. *International Journal of Production Research*, 58(11):3423-3436.

https://doi.org/10.1080/00207543.2020.1754487

Jackson, L.A., & Barber, D.S. (2014). Ethical and sustainable healthcare tourism development: A primer. *Tourism and Hospitality Research*, 15(1):19-26.

https://doi.org/10.1177/1467358414553868

Johnson, K.R., & Park, S. (2020). Mindfulness training for tourism and hospitality frontline employees. *Industrial and Commercial Training*, 52(4):185-193.

https://doi.org/10.1108/ICT-10-2019-0095

Johnson, K.R., Park, S., & Chaudhuri, S. (2020). Mindfulness training in the workplace: Exploring its scope and outcomes. *European Journal of Training and Development*, 44(4/5):341-354.

https://doi.org/10.1108/EJTD-09-2019-0156

Kabil, M., Priatmoko, S., Magda, R., & Dávid, L.D. (2021). Blue economy and coastal tourism: A comprehensive visualization bibliometric analysis. *Sustainability*, 13(7):3650.

https://doi.org/10.3390/su13073650

Khanuja, A., Sreedharan, R., & Sharma, N. (2024). Bibliometric analysis on usage of Industry 4.0 technologies in healthcare. *The TQM Journal*.

https://doi.org/10.1108/TQM-08-2023-0252

Kim, B., & Yang, X. (2021). "I'm here for recovery": The eudaimonic wellness experiences at the le Monastère des Augustines wellness hotel. *Journal of Travel and Tourism Marketing*, 38(8):802-818.

https://doi.org/10.1080/10548408.2021.1921093

Kristjánsdóttir, K.R., Ólafsdóttir, R., & Ragnarsdóttir, K.V. (2018). Reviewing integrated sustainability indicators for tourism. *Journal of Sustainable Tourism*, 26(4):583-599.

https://doi.org/10.1080/09669582.2017.1364741

Kundury, K.K., Shylaja, K.C., Namitha, & Gowdappa, H.B. (2024). Medical tourism: An overview on the cross-border care. In: Chaudhary, B., Bhatia, D., Patel, M., Singh, S., & Sharma, S., (eds.). Medical Tourism in Developing Countries: A Contemporary Approach. Singapore: Springer Nature Singapore, p.1-27.

https://doi.org/10.1007/978-981-99-8909-6_1

Lu, J., & Nepal, S.K. (2009). Sustainable tourism research: An analysis of papers published in the Journal of Sustainable Tourism. *Journal of Sustainable Tourism*, 17(1):5-16.

https://doi.org/10.1080/09669580802582480

Luo, C., Jiang, S., Pu, R., Li, L., & Yang, H. (2022). Knowledge map of digital tourism: A bibliometric approach using CiteSpace. *Problems and Perspectives in Management*, 20(4), 573-587.

https://doi.org/10.21511/ppm.20(4).2022.43

Majeed, S., Lu, C., Majeed, M., & Shahid, M.N. (2018). Health resorts and multi-textured perceptions of international health tourists. *Sustainability*, 10(4):1063.

https://doi.org/10.3390/su10041063

Marinello, S., Butturi, M.A., Gamberini, R., & Martini, U. (2023). Indicators for sustainable touristic destinations: A critical review. *Journal of Environmental Planning and Management*, 66(1):1-30.

https://doi.org/10.1080/09640568.2021.1978407

Mathew, P.V., & Nimmi, P.M. (2022). Sustainable tourism development: Discerning the impact of responsible tourism on community well-being. *Journal of Hospitality and Tourism Insights*, 5(5):987-1001.

https://doi.org/10.1108/JHTI-02-2021-0052

Medhekar, A., Wong, H.Y., & Hall, J.E. (2020). Health-care providers perspective on value in medical travel to India. *Tourism Review*, 75(4):717-731.

https://doi.org/10.1108/TR-06-2019-0276

Milano, C., & Koens, K. (2022). The paradox of tourism extremes. Excesses and restraints in times of COVID-19. *Current Issues in Tourism*, 25(2):219-231.

https://doi.org/10.1080/13683500.2021.1908967

Monika, Gautam, P., & Bhatia, D. (2024). Sustainability through Community-based tourism development (CBTD): Planning initiatives, concerns, and strategies in the growth of medical tourism. In: Chaudhary, B., Bhatia, D., Patel, M., Singh, S. & Sharma, S. (eds.). Medical Tourism in Developing Countries: A Contemporary Approach. Singapore: Springer Nature Singapore, p.145-159.

https://doi.org/10.1007/978-981-99-8909-6_10

Narechania, A., Karduni, A., Wesslen, R., & Wall, E. (2022). Vitality: Promoting serendipitous discovery of academic

literature with transformers and visual analytics. *IEEE Transactions on Visualization and Computer Graphics*, 28(1):486-496.

https://doi.org/10.1109/TVCG.2021.3114820

Nilashi, M., Samad, S., Manaf, A.A., Ahmadi, H., Rashid, T.A., Munshi, A., *et al.* (2019). Factors influencing medical tourism adoption in Malaysia: A DEMATEL-Fuzzy TOPSIS approach. *Computers and Industrial Engineering*, 137:106005.

Ohe, Y. (2021). Investigating farmer's identity and efficiency of tourism-oriented farm diversification. *Tourism Economics*, 28(2):535-558.

https://doi.org/10.1177/1354816620980185

Ohe, Y., Ikei, H., Song, C., & Miyazaki, Y. (2017). Evaluating the relaxation effects of emerging forest-therapy tourism: A multidisciplinary approach. *Tourism Management*, 62:322-334.

https://doi.org/10.1016/j.tourman.2017.04.010

Ospina, S.M., Esteve, M., & Lee, S. (2018). Assessing qualitative studies in public administration research. *Public Administration Review*, 78(4):593-605.

https://doi.org/10.1111/puar.12837

Pessot, E., Spoladore, D., Zangiacomi, A., & Sacco, M. (2021). Natural resources in health tourism: A systematic literature review. *Sustainability*, 13(5):2661.

https://doi.org/10.3390/su13052661

Pessot, E., Zangiacomi, A., Battistella, C., Rocchi, V., Sala, A., & Sacco, M. (2021). What matters in implementing the factory of the future: Insights from a survey in European manufacturing Regions. *Journal of Manufacturing Technology Management*, 32(3):795-819.

https://doi.org/10.1108/JMTM-05-2019-0169

Qureshi, N.Q., Mufarrih, S.H., Bloomfield, G.S., Tariq, W., Almas, A., Mokdad, A.H., *et al.* (2021). Disparities in cardiovascular research output and disease outcomes among high-, middle- and low-income countries-an analysis of global cardiovascular publications over the last decade (2008-2017). *Global Heart*, 16(1):4.

https://doi.org/10.5334/gh.815

Rai, A. (ed.). (2019). Management of medical tourism in Kolkata: Strategies and evaluation. In: Medical Tourism in Kolkata, Eastern India. Germany: Springer International Publishing, p.185-204.

https://doi.org/10.1007/978-3-319-73272-5_8

Scheyvens, R., & Van der Watt, H. (2021). Tourism, empowerment and sustainable development: A new framework for analysis. *Sustainability*, 13(22):12606.

https://doi.org/10.3390/su132212606

Shahzalal, M., & Elgammal, I. (2023). Stakeholders' perception of accessible tourism implementation based on corporate sustainability and responsibility: A SEM-based investigation. *Tourism Review*, 78(3):986-1003.

https://doi.org/10.1108/TR-05-2022-0249

Sharpley, R. (2020). Tourism, sustainable development and the theoretical divide: 20 years on. *Journal of Sustainable Tourism*, 28(11):1932-1946.

https://doi.org/10.1080/09669582.2020.1779732

Shaw, E., Walpole, S., McLean, M., Alvarez-Nieto, C., Barna, S., Bazin, K., *et al.* (2021). AMEE consensus statement: Planetary health and education for sustainable healthcare. *Medical Teacher*, 43(3):272-286.

https://doi.org/10.1080/0142159X.2020.1860207

Souza, V.S., Marques, S.R.B.V., & Veríssimo, M. (2020). How can gamification contribute to achieve SDGs? *Journal of Hospitality and Tourism Technology*, 11(2):255-276.

https://doi.org/10.1108/JHTT-05-2019-0081

Stavroula, G., & Vasiliki, D. (2020). Alternative forms of sustainable development: The case of thermal tourism. *International Journal of Environment and Sustainable Development*, 19(4):367-377.

https://doi.org/10.1504/IJESD.2020.110637

Sujatha, V. (2020). Globalisation of South Asian medicines: Knowledge, power, structure and sustainability. *Society and Culture in South Asia*, 6(1):7-30.

https://doi.org/10.1177/2393861719883063

Sun, S., Zhong, L., Law, R., Li, X., Deng, B., & Yang, L. (2022). Health tourism evolution: A review based on bibliometric analysis and the china national knowledge infrastructure database. *Sustainability*, 14(16):10435.

https://doi.org/10.3390/su141610435

Thompson, B.Y. (2021). Marginalized identities, social justice, and volun-tourism. In: Digital Nomads Living on the Margins: Remote-Working Laptop Entrepreneurs in the Gig Economy. United Kingdom: Emerald Publishing Limited, p.91-100

https://doi.org/10.1108/978-1-80071-545-520211008

Trinh Thi Phuong, T., Nguyen Danh, N., Tuyet Thi Le, T., Nguyen Phuong, T., Nguyen Thi Thanh, T., & Le Minh, C. (2022). Research on the application of ICT in Mathematics education: Bibliometric analysis of scientific bibliography from the Scopus database. *Cogent Education*, 9(1):2084956.

https://doi.org/10.1080/2331186X.2022.2084956

Verharen, C., Bugarin, F., Tharakan, J., Wensing, E., Gutema, B., Fortunak, J., *et al.* (2021). African environmental ethics: Keys to sustainable development through agroecological villages. *Journal of Agricultural and Environmental Ethics*, 34(3):18.

https://doi.org/10.1007/s10806-021-09853-4

Virani, A., Wellstead, A.M., & Howlett, M. (2020). Where is the policy? A bibliometric analysis of the state of policy research on medical tourism. *Global Health Research and Policy*, 5(1):19.

https://doi.org/10.1186/s41256-020-00147-2

Voigt, C., Brown, G., & Howat, G. (2011). Wellness tourists: In search of transformation. *Tourism Review*, 66(1/2):16-30.

https://doi.org/10.1108/16605371111127206

Weaver, D.B., Moyle, B., & McLennan, C.L.J. (2022). The citizen within: Positioning local residents for sustainable tourism. *Journal of Sustainable Tourism*, 30(4):897-914.

https://doi.org/10.1080/09669582.2021.1903017

White, S.M., Shelton, C.L., Gelb, A.W., Lawson, C., McGain, F., Muret, J., *et al.* (2022). Principles of environmentally-sustainable anaesthesia: A global consensus statement from the world federation of societies of anaesthesiologists. *Anaesthesia*, 77(2):201-212.

https://doi.org/10.1111/anae.15598

Xiang, K., & Qiao, G. (2023). Exploring well-being outcomes and influenced mechanism of senior tourists: Evidence from an embodiment and continuity perspective. *Current Issues in Tourism*, 26(13):2203-2220.

https://doi.org/10.1080/13683500.2022.2081134

Xu, F., Nash, N., & Whitmarsh, L. (2020). Big data or small data? A methodological review of sustainable tourism. *Journal of Sustainable Tourism*, 28(2):144-163.

https://doi.org/10.1080/09669582.2019.1631318

Yu, W., Zhang, L., & Yang, C. (2023). The impact of the digital economy on enterprise innovation behavior: Based on CiteSpace knowledge graph analysis [Systematic review]. *Frontiers in Psychology*, 14:1031294.

https://doi.org/10.3389/fpsyg.2023.1031294

Zamani-Farahani, H. (2016). [Host attitudes toward tourism: A study of sareyn municipality and local community partnerships in therapeutic tourism]. *Journal of Tourismology*, 2(1):16-34.

https://doi.org/10.26650/jot.2016.2.1.0002

Zhao, H., Jiang, S., Fu, L., & Ke, X. (2023). Elderly tourism management: A bibliometric approach. *Innovative Marketing*, 19(3):211-225.

https://doi.org/10.21511/im.19(3).2023.18

Zhong, L., Deng, B., Morrison, A.M., Coca-Stefaniak, J.A., & Yang, L. (2021). Medical, health and wellness tourism research-a review of the literature (1970-2020) and research Agenda. *International Journal of Environmental Research and Public Health*, 18(20):10875.

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ORIGINAL RESEARCH ARTICLE

Optimizing last-mile delivery of essential medicines in Nigeria: Insights from Niger State's health-care supply chain

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Abstract

Last-mile delivery of health commodities is a critical component of efficient supply chains, and third-party logistics (3PL) providers are pivotal in ensuring cost-effective and reliable product distribution. This study explores the implementation of last-mile delivery outsourcing by government-operated warehouses and drug management agencies (DMAs). This research focuses on the relationship between 3PL utilization and key performance metrics, such as cost reduction, timely delivery, and end-user satisfaction. This study combines a literature review, surveys, and interviews conducted with employees of the DMAs in Minna, Niger State, to establish significant correlations. The findings show that using 3PLs significantly reduced operational costs, improved the frequency of timely deliveries, and enhanced end-user satisfaction. These findings underscore the need for continued engagement with 3PL providers to optimize supply chain performance and improve service delivery outcomes. Managers are recommended to maintain and expand such collaborations to sustain these benefits.

Keywords: Outsourcing; Last-mile delivery; Essential medicines; Niger State; Drug management agency

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1. Introduction

Ensuring the delivery of products where they are needed is a crucial element of any effective supply chain. Third-party logistics (3PL) providers are pivotal in cost-effectively delivering products to end-users, and using 3PLs requires delegating logistics-related functions, either partially or entirely, to an external organization for execution. Transportation and basic value-added logistics services are well-established outsourcing domains; thus, 3PL companies are key stakeholders in most supply chains. These companies do not own the commodities that flow through a supply chain; however, they assume responsibility for their clients' goods as they transit through warehouses or are transported globally (Manotas-Duque *et al.*, 2016).

Outsourcing logistics in this manner has numerous benefits, such as reducing the burden of logistics activities, and making it increasingly common among organizations

(Giri & Sarker, 2017; Adebambo, Omolola, and Victor, 2016). For instance, contracting 3PLs manage orders in Senegal and deliver essential medicines and health products from government-managed district warehouses to local health facilities (Daff *et al.*, 2014). This arrangement has led to declining stockouts at service delivery points and reduced distribution costs (Agrawal *et al.*, 2016). Sub-Saharan Africa is characterized by vast topography and weak infrastructure, and reliable transport fleets are essential for distributing vital medicines to rural health institutions, including vaccines, antiretroviral drugs, and other life-saving medications. Stockouts of these crucial medications, often resulting from ineffective or inefficient distribution systems, have significant implications, necessitating outsourcing transportation to capable 3PL providers (Village Reach, 2016).

This study explores outsourcing for last-mile delivery by government-managed warehouses or drug management agencies (DMAs) in Nigeria. Last-mile delivery of health commodities refers to the distribution process where essential health products, such as medicines and medical supplies, are transported from central or regional warehouses to the service delivery points, such as clinics or hospitals. Such agencies oversee drug revolving fund schemes, where the government, donor agencies, or partners provide seed money to procure an initial stock of essential medicines. These medicines are dispensed at prices sufficient to replenish the stock, ensuring continuous supply and availability (Ogbonna & Nwako, 2016). This research employs a case study approach, focusing on the Niger State Drugs and Hospitals Consumables Management Agency (NSDHCMA) in Niger State, Nigeria. The primary data were collected through a cross-sectional study design incorporating a qualitative research methodology. Key informant interviews (KII) were conducted with key personnel within the selected DMA and relevant departments of the state Ministry of Health; a questionnaire was also administered to relevant staff.

1.1. Problem statement

To date, no studies have examined outsourcing the last-mile delivery of essential medicines by government-owned Central Medical Stores in Niger State, Nigeria. Moreover, no research has investigated whether the use of 3PL services for last-mile delivery of essential medicines can reduce transportation costs, increase timely delivery of essential drugs, and enhance customer satisfaction within government Central Medical Stores in Niger State.

This study seeks to answer the following questions:

1. What is the relationship between using 3PL services for the last-mile delivery of essential medicines and reducing transportation costs in the NSDHCMA?
2. What is the relationship between using 3PL services for last-mile delivery of essential medicines and the timely delivery of essential medicines in the NSDHCMA?
3. What is the relationship between using 3PL services for the last-mile delivery of essential medicines and increased customer satisfaction in the NSDHCMA?

1.2. Research objectives

This study primarily aims to examine the outsourcing of last-mile delivery of essential medicines through 3PL providers in the NSDHCMA in Niger State, Nigeria. The specific objectives are

1. To determine the relationship between using 3PL outsourcing for the last-mile delivery of essential medicines and reducing transportation costs in the NSDHCMA
2. To establish the relationship between using 3PL services for last-mile delivery of essential medicines and increased timely delivery of medicines within the government DMA in Niger State
3. To measure the relationship between using 3PL services for the last-mile delivery of essential medicines and increased customer satisfaction within the government DMA in Niger State.

1.3. Significance of the research

This study contributes to the body of knowledge on using 3PL providers in the last-mile distribution of essential medicines in Nigeria. The findings also highlight the additional benefits of outsourcing last-mile delivery, such as reduced logistics costs.

1.4. Contribution of the study to the literature

This study significantly contributes to the growing body of healthcare supply chain management literature, highlighting the efficiency and operational benefits of utilizing 3PL providers for the last-mile delivery of essential medicines in Nigeria. The research supports using 3PL services to reduce operational costs, improve delivery timeliness, and enhance end-user satisfaction, critical metrics in health logistics.

The findings fill an important gap in the literature, demonstrating how 3PL outsourcing can optimize the distribution of essential medicines, particularly in resource-constrained environments such as Niger State. This study also contributes to understanding how strategic outsourcing can streamline health-care logistics, reducing stockouts and ensuring the availability of life-saving medications in remote areas.

1.4.1. Contribution to industry

This study's practical contributions are evident in its implications for health-care managers and policymakers. The study results show that using 3PL providers can reduce operational costs by 23% reduction and improve timely deliveries by 77%, illustrating the potential for cost savings and service enhancements. This evidence empowers health-care administrators to make informed decisions on leveraging private sector capabilities for improved supply chain efficiency, especially in the public health domain.

In addition, by adopting this study's 3PL "QUICKSILVER" model, health-care organizations can enhance delivery speed and patient satisfaction while maintaining operational sustainability. This model can inspire private logistics startups to develop competitive services that challenge in-house operations, driving innovation in the sector.

1.4.2. Limitations of the study

The results of this study are only generalizable to only one organization – the NSDHCMA Minna, Niger State. Another limitation is this study's small sample and the fact that the research was conducted in one location: Minna, Niger State.

1.5. Future research focus

Future research using cross-sectoral data instead of organizational data is needed to study 3PL and last-mile delivery logistics.

1.6. Scope of the research

This study encompasses three main vectors. The first vector is the subject matter – outsourcing last-mile delivery of essential medicines using 3PL services and its relationship with reduced direct transportation costs, increased timely delivery to end-users, and enhanced customer satisfaction. The second vector includes the actors involved in outsourcing through 3PL, such as the NSDHCMA, 3PL service providers, health-care workers requesting the drugs, and end-user patients. The third vector pertains to the geographic location of the outsourcing activities, specifically Minna, Niger State.

1.7. Operational definitions

1.7.1. 3PL provider

An external organization that provides outsourced logistics services, which may include transporting products on behalf of another organization.

1.7.2. DMAs

Government agencies are responsible for the procurement, warehousing, and distribution of essential medicines to health facilities within a state in Nigeria.

1.7.3. Essential medicines

Medications used within the basic health-care system, which are known for their efficacy, safety, and cost-effectiveness in treating priority health conditions (World Health Organization, 2019).

1.7.4. Last-mile delivery

The final step in the delivery process is where a product is transported from a hub to its destination, such as a health facility for health products.

1.8. Literature review

This review encompasses the existing literature on outsourcing logistics by organizations using 3PL providers, emphasizing the benefits and trends in this practice. This study also explores the use of 3PL in last-mile delivery, particularly within the health-care sector, and discusses the management of contracts and relationships between organizations and 3PL providers.

1.9. Broader concepts: Industry and dependent variables

Outsourcing supply chain functions has become integral to organizational processes globally. Many organizations are increasingly adopting this practice due to its numerous benefits, such as reduced operational costs, enhanced flexibility, and improved logistical service operationalization. Agrawal *et al*. (2016) and Dittmann (2015) note that while supply chain costs in health care have historically been high, accounting for over 50% of total costs, the industry has lagged others regarding supply chain maturity. However, there has been a growing shift toward embracing excellence in supply chain cost management, and health-care organizations are increasingly engaging 3PL providers to implement best practices from other industries.

Global supply chains are complex, necessitating collaboration among various providers, often leading to outsourcing some or all supply chain functions to 3PLs (Manotas-Duque *et al*., 2016). In Sub-Saharan Africa, physical barriers in rural areas pose significant challenges to the efficient delivery of health-care products, particularly in last-mile delivery (Sahebi and Helo, 2021). Village Reach (2016) highlights that rural health facilities are often far from district and regional storage facilities. Moreover, the multi-tiered, complex supply chains in low-income countries, inadequate data flow, and vehicle maintenance issues further complicate logistics. Consequently, outsourcing the last-mile delivery of essential medicines to private sector 3PL providers is increasingly being considered to enhance efficiency (Village Reach, 2016).

1.10. Specific concepts: Independent variables

As defined by Kalinzi (2020), outsourcing involves contracting out job functions to specialized, efficient service providers who become valued business partners. In supply chain management, 3PL refers to an organization that uses external enterprises to handle distribution, warehousing, and fulfillment services. Although 3PL providers do not own the products within the supply chain, they take responsibility for their clients' goods through various distribution centers (Manotas-Duque *et al.*, 2016). These providers often specialize in integrated warehouse and transportation operations, which can be scaled and adapted to meet customer demands and delivery service requirements (Essilfie-Baiden, 2020).

Outsourcing logistics to 3PL providers is a strategic decision involving several processes and criteria that vary across industries and organizations. A 3PL provider's performance directly impacts the outsourcing organization's supply chain performance and competitiveness (Aigbavboa & Mbohwa, 2019); therefore, organizations must possess the necessary skills and capacity to select and manage 3PLs effectively to achieve the desired outcomes. While 3PL usage has generally reduced logistics costs, Premkumar *et al.* (2021) attribute this decrease to innovative practices by logistics service providers. Effective communication, transparency, and collaboration between the outsourcing organizations and logistics service providers are critical to achieving long-term success in logistics outsourcing; these elements ensure ongoing performance, early conflict resolution, and smoother termination of relationships (Etokudoh *et al.*, 2017; Paulraj & Chen, 2007).

In Africa, government agencies face challenges outsourcing to private sector players due to difficulty measuring outcomes. Private companies typically assess success in monetary terms, whereas governments and health systems rely on specific key performance indicators (KPIs) (Muthoni, 2016; Simon *et al.*, 2020; USAID, 2011). The potential for outsourcing to diminish some controls imposed by KPIs requires that public and private sectors collaborate to manage outsourcing contracts effectively (Village Reach, 2016).

The selection of a suitable 3PL provider is crucial for logistical performance. Choosing an inappropriate provider can reduce service quality, increase inefficiencies, and lead to a disconnect between the 3PL and the outsourcing organization, resulting in significant issues (Karamaşa *et al.*, 2020). Figure 1 outlines the six key criteria affecting the selection of 3PL providers: cost, customer service quality, data processing ability, operational performance, supply chain capability, and sustainability.

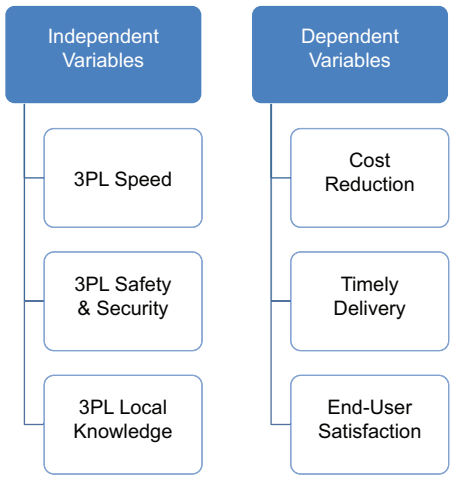


Figure 1. Conceptual model for the study. (Source: The authors, 2022)
Abbreviation: 3PL: Third-party logistics.

1.11. Fundamental theories

This study is grounded in resource-based theory (RBT) and network theory. The RBT posits that organizations seeking valuable, scarce, inimitable, and well-organized resources should consider outsourcing to external providers to overcome internal resource deficiencies. A strong relationship between firms and external providers can become an intangible resource for the organization, emphasizing the importance of relationship management and service adaptability for outsourcing success (Van Thai *et al.*, 2021); however, critics argue that the theory does not clearly define valuable or scarce resources (Hitt *et al.*, 2015; Ibrahim, 2020).

Network theory focuses on the synergies achieved through collaborations within a network, which can lead to competitive advantages through enhanced service and flexibility (Skjoett-Larsen, 2000). It stresses the importance of managing relationships by fostering an information-sharing culture with other companies; however, organizations within established networks may face limitations in pursuing activities that align with their objectives (Ibrahim, 2020).

1.12. Gaps in the literature

Existing literature primarily addresses supply chain operations in public, non-profit environments, where development partners largely bear costs. Studies have shown that using 3PL providers for last-mile delivery of health products, often funded by donors, reduces stockouts and improves product availability. This situation allows health workers to focus on clinical duties rather than logistics (Agrawal *et al.*, 2016); however, when donor funding ceases, the transition to local government responsibility is often problematic, and government agencies may be reluctant to continue the program due to various factors.

This situation can lead to alternative models that may delay delivery times and stockouts (Karimi, 2020).

Given the financial constraints governments face in developing countries, it is essential to use resources judiciously when deploying 3PL providers for the last-mile delivery of essential medicines (Kazaz *et al*., 2016; Karimi, 2020). Government agencies that operate drug-revolving fund schemes are expected to adopt private sector best practices to ensure quality service delivery and patient care (Ogbonna & Nwako, 2016).

This study aims to fill a gap in the literature concerning government-operated DMAs outsourcing last-mile delivery of health products to 3PL providers and its impact on operational cost reduction, timely delivery, and customer satisfaction.

2. Data and methods

This study distributed a structured questionnaire and conducted direct interviews, adopting a qualitative case study research methodology to collect primary data. In-depth interviews were conducted with managers and supervisors in the NSDHCMA Minna in Niger State, Nigeria.

2.1. Research design

This research seeks an in-depth understanding of how government-managed DMAs implement 3PL outsourcing (a known concept in distribution services). Hence, the case study approach is needed, which is a proven tool for logistics research (Easterby-Smith *et al*., 2012; Etokudoh *et al*., 2017).

2.2. Unit of analysis

The unit of analysis is the individuals in the government DMAs responsible for warehousing and distributing essential medicines to the public.

2.3. Sampling design

This study used a non-probability purposive sampling technique, which is most effective when data are collected from predetermined individuals. Individuals from the targeted organization provided information in response to this study's objectives. Participants included personnel in management positions (executive director and directors in charge of warehousing and distribution), procurement and contract management managers, and key operations staff directly involved in logistics or last-mile delivery operations. The sampling process involved identifying the informants and developing a schedule to meet and interview them.

2.4. Target population and study site

The survey was distributed to 58 participants from various departments of DMAs, including top management, warehousing and distribution, procurement and contract management, and transportation, and 15 managers were interviewed. Table 1 shows the distribution of the population sample.

The NSDHCMA in Minna, Niger State, Nigeria, manages the procurement, storage, and distribution of essential medicines and hospital consumables throughout the state. The agency ensures that health commodities, including life-saving medications and medical supplies, reach health-care facilities efficiently and reliably. It is a critical component of the state's health-care system and works to improve access to quality health-care services through effective supply chain management. The agency aims to enhance service delivery outcomes across both rural and urban health facilities in Niger State by overseeing last-mile delivery operations and collaborating with 3PL providers. This strategic role makes it an ideal site for studying how logistics outsourcing affects health-care service performance, particularly regarding cost reduction, timely delivery, and end-user satisfaction (Marshet *et al*., 2018).

2.5. Measuring instrument

A discussion guide was developed for conducting KIIs, which was used to solicit in-depth information from the selected target audience.

2.6. Data collection methodology

An initial pilot test was conducted to develop interview questions (Appendix), which were tested with some participants to ascertain their understanding of the questions. Approval was sought from the management of the NSDHCMA. An interview guide was also developed and sent to the identified participants before the interview, and a commitment to maintain the participants' confidentiality was also provided. The questionnaire was then administered to selected individuals.

Recorded discussions were reviewed using constant comparison methods, and commonalities in responses were drawn to gain an in-depth understanding.

Table 1. Distribution of the population and sample

Functional areas	Number of employees	%
Procurement	10	17.0
Accounts/finance	8	14.0
Warehouse/store	10	17.0
Management	5	9.0
Human resource management	10	17.0
Distribution and transportation	15	26.0
Total	58	100.0

Source: Field survey 2022.

2.7. Analysis methodology

The recorded interviews were transcribed, coded, and tallied. The transcribed data and data derived from the administered questionnaire were subsequently analyzed using the Statistical Package for Social Sciences and Microsoft Excel version 2016 and presented in charts.

2.8. Summary

This study employed a mixed method consisting of a qualitative case study approach, using in-depth interviews to collect data from appropriate and relevant personnel within the government DMA and the state Ministry of Health. The transcribed data were coded, analyzed, and presented in charts for discussion and findings.

3. Results

This section presents the responses of 50 employees of the NSDHCMA, Minna, Niger State. The interview results of the respondents and the responses are presented in Tables 2-6.

3.1. Descriptive statistics

Tables 2-6 demonstrate the sample's responses to the three research questions and objectives.

Table 2 reveals that 45 (90.0%) of the respondents were between 24 and 45 years of age, 35 (70%) were males, 30 (60%) were married, and 35 (70%) had a university education.

Table 2. Personal data

Propositions	Responses	Number	Percentage
Age	24 – 35 years	20	40
	35 – 45 years	25	50
	46 – 56 years	5	10
	57 – 67 years		
	Total	50	100
Gender	Male	35	70
	Female	15	30
	Total	50	100
Marital status	Married	30	60
	Single	20	40
	Total	50	100
Educational status	<OND	5	10
	OND	10	20
	BSc/HND	20	40
	>BSc/HND	15	30
	Total	50	100

Source: Field survey, 2022.
Abbreviations: BSc: Bachelor of Science; HND: Higher national diploma; OND: Ordinary national diploma.

On average, 70% of the respondents agreed that using 3PL for last-mile delivery reduced the cost of medicine delivery operations.

An average of 77.0% of respondents agreed that using 3PL increased the timely delivery of essential medicines to facilities requesting such medicines from the NSDHCMA.

Table 3. Objective 1: 3PL last-mile delivery and operational costs

Propositions	Responses	Number	Percentage
3PL last-mile delivery is very responsive to the needs of end-users.	Strongly agree	30	60
	Agree	20	40
	Disagree		
	Strongly disagree		
	Total	50	100
3PL last-mile delivery is always professional to all parties. They overcome local constraints faster	Strongly agree	20	40
	Agree	5	10
	Disagree		
	Strongly disagree	25	50
	Total	50	100
3PL last-mile delivery services are short and cost less to carry out long-distance delivery	Strongly agree	30	60
	Agree		
	Disagree	10	20
	Strongly disagree	10	20
	Total	50	100

Source: Field survey, 2022.
Abbreviation: 3PL: Third-party logistics.

Table 4. Objective 2: 3PL services and increased timely delivery

Propositions	Responses	Number	Percentage
3PL service providers are faster	Strongly agree	30	60
	Agree	20	40
	Disagree	/	/
	Strongly disagree	/	/
	Total	50	100
3PL service providers have zero tolerance for distraction	Strongly agree	30	60
	Agree	5	10
	Disagree	10	20
	Strongly disagree	5	10
	Total	50	100
3PL service providers are under contract to deliver fast and safely	Strongly agree	10	20
	Agree	20	40
	Disagree	10	20
	Strongly disagree	10	20
	Total	50	100

Source: Field survey, 2022.
Abbreviation: 3PL: Third-party logistics.

Table 5 demonstrates the evaluation of the 15 managers/supervisors interviewed. Their estimation showed the following:

- The practice of outsourcing management of last-mile delivery operations
- Using 3PL in outsourcing
- Lower cost of last-mile delivery using 3PL than last-mile delivery without 3PL
- Last-mile delivery estimated lead time of about 24 h for the farthest distance
- High frequency of timely delivery with 3PL
- High level of customer satisfaction with last-mile delivery using 3PL providers.

Table 5. Objective 3: 3PL services and end-user customer satisfaction

Propositions	Responses	Number	Percentage
Health-care workers in supported health facilities emphasize 3PL service delivery	Strongly agree	15	30
	Agree	35	70
	Disagree		
	Strongly disagree		
	Total	50	100
Patients and their families prefer essential medicine delivery through 3PL services for faster response	Strongly agree	20	40
	Agree	10	20
	Disagree	10	20
	Strongly disagree	10	20
	Total	50	100
Patients expressed satisfaction with the delivery of essential medicines by 3PL providers	Strongly agree	35	70
	Agree		
	Disagree	10	20
	Strongly disagree	5	10
	Total	50	100

Source: Field survey, 2022.
Abbreviation: 3PL: Third-party logistics.

3.2. Results of preliminary data analysis

The following results were revealed.

1. Of respondents, 70.0% agreed that in each of their 1,500 implementations of 3PL for last-mile delivery of essential medicines, delivery costs were reduced by 23% from the Niger State Drug and Hospital Consumables Management Agency, Minna, Niger State
2. An average of 77.0% of respondents agreed that their 1,500 uses of 3PL for last-mile delivery of essential medicines resulted in 80 timely (same-day) delivery times across the state. Deliveries without 3PL averaged three days for last-mile delivery
3. An average of 77.0% of respondents agreed that using 3PL to deliver essential medicines yielded 160 end-user customer satisfaction for 120 health-care officers/workers.

Table 6. Analysis of interview data

Variables handled during the interview	Average data	Survey data
Number of times the organization used outsourcing p.a	3,000 p.a	
Number of times the organization used 3PL p.a	1,500	An average of 74.7% of the respondents supported the interview data.
Cost of last-mile delivery without 3PL	N12.8 p.a	
Cost of last-mile delivery using 3PL	N9.86 p.a	An average of 70.0% of respondent-supported interview data.
Estimated time of last-mile delivery using 3PL to the farthest distance	Within 24 h	
Estimated time of last-mile delivery without 3PL to the farthest distance	5 days	An average of 77.0% of respondent-supported interview data.
Number of timely deliveries using 3PL for last-mile delivery	80	An average of 77.0% of respondent-supported interview data.
Number of customer-end-user satisfaction p.a	160 p.a	An average of 77.0% of respondent-supported interview data.
Number of times hospital pharmacists/HCW requested the NSDHCMA p.a	120	An average of 77.0% of respondents agreed.
Operational benefits of 3PL last-mile delivery	Safety of essential medicines=8; security of essential medicines=8; speed of delivery=10; zero distractions; ability to maneuver constraints	An average of 74.0% of respondents agreed.

Source: Interview, 2022.
Abbreviations: 3PL: Third-party logistics; HCW: Healthcare worker; NSDHCMA: Niger state drugs and hospital consumables management agency.

3.2.1. Results of hypothesis testing

1. A significant link exists between the use of 3PL services for last-mile delivery of essential medicines and the reduction in the cost of delivery without 3PL in the Government Central Medical Stores in Minna, Niger State (70.0%, $\chi^2 = 33.1$, $n = 50$, $p < 0.05$)
2. A significant link exists between the use of 3PL outsourcing for last-mile delivery of essential medicines and an increase in timely deliveries (same-day delivery) in Government Central Medical Stores, Minna Niger State (77.0%, $\chi^2 = 24.2$, $n = 50$, $p < 0.05$)
3. A significant link exists between the use of 3PL outsourcing for last-mile delivery of essential medicines and end-user satisfaction in the Government Central Medical Stores in Minna, Niger State (77.0%, $\chi^2 = 24.2$, $n = 50$, $p < 0.05$).

3.2.2. Summary of findings

Using 3PL outsourcing for last-mile delivery of essential medicines is cost-efficient, high speed/same-day delivery time, and end-user customer satisfaction generating in NSDHCMA, Minna, Niger State.

4. Discussion

This study's findings provide a detailed analysis of the effectiveness of outsourcing last-mile delivery of essential medicines to 3PL providers, particularly within the context of the NSDHCMA. This discussion examines the benefits of operational cost reduction, timely delivery improvements, and enhanced customer satisfaction. It also explores the broader strategic considerations for integrating 3PL services into healthcare logistics.

4.1. Reduction in operational costs

One of this study's most significant outcomes is the evident reduction in operational costs associated with adopting 3PL services for last-mile delivery. The data indicates that 70% of respondents observed a 23% decrease in delivery costs when 3PL providers were utilized. This reduction does not simply reflect lower logistical expenses; instead, it highlights the strategic advantage of outsourcing to specialized providers who can achieve efficiencies that in-house operations may struggle to attain.

The cost-saving benefits can be attributed to several factors inherent in the 3PL model (Wan, Yuan, and Lai, 2019). First, 3PL providers typically have advanced logistics networks and technologies for more efficient route planning, inventory management, and delivery execution. These capabilities enable them to minimize wastage, reduce fuel consumption, and optimize resource use, collectively contributing to lower overall costs. In addition, 3PL providers often benefit from economies of scale as they manage deliveries for multiple clients, spreading their fixed costs across a broader base.

Moreover, the study's statistical analysis ($\chi^2 = 33.1$, $p < 0.05$) supports the hypothesis that a significant link exists between using 3PL services and cost reduction. This finding aligns with the existing literature, consistently demonstrating that outsourcing logistics functions to 3PL providers can lead to substantial cost savings, especially in complex and resource-intensive sectors such as health care.

4.2. Improvement in timely deliveries

The timely delivery of essential medicines is critical to the effectiveness of health-care systems, particularly where health-care facilities are spread across vast and often challenging terrains. The study's results show that 77% of respondents reported an improvement in the timeliness of deliveries, with 3PL services enabling same-day delivery across Niger State. This contrasts sharply with the 3-day delivery timeframe when 3PL services were not employed.

The enhanced delivery speed of 3PL providers can be attributed to their specialized infrastructure and expertise in navigating logistical challenges; 3PL companies are equipped with advanced tracking systems, real-time data analytics, and a deep understanding of local conditions, allowing them to anticipate and mitigate potential delays. In addition, contractual obligations to meet specific delivery standards further incentivize 3PL companies to maintain high levels of efficiency.

The statistical evidence ($\chi^2 = 24.2$, $p < 0.05$) underscores the significance of the relationship between 3PL usage and improved delivery speed. This improvement is significant in the health-care sector, where delays in delivering essential medicines can severely affect patient outcomes. The ability of 3PL providers to ensure timely deliveries directly supports health-care facilities' operational effectiveness, reducing stockouts and ensuring that patients receive the necessary treatments without interruption.

4.3. Enhancement of customer and end-user satisfaction

Customer satisfaction is crucial in evaluating the success of logistics operations, particularly in health care, where the timely and reliable delivery of medicines can significantly impact patient care. The study found that 77% of respondents observed high satisfaction among health-care workers and patients when 3PL services were used for last-mile delivery.

This satisfaction is likely driven by the consistency and reliability of 3PL services, which ensure that essential medicines are delivered on time and in good condition.

These factors cannot be overstated in health care, where delays or errors in delivery can compromise patient safety and treatment efficacy. Furthermore, using 3PL services reduces the burden on health-care workers, allowing them to focus on patient care rather than logistics, thereby improving the overall patient experience.

The statistical analysis ($\chi^2 = 24.2$, $p < 0.05$) further validated the positive impact of 3PL services on customer satisfaction. This finding is consistent with other studies in the field, highlighting that outsourcing logistics to specialized providers improves operational efficiency and enhances the quality of service delivered to end-users.

4.4. Operational efficiency and strategic implications

Beyond the immediate benefits of cost reduction, timely delivery, and customer satisfaction, adopting 3PL services has broader strategic implications for the NSDHCMA. By outsourcing logistics functions, the agency can focus its resources on its core competencies, such as procurement, health-care service delivery, and policy implementation. This strategic focus allows for better resource allocation, improved management of health-care operations, and the potential for further innovation in service delivery.

Furthermore, using 3PL services introduces flexibility and scalability that in-house logistics operations may not achieve; 3PL providers can quickly adapt to changes in demand, scale their operations up or down as needed, and continuously implement new technologies and processes to improve service quality. This adaptability is particularly valuable in the dynamic and often unpredictable health-care environment, where the ability to respond quickly to changing circumstances can be critical.

4.5. Challenges and considerations

The benefits of using 3PL services are apparent; however, it is also essential to consider the potential challenges. Dependency on external providers can pose risks, particularly if disruptions occur in the 3PL provider's operations or if issues arise with contract management (Gong, Kung, and Zeng, 2018). Quality control is another critical area that requires careful oversight to ensure that the 3PL's service standards align with the agency's expectations.

To mitigate these risks, robust contracts should be established to clearly define the expectations, responsibilities, and performance metrics for the 3PL provider. Regular monitoring and evaluation of the 3PL's performance, along with effective communication and collaboration, are also vital in ensuring the success of the outsourcing arrangement (Gwala, 2019).

5. Conclusion

This study highlights the significant benefits of outsourcing the last-mile delivery of essential medicines to 3PL providers, revealing substantial improvements in cost efficiency, delivery timeliness, and customer satisfaction. These findings make a compelling case for the continued use and potential expansion of 3PL services within the health-care logistics framework in Niger State. The strategic advantages of outsourcing and the operational benefits provide a strong foundation for further investment in 3PL services to enhance health-care delivery and outcomes.

These insights contribute to the ongoing discourse on health-care logistics and offer practical guidance for policymakers and health-care administrators seeking to optimize supply chain operations. Addressing the challenges associated with outsourcing and exploring ways to leverage 3PL services will be essential to achieving even greater efficiencies and improvements in health-care delivery.

Several recommendations for last-mile delivery of essential medicines to 3PL providers are given in the following:

- Managers in the NSDHCMA Minna, Niger State, should embrace using 3PL for last-mile deliveries of essential medicines and medical consumables to generate reductions in operation costs across the state
- The same-day delivery strategy should be negotiated as a strategic objective with all 3PL service providers and even be rewarded differently to ensure sustainability
- The operations of 3PL should be trackable and shared in real time to provide continuous satisfaction for end-users of last-mile deliveries.

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Conflict of interest

The authors declare they have no competing interests.

Author contributions

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Ethics approval and consent to participate

The Institutional Review Board (IRB) of the Malaysia University of Science and Technology approved the study. In addition, written consent was obtained from all those who had accepted to be interviewed.

Consent for publication

The participants in the study were verbally informed that their responses would be published in a journal, and a "no objection" to that is required before proceeding.

Availability of data

The data used in this study were provided by the staff at the Drugs and Hospital Consumables Management Agency, Minna, Niger State.

References

Adebambo, S.O., Omolola, O.M., & Victor, D.A. (2016). Analysis of outsourcing logistics service and customer satisfaction in manufacturing companies in South Western Nigeria. *European Journal of Logistics, Purchasing and Supply Chain Management*, 4(1):1-10.

Agrawal, P., Barton, I., Dal Bianco, R., Hovig, D., Sarley, D., & Yadav, P. (2016). Moving medicine, moving minds: Helping developing countries overcome barriers to outsourcing health commodity distribution to boost supply chain performance and strengthen health systems. *Global Health: Science and Practice*, 4(3):359-365.

https://doi.org/10.9745/GHSP-D-16-00130

Aigbavboa, S., & Mbohwa, C. (2019). Going the extra mile: Vital third party logistics service providers' pre-selection activities by pharmaceutical organizations. *IOP Conference Series: Materials Science and Engineering*, 640(1):012126.

https://doi.org/10.1088/1757-899X/640/1/012126

Daff, B.M., Seck, C., Belkhayat, H., & Sutton, P. (2014). Informed push distribution of contraceptives in Senegal reduces stockouts and improves quality of family planning services. *Global Health: Science and Practice*, 2(2):245-252.

https://doi.org/10.9745/GHSP-D-13-00171

Dittmann, J.P. (2015). Best Practices for Managing Cost in the Healthcare Supply Chain. United States: United Parcel Service.

Easterby-Smith, M., Jaspersen, L.J., Thorpe, R., & Valizade, D. (2021). Management and Business Research. United Kingdom: Sage.

Essilfie-Baiden, E. (2020). Using 3PL in Selection of Service Providers for Warehouse Management. *African Journal of Procurement, Logistics and Supply Chain Management*, 4(4):45-56.

https://doi.org/10.15473/AJPLSCM/2020/VOL4/ISS4/APRIL004

Etokudoh, E.P., Boolaky, M., & Gungaphul, M. (2017). Third party logistics outsourcing: An exploratory study of the oil and gas industry in Nigeria. *SAGE Open*, 7(4).

https://doi.org/10.1177/2158244017735566

Giri, B.C., & Sarker, B.R. (2017). Improving performance by coordinating a supply chain with third party logistics outsourcing under production disruption. *Computers and Industrial Engineering*, 103:168-177.

https://doi.org/10.1016/j.cie.2016.11.022

Gong, F., Kung, D.S., & Zeng, T. (2018). The impact of different contract structures on IT investment in logistics outsourcing. *International Journal of Production Economics*, 195:158-167.

https://doi.org/10.1016/j.ijpe.2017.10.009

Gwala, S.A. (2019). Challenges Experienced when Outsourcing Logistics in South Africa: A Case of Lolli Supermarkets. (Doctoral Dissertation).

Hitt, M.A., Xu, K., & Carnes, C.M. (2015). Resource based theory in operations management research. *Journal of Operations Management*, 41:77-94.

https://doi.org/10.1016/j.jom.2015.11.002

Ibrahim, A.A. (2020). Challenges Experienced when Outsourcing Logistics in South Africa: A Case of Lolli Supermarkets. (Doctoral Dissertation).

Kalinzi, C. (2020). Logistics Outsourcing Practices and Performance of small and Medium Enterprises in Mogadishu, Somalia. (Doctoral Dissertation, University of Nairobi).

Karamaşa, Ç., Demir, E., Memiş, S., & Korucuk, S. (2021). Weighting the factors affecting logistics outsourcing. *Decision Making: Applications in Management and Engineering*, 4(1):19-32.

https://doi.org/10.31181/dmame2104019k

Karimi, A. (2020). Designing Public Health Supply Chains: Towards Improving Health Commodity Availability in Developing Countries. (Doctoral Dissertation, University of Minnesota).

Kazaz, A., Ulubeyli, S., Acikara, T., & Er, B. (2016). Factors affecting labor productivity: Perspectives of craft workers. *Procedia Engineering*, 164:28-34.

https://doi.org/10.1016/j.proeng.2016.11.588

Manotas-Duque, D.F., Osorio-Gómez, J.C., & Rivera, L. (2016). Operational risk management in third party logistics (3PL). In: Handbook of Research on Managerial Strategies for Achieving Optimal Performance in Industrial Processes. United States: IGI Global, p.218-239.

Marchet, G., Melacini, M., Perotti, S., & Sassi, C. (2018). Types of logistics outsourcing and related impact on the 3PL buying process: Empirical evidence. *International Journal of Logistics Systems and Management*, 30(2):139-161.

https://doi.org/10.1504/IJLSM.2018.091959

Muthoni, D.K. (2016). Effect of Supply Chain Processes Outsourcing on the Performance of Manufacturing Firms in Kenya. (Doctoral Dissertation, JKUAT COHRED)

Ogbonna, B.O., & Nwako, C.N. (2016). Essential drugs revolving fund scheme in Nigeria; from the edge of a precipice towards sustainability. *Journal of Advances in Medical and Pharmaceutical Sciences*, 8(2):1-8.

https://doi.org/10.9734/JAMPS/2016/25950

Paulraj, A., & Chen, I.J. (2007). Environmental uncertainty and strategic supply management: A resource dependence perspective and performance implications. *Journal of Supply Chain Management*, 43(3):29-42.

https://doi.org/10.1111/j.1745-493X.2007.00033.x

Premkumar, P., Gopinath, S., & Mateen, A. (2021). Trends in third party logistics-the past, the present & the future. *International Journal of Logistics Research and Applications*, 24(6):551-580.

https://doi.org/10.1080/13675567.2020.1782863

Sahebi, D., & Helo, P. (2021). The Barriers for Iranian Retailers to Outsource Their 3PL Activities. In: Proceedings of the Conference on Production Systems and Logistics. Hannover: CPSL.

https://doi.org/10.15488/11233

Simon, A., Scheidl, H., Campos, R.S., & Matana, G. (2020). Performance management in logistics outsourcing: A study on sugar-energy industry. *International Journal of Productivity and Performance Management*, 70(7):1772-1729.

https://doi.org/10.1108/IJPPM-05-2019-0216

Skjoett-Larsen, T. (2000). Third party logistics-from an interorganizational point of view. *International Journal of Physical Distribution & Logistics Management*, 30(2):112-127.

https://doi.org/10.1108/09600030010318838

USAID. (2011). The Logistics Handbook a Practical Guide for the Supply Chain Management of Health Commodities. Deliver Project, Task Order, 1,174. USAID. Available from: https://deliver.jsi.com/dlvr_content/resources/allpubs/guidelines/logihand.pdf [Last accessed on 2022 Apr 01].

Van Thai, V., Rahman, S., & Tran, D.M. (2021). Revisiting critical factors of logistics outsourcing relationship: A multiple-case study approach. *The International Journal of Logistics Management*, 33(1):165-189.

https://doi.org/10.1108/IJLM-10-2020-0394

Village Reach. (2016). Outsourcing Transport to Improve Health at the Last Mile: A Case Study. Village Reach. Available from: https://www.villagereach.org/resource/outsourcing-transport-improve-health-last-mile-case-study [Last accessed on 2022 Apr 01].

Wan, Q., Yuan, Y., & Lai, F. (2019). Disentangling the driving factors of logistics outsourcing: A configurational perspective. *Journal of Enterprise Information Management*, 32(6):964-992.

https://doi.org/10.1108/jeim-10-2018-0236

World Health Organization. (2019). World Health Organization Model List of Essential Medicines: 21st List 2019 (No. WHO/MVP/EMP/IAU/2019.06). Geneva: World Health Organization.

Appendix

QUESTIONNAIRE

(NB: SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree. Use any of these to respond to our research propositions)

SECTION 1: PERSONAL DATA

1. Age of Respondent

24-34 yrs ( ) 35-45 yrs ( ) 46-56yrs ( ) 57- 67yrs ( )

1. Gender Male ( ) Female ( )
2. Marital Status: Married ( ) Single ( )
3. Educational Status Less OND ( ) OND ( ) Bsc/HND ( ) BSC/HND plus ( )

SECTION 2: LINK BETWEEN USING 3PL FOR LAST-MILE DELIVERY OF ESSENTIAL MEDICINES AND COST OF IN-HOUSE DELIVERY

1. Your organization uses 3PL for last-mile delivery of essential medicines needs of because 3PL operations are very responsive to the needs of end-users

SA ( ) A ( ) D ( ) Sd ( )

1. Using 3PL services for last-mile delivery is always professional to all logistics partners for purposes of handling unique local conditions such as rugged terrain, difficult community access, distractions by local peoples

SA ( ) A ( ) D ( ) SD ( )

7. Your 3PL contracts are for short distances, and the costs are relatively less

than in-house delivery in last-mile delivery of essential medicines

SA ( ) A ( ) D ( ) SD ( )

SECTION 3: LINK BETWEEN 3PL USE FOR LAST MILE DELIVERY OF ESSENTIAL MEDICINES AND TIMELY (SAME DAY) DELIVERY

8. Your organization regularly uses 3PL services because of the 3PL promise of professional speed and precision in the delivery of essential medicines

9 Your organization is impressed with 3PL zero tolerance for local distractions and delays during last-mile delivery of essential medicines in Minna

SA ( ) A( ) D ( ) SD ( ) 33

ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

Factors associated with cervical cancer screening among women attending gynecological consultations at the Maroua Regional Hospital, Cameroon

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Abstract

This study aimed to assess the factors associated with cervical cancer screening at the Maroua Regional Hospital. A cross-sectional study was conducted among 376 women aged ≥25 years attending gynecological consultations at the Maroua Regional Hospital between February and May 2023. Data were collected through a structured questionnaire survey. These factors were evaluated through multiple logistic regression analyses, and associations were established by calculating the odds ratios, confidence intervals, and p-values. A total of 376 women were interviewed. Their mean age was 39.21 ± 10.45 years. Of the 376 women, 9.3% had already been screened for cervical cancer. Results of multivariate analyses indicated that age ≥45 years, belief that every woman should be screened at age 25 years, perceived need for frequent screening, use of screening as a preventive measure, and having had first intercourse before age 15 years or between ages 15 and 20 years significantly increased the likelihood of having been screened. Strategies need to be developed to improve access to cervical cancer screening services in Cameroon by strengthening existing screening programs and effectively implementing campaigns to improve access to screening services.

Keywords: Associated factors; Screening; Cancer; Cervix; Maroua

1. Introduction

Cervical cancer is one of the leading causes of cancer-related deaths in women worldwide. It is a major public health problem, with a growing incidence and devastating effect on women and their families, particularly in low- and middle-income countries (World Health Organization, 2024). The disease is mainly caused by persistent infection with

certain types of human papillomavirus. However, early screening for cervical cancer enables the early detection of precancerous lesions and appropriate management, reducing the risk of developing invasive cancer (Minister of Public Health, 2020). Despite the existence of screening programs, many factors can hinder access to cervical screening, particularly lack of knowledge about the disease, cultural norms, beliefs, fear, stigmatization, and lack of infrastructure and resources.

In Cameroon, cervical cancer is a major public health problem, with a growing incidence and devastating effect on women and their families (Donatus *et al.*, 2019). Epidemiological data for 2022 revealed it to be the second most common cancer in the country, with 2,525 (12.9%) new cases diagnosed, 1,837 (14.4%) deaths recorded, and a 5-year prevalence of 13.4/100,000 population (Global Cancer Observatory, 2022). Despite efforts to promote screening, participation rates in cervical cancer screening remain very low. Studies conducted in the Central African Economic and Monetary Center zone in 2020 revealed that <10% of women aged 25 – 65 years had been screened for cervical cancer (Marie Tebeu *et al.*, 2020), falling substantially short of the 70% coverage target set by the World Health Organization (Bruni *et al.*, 2022).

However, early screening is crucial in the fight against cervical cancer, enabling precancerous or cancerous lesions to be identified at an early stage, facilitating appropriate treatment, and increasing the likelihood of cure (Minister of Public Health, 2020). The lack of regular screening for cervical cancer could have disastrous consequences for women's health. Indeed, without early detection, cancer is often diagnosed at an advanced stage, drastically reducing the likelihood of successful treatment and considerably increasing mortality rates. This also results in more serious complications and aftereffects for patients, significantly increasing treatment costs for the healthcare system and exacerbating inequalities in access to care.

Urgent efforts are needed to set up screening programs accessible to all women to improve the early detection and management of this gynecological cancer. In this context, this study aimed to assess the factors associated with cervical cancer screening at the Maroua Regional Hospital to improve the coverage and effectiveness of early detection programs. Indeed, identifying the socioeconomic, cultural, or health-care-related barriers that limit access to screening enables us to better target vulnerable populations and design appropriate interventions to bridge access disparities. Similarly, understanding the facilitating factors and motivations that motivate women to undergo screening helps adjust organizational arrangements and awareness-raising messages to increase participation.

2. Methodology

2.1. Setting and study period

The study was conducted in the gynecology department of the Maroua Regional Hospital in the far north of Cameroon between February and May 2023. This medical facility in the far north region serves a population of 5,178,810, with 2,602,113 women aged ≥25 years in 2023 (Minister of Public Health, 2023).

2.2. Study design and population

The study was quantitative, cross-sectional, descriptive, and analytical. The general study population consisted of women aged ≥25 years who attended gynecological consultations at Maroua Regional Hospital during the study period. However, study participation was conditional on obtaining informed consent by signature.

2.3. Sample size and the procedure

The Lorenz formula enabled determining the minimum size of women to be surveyed, taking into account a precision of 5%, a confidence interval (CI) of 95%, and a value for the prevalence of cervical cancer screening equal to 22.1%, taken from the results of a survey carried out in Morocco (Bouslah *et al.*, 2014). This calculation gave us a sample size (n = 264) of participants. Adding 10% for possible non-response and for a better scientific validity of the results, this study included 376 participants. In addition, a non-probabilistic sampling technique of convenience was used. Participants were selected in the gynecology department, and participant selection for the interview was up to the discretion of the investigators.

2.4. Data collection techniques and tools

The study was conducted through a survey conducted in the gynecology department of Maroua Regional Hospital. Data were collected using a semistructured questionnaire consisting of four distinct sections: respondents' sociodemographic characteristics and their knowledge, attitudes, and practices regarding cervical cancer. To improve comprehension, clarity, and administration time during the interview, the questionnaire was pre-tested with 10 women before the actual rollout of data collection.

2.5. Data collection procedure

After obtaining the necessary administrative authorization to conduct the research, we applied to the director of the Maroua Regional Hospital for survey authorization. Once on-site, we met with the head of the gynecology department to obtain permission to contact the patients. During the data collection phase, the investigator introduced himself and explained the objectives and activities of the study to

the patients through an information leaflet and answered any questions they might have to ensure adequate understanding. When the patient consented to participate in the study, the informed consent form was given to her for signature, after which a questionnaire was administered face-to-face, and those who refused were considered non-respondents. Data were collected anonymously to preserve confidentiality, with each participant identified by a unique code.

2.6. Data processing and analysis

The data collected using the Kobo Collect application were compiled and analyzed using Rstudio software version 4.2.4. Microsoft Office Excel 2013 was also used to create the various tables. Descriptive statistics were calculated for all the variables considered. The analysis considered one dependent variable (cervical cancer screening) and several independent variables divided into four main groups (sociodemographic characteristics, knowledge, attitudes, and practices). The association between dependent and independent variables was determined through binary logistic regression, and all variables with $p < 0.05$ in the bivariate analysis were candidates for the multivariate analysis to control for confounding factors and identify independent predictors of cervical cancer screening. The indicators were estimated with an alpha (α) significance level of 0.05, and associations were considered significant at $p < 0.05$.

3. Results

Data were collected over 2 months from April 4 to May 26, 2023, during which 532 patients attending gynecological consultations at the Maroua Regional Hospital were recruited. Of these participants, 376 consented to participate in the study, representing a participation rate of 70.68%.

3.1. Participant characteristics

Table 1 shows the sociodemographic characteristics of the study participants. Of the 376 women surveyed, the most represented age group was between 35 and 44 years (39.4%), with an average age of 39.21 ± 10.45 years. Most participants were married (64.6%), worked in the informal sector (23.7%), were Christian (51.6%), lived in urban areas (82.7%), and had a secondary education (45.5%).

3.2. Prevalence of cervical cancer screening among women attending gynecological consultations at the Maroua Regional Hospital

Figure 1 shows the prevalence of cervical cancer screening among women attending gynecological consultations at the Maroua Regional Hospital. As shown, 9.3% of women had already undergone screening, and 90.7% had never done so.

Table 1. Distribution of participants by sociodemographic characteristics

Variables	Terms and conditions	Absolute value	Relative frequency (%)
Age group (years)	25 – 34	112	29.8
	35 – 44	148	39.4
	45+	116	30.9
Marital status	Single	107	28.5
	Married	243	64.6
	Divorced	17	4.52
	Widowed	9	2.39
Profession	Student	81	21.5
	Informal sector	89	23.7
	Private sector	47	12.5
	Public sector	76	20.2
	Housekeeper	83	22.1
Religion	Polytheistic	75	19.9
	Christian	194	51.6
	Muslims	107	28.5
Area of residence	Rural	65	17.3
	Urban	311	82.7
Education level	Out of school	14	3.72
	Primary	56	14.9
	Secondary	171	45.5
	Superior	135	35.9

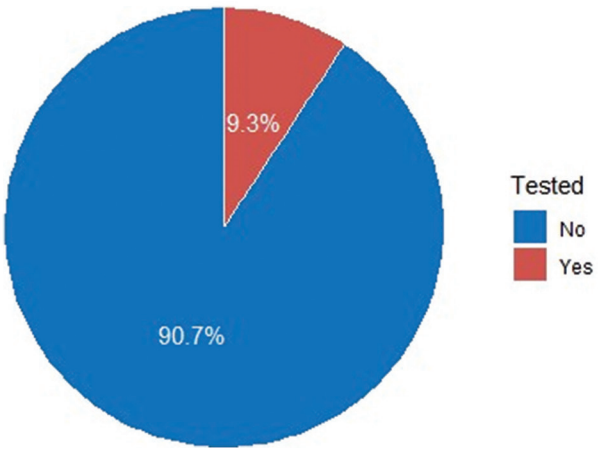


Figure 1. Frequency of cervical cancer screening

3.3. Sociodemographic factors associated with cervical cancer screening among women at the Maroua Regional Hospital

Table 2 presents the results of the bivariate analyses of sociodemographic factors associated with cervical

Table 2. Sociodemographic factors associated with cervical cancer screening among women at the Maroua Regional Hospital

Explanatory variables	Screened		OR	*p*-value
	Yes	No	(95% CI)	
	(*n*=35)	(*n*=341)		
Age group (years)				
25 – 34	3	109	1	
35 – 44	7	141	1.80 (0.48 – 8.51)	0.400
45+	25	91	9.98 (3.36 – 42.88)	0.0002***
Marital status				
Married	26	217	3.08 (1.16 – 10.65)	0.040 *
Single	4	103	1	
Divorced	2	15	3.43 (0.44 – 19.25)	0.174
Widow	3	6	12.87 (2.15 – 73.35)	0.003 **
Profession				
Student	1	81	1.26 (0.36 – 4.62)	0.790
Informal sector	6	82	1.09 (0.34 – 3.54)	0.874
Private sector	4	43	1.19 (0.29 – 4.41)	0.792
Public sector	18	58	3.98 (1.56 – 11.5)	0.005 **
Housekeeper	6	77	1	
Religion				
Polytheistic	4	71	1	
Christian	26	168	2.74 (1.02 – 9.56)	0.068
Muslims	5	102	0.87 (0.22 – 3.62)	0.839
Residence area				
Rural	9	56	1	
Urban	26	285	0.56 (0.26 – 1.34)	0.171
Education level				
Out of school	2	14	0.87 (0.35 – 2.40)	0.787
Primary	6	48	1	
Secondary	10	161	0.37 (0.13 – 1.02)	0.049 *
Superior	17	118	0.86 (0.35 – 2.24)	0.752

Abbreviations: OR: Odds ratio; CI: Confidence interval; *P*-value: Significance level; *** *P*<0.001; ** *P*<0.01; * *P*<0.05.

cancer screening among women attending gynecological consultations at the Maroua Regional Hospital. An age of ≥45 years (OR = 9.98 [95% CI, 3.36 – 42.88]; $p = 0.0002$), being married (OR = 3.08 [95% CI, 1.16 – 10.65]; $p = 0.040$) or widowed (OR = 12.87 [95% CI, 12.15 – 73.35]; $p = 0.003$), and working in the public sector (OR = 3.98 [95% CI, 1.56 – 11.5]; $p = 0.005$) significantly increased the likelihood of having already undergone a screening test. However, having a secondary education (OR = 0.37 [95% CI, 0.13 – 1.02]; $p = 0.049$) significantly increased the likelihood of never having been tested.

3.4. Cervical cancer knowledge and screening among women attending gynecological consultations at the Maroua Regional Hospital

Table 3 presents the results of the bivariate analyses of women's knowledge associated with cervical cancer screening at the Maroua Regional Hospital. The table shows that good knowledge of risk factors (OR = 2.54 [95% CI, 1.13 – 5.40]; $p = 0.017$), symptoms (OR = 2.73 [95% CI, 0.95 – 6.86]; $P- = 0.042$), and preventive measures (OR = 4.56 [95% CI, 2.04 – 9.84]; $p = 0.0001$) significantly increased the likelihood of having had a screening test. Furthermore, believing that every woman should be screened at the age of 25 (OR = 18.32 [95% CI, 6.09 – 57.80]; $p < 0.0001$) or the age of 40 (OR = 9.39 [95% CI, 3.76 – 25.69]; $p < 0.0001$), and once a year (OR = 24 [95% CI, 9.34 – 86]; $p < 0.0001$) or every 3 years (OR = 9.7 [95% CI, 2.17 – 43]; $p = 0.002$) significantly increased the chance of having had a screening test.

3.5. Attitudes toward cervical cancer and screening among women attending gynecological consultations at the Maroua Regional Hospital

Table 4 presents the results of the bivariate analyses of women's attitudes toward cervical cancer screening at the Maroua Regional Hospital. This table shows that women who consider cervical cancer screening to be a valuable aid in prevention (OR = 4.24 [95% CI, 1.47 – 17.9]; $p = 0.018$), represent no danger to the patient (OR = 6.28 [95% CI, 2.15 – 26.77]; $p = 0.003$) and are accessible to all (OR = 7.4 [95% CI, 3.46 – 17.5]; $p < 0.0001$) were more likely to have had a screening test. Conversely, those who perceived that cervical cancer affects more women in Cameroon (OR = 2.96 [95% CI, 1.43 – 6.52]; $p = 0.004$) were also more likely to have had a screening test.

3.6. Cervical cancer practices and screening among women attending gynecological consultations at the Maroua Regional Hospital

Table 5 presents the results of the bivariate analyses of women's practices associated with cervical cancer screening at the Maroua Regional Hospital. The table shows that integrating screening into prevention practices (OR = 65 [95% CI, 7.32 – 1634.20]; $p = 0.001$) and having sexual intercourse before the age of 15 years (OR = 4.02 [95% CI, 1.44 – 12.3]; $p = 0.009$) significantly increased the likelihood of having undergone a screening test.

3.7. Multivariate analysis of factors associated with cervical cancer screening at the Maroua Regional Hospital

Table 6 presents the results of multivariate analyses performed on the previously significant variables to

Table 3. Knowledge of cervical cancer and factors associated with screening

Explanatory variables	Screened		OR	*p*-value
	Yes	No	(95% CI)	
	(*n*=35)	(*n*=341)		
Having heard about cervical cancer				
No	2	86	1	
Yes	33	255	1.07 (0.35 – 0.866)	0.988
Knowledge of cervical cancer risk factors				
No	24	289	1	
Yes	11	52	2.54 (1.13 – 5.40)	0.017 *
Knowledge of cervical cancer symptoms				
No	29	317	1	
Yes	6	24	2.73 (0.95 – 6.86)	0.042 *
Knowledge of cervical cancer prevention measures				
No	23	306	1	
Yes	12	35	4.56 (2.04 – 9.84)	0.0001 ***
Heard about cervical cancer screening				
No	2	130	1	
Yes	33	211	1.07 (0.35 – 3.66)	0.902
Need for screening				
No	2	113	1	
Yes	33	228	1.13 (0.37 – 3.81)	0.831
Age of screening				
No idea	7	228	1	
18 years	4	45	2.89 (0.73 – 10)	0.101
25 years	9	16	18.32 (6.09 – 57.80)	<0.0001***
40 years	15	52	9.39 (3.76 – 25.69)	<0.0001***
Frequency of screening				
Once a year	27	63	24 (9.34 – 86)	<0.0001***
Once every 3 years	4	24	9.7 (2.17 – 43)	0.002 **
Once every 5 years	1	21	1.06 (0.33 – 2.84)	0.908
No idea	3	233	1	
Knowledge of the therapeutic methods				
No	25	283	1	
Yes	10	58	1.95 (0.85 – 4.17)	0.0954

Abbreviations: OR: Odds ratio; CI: Confidence interval; *P*-value: Significance level; * *P*<0.05; ** *P*<0.01; *** *P*<0.001.

control for confounding factors and identify independent predictors of cervical cancer screening at Maroua Regional

Table 4. Attitude toward cervical cancer and factors associated with screening

Explanatory variables	Screened		OR	*p*-value
	Yes	No	(95% CI)	
	(*n*=35)	(*n*=341)		
Cervical cancer treatment cost				
No idea	22	236	1	
Free	1	5	1.06 (0.43 – 2.49)	0.882
Reasonable price	2	13	1.57 (0.23 – 6.19)	0.564
Very expensive	10	87	1.17 (0.51 – 2.51)	0.679
Concern about cervical cancer				
Very worried	8	48	1.59 (0.68 – 3.45)	0.254
A little worried	25	191	1	
Not at all worried	2	102	0.95 (0.29 – 2.71)	0.849
All adult women can develop cervical cancer				
No idea	1	91	0.833 (0.09 – 5.77)	0.857
No	1	42	1	
Yes	33	208	6.86 (1.41 – 1.23)	0.061
Cervical cancer is not passed from person to person				
No idea	3	111	0.833 (0.09 – 5.77)	0.857
No	18	105	1	
Yes	15	125	0.63 (0.3 – 1.28)	0.207
See a doctor if there is bleeding between periods or after sex				
No idea	1	23	1	
No	2	5	1.07 (0.35 – 3.66)	0.902
Yes	32	313	4.75 (1.19 – NA)	0.985
Screening helps prevent cervical cancer				
No idea	2	96	1	
No	1	4	1.06 (0.33 – 2.84)	0.908
Yes	32	241	4.24 (1.47 – 17.9)	0.018 *
Screening poses no danger to the patient				
No idea	3	127	1	
No	6	39	6.51 (1.63 – 32)	0.210
Yes	26	175	6.28 (2.15 – 26.77)	0.003 **
Screening for precancerous lesions is accessible to everyone				
No idea	9	231	1	
No	1	24	1.06 (0.05 – 6.05)	0.95
Yes	25	86	7.4 (3.46 – 17.5)	<0.0001***
Cervical cancer affects most women in Cameroon				
No idea	11	196	1	
No	1	7	2.54 (0.13 – 16.22)	0.401
Yes	23	138	2.96 (1.43 – 6.52)	0.004 **

Abbreviations: OR: Odds ratio; CI: Confidence interval; *P*-value: Significance level; NA: Not applicable; * *P*<0.05; ** *P*<0.01; *** *P*<0.001.

Table 5. Cervical cancer practices and factors associated with screening

Explanatory variables	Screened		OR	*p*-value
	Yes	No	(95% CI)	
	(*n*=35)	(*n*=341)		
Tobacco consumption				
No	34	341	1	
Yes	1	0	0.833 (0.09 – 5.77)	0.985
Use of oral contraceptives				
No	32	290	1	
Yes	1	5	1.06 (0.33 – 2.84)	0.996
Sometimes	2	46	1.13 (0.16 – 4.49)	0.986
Cervical cancer prevention practice				
Screening	10	2	65 (7.32 – 1634.20)	0.001**
Abstinence and fidelity	1	13	1	
Condom	2	6	4.33 (0.34 – 104.72)	0.266
None	22	320	0.89 (0.16 – 16.60)	0.915
Sexually active				
No	2	21	1	
Yes	33	320	0.87 (0.35 – 2.40)	0.986
Age of first sexual intercourse				
Not yet	2	21	1.13 (0.37 – 3.81)	0.986
Before 15 years	11	46	4.02 (1.44 – 12.3)	0.009**
Between 15 and 20 years	17	173	1.75 (0.7 – 4.96)	0.250
After 20 years		101	1	

Abbreviations: OR: Odds ratio; CI: Confidence interval; *P*-value: Significance level; NA: Not applicable; * $P<0.05$; ** $P<0.01$; *** $P<0.001$.

Hospital. The table shows that having an age ≥45 years (AOR = 3.47 [95% CI, 0.14 – 155]; $p = 0.036$), estimated that every woman should be screened at the age of 25 years (AOR = 20.5 [95% CI, 5.74 – 41.5]; $p = 0.0005$) with a frequency of once a year (AOR = 3.29 [95% CI, 1.62 – 7.25]; $p = 0.011$), having screening as a preventive practice (AOR = 10.7 [95% CI, 1.39 – 135]; $p = 0.018$), and having had their first sexual intercourse before the age of 15 years (AOR = 10.7 [95% CI, 1.39 – 135]; $p = 0.004$) or between the ages 15 and 20 years (AOR = 7.59 [95% CI, 4.33 – 31.9]; $p = 0.009$) significantly increased the chance of having been tested.

4. Discussion

The investigations revealed that 9.3% of women had undergone cervical cancer screening at the Maroua Regional Hospital, whereas 90.7% had never done so. This result differs from those obtained by Guèye *et al.* (2021) and Faye *et al.* (2017) in Senegal, where the frequencies of screening were 28.32% and 6.3%, respectively. This disparity can be explained by contextual factors linked to geographical and economic accessibility to health services, the effectiveness of awareness campaigns, sociocultural barriers, and the organization of the health system, which can vary considerably between these two West African countries. Furthermore, the high rate of women not participating in cervical cancer screening could be attributed to cultural taboos, fear of stigmatization by the community, cultural beliefs, and concerns about discrimination or revealing details about their sex life. In addition, the distance between their homes and the hospital acted as a barrier for many women. However, women's participation in the screening test, although low, could be attributed to receiving advice from their gynecologists and attending awareness and education campaigns.

Multivariate analysis of factors associated with cervical cancer screening showed that age group, age at screening, frequency of screening, and age at first sexual intercourse were independent predictors of cervical cancer screening at Maroua Regional Hospital. By age group, women aged >45 years were more likely to have been screened. This result is consistent with those obtained by Guèye *et al.* (2021) in Senegal and Tiruneh *et al.* (2017) in Kenya and differs from that obtained by Kabore (2020) in Burkina Faso. This result could be explained by the fact that women reaching this age were more aware of the risks of developing cervical cancer. At this age, most women were more likely to participate in preventive health care such as cervical cancer screening, which coincided with important life transitions such as marriage, childbirth, or a period of professional stability that could influence their health awareness and commitment to preventive care. Indeed, older women are generally more aware of the importance of regular screening, largely due to prevention campaigns targeting this age group, which is considered more at risk. Moreover, older women are often more familiar with the health-care system and more accustomed to consulting health-care professionals regularly, which facilitates access to screening.

However, the belief that every woman should be screened at the age of 25 significantly increased the chance of having been screened. This result differs from that obtained by Antaon *et al.* (2021) in Brazzaville and can be explained by the fact that public health recommendations and guidelines play an important role in raising awareness and motivating women to undergo these preventive medical examinations. Health professionals and health authorities advocating a target age for screening create a collective awareness and greater incentive for women to comply with these recommendations, resulting in higher participation rates in cervical cancer screening programs.

Table 6. Multivariate analysis of factors associated with cervical cancer screening

Variables	Terms and conditions	AOR (95% CI)	*p*-value
Age group (years)	25 – 34	1	
	35 – 44	0.36 (0.006 – 19.8)	0.610
	45+	3.47 (0.14 – 155)	0.036 *
Marital status	Married	0.33 (0.01 – 5.66)	0.447
	Single	1	
	Divorced	0.02 (0.0001 – 2.96)	0.142
	Widowed	1.82 (0.01 – 15.6)	0.788
Profession	Student	0.55 (0.21 – 1.36)	0.604
	Informal sector	0.01 (0.009 – 0.45)	0.465
	Private sector	0.05 (0.001 – 0.30)	0.469
	Public sector	0.11 (0.002 – 2.64)	0.220
	Housekeeper	1	
Knowledge of cervical cancer risk factors	No	1	0.206
	Yes	0.14 (0.005 – 2.87)	
Knowledge of cervical cancer symptoms	No	1	
	Yes	0.12 (0.002 – 2.54)	0.218
Knowledge of cervical cancer prevention measures	No	1	
	Yes	5.27 (0.34 – 8.59)	0.220
Age of screening	No idea	1	
	18 years	14.2 (7.14 – 48.2)	0.099
	25 years	20.5 (5.74 – 41.5)	0.0005 ***
	40 years	12.4 (1.13 – 24.8)	0.058
Frequency of screening	Once a year	3.29 (1.62 – 7.25)	0.011 *
	Once every 3 years	0.18 (0.001 – 1.03)	0.453
	Once every 5 years	0.3 – 08 (0 – 5.23)	0.99
	No idea	1	
Screening helps prevent cervical cancer	No idea	1	
	No	0.12 (0.01–6.73)	0.999
	Yes	2.17 (0.29 – 19.9)	0.494
Screening poses no danger to the patient	No idea	1	
	No	0.3 (0.03 – 3.34)	0.340
	Yes	0.01 (0.04 – 5.08)	0.349
Screening for precancerous lesions is accessible to everyone	No idea	1	0.171
	No	0.34 (0.004 – 3.27)	0.181
	Yes	1.81 (0.83 – 1.77)	
Cervical cancer affects most women in Cameroon	No idea	1	
	No	1.29 (0.06 – 5.19)	0.959
	Yes	2.17 (0.29 – 19.4)	0.456
How to avoid cervical cancer	Screening	10.7 (1.39 – 135)	0.018 *
	Abstinence and fidelity	1	
	Condom	9.04 (0.13 – 64.0)	0.324
	None	1.30 (0.04 – 4.55)	0.878

(Cont'd...)

Table 6. ***(Continued)***

Variables	Terms and conditions	AOR (95% CI)	*p*-value
Age of first sexual intercourse	Not yet	1.37 (0.47 – 4.55)	0.773
	Before 15 years	12.7 (1.92 – 45.5)	0.004 **
	Between 15 and 20 years	7.59 (4.33 – 31.9)	0.009 **
	After 20 years	1	

Abbreviations: OR: Odds ratio; CI: Confidence interval; *P*-value: Significance level; NA: Not applicable; * $P<0.05$; ** $p<0.01$; *** $p<0.001$.

Knowledge of the frequency of screening significantly increased the chance of having had a screening test. This result is in line with those obtained by Chan Chee *et al.* (2005) and Ago *et al.* (2022) in Nigeria and can be explained by the fact that women are informed of the recommendations concerning the frequency of screening. This enables them to better understand the importance and necessity of undergoing these examinations regularly. This knowledge makes them aware that screening should not be a one-off act but a preventive approach to be repeated at regular intervals. Indeed, having this information encourages women to be more proactive in planning and carrying out their screening tests. As a result, they are more likely to follow up regularly with their doctor and not omit or postpone these important health tests. Therefore, awareness of the recommended frequency is a key factor in significantly increasing the participation rates in cervical cancer screening.

Conversely, undergoing screening as a preventive practice significantly increased the likelihood of undergoing cervical cancer screening. This may be due to the perception of screening as a preventive measure, rather than as a routine medical examination, giving it greater importance and legitimacy among women. As a result, they better understood the value of regular screening to detect any abnormalities at an early stage and prevent cancer development. Moreover, this preventive vision of screening encourages women to take a proactive approach to their health. Consequently, they are more inclined to take the initiative in planning and undergoing checkups regularly to monitor their state of health.

In addition, having had sexual intercourse for the 1st time before the age of 15 or between the ages of 15 and 20 significantly increased the chance of being screened for cervical cancer. This result is in line with that obtained by Tesfaw *et al.* (2022) in Ethiopia and may be explained by the fact that health professionals often recommend starting gynecological follow-up and screening as soon as sexual activity begins. Therefore, women who had their first intercourse before the age of 20 are more likely to have been referred and closely monitored for these screening tests. Similarly, earlier sexual initiation may be associated with an increased risk of contracting sexually transmitted infections, some of which are linked to cervical cancer development. This encourages these women to be more attentive to their gynecological health and undergo screening examinations more regularly.

5. Study limitations

This study has several limitations. First, it is based on a cross-sectional methodology, which limits our ability to establish cause-and-effect relationships between the studied variables. Second, data were collected from a sample of women attending gynecological consultations at the Maroua Regional Hospital, which may introduce a selection bias and limit the generalizability of the results to other populations. Third, data collection through self-administered questionnaires may lead to reporting bias or omissions. Finally, some important variables such as socioeconomic status or geographical access to screening services were not included in the analysis, which may limit the overall understanding of the factors associated with cervical cancer screening in this population.

6. Conclusion

This study highlights several factors associated with cervical cancer screening among women attending the regional hospital in Maroua, Cameroon. Age, perceptions of the age at which screening should start, frequency of screening, use of screening as a preventive measure, and age at first sexual intercourse are significant determinants of screening uptake. These results highlight the importance of raising awareness of the importance of early screening, improving accessibility to screening services, and strengthening local cervical cancer awareness and screening programs. Targeted interventions on these factors can help reduce the incidence and mortality of this disease in Cameroon.

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Conflict of interest

The authors declare they have no competing interests.

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Ethical considerations and participant consent

To carry out this study, we obtained ethical clearance from the Institutional Ethics and Assurance Committee of Université des Montagnes (IEACUdM) [N°2023/081/UDM/PR/CEAQ], research authorization from the Far North Regional Public Health Delegate [N°262/L/MISANTE/SG/DRSPEN]. Subsequently, an agreement was obtained from the director of the Maroua Regional Hospital, to which was added an agreement obtained through the signing of informed consent by the participants to justify their voluntary participation in the research. In addition, confidentiality and anonymity were safeguarded during data collection.

Consent for publication

Not applicable.

Availability of data

All data used and/or analyzed for this study are available from the corresponding author upon reasonable request.

References

Ago, B., E Efiok, E., & Abeng, S. (2022). Sociodemographic and gynecological factors that influence uptake of cervical cancer screening. A cross-sectional study in Calabar, Nigeria. *African Health Sciences*, 22(4):96-103.

https://doi.org/10.4314/ahs.v22i4.13

Antaon, J.S.S., Malanda, J.N., Suh, S.A., Nemy, J.H., Essi, M.J., & Tebeu, P.M. (2021). Factors associated with access barriers to cervical cancer screening in Brazzaville. *Health Sciences and Disease*, 22(6):579-589.

https://doi.org/10.5281/hsd.v22i6.2793

Bouslah, S., Soltani, M.S., Ben Salah, A., & Sriha, A. (2014). Knowledge, attitudes and practices of Tunisian women regarding breast and cervical cancer screening. *Psycho-Oncology*, 8(2):123-132.

https://doi.org/10.1007/s11839-014-0460-8

Bruni, L., Serrano, B., Roura, E., Alemany, L., Cowan, M., Herrero, R., *et al.* (2022). Cervical cancer screening programs and age-specific coverage estimates for 202 countries and territories worldwide: A review and synthetic analysis. *The Lancet, Global Health,* 10(8):e1115-e1127.

https://doi.org/10.1016/S2214-109X (22)00241-8

Chan Chee, C., Begassat, M., & Kovess, V. (2005). Factors associated with cervical cancer screening in a mutualist population. *Journal of Epidemiology and Public Health*, 53(1):69-75.

https://doi.org/10.1016/S0398-7620 (05)84573-0

Donatus, L., Nina, F.K., Sama, D.J., Nkfusai, C.N., Bede, F., Shirinde, J., *et al.* (2019). Assessing the uptake of cervical cancer screening among women aged 25-65 years in Kumbo West Health District, Cameroon. *Pan African Medical Journal*, 33(1):106.

https://doi.org/10.11604/pamj.2019.33.106.16975

Faye, A., Thierno Mbengue, E., & Tal-Tal, A. (2017). Factors associated with cervical cancer screening in rural Senegal. *Journal of Epidemiology and Public Health*, 65:S77.

https://doi.org/10.1016/j.respe.2017.03.063

Global Cancer Observatory. (2022). International Agency for Research on Cancer. Available from: https://gco.iarc.who.int/media/globocan/factsheets/populations/903-africa-fact-sheet.pdf [Last accessed on 2024 Apr 08].

Guèye, I., Diallo, A.I., Sangho, O., Sawadogo, B., & Tine, J.A.D. (2021). Factors associated with the practice of cervical cancer screening in the health district of Joal, Senegal, 2018: Household survey. *Journal of Interventional Epidemiology and Public Health*, 4(11):1-11.

https://doi.org/10.11604/JIEPH.supp.2021.4.3.1096

Kabore, A. (2020). "Health Belief Model": Factors associated with adherence to cervical cancer screening in the gynecology department of the Souro Sanou university hospital center in Bobo Dioulassa (Burkina Faso). *Journal of sago (Gynecology-Obstetrics and Reproductive Health)*, 21(1):42-49.

Marie Tebeu, P., Antaon, J.S.S., Adjeba, M., Pikop, F., Fouogue, J.T., & Ndom, P. (2020). Knowledge, attitudes and practices of health professionals on cervical cancer in Cameroon. *Sante Publique*, 32(5):489-496.

https://doi.org/10.3917/spub.205.0489

Minister of Public Health. (2020). National Strategic Plan

for Prevention and Control of Cancer (PSNLCa) 2020-2024. Available from: https://fr.readkong.com/page/plan-strategique-national-de-prevention-et-de-lutte-contre-8891066 [Last accessed on 2024 Apr 08].

Minister of Public Health. (2023). Demographic Projections and Estimates of Priority Targets for Various Health Programs and Interventions. Available from: http://onsp.minsante.cm/sites/default/files/publications/232/Projections%20d_mographiques%20et%20estimations%20des%20cibles%20des%20programmes.pdf [Last accessed on 2024 Jul 20].

Tesfaw, K., Kindie, W., Mulatu, K., & Bogale, E.K. (2022). Utilization of cervical cancer screening and factors associated with screening utilization among women aged 30–49 years in Mertule Mariam Town, East Gojjam Zone, Ethiopia, in 2021: A cross-sectional survey. *BMJ Open*, 12(11):e067229.

https://doi.org/10.1136/bmjopen-2022-067229

Tiruneh, F.N., Chuang, K.Y., Ntenda, P.A.M., & Chuang, Y.C. (2017). Individual-level and community-level determinants of cervical cancer screening among Kenyan women: A multilevel analysis of a nationwide survey. *BMC Women's Health,* 17(1):109.

https://doi.org/10.1186/s12905-017-0469-9

World Health Organization. (2024). Cervical Cancer. Available from: https://www.who.int/news-room/fact-sheets/detail/cervical-cancer [Last accessed on 2024 Apr 06].

ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

Fatigue, quality of life, and social support in Greek health staff: Public versus private kidney units

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Abstract

Healthcare professionals often experience fatigue and a diminished quality of life due to demanding hours and challenges in balancing work and personal life. Social support plays a critical role in influencing these factors. This study focused on nurses and healthcare workers in the artificial kidney unit, a specialized area requiring significant expertise to operate complex machinery for seriously ill patients. We assessed levels of fatigue, social support, and quality of life among 159 doctors and nurses in public and private facilities across Greece using the Fatigue Assessment Scale, Multidimensional Scale of Perceived Social Support, and General Health Questionnaire-28. Participants reported moderate fatigue (mean = 2.63, standard deviation [SD] = 0.57 for doctors; mean = 2.42, SD = 0.49 for nurses) and moderate-to-high levels of social support (mean = 5.66, SD = 1.35). Factors negatively impacting quality of life, such as physical symptoms, anxiety, social dysfunction, and severe depression, yielded low scores. Notably, fatigue and quality of life differed significantly between public and private sectors ($p < 0.05$), with public sector professionals reporting higher fatigue levels and lower quality of life. These findings highlight the need for healthcare authorities to address the unique challenges faced by staff in artificial kidney units, particularly in public hospitals, to improve working conditions and overall well-being.

Keywords: Fatigue; Social support; Quality of life; Artificial kidney unit; Dialysis unit

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1. Introduction

Studies on healthcare professionals working in artificial kidney units emphasize an important area of research interest. These units are critical reception centers for patients with kidney failure, but they also present challenges for the doctors and nurses working in them. Research in this area can provide valuable insights for improving working conditions and protecting the health of workers in the sector. In this context, social support plays a key role. Social support is defined as help from others that a person can sense, understand, observe, or accept. This environmental resource serves as a protective factor for individuals experiencing stressful life events and promotes their physical and mental health. For instance, a supportive network mitigates the possibility of depression

by encouraging patients to resist negative emotions and by helping those already experiencing depression to improve their self-esteem. Social support can enhance coping skills and problem-solving strategies for patient issues and can reduce anxiety associated with living with a chronic illness (Theofilou, 2023). Regarding the types of social support, Schaefer *et al.* (1981) identify five categories: (a) Emotional support, (b) esteem support, (c) support from the social network (network support), (d) informational support, and (e) tangible or instrumental support (practical/material support). In fact, a recent study reported the impact of social support on the general health of healthcare professionals (Theofilou & Varemenos, 2024).

A study conducted in 2018 in six public and private hospitals in China examined 283 female nurses in hemodialysis units to determine the percentage of job satisfaction and to identify the rates of "compassion" fatigue prevalent in these units. The results demonstrated that the rates of compassion fatigue experienced by nurses in artificial kidney units were equivalent to those experienced by healthcare professionals in intensive care units and pediatric clinics but were significantly higher than those observed in oncology clinics. This finding relates to the stressors inherent in their work and work environment, such as the specialization required, the difficulty and attention needed for vascular puncture, and the long follow-up duration for patients, all of which contribute to high levels of burnout and severe stress. Building a better and healthier work environment can play a key role in increasing the satisfaction of nurses working in artificial kidney units and in reducing the fatigue associated with intense compassion for patients. Regarding the distinction between the private and public sectors, the results showed that compassion fatigue rates were significantly higher in public hospitals than in private hospitals, likely because private hospitals offer better working conditions for nurses and impose less pressure. Furthermore, patients who choose private hospitals may be more satisfied with their treatment and the hospital's facilities. The better relationships between doctors and nurses in private hospitals also contribute to improved job satisfaction for nurses, as noted in the study. Nevertheless, job satisfaction in both hospital settings appears to be negatively related to the rates of compassion fatigue experienced by nurses while being positively related to the satisfaction they derive from working hard to help patients with kidney failure (Wang *et al.*, 2022).

A similar study conducted in China involving a sample of 528 nurses working in artificial kidney units analyzed the relationship between workplace problem-solving ability, compassion fatigue, work engagement, and the desire to leave their jobs. Regarding the intention to leave, over 50% of the participants expressed an interest in doing so. This intention was strongly and positively correlated with the degree of compassion fatigue experienced by nurses in hemodialysis units but negatively correlated with their levels of resilience, empathy, and work engagement. The desire to leave was significantly lower among older nurses and those with more years of experience. This is likely due not only to their advanced knowledge of hemodialysis procedures but also to the stable cooperation and good relationships they have developed with fellow doctors and nurses, as well as with chronic patients and their families, who trust and respect their work. Developing the clinical skills of younger and less experienced nurses can significantly reduce their desire to leave. The same study showed that nurses who reported greater compassion fatigue in artificial kidney units were more likely to quit their jobs. The chronic stress of dealing with patients whose lives are in danger, the waiting for kidney transplants, and providing psychological support to patients' families place an emotional burden on workers, increase their mental fatigue, and significantly heighten the likelihood of resignation. Conversely, the study found that employees with strong work engagement were much less likely to quit their jobs. Hospital managers should implement work commitment enhancement programs to reduce employees' intentions to leave (Cao & Chen, 2021).

Another study conducted in China with 345 nurses investigated the consequences of social support and resilience in the workplace, focusing on improving the work engagement of employees in artificial kidney units. The results showed that workers in hemodialysis units had lower rates of work engagement than those in other clinical units, such as pathology, surgery, or oncology clinics. Infrequent professional promotions, limited opportunities for income growth among Chinese nurses, intense work hours, and insufficient resources may play significant roles in the lack of a sense of commitment. Employee resilience – defined as the ability to feel happy and to overcome negative events at work – appears to be directly related to their sense of work engagement. More specifically, the study found that nurses in hemodialysis units with strong levels of resilience could effectively handle complex and specialized hemodialysis equipment and manage various complications related to their work. Moreover, they seemed to cope with stress more effectively and mitigate the consequences of stressful incidents in the workplace. The study emphasized the need to develop strategies aimed at strengthening the resilience of workers in artificial kidney units. Simultaneously, it highlighted the crucial importance of support from employers, supervisors, and colleagues in fostering work engagement. Psychological

and practical support, such as providing resources for work, may be directly linked to the commitment that nurses develop toward their work environment. Therefore, promoting collective support in hemodialysis units is essential. However, the study did not find corresponding results regarding the support employees receive from their friends or family. This may be related to the lack of shared experiences, which can make it difficult to express and share essential feelings due to the demands of daily work in artificial kidney units (Cao & Chen, 2019).

Although there are various studies on fatigue, quality of life, and social support among healthcare staff, the number of studies investigating these variables among health professionals working in artificial kidney units, particularly in Greece, is extremely limited.

Therefore, this study aimed to investigate the levels of fatigue, social support, and quality of life of health professionals working in artificial kidney units in public and private hospitals in Greece.

The questions posed for this study are as follows:

1) What are the fatigue levels of health professionals working in artificial kidney units?
2) What are the social support networks of health professionals working in artificial kidney units?
3) What are the levels of quality of life for health professionals working in artificial kidney units?
4) Is there any difference in fatigue, social support, and quality of life between health professionals working in artificial kidney units in public and private hospitals?

2. Methods

2.1. Study design

This study utilized a quantitative cross-sectional approach. Specifically, it was conducted through the distribution of questionnaires to health professionals (doctors and nurses). Data were collected using two methods. The first method involved distributing paper questionnaires to artificial kidney units in Attica. In the units where the questionnaire was distributed in paper form, special permission was requested from each hospital before distribution and completion by the participants. The second method involved distributing the questionnaire in electronic form, both in the artificial kidney units in Attica and in various regions of Greece. The convenience sampling method was employed, meaning that the sample was selected because the researcher had easy access to it. The study population comprised all health professionals working in artificial kidney units in both public hospitals and private clinics. Respondents were informed about the purpose of the study and ethical considerations through the consent form included in the appendix. It was emphasized that their data would be kept confidential and that absolute anonymity would be maintained. Moreover, the data were used exclusively for the purposes of this research. Participation was completely voluntary, and respondents could withdraw from completing the questionnaire at any time they wished.

The following were the inclusion criteria:

- Participants must work as doctors or nurses in the artificial kidney unit for at least 1 year before completing the questionnaire.
- Participants should work in either the private or public sector.
- Participants must work in an artificial kidney unit in Greece.

2.2. Instruments

Four types of research tools were used in this study. (1) Social/demographic data: this section consists of 10 questions regarding demographic data (such as gender and age) and occupational data (such as years of service and whether the participant works in a public or private hospital). (2) Fatigue assessment: the Fatigue Assessment Scale (FAS), developed by Michielsen *et al.* (2003), was used to evaluate fatigue levels. This scale consists of 10 questions answered on a 5-point Likert scale (from 1 indicating "never" to 5 indicating "always"). The reliability and validity of this tool have been examined in Greece, indicating very good psychometric properties (Alikari *et al.*, 2016; Zyga *et al.*, 2015). (3) Evaluation of social support: social support was evaluated using the Multidimensional Scale of Perceived Social Support (MSPSS) questionnaire (Zimet *et al.*, 1988), which consists of 12 questions answered on a 7-point Likert scale (from 1 indicating "I strongly disagree" to 7 indicating "I strongly agree"). Its subscales are as follows: significant other (questions 1, 2, 5, and 10), family (questions 3, 4, 8, and 11), and friends (questions 6, 7, 9, and 12). The MSPSS has been translated and validated for the Greek population by Paraskevi Theofilou (Theofilou, 2015; Theofilou *et al.*, 2013). (4) Quality of life assessment: the General Health Questionnaire (GHQ)-28, developed by Goldberg & Hillier (1979), was used to evaluate quality of life. This scale consists of 28 questions answered on a 4-point Likert scale (from 0 indicating "not at all" to 3, depending on the question, where a score closer to 0 indicates better quality of life). It is divided into the following four factors: physical symptoms, anxiety/insomnia, social dysfunction, and major depression (Goldberg *et al.*, 1997). The GHQ-28 has been translated into Greek and validated in the Greek population (Garyfallos *et al.*, 1991). For academic purposes, these three questionnaires may be used free of charge.

The statistical analysis initially included a descriptive analysis of the demographic characteristics of the sample, specifically the descriptive analysis of the aforementioned variables. This comprised a frequency analysis of categorical variables and an average analysis of quantitative variables. Next, the descriptive analysis involved scoring the questionnaires, which included both the overall data and the data separated by public and private sectors. Then, the normality of the questionnaire scores was checked using the Kolmogorov–Smirnov test for both the overall data and the data for the public and private sectors. The one-sample *t*-test was used to calculate the confidence intervals of the questionnaire scores for the data from the two sectors as well as for the overall data. The Pearson linear correlation coefficient was used to evaluate the intensity and significance of the correlation between the variables of interest, namely, the questionnaire scores, for both the overall data and the data from the public and private sectors.

3. Results

The study sample consisted of 159 individuals, comprising 138 (86.8%) women and 21 (13.2%) men (Table 1). Regarding their age group, 6 (3.8%) participants were aged up to 25 years, 47 (29.6%) were aged 26 – 35 years, 50 (31.4%) were aged 36 – 45 years, 12 (7.5%) were aged 46 – 55 years, and 12 (7.5%) participants were aged >55 years (Table 1).

Regarding their educational level, 13 (8.2%) participants were high school graduates, 32 (20.1%) were graduates of private schools (e.g., colleges), 69 (43.4%) had some university degrees, and 45 (28.3%) had a master's or doctoral degree (Table 1).

Regarding their marital status, 42 (26.4%) participants were single, 17 (10.5%) were in a relationship, 86 (54.1%) were married or had a cohabitation agreement, 12 (7.5%) were divorced, and 2 (1.3%) were widowed (Table 1).

Concerning their number of children, 70 (44%) had no children, 25 (15.7%) had one child, 52 (32.7%) had two children, 11 (6.9%) had three children, and 1 (.6%) participant did not respond (Table 1).

Regarding the years of service, 57 (35.8%) individuals did not answer, 31 (19.5%) individuals answered 0 – 5 years, 24 (15.1%) individuals mentioned 16 – 20 years, and 47 (29.6%) individuals had >20 years of service (Table 2).

Regarding the job position, 2 (1.3%) individuals were medical specialists, 14 (8.8%) were medical specialists, 116 (73%) were nurses, and 27 (17%) were nursing assistants (Table 3).

Regarding the workplace, 64 (40.3%) participants were in the public sector and 95 (59.7%) were in the private sector (Table 4).

A total of 105 (66%) individuals did not have a position of responsibility in their work, whereas 54 (34%) had the same (Table 5).

Regarding years of service in the artificial kidney unit, 16 (10.1%) participants did not respond, 75 (47.2%) participants answered 0 – 5 years, 15 (9.4%) answered 6 – 10 years, 10 (6.3%) individuals answered 11 – 15 years, 17 (10.7%) answered 16 – 20 years, and 26 (16.4%) individuals answered >20 years (Table 6).

The mean MSPSS score for the entire sample was 5.66 (standard deviation [SD] = 1.35), with a range of 1 – 7. The mean score of the friends subscale for the entire sample was 5.28 (SD = 1.47), with a minimum of 1 and a maximum of 7. The mean score of the family subscale for the entire sample was 5.53 (SD = 1.42), with a minimum of 1 and a maximum of 7. The mean score of social support for the entire sample was 5.49 (SD = 1.29), with a minimum of 1 and a maximum of 7. The mean MSPSS score for the public sector was 5.45 (SD = 1.51) and 5.8 (SD = 1.23) for the private sector. The mean score of the family subscale for the public sector was 5.32 (SD = 1.67) and 5.67 (SD = 1.22) for the private sector. The mean score of the friends subscale for the public sector was 5.07 (SD = 1.55) and 5.67 (SD = 1.22) for the private sector. The mean score of social support for the public sector was 5.25 (SD = 1.42) and 5.62 (SD = 1.18) for the private sector. The mean score of the fatigue questionnaire for the entire sample was 2.51 (SD = 0.53), with a minimum of 1 and a maximum of 4.2 (Table 7).

The mean score of the fatigue questionnaire was 2.63 (SD = 0.57) for the public sector and 2.42 (SD = 0.49) for the private sector (Table 8).

The average score of the physical symptoms factor of the GHQ-28 questionnaire for the entire sample was 1.09 (SD = 0.63), with a minimum of 0 and a maximum of 2.57. The average score of the anxiety/insomnia factor of the GHQ-28 questionnaire for the entire sample was 1.01 (SD = 0.69), with a minimum of 0 and a maximum of 3. The mean score of the social dysfunction factor of the GHQ-28 questionnaire for the entire sample was 0.99 (SD = 0.43), with a minimum of.14 and a maximum of 2.57. The mean score of the severe depression factor of the GHQ-28 questionnaire for the entire sample was 0.35 (SD = 0.50), with a minimum of 0 and a maximum of 2.71. The mean score of the GHQ-28 questionnaire for the entire sample was 0.86 (SD = 0.47), with a minimum of 0.07 and a maximum of 2.57.

Table 1. Sociodemographics of the total sample

	Frequency	Percentage	Valid percentage	Cumulative percentage
Gender				
Valid				
Female	138	86.8	86.8	86.8
Male	21	13.2	13.2	100.0
Total	159	100.0	100.0	
Age (years)				
Valid				
Up to 25	6	3.8	3.8	3.8
26 – 35	47	29.6	29.6	33.3
36 – 45	50	31.4	31.4	64.8
46 – 55	44	27.7	27.7	92.5
>55	12	7.5	7.5	100.0
Total	159	100.0	100.0	
Education				
Valid				
Lyceum	13	8.2	8.2	8.2
Private studies (College)	32	20.1	20.1	28.3
Holder of a degree from Universities/Technological Educational Institutes	69	43.4	43.4	71.7
Master's/PhD holder	45	28.3	28.3	100.0
Total	159	100.0	100.0	
Marital status				
Valid				
Single	42	26.4	26.4	26.4
In relation	17	10.7	10.7	37.1
Married or registered partnership	86	54.1	54.1	91.2
Divorced	12	7.5	7.5	98.7
Widower	2	1.3	1.3	100.0
Total	159	100.0	100.0	
Number of children				
Valid				
0	70	44.0	44.3	44.3
1	25	15.7	15.8	60.1
2	52	32.7	32.9	93.0
3	11	6.9	7.0	100.0
Total	158	99.4	100.0	
Missing				
System	1	0.6		
Total	159	100.0		

The mean score of the physical symptoms factor of the GHQ-28 questionnaire was 1.27 (SD = 0.61) for the public sector and 0.96 (SD = 0.61) for the private sector. The mean score of the anxiety/insomnia factor of the GHQ-28 questionnaire was 1.24 (SD = 0.78) for the public sector and 0.85 (SD = 0.58) for the private sector. The mean score of the social dysfunction factor of the GHQ-28 questionnaire was 1.12 (SD = 0.46) for the public sector and 0.91 (SD = 0.39) for the private sector. The mean score of the severe depression factor of the GHQ-28 questionnaire was

Table 2. Years of service

	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid				
Years of service	57	35.8	35.8	35.8
0 – 5	31	19.5	19.5	55.3
16 – 20	24	15.1	15.1	70.4
>20	47	29.6	29.6	100.0
Total	159	100.0	100.0	

Table 3. Job position

	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid				
Trainee doctor	2	1.3	1.3	1.3
Specialist doctor	14	8.8	8.8	10.1
Nurse	116	73.0	73.0	83.0
Nursing assistant	27	17.0	17.0	100.0
Total	159	100.0	100.0	

Table 4. Field of work

	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid				
Public hospital	64	40.3	40.3	40.3
Private clinic/ hospital	95	59.7	59.7	100.0
Total	159	100.0	100.0	

Table 5. Position of responsibility

	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid				
No	105	66.0	66.0	66.0
Yes	54	34.0	34.0	100.0
Total	159	100.0	100.0	

Table 6. Years of experience in the artificial kidney unit

	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid				
Years of experience in the artificial kidney unit	16	10.1	10.1	10.1
0 – 5	75	47.2	47.2	57.2
6 – 10	15	9.4	9.4	66.7
11 – 15	10	6.3	6.3	73.0
16 – 20	17	10.7	10.7	83.6
>20	26	16.4	16.4	100.0
Total	159	100.0	100.0	

0.47 (SD = 0.61) for the public sector and 0.27 (SD = 0.39) for the private sector. The mean score of the entire GHQ-28 questionnaire was 1.02 (SD = 0.51) for the public sector and 0.75 (SD = 0.40) for the private sector.

The MSPSS variable was significantly positively correlated with the family subscale variable ($r[157] = 0.81$, $p = 0.00$) and with the friends subscale variable ($r[157] = 0.72$, $p = 0.00$). It was significantly negatively correlated with the physical symptoms factor ($r[156] = -0.30$, $p = 0.00$), anxiety/insomnia factor ($r[157] = -0.39$, $p = 0.00$), social dysfunction factor ($r[157] = -0.50$, $p = 0.00$), severe depression factor ($r[157] = -0.42$, $p = 0.00$), fatigue variable ($r[157] = -0.25$, $p = 0.00$), and complete GHQ-28 questionnaire ($r[156] = -0.47$, $p = 0.00$) (Table 9). The family subscale variable was significantly positively correlated with the friends subscale variable ($r[157] = 0.71$, $p = 0.00$). However, it was significantly negatively correlated with the physical symptoms factor ($r[156] = -0.25$, $p = 0.00$), anxiety/insomnia factor ($r[157] = -0.35$, $p = 0.00$), social dysfunction factor ($r[157] = -0.41$, $p = 0.00$), severe depression factor ($r[157] = -0.42$, $p = 0.00$), fatigue variable ($r[157] = -0.20$, $p = 0.00$), and complete GHQ-28 questionnaire ($r[156] = -0.42$, $p = 0.00$) (Table 9). The friends subscale variable was significantly negatively correlated with the physical symptoms factor ($r[156] = -0.21$, $p = 0.01$), anxiety/insomnia factor ($r[157] = -0.31$, $p = 0.00$), social dysfunction factor ($r[157] = -0.37$, $p = 0.00$), severe depression factor ($r[157] = -0.30$, $p = 0.00$), fatigue variable ($r[157] = -0.20$, $p = 0.01$), and complete GHQ-28 questionnaire ($r[156] = -0.35$, $p = 0.00$) (Table 9). The social support variable was significantly negatively correlated with the physical symptoms factor ($r[156] = -0.28$, $p = 0.00$), anxiety/insomnia factor ($r[157] = -0.39$, $p = 0.00$), social dysfunction factor ($r[157] = -0.45$, $p = 0.00$), severe depression factor ($r[157] = -0.40$, $p = 0.00$), variable fatigue ($r[157] = -0.26$, $p = 0.00$), and complete GHQ-28 questionnaire ($r[156] = -0.45$, $p = 0.00$. The fatigue variable was significantly positively correlated with the physical symptoms factor ($r[156] = 0.59$, $p = 0.00$), anxiety/insomnia factor ($r[157] = 0.59$, $p = 0.00$), social dysfunction factor ($r[157] = 0.55$, $p = 0.00$), severe depression factor ($r[157] = 0.43$, $p = 0.00$), and complete GHQ-28 questionnaire ($r[156] = 0.66$, $p = 0.00$) (Table 9).

Table 7. Average values of scales and subscales

	MSPSS	Family	Friends	Fatigue	Social support	Factor A: Physical symptoms	Factor B: Anxiety/ Insomnia	Factor C: Social dysfunction	Factor D: Severe depression	Total GHQ-28
N										
Valid	159	159	159	159	159	158	159	159	159	158
Missing	0	0	0	0	0	1	0	0	0	1
Mean	5.6572	5.5283	5.2830	2.5063	5.4892	1.0859	1.0108	0.9928	0.3477	0.8626
Standard deviation	1.35407	1.42341	1.46804	0.53471	1.28554	0.63088	0.69384	0.43360	0.49917	0.46787
Minimum	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.14	0.00	0.07
Maximum	7.00	7.00	7.00	4.20	7.00	2.57	3.00	2.57	2.71	2.57

Abbreviations: GHQ-28: General health questionnaire-28; MSPSS: Multidimensional scale of perceived social support.

Table 8. Descriptive analysis of scales and subscales by field of work

	Place of work	N	Mean	Standard deviation	Standard error of mean
MSPSS	Public hospital	64	5.4453	1.50691	0.18836
	Private clinic/hospital	95	5.8000	1.22832	0.12602
Family	Public hospital	64	5.3203	1.67229	0.20904
	Private clinic/hospital	95	5.6684	1.21736	0.12490
Friends	Public hospital	64	5.0742	1.54796	0.19350
	Private clinic/hospital	95	5.4237	1.40245	0.14389
	Private clinic/hospital	95	5.6307	1.16601	0.11963
Fatigue	Public hospital	64	2.6312	0.57096	0.07137
	Private clinic/hospital	95	2.4221	0.49426	0.05071
Social support	Public hospital	64	5.2899	1.41845	0.17731
	Private clinic/hospital	95	5.6234	1.17648	0.12070
	Private clinic/hospital	95	5.6526	1.26315	0.12960
Factor A: Physical symptoms	Public hospital	64	1.2679	0.61432	0.07679
	Private clinic/hospital	94	0.9620	0.61478	0.06341
Factor B: Anxiety/Insomnia	Public hospital	64	1.2433	0.78316	0.09789
	Private clinic/hospital	95	0.8541	0.58009	0.05952
Factor C: Social dysfunction	Public hospital	64	1.1205	0.45973	0.05747
	Private clinic/hospital	95	0.9068	0.39469	0.04049
Factor D: Severe depression	Public hospital	64	0.4665	0.61048	0.07631
	Private clinic/hospital	95	0.2677	0.39109	0.04012
Total GHQ-28	Public hospital	64	1.0246	0.51231	0.06404
	Private clinic/hospital	94	0.7523	0.40174	0.04144

Abbreviations: GHQ-28: General health questionnaire-28; MSPSS: Multidimensional scale of perceived social support.

The MSPSS variable was significantly positively correlated with the family subscale variable ($r[62] = 0.80, p = 0.00$) and with the friends subscale variable ($r[62] = 0.74, p = 0.00$). However, it was significantly negatively correlated with the physical symptoms factor ($r[62] = -0.26, p = 0.05$), anxiety/insomnia factor ($r[62] = -0.30, p = 0.02$), social dysfunction factor ($r[62] = -0.52, p = 0.00$), severe depression factor ($r[62] = -0.37, p = 0.00$), fatigue variable ($r[62] = -0.35, p = 0.01$), and complete GHQ-28 questionnaire ($r[62] = -0.41, p = 0.00$) (Table 10). The family subscale variable was significantly positively correlated with the friends subscale variable ($r[62] = 0.71, p = 0.00$) but not with the physical symptoms factor ($r[62] = -0.22, p = 0.09$). It was significantly negatively correlated with the anxiety/insomnia factor ($r[62] = -0.30, p = 0.02$), social dysfunction factor ($r[62] = -0.47, p = 0.00$), severe

Table 9. Pearson correlation across scales in the dataset

	MSPSS	Family	Friends	Fatigue	Social support	Factor A: Physical symptoms	Factor B: Anxiety/ Insomnia	Factor C: Social dysfunction	Factor D: Severe depression	Total GHQ-28
MSPSS										
Pearson correlation	1	0.808**	0.722**	−0.249**	0.916**	−0.295**	−0.387**	−0.498**	−0.418**	−0.468**
Sig. (two-tailed)		0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Family										
Pearson correlation	0.808**	1	0.713**	−0.264**	0.907**	−0.245**	−0.347**	−0.406**	−0.424**	−0.415**
Sig. (two-tailed)	0.000		0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Friends										
Pearson correlation	0.722**	0.713**	1	−0.196*	0.889**	−0.213**	−0.311**	−0.371**	−0.297**	−0.350**
Sig. (two-tailed)	0.000	0.000		0.013	0.000	0.007	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Overall social support-quality of Life										
Pearson correlation	0.921**	0.921**	0.894**	−0.259**	0.991**	−0.274**	−0.381**	−0.464**	−0.415**	−0.449**
Sig. (two-tailed)	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Fatigue										
Pearson correlation	−0.249**	−0.264**	−0.196*	1	−0.261**	0.592**	0.592**	0.550**	0.431**	0.658**
Sig. (two-tailed)	0.002	0.001	0.013		0.001	0.000	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Social support										
Pearson correlation	0.916**	0.907**	0.889**	−0.261**	1	−0.281**	−0.390**	−0.451**	−0.402**	−0.447**
Sig. (two-tailed)	0.000	0.000	0.000	0.001		0.000	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Quality of life										
Pearson correlation	0.852**	0.875**	0.829**	−0.229**	0.879**	−0.234**	−0.323**	−0.460**	−0.412**	−0.418**
Sig. (two-tailed)	0.000	0.000	0.000	0.004	0.000	0.003	0.000	0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Factor A: Physical symptoms										
Pearson correlation	−0.295**	−0.245**	−0.213**	0.592**	−0.281**	1	0.733**	0.517**	0.449**	0.847**
Sig. (two-tailed)	0.000	0.002	0.007	0.000	0.000		0.000	0.000	0.000	0.000
N	158	158	158	158	158	158	158	158	158	158
Factor B: Anxiety/Insomnia										
Pearson correlation	−0.387**	−0.347**	−0.311**	0.592**	−0.390**	0.733**	1	0.597**	0.542**	0.897**
Sig. (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Factor C: Social dysfunction										
Pearson correlation	−0.498**	−0.406**	−0.371**	0.550**	−0.451**	0.517**	0.597**	1	0.605**	0.784**
Sig. (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
N	159	159	159	159	159	158	159	159	159	158
Factor D: Severe depression										
Pearson correlation	−0.418**	−0.424**	−0.297**	0.431**	−0.402**	0.449**	0.542**	0.605**	1	0.757**
Sig. (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
N	159	159	159	159	159	158	159	159	159	158
Total GHQ-28										
Pearson correlation	−0.468**	−0.415**	−0.350**	0.658**	−0.447**	0.847**	0.897**	0.784**	0.757**	1
Sig. (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
N	158	158	158	158	158	158	158	158	158	158

Abbreviations: GHQ-28: General health questionnaire-28; MSPSS: Multidimensional scale of perceived social support; Sig: Significance.

Table 10. Pearson correlation between scales in the public sector

	MSPSS	Family	Friends	Fatigue	Social support	Factor A: Physical symptoms	Factor B: Anxiety/ Insomnia	Factor C: Social dysfunction	Factor D: Severe depression	Total GHQ-28
MSPSS										
Pearson correlation	1	0.803**	0.739**	−0.345**	0.923**	−0.250*	−0.295*	−0.523**	−0.365**	−0.414**
Sig. (two-tailed)		0.000	0.000	0.005	0.000	0.047	0.018	0.000	0.003	0.001
N	64	64	64	64	64	64	64	64	64	64
Family										
Pearson correlation	0.803**	1	0.710**	−0.406**	0.902**	−0.215	−0.295*	−0.474**	−0.456**	−0.419**
Sig. (two-tailed)	0.000		0.000	0.001	0.000	0.089	0.018	0.000	0.000	0.001
N	64	64	64	64	64	64	64	64	64	64
Friends										
Pearson correlation	0.739**	0.710**	1	−0.301*	0.892**	−0.171	−0.308*	−0.416**	−0.299*	−0.352**
Sig. (two-tailed)	0.000	0.000		0.016	0.000	0.176	0.013	0.001	0.016	0.004
N	64	64	64	64	64	64	64	64	64	64
Overall social support-quality of life										
Pearson correlation	0.925**	0.923**	0.892**	−0.386**	0.992**	−0.232	−0.328**	−0.515**	−0.412**	−0.433**
Sig. (two-tailed)	0.000	0.000	0.000	0.002	0.000	0.065	0.008	0.000	0.001	0.000
N	64	64	64	64	64	64	64	64	64	64
Fatigue										
Pearson correlation	−0.345**	−0.406**	−0.301*	1	−0.377**	0.588**	0.550**	0.582**	0.469**	0.657**
Sig. (two-tailed)	0.005	0.001	0.016		0.002	0.000	0.000	0.000	0.000	0.000
N	64	64	64	64	64	64	64	64	64	64
Social support										
Pearson correlation	0.923**	0.902**	0.892**	−0.377**	1	−0.253*	−0.336**	−0.507**	−0.400**	−0.437**
Sig. (two-tailed)	0.000	0.000	0.000	0.002		0.043	0.007	0.000	0.001	0.000
N	64	64	64	64	64	64	64	64	64	64
Quality of life										
Pearson correlation	0.856**	0.902**	0.819**	−0.379**	0.891**	−0.157	−0.281*	−0.495**	−0.409**	−0.387**
Sig. (two-tailed)	0.000	0.000	0.000	0.002	0.000	0.216	0.025	0.000	0.001	0.002
N	64	64	64	64	64	64	64	64	64	64
Factor A: Physical symptoms										
Pearson correlation	−0.250*	−0.215	−0.171	0.588**	−0.253*	1	0.755**	0.483**	0.457**	0.833**
Sig. (two-tailed)	0.047	0.089	0.176	0.000	0.043		0.000	0.000	0.000	0.000
N	64	64	64	64	64	64	64	64	64	64
Factor B: Anxiety/Insomnia										
Pearson correlation	−0.295*	−0.295*	−0.308*	0.550**	−0.336**	0.755**	1	0.615**	0.517**	0.901**
Sig. (two-tailed)	0.018	0.018	0.013	0.000	0.007	0.000		0.000	0.000	0.000
N	64	64	64	64	64	64	64	64	64	64
Factor C: Social dysfunction										
Pearson correlation	−0.523**	−0.474**	−0.416**	0.582**	−0.507**	0.483**	0.615**	1	0.615**	0.787**
Sig. (two-tailed)	0.000	0.000	0.001	0.000	0.000	0.000	0.000		0.000	0.000
N	64	64	64	64	64	64	64	64	64	64
Factor D: Severe depression										
Pearson correlation	−0.365**	−0.456**	−0.299*	0.469**	−0.400**	0.457**	0.517**	0.615**	1	0.770**
Sig. (two-tailed)	0.003	0.000	0.016	0.000	0.001	0.000	0.000	0.000		0.000
N	64	64	64	64	64	64	64	64	64	64
Total GHQ-28										
Pearson correlation	−0.414**	−0.419**	−0.352**	0.657**	−0.437**	0.833**	0.901**	0.787**	0.770**	1
Sig. (two-tailed)	0.001	0.001	0.004	0.000	0.000	0.000	0.000	0.000	0.000	
N	64	64	64	64	64	64	64	64	64	64

Abbreviations: GHQ-28: General health questionnaire-28; MSPSS: Multidimensional scale of perceived social support; Sig: Significance.

depression factor ($r[62] = -0.30$, $p = 0.02$), fatigue variable ($r[62] = -0.30$, $p = 0.02$), and complete GHQ-28 questionnaire ($r[62] = -0.42$, $p = 0.00$) (Table 10). The friends subscale variable was non-significantly negatively correlated with the physical symptoms factor ($r[62] = -0.17$, $p = 0.18$) but significantly negatively correlated with the anxiety/insomnia factor ($r[62] = -0.31$, $p = 0.01$), social dysfunction factor ($r[62] = -0.42$, $p = 0.00$), severe depression factor ($r[62] = -0.30$, $p = 0.02$), fatigue variable ($r[62] = -0.30$, $p = 0.02$), and complete GHQ-28 questionnaire ($r[62] = -0.35$, $p = 0.00$) (Table 10).

The MSPSS variable was significantly positively correlated with the family subscale variable ($r[93] = 0.81$, $p = 0.00$) and the friends subscale variable ($r[93] = 0.70$, $p = 0.00$). It was significantly negatively correlated with the physical symptoms factor ($r[92] = -0.30$, $p = 0.00$), anxiety/insomnia factor ($r[93] = -0.45$, $p = 0.00$), social dysfunction factor ($r[93] = -0.45$, $p = 0.00$), and severe depression factor ($r[93] = -0.46$, $p = 0.00$) but was non-significantly correlated with the fatigue variable ($r[93] = -0.12$, $p = 0.24$) and significantly negatively correlated with the complete GHQ-28 questionnaire ($r[92] = -0.50$, $p = 0.00$) (Table 11). The variable family subscale was significantly positively correlated with the friends subscale variable ($r[93] = 0.72$, $p = 0.00$). However, it was significantly negatively correlated with the physical symptoms factor ($r[92] = -0.24$, $p = 0.02$), anxiety/insomnia factor ($r[93] = -0.37$, $p = 0.00$), social dysfunction factor ($r[93] = -0.31$, $p = 0.00$), and severe depression factor ($r[93] = -0.35$, $p = 0.02$) but was non-significantly correlated with the fatigue variable ($r[93] = -0.01$, $p = 0.44$) and significantly negatively correlated with the complete GHQ-28 questionnaire ($r[92] = -0.38$, $p = 0.00$) (Table 11). The friends subscale variable was significantly negatively correlated with the physical symptoms factor ($r[92] = -0.21$, $p = 0.04$), anxiety/insomnia factor ($r[93] = -0.28$, $p = 0.01$), social dysfunction factor ($r[93] = -0.30$, $p = 0.00$), and severe depression factor ($r[93] = -0.27$, $p = 0.01$) but was nonsignificantly correlated with the fatigue variable ($r[93] = -0.01$, $p = 0.48$) and was significantly negatively correlated with the complete GHQ-28 questionnaire ($r[92] = -0.32$, $p = 0.00$) (Table 11). The social support variable was significantly negatively correlated with the physical symptoms factor ($r[92] = -0.27$, $p = 0.01$), anxiety/insomnia factor ($r[93] = -0.42$, $p = 0.00$), social dysfunction factor ($r[93] = -0.37$, $p = 0.00$), and severe depression factor ($r[93] = -0.38$, $p = 0.00$) but was nonsignificantly correlated with the fatigue variable ($r[93] = -0.11$, $p = 0.25$) and was significantly negatively correlated with the complete GHQ-28 questionnaire ($r[92] = -0.43$, $p = 0.00$).

The social support questionnaire showed the similar variability in the two groups (public and private sector), as Levene's test resulted in $F = 1.65$, $p = 0.20$, and the same mean value, with $t(157) = -1.61$, $p = 0.11$ (Table 12). In contrast, the fatigue questionnaire did not exhibit the same dispersion in the two groups, as Levene's test resulted in $F = 4.12$, $p = 0.04$, and it also showed different mean values, with $t(157) = 2.39$, $p = 0.02$. The public sector had a higher average score (Table 12). Similarly, the quality of life questionnaire did not have the same dispersion in the two groups, with Levene's test resulting in $F = 7.30$, $p = 0.01$, and it also indicated different mean values, with $t(156) = 3.74$, $p = 0.00$.

4. Discussion

In this study, we aimed to investigate the levels of fatigue, social support, and quality of life among health professionals working in artificial kidney units and to compare these variables between the private and public sectors. According to the questionnaire responses, the majority of participants were women, with a predominant age range of 26 – 45 years. Most individuals had university degrees, and a significant proportion held master's or doctorate degrees. Moreover, most participants were married and had children. Regarding professional data, the largest percentage of participants who answered this question had >20 years of service in general; however, in the artificial kidney unit, most participants had ≤5 years of service. Nurses primarily responded to this questionnaire, whereas doctors comprised a very small percentage. Furthermore, the majority of respondents worked in the private sector, but they showed no significant differences compared with respondents in the public sector. Most individuals did not hold positions of responsibility. Regarding the social support received by the sample, it ranged from moderate to high levels. The family scale recorded a higher average, indicating that most of the social support received came from the family environment, which was greater than that from friends. Social support levels were similar to those reported in other studies, such as that by Theofilou *et al.* (2022), which also investigated the parameters of social support among 165 health professionals in Macedonia and Thrace.

The levels of fatigue were found to be moderate to low, whereas the scores on the quality of life subscales appeared to be low. The lowest score was associated with severe depression, followed by social dysfunction, physical symptoms, and anxiety, which showed higher scores but were still low compared to the maximum. These findings indicate that the study sample, while exhibiting some degree of fatigue, was not seriously affected in terms of quality of life, and social support networks existed to a relatively high

Table 11. Pearson correlation between scales in the private sector

	MSPSS	Family	Friends	Fatigue	Social support	Factor A: Physical symptoms	Factor B: Anxiety/ Insomnia	Factor C: Social dysfunction	Factor D: Severe depression	Total GHQ-28
MSPSS										
Pearson correlation	1	0.808**	0.701**	−0.122	0.905**	−0.298**	−0.451**	−0.450**	−0.461**	−0.498**
Sig. (two-tailed)		0.000	0.000	0.239	0.000	0.004	0.000	0.000	0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Family										
Pearson correlation	0.808**	1	0.716**	−0.080	0.914**	−0.240*	−0.371**	−0.305**	−0.349**	−0.380**
Sig. (two-tailed)	0.000		0.000	0.443	0.000	0.020	0.000	0.003	0.001	0.000
N	95	95	95	95	95	94	95	95	95	94
Friends										
Pearson correlation	0.701**	0.716**	1	−0.074	0.884**	−0.209*	−0.279**	−0.304**	−0.269**	−0.318**
Sig. (two-tailed)	0.000	0.000		0.479	0.000	0.043	0.006	0.003	0.008	0.002
N	95	95	95	95	95	94	95	95	95	94
Overall social support-quality of life										
Pearson correlation	0.914**	0.919**	0.896**	−0.100	0.991**	−0.272**	−0.399**	−0.386**	−0.391**	−0.434**
Sig. (two-tailed)	0.000	0.000	0.000	0.335	0.000	0.008	0.000	0.000	0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Fatigue										
Pearson correlation	−0.122	−0.080	−0.074	1	−0.118	0.565**	0.598**	0.480**	0.345**	0.628**
Sig. (two-tailed)	0.239	0.443	0.479		0.254	0.000	0.000	0.000	0.001	0.000
N	95	95	95	95	95	94	95	95	95	94
Social support										
Pearson correlation	0.905**	0.914**	0.884**	−0.118	1	−0.269**	−0.413**	−0.369**	−0.380**	−0.428**
Sig. (two-tailed)	0.000	0.000	0.000	0.254		0.009	0.000	0.000	0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Quality of life										
Pearson correlation	0.844**	0.839**	0.839**	−0.039	0.864**	−0.256*	−0.320**	−0.394**	−0.383**	−0.412**
Sig. (two-tailed)	0.000	0.000	0.000	0.710	0.000	0.013	0.002	0.000	0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Factor A: Physical symptoms										
Pearson correlation	−0.298**	−0.240*	−0.209*	0.565**	−0.269**	1	0.693**	0.496**	0.409**	0.852**
Sig. (two-tailed)	0.004	0.020	0.043	0.000	0.009		0.000	0.000	0.000	0.000
N	94	94	94	94	94	94	94	94	94	94
Factor B: Anxiety/Insomnia										
Pearson correlation	−0.451**	−0.371**	−0.279**	0.598**	−0.413**	0.693**	1	0.523**	0.522**	0.876**
Sig. (two-tailed)	0.000	0.000	0.006	0.000	0.000	0.000		0.000	0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Factor C: Social dysfunction										
Pearson correlation	−0.450**	−0.305**	−0.304**	0.480**	−0.369**	0.496**	0.523**	1	0.564**	0.753**
Sig. (two-tailed)	0.000	0.003	0.003	0.000	0.000	0.000	0.000		0.000	0.000
N	95	95	95	95	95	94	95	95	95	94
Factor D: Severe depression										
Pearson correlation	−0.461**	−0.349**	−0.269**	0.345**	−0.380**	0.409**	0.522**	0.564**	1	0.723**
Sig. (two-tailed)	0.000	0.001	0.008	0.001	0.000	0.000	0.000	0.000		0.000
N	95	95	95	95	95	94	95	95	95	94
Total GHQ-28										
Pearson correlation	−0.498**	−0.380**	−0.318**	0.628**	−0.428**	0.852**	0.876**	0.753**	0.723**	1
Sig. (two-tailed)	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	
N	94	94	94	94	94	94	94	94	94	94

Abbreviations: GHQ-28: General health questionnaire-28; MSPSS: Multidimensional scale of perceived social support; Sig: Significance.

Table 12. Independent samples test for field of work

	Levene's test for equality of variance		*t*-test for equality of means						
	F	Sig.	t	df	Sig. (two-tailed)	Mean difference	Standard error difference	95% confidence interval of the difference	
								Lower	Upper
Fatigue									
Equal variances assumed	4.116	0.044	2.457	157	0.015	0.20914	0.08512	0.04101	0.37728
Equal variances not assumed			2.389	121.853	0.018	0.20914	0.08755	0.03583	0.38246
Social support									
Equal variances assumed	1.650	0.201	−1.612	157	0.109	−0.33346	0.20685	−0.74202	0.07510
Equal variances not assumed			−1.555	117.947	0.123	−0.33346	0.21449	−0.75822	0.09129
GHQ-28 quality of life									
Equal variances assumed	7.296	0.008	3.736	156	0.000	0.27227	0.07287	0.12832	0.41622
Equal variances not assumed			3.570	113.337	0.001	0.27227	0.07628	0.12116	0.42339

Abbreviations: df: Degrees of freedom; GHQ-28: General health questionnaire-28; Sig: Significance.

degree. Theofilou *et al.* (2022a) reported higher levels of social support overall and for each individual sector among nurses working in emergency departments, especially in relation to the public sector of dialysis units in Greece; in fact, their study focused solely on nurses in public hospitals. This finding demonstrates the variation in social support depending on the department in which the nurses work. Fatigue levels were lower than expected in our study. Previous studies conducted on nurses in various units reported high levels of fatigue (Arimon-Pages *et al.*, 2019; Rotenstein *et al.*, 2018). The same result applies to research conducted in dialysis units (Wang *et al.*, 2022). Similarly, the level of quality of life was higher than that reported in a previous study, where health professionals rated their quality of life as low (He *et al.*, 2012). This finding also holds true in Greece, especially after the pandemic (Vamvakas *et al.*, 2022). Theofilou *et al.* (2022) reported similar results, with all four factors of quality of life scoring almost twice as high, indicating a worse quality of life. Evidently, both surveys Vamvakas *et al.* (2022) and Theofilou *et al.* (2022) were conducted in 2021, when the health system was still grappling with the pandemic, which clearly affected the mental health of healthcare professionals.

When comparing the public and private sectors, the private sector showed greater levels of fatigue, lower levels of social support (both overall and in relation to family and friends), and higher scores in relation to physical symptoms, anxiety/insomnia, social dysfunction, and severe depression. Regarding the correlations between the scales used, several significant correlations were found. First, the social support scale demonstrated a negative correlation with physical symptoms, anxiety/insomnia, social dysfunction, and severe depression; this result was similar for fatigue. These findings imply that the larger the support network of health professionals in artificial kidney units, the lower the fatigue they experience, as well as the various physical and psychological symptoms they may encounter. Theofilou *et al.* (2022a) investigated the levels of fatigue and social support, as well as the relationship between them, among the nursing staff in the emergency departments of hospitals in Athens and reported similar findings. Overall, fatigue as well as mental fatigue was negatively correlated with support from friends. A more detailed analysis regarding the impact of family and friends as sources of social support revealed that both subscales produced results similar to those of the total social support scale. These findings were applicable to both the private and public sectors. A notable difference was that in the public sector, fatigue showed a significant correlation with social support, whereas such a correlation was absent in the private sector. This was true for the social support questionnaire as a whole as well as for the family and friends subscales separately.

The results described above are also supported by other studies. For instance, Theofilou *et al.* (2022) conducted a survey of 165 health professionals working in hospitals in the regions of Macedonia and Thrace. Their analyses revealed a positive correlation between health quality, as measured using the same instrument (GHQ-28), and fatigue (FAS), but a negative correlation, particularly of mental fatigue, with social support. Therefore, these findings are generally corroborated by the literature.

The independent samples *t*-test demonstrated that the public sector exhibited higher levels of fatigue and lower

quality of life; in both cases, the mean values of these scales were greater among those working in public hospitals. To the best of our knowledge, this study is the first, particularly in Greece, to explore the issues of fatigue, social support, and quality of life among health professionals working in kidney units and to compare the results between the public and private sectors. Health professionals in the public sector experienced more fatigue than those in the private sector. This finding may be associated with the greater social support available in the private sector, as indicated by lower levels of physical symptoms, anxiety, social dysfunction, and depression. A possible explanation for the variation found in this study is the extremely difficult conditions faced by health professionals in public hospitals. The heavy workload due to the large number of patients was a significant factor. Moreover, staff shortages in the public sector further burden working conditions, an issue that is likely absent in the private sector.

This study has some limitations. Initially, the sample included in the survey was not representative of artificial kidney units in general. For instance, 86.8% were women, indicating that this element concerns only the present study. Another important limitation was the time. The period during which the data were collected was relatively short due to the need to obtain approvals from the hospitals to distribute the paper questionnaire, which did not allow the time required to distribute and collect the questionnaires from some units. A third limitation was that some units did not even respond to the request made to distribute the questionnaires, which implies that the sample size could be much larger if this limitation did not exist. Further qualitative research should be conducted through interviews or focus groups to explore the experiences of nurses and doctors working in artificial kidney units. Moreover, further studies are required to investigate the potential confounding factors that differentiate working conditions in the public and private sectors and play a role in perceived fatigue and quality of life. Finally, a comparative study could be performed between different countries, for example, between Greece and Cyprus.

5. Conclusion

Fatigue is an extremely common issue among health professionals and results from various aspects related to the nature of the profession. The effects of fatigue can be numerous and significant, impacting various facets of daily life, including professional, social, and personal aspects. The quality of life of health professionals often reflects a similar trend, with many experiencing a lower quality of life due to factors affecting the balance between work and personal life, such as stressful work environments and irregular hours. A protective factor may be the social support network that health professionals have. The social bonds and caring relationships that develop among individuals contribute positively to well-being. Previous studies on healthcare professionals have demonstrated a significant link between quality of life and the fatigue they experience, suggesting that improving quality of life can alleviate fatigue. In this study, participants reported relatively high levels of social support, whereas negative factors affecting quality of life received overall low scores. However, the public sector faces greater challenges than the private sector regarding both fatigue levels and quality of life, and health professionals in the public sector receive less support than their counterparts in the private sector. As anticipated, social support influences perceived fatigue and quality of life, with these effects being more pronounced in the public sector. Conversely, this relationship may not hold true in the private sector, based on regression analyses from previous studies. A major aspect of the study's findings is the differentiation between the public and private sectors concerning all three factors examined. Working conditions are poorer in the public sector compared to the private sector, leading to higher fatigue and lower quality of life. These findings should be considered by authorities responsible for designing and planning the operations of units in public hospitals.

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Conflict of interest

Paraskevi Theofilou is an Editorial Board Member and Guest Editor of this journal, but was not in any way involved in the editorial and peer-review process conducted for this paper, directly or indirectly. Separately, other authors declared that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Writing – original draft: All authors
Writing – review & editing: All authors

Ethics approval and consent to participate

This study was approved by the scientific committees of participating hospitals (numbers of approval 9177/19.4.2024, 165/27.3.2024-28.3.2024). Written consent was given by the subjects before their participation in this study.

Consent for publication

Written consent was given by the subjects for publishing their data.

Availability of data

Data are available from the corresponding author on reasonable request.

References

Alikari, V., Fradelos, E., Sachlas, A., Panoutsopoulos, G., Lavdaniti, M., Palla, P., *et al.* (2016). Reliability and validity of the Greek version of "the fatigue assessment scale". *Archives of Hellenic Medicine*, 33:231-238.

Arimon-Pagès, E., Torres-Puig-Gros, J., Fernández-Ortega, P., & Canela-Soler, J. (2019). Emotional impact and compassion fatigue in oncology nurses: Results of a multicentre study. *European Journal of Oncology Nursing*, 43:101666.

https://doi.org/10.1016/j.ejon.2019.09.007

Cao, X., & Chen, L. (2019). Relationships among social support, empathy, resilience and work engagement in haemodialysis nurses. *International Nursing Review*, 66(3):366-373.

Cao, X., & Chen, L. (2021). Relationships between resilience, empathy, compassion fatigue, work engagement and turnover intention in haemodialysis nurses: A cross-sectional study. *Journal of Nursing Management*, 29(5):1054-1063.

Garyfallos, G., Karastergiou, A., Adamopoulou, A., Moutzoukis, C., Alagiozidou, E., Mala, D., *et al.* (1991) Greek version of the general health questionnaire: Accuracy of translation and validity. *Acta Psychiatr Scand*. 1991;84(4):371-378.

https://doi.org/10.1111/j.1600-0447.1991.tb03162.x

Goldberg, D. P., & Hillier, V. F. (1979). A scaled version of the general health questionnaire. *Psychol Med*, 9, 139-145.

https://doi.org/10.1017/S0033291700021644

Goldberg, D.P., Gater, R., Sartorius, N., Ustun, T.B., Piccinelli, M., Gureje, O., *et al.* (1997). The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine*, 27(1):191-197.

https://doi.org/10.1017/s0033291796004242

He, M., Wang, Q., Zhu, S., Tan, A., He, Q., Chen, T., *et al.* (2012). Health-related quality of life of doctors and nurses in China: Findings based on the latest open-access data. *Quality of Life Research*, 21(10):1727-1730.

https://doi.org/10.1007/s11136-011-0088-0
https://doi.org/10.1111/inr.12516

Michielsen, H.J., De Vries, J., & Van Heck, G.L. (2003). Psychometric qualities of a brief self-rated fatigue measure: The Fatigue Assessment Scale. *Journal of Psychosomatic Research*, 54(4):345-352.

https://doi.org/10.1016/s0022-3999(02)00392-6

Rotenstein, L.S., Torre, M., Ramos, M.A., Rosales, R.C., Guille, C., Sen, S., *et al.* (2018). Prevalence of burnout among physicians: A systematic review. *JAMA*, 320(11):1131-1150.

https://doi.org/10.1001/jama.2018.12777

Schaefer, C., Coyne, J.C., & Lazarus, R.S. (1981). The health-related functions of social support. *Journal of Behavioral Medicine*, 4(4):381-406.

https://doi.org/10.1007/BF00846149

Theofilou, P. (2015). Translation and cultural adaptation of the multidimensional scale of perceived social support for Greece. *Health Psychology Research*, 3(1):1061.

https://doi.org/10.4081/hpr.2015.1061

Theofilou, P. (2023). Perceived social support among patients and the contribution in the management of the chronic disease: A brief review. *Series of Clinical and Medical Case Reports and Reviews*, 1(5):1-9.

Theofilou, P., & Varemenos, I. (2024). Perceived Social support as a predictive factor of fatigue and quality of life among healthcare professionals in Greece. Qeios.

https://doi.org/10.32388/N3U7W8.3

Theofilou, P., Iona, D., & Tzavella, F. (2022). Association between General health, fatigue and social support among health professionals: A cross - sectional study in Greece. *Journal of Community Medicine and Health Care*, 7(2):1058.

Theofilou, P., Tzavella, F., & Zyga, S. (2022a). Demographic and occupational factors affecting fatigue and social support among nurses in the emergency department: A cross-sectional study. *Austin Journal of Public Health and Epidemiology*, 9(3):1132.

Theofilou, P., Zyga, S., Tzitzikos, G., Malindretos, P., & Kotrotsiou, E. (2013). Assessing social support in Greek patients on maintenance hemodialysis: Psychometric Properties of the Multidimensional Scale of Perceived Social Support. In: Balogun, R.A., Abdel-Rahman, E.M., & Balogun, S.A., editors. Chronic Kidney Disease: Signs/Symptoms, Management Options and Potential Complications, Nova Publishers. (University of Virginia, Divisions of Nephrology and Geriatrics, USA,). p265-279.

Vamvakas, E., Kontogeorgou, I., Ntaountaki, A., Karkouli, G.,

Pisimisi, E., Karampekiou, E., *et al.* (2022). Occupational stress and quality of life among health professionals during the COVID-19 pandemic. *Journal of Critical Care Medicine (Universitatea de Medicina si Farmacie din Targu-Mures)*, 8(3):182-192.

https://doi.org/10.2478/jccm-2022-0012

Wang, Y.Y., Xiong, Y., Zhang, Y., Li, C.Y., Fu, L.L., Luo, H.L., *et al.* (2022). Compassion fatigue among haemodialysis nurses in public and private hospitals in China. *International Journal of Nursing Practice*, 28(1):e13011.

https://doi.org/10.1111/ijn.13011

Zimet, G.D., Dahlem, N.W., Zimet, S.G., & Farley, G.K. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment*, 52(1):30-41.

https://doi.org/10.1207/s15327752jpa5201_2

Zyga, S., Alikari, V., Sachlas, A., Fradelos, E.C., Stathoulis, J., Panoutsopoulos, G., *et al.* (2015). Assessment of fatigue in end stage renal disease patients undergoing hemodialysis: Prevalence and associated factors. *Medical Archives*, 69(6):376-380.

https://doi.org/10.5455/medarh.2015.69.376-380

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ORIGINAL RESEARCH ARTICLE

Fertility model evolution: A survey on mathematical models of age-specific fertility with application to Nepalese and Malaysian data

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Abstract

Fertility pattern analysis and modeling to smooth age-specific fertility rates (ASFRs) form a well-established research field that holds particular importance for Asian countries. In developed nations, ASFRs typically display a bimodal skewed fertility curve, whereas, in developing countries, they usually exhibit a unimodal skewed fertility curve that diverges from the normal one. For decades, demographic experts worldwide have been interested in creating models using deterministic and stochastic approaches to represent these fertility curves. In this regard, parametric and non-parametric models have been created, with the latter providing a better fit for ASFR data. This research investigates the evolution of fertility models aimed at smoothing ASFRs. It explores suitable alternative models for countries with fast-declining, unimodal, and skewed fertility curves of ASFRs, such as Nepal and Malaysia. Nepal's fertility rate is transitioning from a high level toward the replacement rate (2.1) at the year 2021; meanwhile, Malaysia's fertility rate (1.7) in the year 2021 has dropped below the replacement rate. Given the lack of a universally applicable model for ASFR pattern variation, this study proposes the Kumaraswamy log-logistic distribution as a promising model to represent the ASFRs of Nepal and Malaysia accurately. Various approaches, including the Akaike information criterion, and Bayesian information criterion, are employed to validate the fitting of the proposed model.

Keywords: Age-specific fertility rate; Parametric; Non-parametric; Malaysia; Nepal

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1. Introduction

Women's fertility represents their innate ability to have children. It is a fundamental element of population growth, along with mortality and migration. Fertility and mortality are biological factors, whereas migration is a socioeconomic factor. Age-specific fertility rate (ASFR) is a fertility measure for a specific age group, typically expressed per thousand women in that age group in a particular locality. ASFRs depict the reproductive behavior of females in various age groups. Policymakers are concerned with women of specific age groups concerning policies relating to reproductive rights and health, especially teenagers. Although adolescence is widely accepted to be an inappropriate period for pregnancy, in Nepal, among women aged 15 – 49, more than 17% of them started having children in their

teen years in the year 2016 (NDHS, 2017). This number was reduced to approximately 14% in the year 2021. Specifically, 10% had had at least one live birth, 2% had experienced pregnancy loss, and 4% were still pregnant (NDHS, 2022). Adverse health effects on mothers and newborns are likely to result from pregnancy and childbirth in the teen years. Teenage mothers face challenges that prevent them from completing their education and increase the risk of illness as well as child and mother fatalities. Further, young adolescent pregnancies have been associated with an increased likelihood of underweight children (Santos *et al*., 2014). Teenage mothers are more likely to experience anemia, postpartum depression, and infections, as well as a high risk of surgical birth and improper beginning of lactation (Jeha *et al*., 2015). In addition, according to a report by the World Health Organization (WHO, 2018), pregnancy during adolescence can lead to an increased risk of low weight, preterm birth, and severe health complications for newborns, including neonatal sepsis. These outcomes underscore the health challenges adolescent mothers and their infants may face, which can have long-term implications for child development and survival.

Fertility pattern analysis and modeling to smooth ASFRs form a well-established research field globally, possibly representing an emerging research area of inquiry within Asian contexts. In developed countries, ASFRs typically exhibit a bimodal skewed fertility curve, whereas in developing nations, they usually display a unimodal right-skewed fertility curve. This distinction highlights the varied demographic landscapes across regions. For decades, demographers worldwide have been engaged in the mathematical modeling fertility curves. In Nepal, research had largely concentrated on identifying specific factors that influence women's reproductive behavior and fertility patterns, while little attention had been given to advanced modeling approaches of demographic variables.

Various researchers have employed smoothing or statistical graduation techniques to determine the actual patterns of ASFRs and estimate fertility parameters. Mathematical modeling is creating an accurate mathematical representation of a real-world scenario for making predictions or gaining insight into a given subject (Salomon & Murray, 2001). These techniques provide precise descriptions of the natural shape of ASFR patterns and aid population projection. Historically, demographers have employed parametric models, with the parameter being the involved mother's age at childbirth. Mixture probability models have been proposed to fit bimodal-shaped ASFRs. Subsequently, standard non-parametric techniques, such as kernels, splines, and support vector machines, have been used to smooth ASFRs.

Various models for describing and predicting fertility behavior have been proposed. Two primary types of fertility models exist deterministic and stochastic models. Deterministic models assume that fertility is a fixed outcome determined by known factors. Meanwhile, stochastic models allow for random variations in fertility outcomes. The selection of model type depends on the specific research question under consideration. The history of modeling fertility curves dates back to the 1940s. The Hadwiger function (Hadwiger, 1940) has three parameters and is helpful for bimodal ASFRs. Gilje & Yntema (1971) proposed a shifted Hadwiger function by introducing a fourth threshold parameter. Hoem *et al*. (1981) proposed a probabilistic aspect for investigating fertility; they articulated numerous types of probability density functions (PDFs) using the Hadwiger, Gamma, Beta, Coal-Trussel, Brass, and Gompertz functions. Furthermore, they employed a deterministic form of the fertility curve based on regression spline and polynomial functions. Chandola *et al*. (1999; 2002) investigated and applied a two-component combination model of Hadwiger in this regard. Peristera & Kostaki (2007) investigated and applied the normal mixture model to fertility and claimed that the model is flexible in capturing various fertility data. Mazzuco & Scarpa (2011) proposed a flexible generalized skew-normal (FGSN) distribution. Further, in this context, the skew-logistic distribution has been used by Asili *et al*. (2014) and Mishra *et al*. (2017); meanwhile, Gaire and Aryal (2015) employed an inverse Gaussian distribution. In addition, non-parametric models have been proposed. For example, Schmertmann (2003) proposed a piece-wise quadratic spline function. An adjusted error model was used by Gayawan *et al*. (2010). Support vector mechanics – a non-parametric technique – was used by Kostaki *et al*. (2009). Different forms of polynomial models have been used by Islam & Ali (2004), Islam (2009; 2011), Singh *et al*. (2015), and Gaire *et al*. (2022).

The mathematical models used for ASFR modeling are generally divided into deterministic and stochastic categories, or alternatively into parametric and non-parametric models. Effectively modeling diverse fertility patterns worldwide is critical, especially in regions with high fertility rates as well as those approaching or below replacement levels. These models effectively describe the ASFRs in developed areas, where fertility generally as correspond to lower levels. Nevertheless, fertility remains high in many countries across Africa, parts of Latin America, and region in Asia. Therefore, researchers are working or develop flexible, adaptable models capable of capturing these diverse fertility patterns, particularly to identify the differentials and determinants. Developing countries such as Nepal have a unimodal, right-skewed

curve of ASFR. Education and economic development substantially contribute to delayed fertility. High education levels, particularly for women, enhance the awareness of reproductive health and expand career opportunities, typically resulting in postponed marriage and childbearing. Economic development complements this trend by increasing employment opportunities for women and raising the cost of living, motivating couples to delay starting a family until they achieve financial stability. These factors are closely associated with low fertility rates and small family sizes. To model such fertility patterns, we propose a log-logistic (LLog) distribution that features a unimodal density function with a heavy right tail and a hazard function rapidly increasing before gradually decreasing, resulting in a right-skewed curve. Further, the proposed LLog distribution and its generalized forms are employed to fit the ASFRs of women in Nepal and Malaysia. The Kumaraswamy LLog (KuLLog) distribution is identified as the best fit for the ASFR data of both countries.

2. Mathematical formulation of ASFRs

Herein, we explore the development of various graduation models designed to fit and smooth ASFRs, as documented in the literature by demographers. The mathematical formulation of the fertility model proposed by Hoem *et al.* (1981) to fit ASFRs in a probabilistic framework is as follows:

$$h(x;R,\theta_2,\ldots\theta_r) = \alpha\, t(x;R,\theta_2,\ldots\theta_r) \quad (1)$$

where $t(x;R,\theta_2,\ldots\theta_r)$ is a density function on the real line R with $(r-1)$ parameters, α denotes the r^{th} parameter representing the total fertility rate (TFR). Various PDFs and additional functional forms have been established based on the relation expressed in Equation 1. We aim to trace fertility model evolution and identify a right-skewed distribution that accurately characterizes ASFRs, particularly in populations where such probabilistic approaches can yield valuable insights, for example, for Nepalese and Malaysian women.

2.1. Parametric models

Parametric models are widely employed to fit ASFRs due to their ability to describe complex fertility patterns using predefined functional forms. These models rely on a specific mathematical function, which is determined by a fixed number of parameters. By estimating these parameters using the data, parametric models can provide structured and interpretable representations of fertility dynamics. These models facilitate detailed analyses and comparisons of fertility patterns across different populations by providing robustness and clarity when interpreting demographic patterns.

2.1.1. Stochastic models

This section presents stochastic models used to analyze fertility parents, which account for random variations in fertility outcomes as they have evolved in the literature. The Hadwiger function, initially proposed by Hadwiger (1940), is expressed as follows:

$$f(x) = \frac{\alpha\beta}{\gamma}\left(\frac{\gamma}{x}\right)^{\frac{3}{2}} \exp\left\{-\beta^2\left(\frac{x}{\gamma}+\frac{\gamma}{x}-2\right)\right\},$$

for $(x \geq 0)$, $(\alpha, \beta, \gamma > 0)$. (2)

In this model, x represents a mother's age at the time of childbirth, and α, β, and γ denote three parameters associated with the model. The first parameter, α, relates to total fertility, providing the gross reproduction rate. The second parameter, β, measures the height of the model, and γ is associated with the average age of fertility lifespan of women. The relation $\alpha\gamma/\beta$ corresponds to the maximum ASFR. The model has been demonstrated to be particularly useful for bimodal ASFR distributions.

Gilje (1969) extended the Hadwiger function by introducing a fourth parameter, δ, to the existing model expressed in Equation 2. This modification incorporates the threshold for the mother's age at childbirth, which is expressed as follows:

$$f(x) = \frac{\alpha\beta}{\gamma}\left(\frac{\gamma}{x-\delta}\right)^{\frac{3}{2}} \exp\left\{-\beta^2\left(\frac{x-\delta}{\gamma}+\frac{\gamma}{x-\delta}-2\right)\right\},$$

for $x \geq \delta$ (3)

As an alternative to the Hadwiger function, Murphy & Nagnur (1972) employed the four-parameter Gompertz model to fit Canada's ASFRs. The model is defined as follows:

$$f(x) = c\alpha^{\beta(X-X_0)} \quad (4)$$

where α, β and c are parameters, with X_0 representing the new origin that has been shifted.

Similarly, Brass (1974) proposed a linear model to transform the fertility schedule, which is expressed as follows:

$$Q_x = \alpha + \beta Q_x^* \quad (5)$$

Where $Q_x = -ln(ln\, f(x))$ and $Q_x^* = -ln(ln\, f^*(x))$. Here, $f(x)$ represents the observed ASFR, and $f^*(x)$ denotes the theoretical standard fertility rate. The ordinary least-squares (OLS) method was employed to estimate the model's associated constants. However, Beer (2011) highlighted that interpreting these constants regarding fertility dynamics poses challenges.

Subsequently, Hoem *et al.* (1981) introduced the gamma and beta functions, offering a more straightforward demographic interpretation of the model parameters. The Gamma function is defined as follows:

$$f(x) = R\frac{1}{\Gamma(\alpha)\beta^{\alpha}}(x-\gamma)^{(\alpha-1)}\exp\left\{-\left(\frac{x-\gamma}{\beta}\right)\right\}$$

for x > γ (6)

In this model, γ represents the lower age at childbearing, and R denotes the level of fertility. In particular, the first constant αis interpreted as the median age of women at childbirth. The mode of the distribution is denoted by m, the mean is denoted by μ, and the variance is denoted by σ^2. These parameters are related to the parameters of the distribution by the following relations: $\beta = \mu - m$ and $\alpha = \frac{\mu-\gamma}{\beta} = \frac{\sigma^2}{\gamma^2}$, where α and β denote the shape parameters of the gamma function.

Furthermore, the beta function is defined as follows:

$$f(x) = R\frac{\Gamma(A+B)}{\Gamma(A)\Gamma(B)}(\beta-\alpha)^{-(A+B-1)}(x-\alpha)^{(A-1)}(\beta-x)^{(B-1)}$$

, *for* $\alpha < x < \beta$ (7)

Here, μ and σ^2 represent the average and variance of the distribution, respectively. These parameters are related through the following relation: $B = \left(\frac{(\mu-\alpha)(\beta-\mu)}{\sigma^2} - 1\right)\frac{\beta-\mu}{\beta-\alpha}$ $and A = B\frac{\mu-\alpha}{\beta-\mu}$, where α and β denote the lower and upper limits of fertility, respectively, and R denotes the level of fertility.

Subsequently, Chandola *et al.* (1999) proposed a two-component mixture model of the Hadwiger function to capture the evolving fertility patterns and address the non-uniformity in the fertility behavior of some European countries. The model is defined as follows:

$$f(x) = \alpha m\frac{\beta_1}{\gamma_1}\left(\frac{x}{\gamma_1}\right)^{\frac{3}{2}} e^{\left\{-\beta_1^2\left(\frac{x}{\gamma_1}+\frac{\gamma_1}{x}-2\right)\right\}} +$$

$$(1-m)\frac{\beta_2}{\gamma_2}\left(\frac{x}{\gamma_2}\right)^{\frac{3}{2}} e^{\left\{-\beta_2^2\left(\frac{x}{\gamma}+\frac{\gamma_2}{x}-2\right)\right\}}, \quad (8)$$

where $0 \le m \le 1$ denotes the mixture parameter.

In addition, to address both conventional and modern bimodal ASFRs, Peristera & Kostaki (2007) proposed a modified flexible model in Gaussian form, which is defined as follows:

$$f(x) = c\exp\left\{-\left(\frac{x-\mu}{\sigma(x)}\right)^2\right\} \quad (9)$$

Where $f(x)$ denotes the ASFR for an age x of the involved woman during childbirth. In this formulation, the parameter $c$denotes the base level of the fertility curve and is related to the TFR; the parameter μ indicates the location of the fertility curve, representing the mother's age at childbearing. The standard deviation is defined as $\sigma(x) = \sigma_{11}$if $x \le \mu$ and $\sigma(x) = \sigma_{12}$ if $x > \mu$. To capture the evolving shape of the fertility pattern, they proposed an alternative form that combines Gaussian components in a model, which is defined as follows:

$$f(x) = c_1\exp\left\{-\left(\frac{x-\mu_1}{\sigma_1(x)}\right)^2\right\} + c_2\exp\left\{-\left(\frac{x-\mu_2}{\sigma_2}\right)^2\right\}, \quad (10)$$

Where $\sigma_1(x) = \sigma_{11}$ if $x \le \mu_1$ and $\sigma_1(x) = \sigma_{12}$ if $> \mu_1$.

To address the asymmetrical nature of ASFRs, Gayawan *et al.* (2010) introduced an adjusted error model that uses the complementary error function. The model is expressed as follows:

$$f(x) = a + b\begin{cases} Erfc\left[\left(\frac{x-\gamma}{\beta_1}\right)^2\right] if\, x \le \gamma \\ Erfc\left[\left(\frac{x-\gamma}{\beta_2}\right)^2\right] if\, x > \gamma \end{cases} \quad (11)$$

where *Erfc*(.) denotes a complementary error function, which is defined as follows:

$$Erfc(z) = \frac{2}{\sqrt{\pi}}\int_z^{\infty} e^{t^2}\,dt \quad (12)$$

$f(x)$ denotes the fertility function, and the parameters have different demographic interpretations.

Subsequently, to model ASFRs with a bimodal distribution, Mazzuco & Scarpa (2011) introduced and analyzed the FGSN distribution. They expanded on the concept of skew-normal distribution to develop the FGSN model. The mathematical formulations for both skew-normal distribution and FGSN models are expressed in Equations 13 and 14, respectively.

$$f(x) = \frac{2}{\sigma}\phi\left\{\left(\frac{x-\mu}{\sigma}\right)\right\} + \Phi\left\{\alpha\left(\frac{x-\mu}{\sigma}\right)\right\}, \quad (13)$$

$$f(x)=\frac{2}{\sigma}\phi\left\{\left(\frac{x-\mu}{\sigma}\right)\right\}+\Phi \left\{\alpha\left(\frac{x-\mu}{\sigma}\right)+\beta\left(\frac{x-\mu}{\sigma}\right)^3\right\} \quad (14)$$

Where ϕ and Φ denote the density and distribution function of the normal distribution, respectively. However, parameter estimation using these mixture methods has no direct demographic interpretation; thus, reparameterization is required for accurate demographic understanding. This model accommodates various distribution shapes and captures the nuances of bimodal fertility data.

Similarly, Asili *et al*. (2014) proposed another model, the skew-logistic distribution, which specifically addresses the challenge of fitting modern populations with bimodal ASFRs. The PDF is presented as follows:

$$f(x)=\frac{2}{\beta}\frac{e^{-\left(\frac{(x-\gamma)}{\beta}\right)}}{\left(1+e^{-\left(\frac{(x-\gamma)}{\beta}\right)}\right)^2\left(1+e^{-a\left(\frac{(x-\gamma)}{\beta}\right)-b\left(\left(\frac{(x-\gamma)}{\beta}\right)\right)^3}\right)} \quad (15)$$

where γ denotes the location parameter, β denotes the scale parameter, and a and b denote shape parameters that control the skewness and kurtosis of the distribution, respectively. They applied this model to fit fertility data from Italy, Ireland, and Greece, employing the nonlinear least-squares method for model fitting. Mishra *et al*. (2017) used the same model to analyze ASFR data from India.

To capture the skewness of ASFRs, Gaire & Aryal (2015) applied the inverse Gaussian model. This model is suitable for handling the asymmetry observed in fertility data. In this model, the parameter α adjusts the location of the distribution, providing insight into the average age at childbearing. The expression $(\mu + \alpha)$ is the average childbearing age, and λ scales the variance of the distribution, reflecting the degree of skewness. This approach allows for a nuanced representation of fertility patterns, effectively accommodating skewness in the data. The PDF is defined as follows:

$$f(x)=\sqrt{\frac{1}{2\pi(x-\alpha)^3}}e^{\left(\frac{-\lambda(x-\alpha-\mu)^2}{(x-\alpha)\mu^2}\right)} \quad (16)$$

Gaire (2023) recently introduced the skewed Lomax distribution to fit the ASFR data. The model is designed to address the skewness in fertility data. The PDF is defended as follows:

$$f(x)=2\alpha\beta^{\alpha}\left(\frac{(x+\beta-\gamma)^{\alpha}-\beta^{\alpha}}{(x+\beta-\gamma)^{2\alpha+1}}\right), \text{ for } x\geq\gamma \quad (17)$$

Gaire's application of the skewed Lomax distribution allows for a flexible and detailed representation of fertility rates, effectively capturing the skewness and shape of the overall distribution.

2.1.2. Deterministic models

Various deterministic models have been employed to smooth and fit fertility patterns. Deterministic models operate under the assumption that fertility outcomes are fixed and determined by known factors rather than by random variables or stochastic processes. This section outlines some of these deterministic approaches. To deterministically model the distributional pattern of ASFRs, researchers typically employ models that assume a specific functional form for fertility rates, with coefficients estimated to best fit observed data. One such approach is the polynomial model, which is defined as follows:

$$f(x)=a_0+\sum_{i=1}^{r}a_i x^i+e, \quad (18)$$

Where e represents a residual that is normally distributed with a mean of zero and variance σ^2.

Different polynomial models have been employed in the literature to model ASFRs. These include the bi-quadratic and fourth-order polynomials used (Islam & Ali, 2004; Gaire *et al*., 2022); the cubic polynomial used by Islam (2011); the quadratic model applied by Islam (2009); and the third-degree polynomials of age reciprocal that were explored by Singh *et al*. (2015). In particular, the third-degree polynomial model of the reciprocal of the age of a mother at childbirth is defined as follows:

$$f(x)=a+\frac{b}{x}+\frac{c}{x^2}+\frac{d}{x^3}, \quad (19)$$

where $f(x)$ denotes the ASFR, and x denotes the mother's age. The polynomial coefficients are to be estimated to fit the observed data best.

2.2. Non-parametric models

In addition to parametric models, various non-parametric models have been employed to smooth ASFRs. These non-parametric approaches typically provide a better fit for the ASFR curve but can present challenges in terms of demographic interpretation. Non-parametric models do not rely on a predetermined functional form for fertility rates but derive their structure and parameters from data. Although these models involve parameters, they are not fixed a priori rather estimated from data, allowing greater

flexibility in fitting the fertility curve. However, this flexibility occasionally comes at the cost of interpretability because the parameters of non-parametric models may not have precise demographic meanings or may be directly associated with specific demographic concepts (Beer, 2011).

2.2.1. Support vector machines

Kostaki *et al.* (2009) proposed a regression version of support vector machines as a modern non-parametric graduation technique for smoothing ASFRs. This regression, also known as support vector regression, employs regularization techniques to handle complex, non-linear relations between variables. Kostaki *et al.* (2009) applied the support vector machine method and a kernel technique to improve model flexibility and accuracy. They compared the model's performance with various parametric models to evaluate its effectiveness in fitting fertility data. This approach leverages the power of kernel functions to map data into higher-dimensional spaces, thereby allowing for a more nuanced and flexible fitting of the fertility curve.

2.2.2. Linear spline and TOPALS

Beer (2011) employed the "tool for projecting age patterns using the linear spline" (TOPALS) method to fit fertility rates. This approach is designed for projecting fertility schedules using linear spline, a relational model that links ASFRs $f(x)$ to a standard age schedule $g(x)$, which is approximated by the linear spline curve. This relation can be expressed as follows:

$$r(x) = \frac{f(x)}{g(x)} \tag{20}$$

The following equation is used to estimate the ties connected in each subdivision of the mother's age at childbirth:

$$\check{r}(x) = a + b_0(x - m) + \sum_{j=1}^{n} b_j (x - m - k_j) D_j. \tag{21}$$

This method facilitates the smoothing and projection of fertility patterns by leveraging linear splines, resulting in a flexible and interpretable model of ASFRs.

2.2.3. Quadratic and cubic spline

The quadratic spline model, also known as a piece-wise quadratic function, is a method used to fit a smooth fertility curve through data points by combining several quadratic functions. A quadratic spline comprises a set of quadratic functions, each applied to a specific interval of the domain, with constraints to ensure continuity and smoothness at the boundaries between these intervals. Mathematically, it can be expressed as follows:

$$f(x) = a + b(x - \gamma) + \sum_{j=1}^{n} d_j (x - \gamma - k_j)^2 D_j \tag{22}$$

Similarly, the cubic spline is a highly flexible model used to fit the curve of ASFRs by producing a smooth fertility curve that adapts to the data over different intervals. The cubic spline is expressed as follows:

$$f(x) = a + b(x - \gamma) + c(x - \gamma)^2 + \sum_{j=1}^{n} d_j (x - \gamma - k_j)^3 D_j \tag{23}$$

Where $D_j = 0$ if $x - \gamma \leq k_j$; otherwise, $D_j = 1$ if $x \geq \gamma$, with k_j denoting the ties, n representing the count of ties, and other constants to be computed.

Schmertmann (2003) proposed a piece-wise quadratic spline function for ASFRs. This approach defines fertility patterns using quadratic functions within specified age intervals, which are determined by three key age indices: a, the youngest age at which fertility rises above zero, P, the age at which fertility reaches its peak level, and H, the youngest age above P at which fertility falls to half of its peak level. The model is given by

$$f(x) = \begin{cases} R\sum_{k=0}^{4} \theta_k (x - t_k)^2 \; for \; a \leq x \leq \beta \\ 0, otherwise \end{cases} \tag{24}$$

Here, the knots, $t_0 < t_1 \ldots < t_4$, fall in the interval between ages α and β, where $t_0 = \alpha$, the lowest childbearing age. The quadratic spline model is helpful in describing the shape of many fertility schedules; however, it requires 13 parameters to be estimated, which shows a good fit with a wide variety of fertility data. Schmertmann (2003) selected different knots at various ages for demographic interpretation. Continuity conditions on function and its first derivative at defined points are enforced to ensure a smooth transition between quadratic segments. This piece-wise quadratic spline function effectively captures the typical shape of fertility patterns with a rise, peak, and decline while maintaining smoothness across the intervals.

3. Mathematical models and data

The LLog distribution is characterized by its unimodal density function with a heavy right tail, which makes it suitable for modeling data with such properties. It features a hazard function that increases rapidly and decreases slowly, resulting in a right-skewed curve. In this study, the LLog distribution and its generalized forms were selected to fit the ASFR data of Malaysia and Nepal. The ASFR data for Nepalese women were obtained from the Nepal Demographic and Health

Survey (NDHS, 2022), and those for Malaysian women were obtained from the National Population and Family Development Board of Malaysia (NPFDB, 2023). The PDFs of the proposed distributions are expressed as follows:

3.1. LLog distribution

The PDF of the three-parameter LLog distribution is expressed as follows:

$$f(x)=\frac{\alpha}{\beta}\frac{\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}}{\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{2}},\ \text{for } x>\gamma \tag{25}$$

3.2. Rayleigh-generated LLog distribution

The Rayleigh-generated LLog (RGLLog) distribution proposed and investigated by Gaire & Gurung (2024a) extends the standard LLog distribution. It introduces a new form by incorporating a transformation based on the Rayleigh distribution. The PDF of the RGLLog distribution is expressed as follows:

$$f(x)=\frac{2\alpha\theta}{\beta\left\{1-exp(-\theta)\right\}}\frac{\left(\frac{x-\gamma}{\beta}\right)^{2\alpha-1}exp\left(-,\frac{\left(\frac{x-\gamma}{\beta}\right)^{2\alpha}}{\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{2}}\right)}{\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{3}},$$

$$\text{for } x>\gamma \tag{26}$$

3.3. Skewed LLog distribution

The PDF of the skewed LLog (SLLog) distribution, which was introduced by Gaire *et al.* (2019) and studied in detail by Gaire & Gurung (2024b), can be expressed as follows:

$$f(x)=\frac{2\alpha}{\beta}\frac{\left(\frac{x-\gamma}{\beta}\right)^{2\alpha-1}}{\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{3}},\text{for } x>\gamma \tag{27}$$

This distribution was recently applied to model age-at-menopause data by Gaire *et al.* (2023) and age-at-first-marriage data by Gaire *et al.* (2024).

3.4. Transmuted LLog distribution

The PDF of the four-parameter transmuted LLog (TrLLog) distribution proposed by Aryal (2013) can be expressed as follows:

$$f(x)=\frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}\left\{\frac{(1+\lambda)+(1-\lambda)\left(\frac{x-\gamma}{\beta}\right)^{\alpha}}{\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{3}}\right\} \tag{28}$$

3.5. Kumaraswamy LLog distribution

Finally, the PDF of the four-parameter KuLLog distribution proposed by De-Santana *et al.* (2012) is expressed as follows:

$$f(x)=\frac{\alpha\theta\lambda}{\beta^{\alpha\theta}}x^{\alpha\theta-1}\left(1+\left(\frac{x}{\beta}\right)^{\alpha}\right)^{-(\theta+1)}\left[1-\left\{1-\frac{\left(\frac{x}{\beta}\right)^{\alpha}}{1+\left(\frac{x}{\beta}\right)^{\alpha}}\right\}^{\theta}\right]^{\lambda-1} \tag{29}$$

4. Method of parameter estimation and validity tools

Various demographers have employed different models to smooth and identify the nature of fertility dynamics. Most models used to graduate ASFRs are non-linear. Therefore, numerical simulation methods are used to estimate the parameters of these models. Brass (1974) used the OLS method to estimate model parameters. The least-squares method has been used to test model validity (Gilje, 1969; Gilje & Yntema, 1971). Murphy & Nagnur (1972) used an iterative approach to estimate model parameters by minimizing the sum of squared errors (SSE). Hoem & Berge (1975) discovered inconsistencies in the moment estimation of model parameters; however, such estimators provide initial guesses for other estimation methods and suggest the minimum Chi-square estimator for the parameters in the Hadwiger and gamma functions. Hoem *et al.* (1976) reviewed four previously published research papers and proposed a modified minimum chi-square estimation method for optimality. Bozik & Bell (1987) used principal component analysis to forecast ASFRs. Schmertmann & Caetano (1999) used different methods to estimate the parameters of open birth interval data.

Peristera & Kostaki (2007) employed Gauss–Newton optimization criteria for fitting fertility curves by applying the non-linear least-squares method. Gayawan & Ipinyomi (2009) selected the Akaike, Schwarz, and adjusted R square criteria to fit ASFR data. Kostaki *et al.* (2009) used the least value criterion to choose the suitable model. Beer (2011) used the non-linear least-squares method to estimate model parameters. Liu *et al.* (2011) proposed using single-age age-specific fertility data. In contrast to the 5-year age group, Asili *et al.* (2014) tested model suitability using the norm of the residual obtained from MATLAB. Gaire & Aryal (2015) employed the Chi-square test as a model validation tool.

In addition, Gayawan *et al.* (2010) estimated ASFR parameters by considering the least value of the $SSE = \sum_{x}\left(f(x) - \breve{f}(x)\right)$. They used different variants of Akaike's information criterion (AIC) Akaike (1974) for model selection for African fertility data. The new AIC variant employed by Gayawan *et al.* (2010) is expressed as follows:

$$AIC = 2\,\upsilon + n\,ln(SSE/n - \upsilon) \tag{30}$$

Here υ and n represent the numbers of model parameters and observations, respectively.

Islam & Ali (2004), Islam (2009; 2011), Singh *et al.* (2015), and Gaire *et al.* (2022) used various model selection criteria, including cross-validity prediction power, F-test, shrinkage of the fitted model, and coefficient of determination, to assess the suitability and validity of their fitted models. These researchers have developed models for fertility data's velocity and elasticity curves. In addition, Gaire *et al.* (2022) introduced a novel criterion, the area covered by the function of fitted ASFRs, to estimate the TFR. Gaire *et al.* (2022) recommended using the AIC and Bayesian information criteria (BIC) for future research, suggesting that these criteria, which utilize a penalty for the number of model parameters, enhance the selection of the most appropriate method.

Several validity tools have been used to identify the most suitable and flexible model for fitting the Nepalese and Malaysian woman ASFR data, including, negative log-likelihood (NLL), AIC, and BIC. These tools were employed to assess the accuracy of the models in capturing the observed and estimated ASFR values.

The *AIC* and *BIC* for the fitted models can be calculated as follows:

$$AIC = 2k - 2\,LL, \tag{31}$$

$$BIC = k\,Ln(n) - 2\,LL \tag{32}$$

Where k represents the number of parameters associated with the probability distribution function, n represents the number of observations, and LL denotes the log-likelihood function at the maximum likelihood estimate of the distribution.

5. The population used for fitting ASFRs

Researchers have employed the ASFRs of different countries and regions (developed and developing) for model fitting. Hadwiger (1940) used fertility data from Hungary and Norway. Murphy & Nagnur (1972) used Canada's ASFRs. Brass (1974) assumed a transformed linear relationship between age at childbirth and England and Wales's fertility patterns. Chandola *et al.* (1999) used the fertility patterns of the UK, Ireland, and the USA. Gilje & Yntema (1971) applied the ASFR data of Rotterdam, Hungary, Japan, and Norway. Hoem and Berge (1975) used Norway's ASFR data. Schmertmann & Caetano (1999) used open birth interval data from Brazil. Schmertmann (2003) used the fertility schedules of European and Asian countries. Peristera & Kostaki (2007) used the ASFRs of some European countries such as Denmark, Sweden, Norway, Greece, Spain, the UK, Belgium, Italy, and Ireland, and ASFR data of the US for both non-Hispanic European-descent and non-Hispanic African-descent populations. Gayawan & Ipinyomi (2009) used ASFR data from African and European countries. Kostaki *et al.* (2009) used data from single-year ASFRs for the population of 10 countries: Sweden, Norway, Denmark, Belgium, Greece, Italy, the UK, Ireland, Spain, and the white and black population of the USA. Gayawan *et al.* (2010) applied their model to data from African countries. Beer (2011) used data from European countries. Mazzuco & Scarpa (2011) used the modern fertility patterns of countries, for example, the USA, the UK, and Ireland, and countries with a traditional fertility pattern, for example, Italy and the Czech Republic. Asili *et al.* (2014) fitted the ASFR data for Italy, Ireland, and Greece. The distributional pattern of the ASFRs of Nepalese mothers was described by (Gaire & Aryal, 2015; Gaire *et al.*, 2022). The ASFRs of rural areas of Bangladesh were used by Islam & Ali (2004); the age-specific marital fertility rate of Bangladesh was used by Islam (2009). Islam (2011) fitted the ASFRs of Indonesia. ASFR data from India were used by (Pasupuleti & Pathak, 2011; Singh *et al.*, 2015; Mishra *et al.*, 2017). Herein, to demonstrate that the proposed model fits the data and validates its applicability, the ASFR data of Nepal and Malaysia were used. By applying the model to the ASFR data of Nepal and Malaysia, we assessed its performance in capturing the nuances of fertility patterns in diverse contexts. Despite differences in socioeconomic, cultural, and demographic factors between Nepal and Malaysia, both countries provide an interesting comparison for testing the robustness of the model.

6. Results and discussion

Various probability models have been applied to smooth conventional and modern fertility patterns around the globe. A brief review of the evolution of these models is provided. No single universal model adequately captures fertility dynamics across different countries. By observing the unimodal and right-skewed nature of the curve of the ASFRs of Nepalese and Malaysian women, the LLog distribution and its generalized distributions were selected to fit the ASFR data of Nepalese women (NDHS, 2022) and Malaysian women (NPFDB, 2023). The density function of the LLog distribution is characterized by its unimodality, heavy right tails, and a hazard function that increases rapidly, contributing to the right-skewed shape of the curve. Among the fitted distributions, the KuLLog distribution provides the best fit for the ASFR data from both countries.

Table 1 presents Nepalese women's observed and fitted ASFRs, along with various test statistics. The KuLLog distribution demonstrated superior fit to the other models for multiple criteria. Specifically, the KuLLog model obtained the lowest AIC, BIC, and values. Conversely, it produced the highest NLL values. The consistently superior performance of the KuLLog distribution across multiple goodness-of-fit measures suggests its suitability for modeling the ASFR data of Nepalese women. There is no universal graduation technique for smoothing the ASFRs of different regions due to the changing nature of ASFRs in various stages of demographic transition. In this study, using minimum values of AIC and BIC for the maximum likelihood value of the model fitting, the KuLLog model is considered the best model to fit ASFR data for developing regions and countries such as Nepal, where the TFR is decreasing, but ASFRs exhibit a unimodal trend. Figure 1 presents the empirical and observed ASFRs of Nepalese mothers.

The observed and fitted ASFRs for Nepal are presented in Figure 1. Although the LLog distribution and its various generalizations fit the data adequately, rigorous statistical analysis using multiple test statistics and model validation tools confirms that the KuLLog distribution provides a superior fit compared to the other models. This finding highlights the importance of employing comprehensive statistical measures to assess model suitability in demographic studies.

To evaluate the generalizability of the KuLLog model, it was additionally applied to the ASFR data of Malaysian women (NPFDB, 2023). Table 2 provides a comparison of the observed and fitted ASFR values of Malaysia using different models.

From the analysis, the computed NLL, AIC, and BIC values indicate that the KuLLog model also better fits the Malaysian data. The fitted ASFRs from both countries indicate a strong correlation between the observed and predicted values. In the case of Nepal, the model successfully captured the peak fertility age and the gradual

Table 1. Observed and estimated ASFRs of Nepalese women and values of test statistics

Age group	Observed ASFRs	Fitted ASFRs by				
		LLog	RGLLog	TrLLog	SLLog	KuLLog
15 – 19	71	69.907	70.596	69.985	69.468	70.515
20 – 24	160	157.101	158.874	157.666	157.796	157.806
25 – 29	110	112.218	111.676	111.959	111.264	112.533
30 – 34	57	47.018	52.221	48.879	47.855	49.554
35 – 39	17	18.507	19.245	18.803	19.076	18.788
40 – 44	5	7.886	6.066	7.430	8.003	7.025
45 – 49	1	3.699	1.719	3.159	3.618	2.727
α		4.475	0.918	2.594	6.267	3.193
β		14.771	126.852	14.407	21.249	11.709
γ		9.701	16.206	14.182	0.000	-
θ		-	124.992	1.000	-	16.554
γ		-	-	-	-	2.784
NLL		−29.595	−29.578	−30.343	−29.675	−19.753
AIL		65.190	65.156	68.686	67.351	47.507
BIC		65.028	64.994	68.470	67.134	47.290

Abbreviations: ASFRs: Age-specific fertility rates; NLL: Negative log-likelihood; BIC: Bayesian information criteria.

Table 2. Observed and estimated ASFRs of Malaysian women and values of test statistics

Age group	Observed ASFRs	Fitted ASFRs by				
		LLog	RGLLog	TrLLog	SLLog	KuLLog
15–19	6	6.862	2.042	4.582	2.590	5.289
20–24	39	37.649	41.658	39.473	33.710	40.162
25–29	106	101.365	102.442	101.591	105.560	101.873
30–34	103	106.282	107.024	106.604	102.191	106.743
35–39	64	53.437	60.155	55.951	52.914	57.468
40–44	19	20.018	19.893	20.066	22.657	19.743
45–49	1	7.312	4.142	6.413	9.656	5.195
α		8.475	1.449	4.228	7.285	3.016
β		29.840	77.030	21.776	27.592	25.518
γ		1.114	17.499	13.300	0.000	-
θ		-	126.289	1.000	-	5.486
γ		-	-	-	-	7.619
NLL		−28.583	−29.484	−43.012	−29.126	−21.606
AIL		63.166	64.968	94.024	66.252	51.213
BIC		63.004	64.806	93.808	66.036	50.996

Abbreviations: ASFRs: Age-specific fertility rates; NLL: Negative log-likelihood; BIC: Bayesian information criteria.

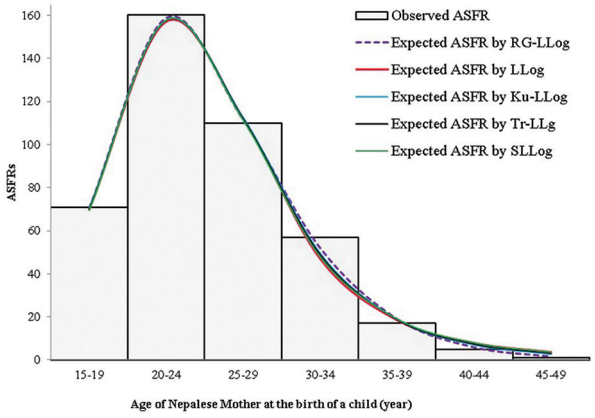


Figure 1. Empirical and fitted values of the age-specific fertility rates of Nepal using different models

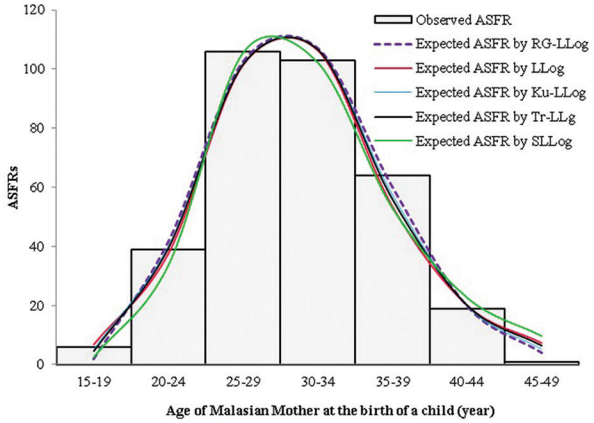


Figure 2. Empirical and fitted age-specific fertility rates of Malaysia obtained using different models

decline in fertility rates as women age. Similarly, according to the Malaysian data presented in Figure 2, the model accurately reflected the shift in fertility patterns, with a lower peak age and a slower decline, consistent with the country's demographic transition.

We conducted a series of goodness-of-fit tests and cross-validation procedures to validate the model. The results of these tests further confirmed the model's validity, demonstrating that it can reliably estimate ASFRs across various populations. The ability of the model to fit data from both Nepal and Malaysia despite their differences highlights its versatility and robustness. In conclusion, applying the KuLLog model to the ASFRs of Nepal and Malaysia highlights its ability to fit the data accurately and validates its effectiveness across different demographic settings. This validation provides confidence in using the model to investigate reproductive behavior and assess its potential applicability in broader demographic research.

7. Conclusion

This research provides a comprehensive review of the literature on graduating and smoothing fertility curves and fitting ASFRs around the globe. This study identifies various models (parametric and non-parametric models as

well as deterministic and stochastic models) that have been employed to fit and smooth ASFRs, thereby highlighting the absence of a universally accepted model. Non-parametric models offer greater flexibility in smoothing ASFRs but typically produce parameters that lack clear demographic interpretation. Although much research has focused on ASFRs in developing countries, considerable attention has been paid to modern, distorted, and bimodal fertility data. Various tools have been employed to assess model validity, and it is recommended that future research incorporates a method that applies a penalty for the number of model parameters. Herein, the LLog distribution and its generalized versions were applied to fit the ASFRs of Nepalese and Malaysian women, with the KuLLog distribution emerging as a superior fit for the data. Such stochastic analysis and model fitting of ASFRs using probability distributions and their results provide crucial insights for managing population growth, healthcare resource allocation, and socioeconomic planning while highlighting issues such as early marriage. Understanding fertility patterns across different age groups supports targeted interventions for maternal health, labor force projections, and women's empowerment. It reveals shifts in cultural norms, including the prevalence and impact of early marriage on reproductive health. These insights will inform sustainable development policies and help improve gender equality.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Arjun Kumar Gaire
Formal analysis: Arjun Kumar Gaire
Investigation: All authors
Writing – original draft: Arjun Kumar Gaire
Writing – review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Data used for this research can be obtained from: NDHS (2022). *Demographic and Health Survey 2022: Key Indicators Report*. Kathmandu, Nepal: Ministry of Health and Population, Nepal; New ERA; and ICF. Available at: https://www.dhsprogram.com/pubs/pdf/FR379/FR379.pdf

Further disclosure

The article is not presented in any conferences and not submitted in any preprint.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19(6):716-723.

https://doi.org/10.1109/TAC.1974.1100705

Aryal, G.R. (2013). Transmuted log-logistic distribution. *Journal of Statistics Applications and Probability*, 2(1):11-20.

https://doi.org/10.12785/jsap/020102

Asili, S., Rezaei, S., & Najjar, L. (2014). Using skew-logistic probability density function as a model for age-specific fertility rate pattern. *BioMed Research International*, 2014:790294.

https://doi.org/10.1155/2014/790294

Beer, J.D. (2011). A new relational method for smoothing and projecting age-specific fertility rates: TOPALS. *Demographic Research*, 24:409-454.

https://doi.org/10.4054/DemRes.2011.24.18

Bozik, J.E., & Bell, W.R. (1987). Forecasting Age Specific Fertility Using Principal Components. Washington DC, USA: US Bureau of the Census, p.396-401.

Brass, W. (1974). Perspectives in population prediction: Illustrated by the statistics of England and Wales. *Journal of the Royal Statistical Society: Series A* (*General*), 137(4):532-570.

https://doi.org/10.2307/2344713

Chandola, T., Coleman, D.A., & Hiorns, R.W. (1999). Recent European fertility patterns: Fitting curves to 'distorted' distributions. *Population Studies*, 53(3):317-329.

https://doi.org/10.1080/00324720308089

Chandola, T., Coleman, D.A., & Hiorns, R.W. (2002). Heterogeneous fertility patterns in the English-speaking world. Results from Australia, Canada, New Zealand and the United States. *Population Studies*, 56(2):181-200.

De-Santana, T.V.F., Ortega, E.M., Cordeiro, G.M., & Silva, G.O.

(2012). The Kumaraswamy-log-logistic distribution. *Journal of Statistical Theory and Applications*, 11(3):265-291.

Gaire, A.K. (2023). Skew Lomax distribution: Parameter estimation, its properties, and applications. *Journal of Science and Engineering*, 10(1):1-11.

https://doi.org/10.3126/jsce.v10i1.61011

Gaire, A.K., & Aryal, R. (2015). Inverse Gaussian model to describe the distribution of age specific fertility rates of Nepal. *Journal of Institute of Science and Technology*. 20(2):80-83.

https://doi.org/10.3126/jist.v20i2.13954

Gaire, A.K., & Gurung, Y.B. (2024a). Rayleigh generated log-logistic distribution: Properties and application. *Istatistik Journal of the Turkish Statistical Association*, 15(1).

Gaire, A.K., & Gurung, Y.B. (2024b). Skew log-logistic distribution: Properties and application. *Statistics in Transition New Series*, 25(1):43-62.

https://doi.org/10.59170/stattrans-2024-003

Gaire, A.K., Gurung, Y.B., & Bhusal, T P. (2024). Age at first marriage of Nepalese women: A statistical analysis (status, differential, determinants, and distributional pattern). *Journal of Population and Social Studies*, 32(1):308-328.

https://doi.org/10.25133/JPSSv322024.019

Gaire, A.K., Gurung, Y.B., & Bhusal, T.P. (2023). Stochastic modeling of age at menopause for Nepalese women and development of menopausal life table. *Global Health Economics and Sustainability*, 1(2):1239.

https://doi.org/10.36922/ghes.1239

Gaire, A.K., Thapa G.B., & Samir, K.C. (2019). Preliminary Results of Skew Log-Logistic Distribution, Properties, and Application. In: Proceeding of the 2nd International Conference on Earthquake Engineering and Post Disaster Reconstruction Planning (ICEE-PDRP-2019). Bhaktapur, Nepal, p.37-43. Available from: https://icee-pdrp.khwopaconference.com/themes/icee_pdrp_v3/downloads/2nd_conf_final_proceeding.pdf [Last accessed on 2024 Jul 07].

Gaire, A.K., Thapa, G.B., & Samir, K.C. (2022). Mathematical modeling of age-specific fertility rates of Nepali mothers. *Pakistan Journal of Statistics and Operation Research*, 18(2):417-426.

https://doi.org/10.18187/pjsor.v18i2.3319

Gayawan, E., & Ipinyomi, R.A. (2009). A comparison of Akaike, Schwarz and R square criteria for model selection using some fertility models. *Australian Journal of Basic and Applied Sciences*, 3(4):3524-3530.

Gayawan, E., Adebayo, S.B., Ipinyomi, R.A., & Oyejola, B.A. (2010). Modeling fertility curves in Africa. *Demographic Research*, 22:211-236.

https://doi.org/10.4054/DemRes.2010.22.10

Gilje, E. (1969). Fitting curves to age-specific fertility rates: Some examples. *Statistical Review of the Swedish National Central Bureau of Statistics*, 3(7):118-134.

Gilje, E., & Yntema, L. (1971). The shifted Hadwiger fertility function. *Scandinavian Actuarial Journal*, 1971(1-2):4-13.

https://doi.org/10.1080/03461238.1971.10404657

Hadwiger, H. (1940). Eine analytische Reproduktionsfunktion für biologische Gesamtheiten. *Scandinavian Actuarial Journal*, 1940(3-4): 101-113.

Hoem, J.M., & Berge, E. (1975). Some problems in Hadwiger fertility graduation. *Scandinavian Actuarial Journal*, 1975(3):129-144.

https://doi.org/10.1080/03461238.1975.10405091

Hoem, J.M., Berge, E., & Holmbeck, B. (1976). Four Papers on the Analytic Graduation of Fertility Curves. Oslo, Norway: Central Bureau of Statistics of Norway.

Hoem, J.M., Madien, D., Nielsen, J.L., Ohlsen, E.M., Hansen, H.O., & Rennermalm, B. (1981). Experiments in modelling recent Danish fertility curves. *Demography*, 18(2):231-244.

Islam, M.R., & Ali, M.K. (2004). Mathematical modeling of age-specific fertility rates and study of the productivity in the rural area of Bangladesh during 1980-1998. *Pakistan Journal of Statistics*, 20(3):379-392.

Islam, R. (2009). Mathematical modeling of age-specific marital fertility rates of Bangladesh. *Research Journal of Mathematics and Statistics*, 1(1):19-22.

Islam, R. (2011). Modeling of age-specific fertility rates of Jakarta in Indonesia: A polynomial model approach. *International Journal of Scientific & Engineering Research*, 2(11):1-5.

Jeha, D., Usta, I., Ghulmiyyah, L., & Nassar, A. (2015). A review of the risks and consequences of adolescent pregnancy. *Journal of Neonatal-Perinatal Medicine*, 8(1):1-8.

https://doi.org/10.3233/npm-15814038

Kostaki, A., Moguerza, J.M., Olivares, A., & Psarakis, S. (2009). Graduating the age-specific fertility pattern using support vector machines. *Demographic Research*, 20:599-622.

https://doi.org/10.4054/DemRes.2009.20.25

Liu, Y., Gerland, P., Spoorenberg, T., Kantorova, V., & Andreev, K. (2011). Graduation Methods to Derive age-specific Fertility Rates from Abridged Data: A Comparison of 10 Methods Using HFD Data. Presentation at the First HFD Symposium, MPIDR, Rostock, Germany.

Mazzuco, S., & Scarpa, B. (2011). Fitting Age-specific Fertility Rates by a Skew-symmetric Probability Density Function. Working Paper Series, No. 10. Italy: The University of Padova.

Mishra, R., Singh, K.K., & Singh, A. (2017). A model for age-specific fertility rate pattern of India using skew-logistic

distribution function. *American Journal of Theoretical and Applied Statistics*, 6(1):32-37.

https://doi.org/10.11648/j.ajtas.20170601.14

Murphy, E.M., & Nagnur, D.N. (1972). A Gompertz fit that fits: Applications to Canadian fertility patterns. *Demography*, 9(1):35-50.

NDHS. (2017). Nepal Demographic and Health Survey 2016: Key Indicators. Kathmandu, Nepal: Ministry of Health and Population, New ERA and ICF. Available from: https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf [Last accessed on 2024 Jul 07].

NDHS. (2022). Demographic and Health Survey 2022: Key Indicators Report. Kathmandu, Nepal: Ministry of Health and Population, New ERA and ICF. Available from: https://dhsprogram.com/pubs/pdf/FR379/FR379.pdf [Last accessed on 2024 Jul 07].

NPFDB. (2023). Preliminary Report: Malaysian Demographic and Health Survey 2022. Kuala Lumpur, Malaysia: National Population and Family Development Board. Available from: https://www.dosm.gov.my/portal-main/release-content/vital-statistics-2024 [Last accessed on 2024 Jul 07].

Pasupuleti, S.S., & Pathak, P. (2011). Special form of Gompertz model and its application. *Genus*, 66(2):95-125.

https://doi.org/10.4402/genus-276

Peristera, P., & Kostaki, A. (2007). Modeling fertility in modern populations. *Demographic Research*, 16:141-194.

https://doi.org/10.4054/DemRes.2007.16.6

Salomon, J.A., & Murray, C.J. (2001). Modeling HIV/AIDS epidemics in sub-Saharan Africa using seroprevalence data from antenatal clinics. *Bulletin of the World Health Organizatio*n, 79(7):596-607.

Santos, N.L.C., Costa, M.C.O., Amaral, M.T.R., Vieira, G.O., Bacelar, E.B., & De-Almeida, A.H.V. (2014). Teenage pregnancy: Analysis of risk factors for low birth weight, prematurity and cesarean delivery. *Science and Public Health*, 19(3):719-726.

https://doi.org/10.1590/1413-81232014193.18352013

Schmertmann, C.P. (2003). A system of model fertility schedules with graphically intuitive parameters. *Demographic Research*, 9:81-110.

https://doi.org/10.4054/DemRes.2003.9.5

Schmertmann, C.P., & Caetano, A.J. (1999). Estimating parametric fertility models with open birth interval data. *Demographic Research*, 1(4):1-27.

https://doi.org/10.4054/DemRes.1999.1.5

Singh, B.P., Gupta, K., & Singh, K.K. (2015). Analysis of fertility pattern through mathematical curves. *American Journal of Theoretical and Applied Statistics*, 4(2):64-70.

https://doi.org/10.11648/j.ajtas.20150402.14

WHO. (2018). Global Health Estimates. Deaths by Cause, Age, Sex, Country, and Region, 2000-2016. Geneva: World Health Organization. Available from: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates [Last accessed on 2024 Jul 07].

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Global Health Economics and Sustainability

ORIGINAL RESEARCH ARTICLE

Functional profile of patients with heart failure followed up in a referral ambulatory in southern Brazil

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Abstract

Heart failure (HF) is a complex clinical syndrome, and its prevalence has been increasing in recent years. Despite advancements in pharmacological therapy, symptoms such as fatigue, dyspnea, and exercise intolerance are still likely to persist over time. Therefore, functional evaluation is crucial for treating patients with HF and improving their prognosis. This cross-sectional study aimed to identify the functional profile of patients with HF who were followed up at a referral ambulatory clinic in southern Brazil. In total, 51 patients with HF were treated in an outpatient setting. Functional capacity was assessed using the 6-min walk test, dynamometry, 30s sit-and-stand test, and manovacuometry (maximum inspiratory pressure [MIP] and maximum expiratory pressure [MEP]). The Minnesota Living with HF Questionnaire was used to assess the quality of life (QOL). The sample mostly comprised men (72.5%), with an average age of 48.2 ± 12.4 years. Cardiomyopathy (62.7%) was the most predominant etiology. A reduced left ventricular ejection fraction was prevalent in 94.1% of individuals and New York Heart Association functional class II and III HF in 62.8%. The most predominant risk factors were systemic arterial hypertension (60.8%), sedentary lifestyle (80.4%), obesity (41.2%), and smoking (41.2%). The most used medications were beta-blockers (94.1%), antihypertensives (52.9%), diuretics (100%), antiarrhythmics (64.7%), and angiotensin II blockers (68.6%). The average distance covered in 6MWT (Six Minute Walk Test) was 429.8 ± 96.7 m. The MIP and MEP reduced to 79.6% and 92.6% of the predicted distance, respectively. The right-hand grip strength (39 ± 11 kg) and left-hand grip strength (36 ± 10 kg) and the sit-and-stand test in 30s (30CST) (9.8 ± 2.3 repetitions) also decreased. HF had a moderate impact on QOL (46.6 ± 24.6 points). Individuals with HF have a reduced functional capacity in terms of respiratory and peripheral muscle strength, which moderately impacts QOL.

Keywords: Heart failure; Physical functional performance; Exercise test; Walk test; Quality of life

1. Introduction

Heart failure (HF) is a complex clinical syndrome characterized by the inability of the heart to pump blood to meet the body's metabolic demands. This syndrome can

be caused by structural or functional cardiac changes, which is the final pathway of some heart diseases such as acute coronary syndrome and acute myocardial infarction (Rohde *et al*., 2018). The prevalence of HF has been gradually increasing in recent years. Hence, HS has become a public health concern. There are approximately 26 million people with HF worldwide. In Brazil, it is the main cause of hospitalization in patients aged >60 years (Fernandes *et al*., 2019; Poffo *et al*., 2017).

HF is mainly classified based on left ventricular ejection fraction (LVEF), which can be HF with preserved ejection fraction when LVEF >50%, intermediate when LVEF is 40 – 49%, and reduced when LVEF <40% (Rohde *et al*., 2018).

The New York Heart Association (NYHA) functional classification is used to describe and classify the severity of symptoms based on the degree of exercise tolerance. In particular, NYHA classifications I and II indicate milder symptoms and NYHA classifications III and IV suggest more severe symptoms (Rohde *et al*., 2018).

The most common clinical characteristics of HF are fatigue and dyspnea, which may be accompanied by edema of the lower limbs, cough, dizziness, and orthopnea (Suzuki *et al*., 2018). Due to inefficient cardiac pumping, individuals with HF present with a decreased exercise tolerance and increased metabolic and respiratory responses, causing inactivity that leads to muscle atrophy and decreased muscle strength (Di Naso *et al*., 2011). The prevalence of sarcopenia is approximately 20% higher in individuals with HF than in healthy individuals. In particular, this high incidence may be attributed to mitochondrial dysfunction combined with abnormal energy metabolism and a transition of type I to type II myofiber and increased catabolic stress in skeletal muscle, resulting in exercise intolerance, ventilatory inefficiency, and chronotropic incompetence, which poses significant limitations to individuals with HF (Xavier & Ferretti-Rebustini, 2019). Ultrasonographic evaluation of the quadriceps is a safe, viable, and reliable method for evaluating muscle architecture in various populations (Santos *et al*., 2022; Silva *et al*., 2022; Vieira *et al*., 2019).

Changes in cardiac functions can also impair compromise pulmonary function, potentially indicating conditions such as pulmonary hypertension and decreased ventilatory capacity, both of which exacerbate symptoms and cardiorespiratory conditioning. This results in dyspnea and decreased respiratory muscle strength (Xavier & Ferretti-Rebustini, 2019).

Despite recent advancements in pharmacological therapy and decreasing morbidity and mortality, such symptoms tend to persist over time. Evidence has consistently shown that decreased physical activity levels in HF trigger a vicious cycle that increases signs and symptoms, reduces functional capacity, limits activities of daily living, and promotes negative psychological effects (Carvalho *et al*., 2020).

Fuentes-Abolafio *et al*. (2020) performed a systematic review and meta-analysis of 44 observational longitudinal cohort studies with 22,598 patients with HF. Results showed that functional physical performance based on functional tests is related to the prognosis of these patients. This study concluded that patients with poor physical and functional performance had a higher risk of hospitalization and mortality than those with good performance.

The cardiopulmonary exercise test (CPET) is considered the gold standard for the functional assessment of patients with HF (Herdy *et al*., 2016). Although it is the primary choice for functional evaluation, the cost and need for specialized professionals limit its routine use. Further, other functional tests with more accessible cost and reproduction are some of the indications for the functional evaluation of these patients, which were used in this work.

In this context, a comprehensive functional evaluation is essential to optimize treatment and improve prognosis in patients with HF.

2. Methods

2.1. Population and study design

This was a prospective cross-sectional study that evaluated 51 individuals with HF who were followed up in a specialized outpatient clinic in southern Brazil between March and November 2022. The inclusion criteria were male and female individuals aged ≥18 years who were hemodynamically stable and did not present with a functional limitation that prevented the performance of the tests. The current study was approved by the human research ethics committee of the IC/FUC (CAAE 55002222.3.0000.5333), and all participants signed the free and informed consent form.

2.2. Assessment of functional profile and quality of life (QOL)

To assess functional capacity, the 6-min walk test (6MWT) was performed according to the American Thoracic Society (ATS) 2002 guidelines (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002). The muscle strength of the upper limbs was assessed through manual grip dynamometry using a hand-held analog dynamometer (Seahan® model SH5001). Three measurements were taken with an interval of 30 s at alternating sides to prevent muscle fatigue. At the end, the highest value obtained was recorded (Novaes *et al*., 2009). The strength of the lower limbs was evaluated

using the sit-and-lift test in 30 s (30CST). In this test, the individual was directed to sit and lift as many times as possible for 30 s in a chair with a height of 43 cm and preferably without arm support (Jones *et al.*, 1999). To assess the balance and risk of falling, the timed up-and-go (TUG) test was performed. In this test, the volunteer was instructed to get up from a chair, walk for 3 m in a straight line at his/her usual pace, turn around a cone, and sit down again. The time spent at the end of the route was recorded (Hwang *et al.*, 2016; Podsiadlo & Richardson, 1991). To evaluate respiratory muscle strength, maximum inspiratory pressure (MIP), and maximum expiratory pressure (MEP), a digital manovacuometer (MVD 300-U Homed) was used, and the maximum value obtained through the three maneuvers was recorded, which did not differ by >10% (Oliveira *et al.*, 2016).

During the anamnesis, a standard form was filled out. Thereafter, the QOL of the participants was evaluated using the Minnesota Living with HF Questionnaire (MLHFQ) Brazilian version (Figure A1) (Carvalho *et al.*, 2009).

2.3. Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences software version 26.0. They were presented as the mean and standard deviation or absolute and relative frequencies. The Pearson's test was used to assess the correlation of parametric variables. The Spearman's test was utilized to evaluate the correlation of non-parametric variables. A $p < 0.05$ was considered statistically significant.

3. Results

The average age of the participants was 48.2 ± 12.4 years, with predominance for those aged 41 – 59 years (58.8%). Male participants and those with white skin color comprised 72.5% of the sample. Cardiomyopathy was the most frequent etiology (n = 32, 62.7%), followed by idiopathic disease (n = 10, 19.6%). Approximately 94.1% of individuals presented with reduced LVEF and 62.8% with NYHA II and III HF (Table 1).

The most common risk factors were systemic arterial hypertension (60.8%), sedentary lifestyle (80.4%), obesity, and smoking (41.2%) (Table 2). During evaluation, 13.7% and 17.6% of the patients had dyspnea and edema of the lower limbs, respectively. In relation to therapy, the most frequently prescribed medications were beta-blockers (94.1%), antihypertensives (52.9%), diuretics (100%), antiarrhythmics (64.7%), and angiotensin II blockers (68.6%) (Table 2).

Table 3 presents the tests performed in the functional evaluation and QOL. One individual did not complete the 6MWT due to extreme fatigue. Eight participants did not undergo the manovacuometry due to referred fatigue. Further, seven individuals did not participate in the TUG and 30CST due to referred fatigue or hemodynamic instability, and two did not undergo the dynamometry due to referred fatigue. All patients answered the MLHFQ.

Table 1. Characteristics of the participants

Variables	*n* (%)
Age† (years)	48.2±12.4
21 – 40*	10 (21.6)
41 – 59*	15 (58.8)
60 – 69*	7 (19.6)
Sex*	
Male	37 (72.5)
Race*	
White	37 (72.5)
Black	13 (25.1)
Brown	3 (2)
Body mass (kg)†	86.1±21.1
Height (cm)†	169.7±8.7
HF etiology*	
Ischemic	10 (19.6)
Valve	1 (2)
Idiopathic	8 (15.7)
Cardiomyopathy	32 (62.7)
Ejection fraction (%)*	
Reduced (≤40)	48 (94.1)
Intermediate (41 – 49)	2 (3.9)
Preserved (>50)	1 (1.9)
NYHA*	
1	19 (37.2)
2	21 (41.2)
3	11 (21.6)

Notes: †Data are presented as mean±standard deviation; *Data are presented as frequency. Abbreviations: HF: Heart failure; NYHA: New York Heart Association.

Table 4 depicts the correlations between the variables of the functional, strength, and QOL tests. The association between NYHA and right-hand grip strength and left-hand grip strength had a weak to moderate but significant correlation coefficient value (r = –0.414, p = 0.004 and r = –0.357, p = 0.012, respectively). The association between the 6MWT result and MEP and QOL had a weak to moderate but significant correlation coefficient value (r = 0.356, p = 0.019 and r = –0.601, p = 0.001, respectively). The correlation between MIP as well as MEP and 30CST had a weak to moderate but significant correlation coefficient value (r = 0.607, p = 0.001 and r = 0.372, p = 0.018,

Table 2. Risk factors and medications

Variables	*n* (%)
Comorbidities*	
DM	21 (29.4)
BMI	
Underweight	15 (29.4)
Overweight	15 (29.4)
Obesity	21 (41.2)
Former smoker	21 (41.2)
Former alcoholic	14 (27.5)
Sedentary lifestyle	41 (80.4)
SAH	31 (60.8)
DSLP	11 (21.6)
Medications	
Beta-blockers	48 (94.1)
Antilipemics	25 (49)
ACE inhibitor.	13 (25.5)
Antihypertensives	27 (52.9)
Antiplatelet agents	12 (23.5)
Antianginal agents	4 (7.8)
Diuretics	51 (100)
Antidiabetics	26 (51)
Anticoagulants	20 (39.2)
Antiarrhythmics	33 (64.7)
ARB II35 (68.6)	35 (68.6)

Note: *Data are presented as frequency.
Abbreviations: DM: Diabetes mellitus; BMI: Body mass index; SAH: Systemic arterial hypertension; DSLP: Dyslipidemia; ACE: Angiotensin-converting enzyme; ARB: Angiotensin II receptor blocker.

Table 3. Functional tests and quality of life

Variables	*n*=51 (%)
6MWT (m)†	429.8±96.7
Predicted 6MWT (%)†	73.6±16
Borg scale score	(0 – 10)*
Baseline dyspnea*	1 (0 – 4)
Dyspnea post*	3 (0 – 9)
Baseline fatigue*	0 (0 – 5)
Fatigue post*	3 (0 – 10)
Manovacuometria†	
MIP (cmH_2O)	−83.1±28.6
Predicted (%)	76.9±25.1
MEP (cmH_2O)	105.6±31.8
Predicted (%)	92.6±26.6
TUG (s)†	8±1.9
30CST (repetitions)†	9.8±2.3
Right-hand grip strength (kg)†	39±11
Left-hand grip strength (kg)†	36±10
Minnesota†	46.6±24.6

Notes: †Data are presented as mean±standard deviation. *Data are presented as frequency.
Abbreviations: 6MWT: 6 Min Walk Test; MIP: Maximum inspiratory pressure; MEP: Maximum expiratory pressure; TUG: Timed Up and Go; 30CST: Sit-and-Stand test in 30s.

respectively). If MEP is correlated with 30CST and QOL, it presented with a weak but significant correlation coefficient value (r = 0.346, p = 0.029 and r = –0.367, p = 0.016, respectively). The correlation between the 30CST with right-hand grip strength and left-hand grip had a weak to moderate but significant correlation coefficient value (r = 0.308, p = 0.013 and r = 0.526, p = 0.001, respectively). Finally, the correlation between right-hand grip strength and left-hand grip had a strong and significant correlation coefficient value (r = 0.916, p = 0.001).

4. Discussion

The results of this study can help identify physical and emotional weaknesses in patients with advanced HF who were followed up on an outpatient basis, making it possible to offer an optimized and multi-professional treatment. The negative impact of HF on the lives of patients with this syndrome is well described in the literature (Suzuki *et al*., 2018; Xavier & Ferretti-Rebustini, 2019). TCPE is the gold standard for assessing functional capacity. However, alternative tests such as those used in this study are feasible and a more economical alternative for determining the functional profile of these individuals (Carluccio *et al*., 2022).

Traditionally, the 6MWT has been used to evaluate the effect of various exercise and rehabilitation programs on patients with HF and is a powerful indicator in this population due to its close correlations with the volume of oxygen uptake during peak exercise, maximal oxygen consumption, and anaerobic threshold during CPET (Boşnak Güçlü *et al*., 2021). Boşnak Güçlü *et al*. (2021) performed a study on patients whose characteristics are similar to those in the current study. In this research, the functional capacity of individuals with and without HF was compared. In the HF group, the distance traveled in TC6 was 412.62 ± 96.51 m. Further, the Borg scale values for fatigue 2 (0 – 8) and dyspnea 2 (0 – 10) after the test were similar to those found in our patients, thereby indicating a significant decrease in the distance traveled. However, if there was a correlation between the 6MWT result and the NYHA functional class, the results differed (Boşnak Güçlü *et al*., 2021; Oliveira *et al*., 2016).

Table 4. Correlations between variables from the functional, strength, and questionnaire tests

Variables	Predicted 6MWT (%)	Predicted MIP (%)	Predicted MEP (%)	30CST	RHGS	LHGS	Minnesota
NYHA classification	p=0.251 r=−0.165	p=0.418 r=0.127	p=0.499 r=−0.106	p=0.328 r=0.149	p=0.004* r=−0.414	p=0.012* r=−0.357	p=0.098 r=0.234
Predicted 6MWT (%)		p=0.084 r=0.267	p=0.019* r=0.356	p=0.498 r=0.104	p=0.900 r=−0.019	p=0.700 r=0.057	p=0.001* r=−0.601
Predicted MIP (%)			p=0.001* r=0.607	p=0.018* r=0.372	p=0.790 r=−0.043	p=0.331 r=0.154	p=0.559 r=−0.092
Predicted MEP (%)				p=0.029* r=0.346	p=0.247 r=0.187	p=0.061 r=0.292	p=0.016* r=−0.367
30CST					p=0.013* r=0.308	p=0.001* r=0.526	p=0.414 r=−0.125
RHGS						p=0.001* r=0.916	p=0.430 r=−0.118
LHGS							p=0.154 r=−0.207

Abbreviations: 6MWT: 6 Min Walk Test; MIP: Maximum inspiratory pressure; MEP: Maximum expiratory pressure; 30CST: Sit-and-Stand Test in 30 s; RHGS: Right-hand grip strength; RHGS: Right-hand grip strength; LHGS: Left-hand grip strength.

Approximately 30 – 50% of patients with HF exhibited weakness of the inspiratory muscles, defined as MIP <70% of the predicted value. With aging, the prevalence can reach up to 60% and is related to cardiac output deficiency (Boşnak Güçlü *et al*., 2021; De Decco *et al*., 2021). In accordance with our study, Cahalin & Arena (2015) showed that patients with HF present with inspiratory muscle weakness and a decrease in peripheral muscle strength. However, if NYHA classification is correlated with MIP functional classification, our results were contrary to those of Cahalin & Arena (2015). Notably, almost 20 years after a pre-cursor study on inspiratory muscle training in patients with HF was conducted, our study obtained findings similar to those found by Dall'Ago *et al*. in 2006, which included a pre-intervention sample with inspiratory muscle weakness.

The TUG test was developed to evaluate mobility and balance in elderly individuals with frailty (Podsiadlo & Richardson, 1991). Due to the heterogeneity and functional frailty of patients with HF, this test was performed. Results showed that none of the patients were at risk of hospital stay. This can be explained by the average age, which was lower than that reported in another study (Bretan *et al*., 2013).

Approximately 20% of patients with HF exhibited loss of muscle mass and function, which can reach up to 47% in cases of dilated cardiomyopathy (Suzuki *et al*., 2018). Compared with those in other studies (Mathiowetz *et al*., 1985; Novaes *et al*., 2009), the hand grip strength and 30CST in this study decreased. In addition, a significant correlation was observed between these parameters ($p < 0.05$), which indicated a decrease in peripheral muscle strength in the assessed population. Further, sarcopenia is a common condition in patients with HF, particularly in patients who are in the terminal phase. This condition leads to worse clinical outcomes, low muscle strength, reduced physical fitness, and frailty, thereby contributing to higher hospitalization rates and increased mortality (García-Olmos *et al*., 2019).

In addition to physical limitations, emotional aspects are also affected by this condition, a factor that affects the QOL of its carriers. The MLHFQ (Carvalho *et al*., 2009) addresses physical and emotional limitations often associated with the ways HF restricts patients from living as they desire. The MLHFQ score ranges from 0 to 105. If the score is higher, the IC has a more negative impact on QOL. The literature reviewed did not present cutoff points. However, previous studies (Carvalho *et al*., 2009; Paz *et al*., 2019) that evaluated the QOL of patients with HF using the MLHFQ obtained results similar to ours, showing that the condition had a moderate impact on QOL.

5. Limitations

The data collection period and sample size might have influenced the final results, and more studies should be conducted to evaluate and describe the functional profile of this population. Despite the limited sample size, our study can provide valuable insights, functionally characterizing middle-aged adults with advanced HF from southern Brazil.

6. Conclusion

Individuals with advanced HF who were followed up at a reference ambulatory hospital in southern Brazil presented with characteristics commonly described in the literature.

Further, a decrease in functional capacity and respiratory and peripheral muscle strength is observed with disease progression. Therefore, the functional profile of patients with HF should be examined through a comprehensive evaluation to promote follow-up and achieve better outcomes in individuals with HF.

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Conflict of interest

The authors declare they have no competing interests.

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Ethics approval and consent to participate

The study was approved by the human research ethics committee of the Instituto de Cardiologia/Fundação Universitária de Cardiologia (IC/FUC), Porto Alegre, RS, Brazil (CAAE 55002222.3.0000.5333), and all the subjects signed the informed consent forms.

Consent for publication

We obtained verbal consent from human patients to release their data and/or images in this article.

Availability of data

Data are available from the corresponding author upon reasonable request.

References

ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. (2002). ATS statement: guidelines for the six-minute walk test. *American Journal of Respiratory and Critical Care Medicine*, 166(1):111-117.

https://doi.org/10.1164/ajrccm.166.1.at1102

Boşnak Güçlü, M., Barğı, G., Katayifçi, N., & Şen, F. (2021). Comparison of functional and maximal exercise capacity, respiratory and peripheral muscle strength, dyspnea, and fatigue in patients with heart failure with pacemakers and healthy controls: A cross-sectional study. *Physiotherapy Theory and Practice*, 37(2):295-306.

https://doi.org/10.1080/09593985.2019.1630878

Bretan, O., Elias Silva, J., Ribeiro, O.R., & Corrente, J.E. (2013). Risk of falling among elderly persons living in the community: Assessment by the timed up and go test. *Brazilian Journal of Otorhinolaryngology*, 79(1):18-21.

https://doi.org/10.5935/1808-8694.20130004

Cahalin, L.P., & Arena, R.A. (2015). Breathing exercises and inspiratory muscle training in heart failure. *Heart Failure Clinics*, 11(1):149-172.

https://doi.org/10.1016/j.hfc.2014.09.002

Carluccio, E, Dini, F.L., Bitto, R., Ciccarelli, M., Correale, M., D'Agostino, A., *et al.* Benefit from sacubitril/valsartan is associated with hemodynamic improvement in heart failure with reduced ejection fraction: An echocardiographic study. *Int J Cardiol.* 2022;350:62-68.

https://doi.org/10.1016/j.ijcard.2022.01.004

Carvalho, T., Milani, M., Ferraz, A.S., Silveira, A.D., Herdy, A.H., Hossri, C.A.C., *et al.* (2020). Diretriz brasileira de reabilitação cardiovascular-2020. *Arquivos Brasileiros de Cardiologia*, 114(5):943-987.

https://doi.org/10.36660/abc.20200407

Carvalho, V.O., Guimarães, G.V., Carrara, D., Bacal, F., & Bocchi, E.A. (2009). Validação da versão em português do minnesota living with heart failure questionnaire. *Arquivos Brasileiros de Cardiologia*, 93(1):39-44.

https://doi.org/10.1590/S0066-782X2009000700008

Dall'Ago, P., Chiappa, G.R., Guths, H., Stein, R., & Ribeiro, J.P. (2006). Inspiratory muscle training in patients with heart failure and inspiratory muscle weakness: A randomized trial. *Journal of the American College of Cardiology*, 47(4):757-763.

https://doi.org/10.1016/j.jacc.2005.09.052

De Decco, L., Andrade, M., Da, R., Coelho Barbosa, S., Faria De Carvalho, A.C., *et al.* (2021). Cardiorespiratory Profile of Patients with Heart Failure with Intermediate Ejection Fraction Resumo. Vol. 6. Available from: https://revista.unifeso.edu.br/index.php/jopic/article/view/2857. [Last accessed on 2024 Jul 15].

Di Naso, F.C., Pereira, J.S., Beatricci, S.Z., Bianchi, R.G., Dias, A.S., & Monteiro, M.B. (2011). A classe da NYHA tem relação com a condição funcional e qualidade de vida na insuficiência cardíaca. *Fisioterapia e Pesquisa*, 18(2):157-163.

https://doi.org/10.1590/S1809-29502011000200010

Fernandes, D.F.A., Fernandes, G.C., Rivera Mazza, M., Knijnik, M.L., Soares Fernandes, G., Telis de Vilela, A., *et al.* (2019). Insuficiência cardíaca no brasil subdesenvolvido: Análise de tendência de dez anos. *Arquivos Brasileiros de Cardiologia*, 114(2):222-231.

https://doi.org/10.36660/abc.20180321

Fuentes-Abolafio, I.J., Stubbs, B., Pérez-Belmonte, L.M., Bernal-López, M.R., Gómez-Huelgas, R., & Cuesta-Vargas, A.I. (2020). Physical functional performance and prognosis in patients with heart failure: A systematic review and meta-analysis. *BMC Cardiovascular Disorders*, 20(1):512.

https://doi.org/10.1186/s12872-020-01725-5

García-Olmos, L., Batlle, M., Aguilar, R., Porro, C., Carmona, M., Alberquilla, A., *et al.* (2019). Disability and quality of life in heart failure patients: A cross-sectional study. *Family Practice*, 36(6):693-698.

https://doi.org/10.1093/fampra/cmz017

Herdy, A.H., Ritt, L.E.F., Stein, R., Araújo, C.G.S., Milani, M., Meneghelo, R.S., *et al.* (2016). Cardiopulmonary exercise test: Fundamentals, applicability and interpretation. *Arquivos Brasileiros de Cardiologia*, 107(5):467-481.

https://doi.org/10.5935/abc.20160171

Hwang, R., Morris, N.R., Mandrusiak, A., Mudge, A., Suna, J., Adsett, J., *et al.* (2016). Timed up and go test: A reliable and valid test in patients with chronic heart failure. *Journal of Cardiac Failure*, 22(8):646-650.

https://doi.org/10.1016/j.cardfail.2015.09.018

Jones, C.J., Rikli, R.E., & Beam, W.C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research Quarterly for Exercise and Sport*, 70(2):113-119.

https://doi.org/10.1080/02701367.1999.10608028

Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., & Rogers, S. (1985). Grip and pinch strength: Normative data for adults. *Archives of Physical Medicine and Rehabilitation*, 66(2):69-74.

Novaes, R.D., Miranda, A.S., Silva, J.O., Tavares, B.V.F., & Dourado, V.Z. (2009). Reference equations for predicting handgrip strength in middle-aged and elderly Brazilians. *Psysiotherapy and Research*, 16(3):217-222.

https://doi.org/10.1590/S1809-29502009000300005

Oliveira, M.F., Zanussi, G., Sprovieri, B., Lobo, D.M.L., Mastrocolla, L.E., Umeda, I.I.K., *et al.* (2016). Alternatives to aerobic exercise prescription in patients with chronic heart failure. *Arquivos Brasileiros de Cardiologia*, 106(2):97-104.

https://doi.org/10.5935/abc.20160014

Paz, L.F.A., Medeiros, C.A., Martins, S.M., Bezerra, S.M.M.S., Oliveira Junior, W., & Silva, M.B.A. (2019). Quality of life related to health for heart failure patients. *Revista Brasileira de Enfermagem*, 72(Suppl 2):140-146.

https://doi.org/10.1590/0034-7167-2018-0368

Podsiadlo, D., & Richardson, S. (1991). The timed "Up and Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, 39(2):142-148.

https://doi.org/10.1111/j.1532-5415.1991.tb01616.x

Poffo, M.R., Assis, A.V., Fracasso, M., Londero Filho, O.M., Alves, S.M.M., Bald, A.P., *et al.* (2017). Profile of patients hospitalized for heart failure in tertiary care hospital. *International Journal of Cardiovascular Sciences*, 30(3):189-198.

https://doi.org/10.5935/2359-4802.20170044

Rohde, L.E.P., Montera, M.W., Bocchi, E.A., Clausell, N.O., Albuquerque, D.C., Rassi, S., *et al.* (2018). Brazilian Guideline for Chronic and Acute Heart Failure. *Arquivos Brasileiros de Cardiologia*, 111(3):436-539.

https://doi.org/10.5935/abc.20180190

Santos, T.A.B., Santos, P.M., Wassmuth, T., Mazzo, D.M., Costa, B.M., & Moleta, J.F.K. (2022). The use of ultrasonography as a tool to evaluate the quadriceps muscle in patients with chronic obstructive pulmonary disease: A systematic review. *Research, Society and Development*, 11(1):e19911124728.

https://doi.org/10.33448/rsd-v11i1.24728

Silva, T.M., Chagas, P.S., Nogueira, E.N., & Boone, D.K. (2022). Avaliação da perda de massa muscular em pacientes críticos: Utilizando a ultrassonografia como ferramenta. *Brazilian Journal of Development*, 8(12):78589-78598.

https://doi.org/10.34117/bjdv8n12-117

Suzuki, T., Palus, S., & Springer, J. (2018). Skeletal muscle wasting in chronic heart failure. *ESC Heart Failure*, 5(6):1099-1107.

https://doi.org/10.1002/ehf2.12387

Vieira, L., Rocha, L.P.B., Mathur, S., Santana, L., Melo, P.F., Silva, V.Z.M., *et al.* (2019). Reliability of skeletal muscle ultrasound in critically ill trauma patients. *Revista Brasileira de Terapia Intensiva*, 31(4):464-473.

https://doi.org/10.5935/0103-507X.20190072

Xavier, S.O., & Ferretti-Rebustini, R.E.L. (2019). Clinical characteristics of heart failure associated with functional dependence on admission in hospitalized elderly patients. *Latin American Journal of Nusring*. 27:e3137.

https://doi.org/10.1590/1518-8345.2869-3137

Appendix

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LIVING WITH HEART FAILURE QUESTIONNAIRE

These questions concern how your heart failure (heart condition) has prevented you from living as you wanted during the last month. The items listed below describe different ways some people are affected. If you are sure an item does not apply to you or is not related to your heart failure then circle 0 (No) and go on to the next item. If an item does apply to you, then circle the number rating how much it prevented you from living as you wanted. Remember to think about ONLY THE LAST MONTH.

Did your heart failure prevent you from living as you wanted during the last month by:	*No*	*Very little*				*Very much*
1. Causing swelling in your ankles, legs, etc?	0	1	2	3	4	5
2. Making you sit or lie down to rest during the day?	0	1	2	3	4	5
3. Making your walking about or climbing stairs difficult?	0	1	2	3	4	5
4. Making your working around the house or yard difficult?	0	1	2	3	4	5
5. Making your going places away from home difficult?	0	1	2	3	4	5
6. Making your sleeping well at night difficult?	0	1	2	3	4	5
7. Making your relating to or doing things with your friends or family difficult?	0	1	2	3	4	5
8. Making your working to earn a living difficult?	0	1	2	3	4	5
9. Making your recreational pastimes, sports or hobbies difficult?	0	1	2	3	4	5
10. Making your sexual activities difficult?	0	1	2	3	4	5
11. Making you eat less of the foods you like?	0	1	2	3	4	5
12. Making you short of breath?	0	1	2	3	4	5
13. Making you tired, fatigued, or low on energy?	0	1	2	3	4	5
14. Making you stay in a hospital?	0	1	2	3	4	5
15. Costing you money for medical care?	0	1	2	3	4	5
16. Giving you side effects from medications?	0	1	2	3	4	5
17. Making you feel you are a burden to your family or friends?	0	1	2	3	4	5
18. Making you feel a loss of self-control in your life?	0	1	2	3	4	5
19. Making you worry?	0	1	2	3	4	5
20. Making it difficult for you to concentrate or remember things?	0	1	2	3	4	5
21. Making you feel depressed?	0	1	2	3	4	5

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Figure A1. Minnesota Living with Heart Failure Questionnaire (MLHFQ)

ACCSCIENCE PUBLISHING

Global Health Economics and Sustainability

ORIGINAL RESEARCH ARTICLE

Achieving SDG-3 in India: "Ensuring healthy lives and promoting wellbeing at all ages"

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Abstract

India's concerted efforts to achieve sustainable development goal (SDG)-3 targets, which focus on ensuring universal health coverage and promoting well-being across all age groups, form the focal point of rigorous public health actions. This study aims to assess India's progress toward SDG-3 targets, identify areas needing improvement, and propose measures for future advancements by analyzing the common review mission (CRM) reports of India. Utilizing secondary data collected from public domains, this study employs descriptive data analysis to examine data from 2015 to 2022 and the envisioned 2030 targets across four pivotal domains: maternal health, newborn and child health; communicable diseases; non-communicable diseases and injuries; and overarching health systems strengthening. The qualitative data were obtained from the CRM reports, which are annual reviews conducted by the Government of India. The analysis underscores the average annual rate of change (AARC) calculation for all states and the national average in India, revealing substantive disparities and areas needing enhanced progress. Findings indicate that with the prevailing AARCs (AARC: 6.90%), India will not be able to achieve the maternal mortality ratio (MMR) targets. To achieve the SDGs, the AARC for MMR, neonatal mortality rate, and under-five mortality rate must improve from 6.90% to 7.80%, 3.40% to 5.40%, and 1.30% to 2.11%, respectively. This study highlights that achieving SDG-3 targets requires state-specific, data-driven planning integrated within the Block Health Action Plan, which feeds into district and state health action plans. Effective alignment with SDG-3 imperatives necessitates meticulous planning informed by disease burdens and mortality rates, prioritizing non-communicable diseases, road traffic injuries, and suicides.

Keywords: Universal health coverage; Health systems strengthening; Accessibility; Healthcare services

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1. Introduction

The millennium development goals (MDGs) were set by the United Nations (UN) in 2000. They call for the world community to "spare no effort to free our fellow men,

women, and children from the dismal and degrading conditions of severe poverty" (United Nations Millennium Declaration). The MDGs include eight objectives that must be accomplished by 2015 to address the world's major development concerns. With a primary focus on health and related areas, the eight goals that make up the MDGs were created to address the world's most pressing development concerns. However, the progress in improving health indices related to mortality, morbidity, and environmental factors causing poor health conditions was slow. Therefore, the government implemented various programs, laws, and plans to address these health issues (Pandve, 2015).

India has made varying degrees of progress toward the MDGs related to health. The nation has achieved the essential trend reversal in the fight against the human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS). India has now met the MDG targets for reducing child and maternal mortality, although it varies among the states. Despite some minor oscillations, a trend reversal has been achieved in the fight against tuberculosis (TB) and malaria (Nath, 2011). As a result, to tackle issues like equity more comprehensively, UN member states adopted the Sustainable Development Agenda in 2015. This agenda's goal was to ensure peace and prosperity for people and the planet now and in the future, which includes providing healthy lifestyles and focused promotion of well-being for everyone, regardless of age (Paulson *et al.*, 2021). There are 17 sustainable development goals (SDGs) on the agenda, all of which call for immediate action from all nations working together in a global partnership. The emphasis on equity in the SDGs was institutionalized by switching from the MDG agenda's focus on relative global aims to setting absolute targets for each country (Department of Economic and Social Affairs, UN, 2022). The 17 SDGs, an urgent call for action by all nations – developed and developing – in a global partnership, are central to the SDG framework, which aspires to build on the successes of the MDG era (Mohandas, 2018).

Out of the 17 SDGs, the third goal (SDG-3) focuses on achieving good health and well-being. Every country is actively striving and implementing measures to achieve the targets outlined in SDG-3 by 2030. The 2030 agenda recognizes the intricate relationship between promoting good health and fostering sustainable development. It considers various challenges such as widening economic and social gaps, rapid urbanization, climate-related hazards, environmental concerns, the enduring prevalence of HIV and other infectious ailments, and emerging issues like non-communicable diseases. Moreover, it underscores the imperative for heightened attention to mental health issues (Joosse *et al.*, 2023). To attain universal health coverage, individuals need to be able to access essential healthcare services, receive financial protection against health-related risks, and access safe, effective, high-quality, and affordable medications. There has been notable advancement in extending life expectancy and diminishing certain primary causes of child and maternal deaths. Nevertheless, further actions are necessary to eliminate numerous diseases and tackle both enduring and emerging health challenges. Enhancing funding for health systems, advancing sanitation and hygiene standards, and augmenting access to medical professionals could lead to substantial advancements in preserving millions of lives (De Neve & Sachs, 2020).

For the past 2 years, the COVID-19 virus has caused unprecedented levels of human agony, led to a global economic downturn, and disrupted the lives of billions. Health crises like COVID-19 pose a global risk and underscore the urgent need for preparedness. The pandemic offers a turning point for investment in vital 21st-century public services and health emergency preparedness. Furthermore, to keep it at the highest priority, one of the targets envisaged under SDG-3 is improving the International Health Regulations' core capacity for all nations across the globe and within international borders (México *et al.*, 2018).

India has made tremendous progress toward achieving the SDG-3 targets as a result of the focused efforts of the Government of India (GoI), the Ministry of Health and Family Welfare (MoHFW), and various state health initiatives in both curative and public health services. On that note, this study aims to map the progress toward these goals by examining observational findings and CRM data. It will highlight good practices that have contributed to this progress and offer recommendations for areas needing further attention to accelerate the achievement of SDG-3. This study has three main objectives: (i) To provide a thorough, in-depth numerical assessment of India's progress toward SDG-3; (ii) to assess the comparative development of all SDG-3 indicators from 2015 to 2022, highlighting achievements and identifying areas for potential improvement; (iii) to describe advancements across various regions using evidence from CRM reports, suggest necessary measures for India up to 2030 and beyond, and investigate intersectoral and interdepartmental factors affecting health. This will ensure that the recommended approach for achieving the SDGs includes health in all policies.

2. Methods

This study employs a robust mixed-method framework to comprehensively assess India's advancements toward

achieving the SDG-3 targets, emphasizing healthcare and well-being outcomes. Through an exhaustive literature review of pertinent academic and policy literature, along with an analysis of government reports and national surveys, the study gathers quantitative data on key SDG-3 indicators from 2015 to 2022 (Serra *et al*., 2018; Setia, 2016; Wickham, 2019). Employing descriptive statistical analysis techniques, trends and progress in maternal health, child mortality, disease prevalence, and healthcare access are meticulously evaluated. In addition, qualitative insights from annual common review mission (CRM) reports are synthesized to identify effective interventions, challenges, and recommendations for enhancing healthcare delivery and public health programs (Creswell & Creswell, 2018; Godau, 2004; Hussain, 2013.; Ritchie *et al*., 2003). The authors analyzed the CRM reports available in the public domain. The CRM is a structured and comprehensive approach aimed at evaluating the functionality and efficacy of various programs under the National Health Mission across different states, as undertaken by the GoI. To date, 15 CRMs have been conducted with varying methods for selecting states and districts over various time frames. Factors such as geographic representation, population demographics, and health indicators were considered to ensure a representative sample. Multidisciplinary teams of 12 – 14 members were formed, led by an experienced public health professional overseeing the selected districts' evaluation process. Engagement with stakeholders at all levels is a key aspect of the methodology. The teams conducted interviews, focus group discussions, and interactions with various committees to gather perspectives and feedback and ensure community involvement. The published CRM documents systematically present findings, observations, and recommendations for each state. Detailed reports also highlight strengths, weaknesses, challenges, and opportunities for improvement in the evaluated areas.

By integrating numerical assessments, comparative development analyses, and qualitative findings, this study offers evidence-based recommendations to expedite India's journey toward SDG-3 targets by 2030, underscoring the imperative of inclusive health policies and intersectoral collaboration for sustainable progress. The Guidelines for Accurate and Transparent Health Estimates Reporting were followed in this study (Stevens *et al*., 2016).

2.1. Dimensions of the study

The current study incorporates all SDG-3 target indicators within a methodological framework. Based on the framework, all indicators were included in the analysis using data from 2015 and 2022 (the most recent survey and report). The analysis determined the current reduction rates and identified which states are on track to achieve the SDGs with their existing reduction rates. For states that are falling behind, the analysis calculated the rate of reduction needed to guide the targeted actions for those specific states. Apart from the health-related interventions, the study will also consider sectors affecting the social determinants of health to project a comprehensive and holistic health systems approach for achieving the SDGs.

2.2. Data sources

For secondary data, various data sources from the GoI have been explored and included. These data sources include the National Family Health Surveys, the Public Health Division of MoHFW, the National Centre for Disease Control, the Sample Registration System data reports, the *Ministry of Statistics and Programme Implementation* (MoSPI), the Global Adult Tobacco Survey, the Global Burden of Disease study, the Revised National TB Control Program Survey, the National Vector Borne Disease Control Programme (NVBDCP) annual reports, the National Crime Records Bureau reports, and the National AIDS Control Organization (NACO) annual reports field (MoHFW, 2022; 2021b; NACO, MoHFW, 2022; Registrar General of India, 2020).

2.3. Variables

The variables included in this study span the following domains: maternal health, newborn and child health; communicable diseases; non-communicable diseases and injuries; and health system strengthening. The analyzed variables include: percentage of births attended by skilled health personnel; percentage of institutional deliveries out of the total deliveries reported; percentage of currently married women (15 – 49 years) who use any modern family planning methods; percentage of women aged 15 – 19 years who were already mothers or pregnant; percentage of women aged 15 – 49 years who received four antenatal checkups (ANCs) or more for their last birth; percentage of children fully immunized; percentage of children under age 6 months exclusively breastfed; percentage of children under 5 years who are severely wasted (weight-for-height); prevalence of diarrhea in children under age 5 years; prevalence of adverse reaction to immunization (ARI) in children under age 5 years; number of TB cases notified/100,00 population; cure rate of TB patients (%); treatment success rate (%) of TB cases; percentage of loss to follow-up (TB cases); percentage of people living with HIV currently receiving antiretroviral treatment (ART) among the detected number of adults and children living with HIV; percentage of adults 15 years and above with use of any kind of tobacco (smoke and smokeless); percentage of population (men: 15 – 54 years) who consume alcohol;

number of individuals treated in de-addiction centers (in number); percentage of women aged 15 – 49 who have ever undergone cervix examinations; budgetary allocation for department of health research (in Rs [crore]); percentage of government spending (including current and capital expenditure) in health sector to gross domestic product (GDP); and total physicians nurses, and midwives per 10,000 population (Arora *et al*., 2017; Banke-Thomas *et al*., 2020; Dhakal, 2019; DHS, 2022; Karan *et al*., 2021; Nordenstedt & Rosling, 2016; Puram, 2020).

All variables were categorized into four key domains: maternal health, newborn and child health; communicable diseases; non-communicable diseases and injuries; and health system strengthening. The variables included in these domains are: maternal mortality ratio (MMR), neonatal mortality rate (NMR), under-five mortality rate (U5MR), mortality rates due to TB, HIV, dengue, suicides, road traffic injuries, and International Health Regulations core capacity (Doddamani *et al*., 2021).

2.4. Statistical analysis

The study conducted descriptive analyses of selected variables. Average annual rate of change (AARC) – both current and required to achieve SDGs – was calculated for outcome variables first, followed by exposure outcomes, using Statistical Package for the Social Sciences (SPSS) software. Qualitative data from CRM annual reports were collected, and quantitative findings were integrated with qualitative insights to provide robust evidence for further recommendations. The trend assessment for indicators was performed using SPSS to calculate the average annual growth rates (AGR) or AARC (Equation I).

$$AGR= (y^{t}/y^{t0})^{1/t-t0}-1 \quad (I)$$

3. Results

3.1. Quantitative result

The quantitative findings of this study revealed that at the current AARC (6.90%), India will not be able to achieve the MMR targets. The analysis indicated that the country must further improve the AARC for MMR, NMR, and U5MR from 6.90% to 7.80%, 3.40% to 5.40%, and 1.30% to 2.11%, respectively, to achieve the SDGs (Table 1).

Data from the state-specific reports of Assam, Uttar Pradesh (UP), and Madhya Pradesh (MP), showed that with the required AARC of 9%, 7.2%, and 7%, respectively, states need to strengthen effective strategies for reducing the MMR. Similarly, for NMR, states such as Chhattisgarh, MP, and UP need to work hard toward improving the current AARC by 7.7%, 9.5%, and 8.5%, respectively, by improving the vaccination coverage of women of childbearing age (married or unmarried) with tetanus toxoid, clean and skilled care at delivery, newborn resuscitation, exclusive breastfeeding, management of infections in the newborn, etc. Likewise, the analysis highlighted that UP and MP need to pace up by increasing the AARC by 5.1% and 7.1%, respectively, to achieve the required reduction in U5MR. The analysis further shows that mortality due to HIV and malaria incidence rates have significantly reduced in India and across its states since 2015. With this rate, the states and the country can achieve the SDGs on time.

Our findings highlighted that the current AARC for reducing the death rate due to road traffic accidents per 100,000 population is 6.5%. However, to achieve the required AARC, an annual reduction of 70.13% is required (Table 2). The states contributing majorly toward the needed improvement are Haryana, Karnataka, MP, Odisha, and Telangana, with required reductions in death rates of 162.88%, 135.63%, 100.25%, 77%, and 148.75%, respectively (Table 2). Likewise, for deaths attributed to unintentional poisoning per 100,000 population, Haryana and Himachal Pradesh achieved reduction rates of 26.63% and 39.88%, respectively (Table 3).

The current annual increment in TB cases notification rate per 100,000 population/year is relatively low in states such as Assam, Bihar, Chhattisgarh, UP, Andhra Pradesh, Kerala, Tamil Nadu, Jammu and Kashmir (J&K), and Puducherry, which is required to increase the annual TB notification rate by 18.25%, 20.5%, 19%, 358.25%, 21.6%, 22.8%, 20%, 22.8%, and 21%, respectively (Figure 1). The percentage of people living with HIV who are currently receiving ART among the detected number of adults and children per year is higher in southern states, with Kerala at 4.33% and Telangana at 7.33%. The latest findings of the International Health Regulations (IHR) core capacity index (Figure 2) showed that out of the 13 parameters, a change of 13 points and 20 points was observed in the National Health Emergency Framework and Laboratory Services, respectively, from 2018 to 2019, while the other 11 parameters remained unchanged (WHO, 2022).

3.2. Qualitative results

The study also reviewed the findings of the recent CRM conducted annually to provide a valuable understanding of successful strategies and those that require warranted mid-course adjustments. The findings indicate the various strategies and initiatives put in place by the central and state governments for reducing the global MMR to less than 70 per 100,000 live births, such as the incentivization of institutional deliveries through the *Janani Suraksha Yojana* (*JSY*) to benefit below poverty line (BPL) mothers, the establishment of Mayer Ghar transit homes in remote areas for safe deliveries, MCH clinics to provide ANC services at the level of primary health centers (PHCs)

Table 1. Expected MMR, NMR, and U5MR: Current AARC and AARC needed to achieve SDGs

MMR (Sample Registration System)			
National and state level	**Current MMR**	**Current AARC (%)**	**AARC needed to achieve the SDG goal (%)**
India	103	6.90	7.80
Assam	205	6.50	9.00
Madhya Pradesh	163	5.50	7.00
Uttar Pradesh	167	6.20	7.20
Haryana	96	1.70	2.60
Punjab	114	2.30	4.10
West Bengal	109	2.00	3.70
NMR (Sample Registration System)			
National and state level	**Current NMR**	**Current AARC (%)**	**AARC needed to achieve the SDG goal (%)**
India	20	3.40	5.40
Chhattisgarh	26	0.80	7.70
Madhya Pradesh	31	1.80	9.50
Odisha	28	4.50	8.50
Rajasthan	23	5.30	6.50
Uttar Pradesh	28	2.00	8.50
U5MR (National Family Health Survey-5)			
National and state level	**Current U5MR**	**Current AARC**	**AARC needed to achieve the SDG goal**
India	41.9	1.30	2.11
Chhattisgarh	41	3.20	4.90
Madhya Pradesh	51	3.90	7.10
Uttar Pradesh	43	3.40	5.40

Abbreviations: AARC: Average annual rate of change; MMR: Maternal mortality ratio; NMR: Neonatal mortality rate; SDG: Sustainable Development Goal; U5MR: Under-five mortality ratio.

and above, and the provision of reproductive, maternal, neonatal, child, and adolescents health (RMNCH+A) counselors at community health centers (CHCs) and higher centers. However, particular areas, such as the provision of medical termination of pregnancy (MTP) services at all levels of care, training of ANMs for both intrauterine devices and post-partum intrauterine devices (IUD and PPIUCD) insertion, increasing the footfall on fixed-day sterilization services, developing strategies for ensuring the uniform achievement of total fertility ratio (TFR) to replacement levels, ensuring constant availability of essential drugs in all states, training and capacity building of staff for ensuring adequate advocacy for family planning and spacing requirements, and strengthening of the maternal deaths review (MDR) mechanisms across the country, need focusing (MoHFW, 2021a).

In response to ending the epidemics of AIDS, TB, malaria, and neglected tropical diseases, as well as combating hepatitis and other infectious diseases, most states have successfully implemented the National Tuberculosis Elimination Programme (NTEP), using the NIKSHAY portal, and managed to control leprosy cases. However, some states still need to improve active case detection and regular surveillance, establish identified TB treatment centers, and ensure the availability of TB drugs and anti-rabies vaccines even at the lowest levels of healthcare facilities. Furthermore, differential implementation of the NVBDCP is observed at the primary level. The CRM findings did not highlight significant details regarding HIV/AIDS, neglected tropical diseases, and hepatitis.

To reduce premature mortality from non-communicable diseases by one-third by 2030, the findings suggest that many states have effectively implemented cataract-related services, tobacco control, and cessation measures and conducted routine surveillance for HBsAg and hepatitis vaccination. At the same time, many states are still reporting inconsistent implementation of the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS), the National Programme for Palliative Care (NPPC), the National Oral Health Programme (NOHP), and other non-communicable disease-related national health programs.

Table 2. Current annual reduction in deaths and required annual reduction in death attributed to road traffic accidents, unintentional poisoning, and suicides to achieve SDGs-2030

India and individual states	Current reduction rate in deaths due to road traffic accidents (per 1,00,000 population)	Required reduction rate in deaths due to road traffic accidents (per 1,00,000 population) till 2030	Current reduction rate in deaths attributed to unintentional poisoning (per 100,000 population)	Required reduction rate in deaths attributed to unintentional poisoning (per 100,000 population) till 2030	Current reduction rate in deaths due to suicide (per 1,00,000 population)	Require rate reduction in deaths due to suicide (per 1,00,000 population) till 2030
India	6.50	70.13	8.33	2.38	3.33	86.25
Gujarat	24.17	74.63	18.00	3.25	6.67	96.25
Haryana	5.17	162.88	5.00	26.63	25.00	137.50
Himachal Pradesh	13.50	111.25	14.17	39.88	5.00	56.25
Jharkhand	12.67	45.25	9.83	−0.63	28.33	11.25
Karnataka	14.17	135.63	23.50	11.63	5.00	170.00
Kerala	7.17	80.25	1.50	12.88	45.00	260.00
Madhya Pradesh	19.67	100.25	55.17	43.75	30.00	145.00
Maharashtra	3.00	68.75	9.50	0.75	20.00	148.75
Odisha	29.83	77.00	10.33	16.75	13.33	87.50
Punjab	18.17	125.13	−4.67	18.13	71.67	55.00
Rajasthan	20.50	93.63	18.67	18.25	16.67	28.75
Tamil Nadu	108.50	128.75	14.83	0.50	83.33	178.75
Telangana	295.17	148.75	11.67	6.88	118.33	213.75
Uttarakhand	15.67	47.38	24.83	7.75	1.67	13.75
Uttar Pradesh	24.17	52.13	2.50	10.13	10.00	13.75
West Bengal	26.33	2.25	2.33	3.75	45.00	118.75

Source: National Crime Records Bureau reports.

Furthermore, adequate and timely training, drugs, and diagnostics leading to high out-of-pocket expenditures (OOPE) remain a challenge in many states. The focus is on enhancing acceptance and utilization of contraception, particularly PPIUCD and male sterilization. The concerns regarding documentation of MTP forms and services in comprehensive abortion care are addressed, along with increased awareness and knowledge of family planning services.

To achieve universal health coverage, including financial risk protection, the GoI has implemented *Pradhan Mantri Jan Arogya Yojana* (PM-JAY), the world's largest health assurance scheme, providing cashless secondary and tertiary care services to eligible families. Several states like Andhra Pradesh, Bihar, Goa, Kerala, Meghalaya, Punjab, Tamil Nadu, and UP have integrated or merged PM-JAY with their existing health insurance schemes, providing additional benefits and coverage. Jharkhand, MP, and Telangana have made progress in card distribution and enrollment of beneficiaries. Still, some challenges were noted, such as underutilization of resources or limited coverage for specific populations. Other states, such as Chhattisgarh, Delhi, Nagaland, Rajasthan, and Sikkim, have yet to implement PM-JAY.

3.3. Integrated results

Our study revealed significant insights into India's progress toward achieving the SDG-3 targets across various health indicators. First, the analysis underscores the current AARC of 6.90% in India, suggesting a shortfall in achieving MMR targets. Notably, the requisite improvement in AARC for MMR, NMR, and U5MR is crucial to align with the SDGs, highlighting the imperative for intensified efforts in maternal and child health interventions nationwide. Furthermore, a positive trend is observed in the reduction of mortality rates attributed to HIV and malaria, reflecting the effectiveness of targeted interventions. Regional disparities emerge, with states like Assam, UP, and MP requiring substantial enhancements in maternal healthcare strategies to meet SDG targets.

Table 3. India's status concerning the achievement of SDG-3 targets until 2030

SDG-3 target indicators	India's status			
	2015	2022	Target for 2030	AARC (%) required to achieve the targets
MMR per 100,000 live births*	130	97	70	4.82
Births attended by skilled health personnel* (%)	81.4	89.4	100	1.33
Percentage of institutional deliveries out of the total deliveries reported*	78.9	88.6	100	1.43
Currently, married women (15 – 49 years) who use any modern family planning methods, 2015 – 2016* (%)	47.8	56.5	100	5.44
Women aged 15 – 19 years who were already mothers or pregnant, 2015 – 2016* (%)	7.9	6.8	5.3	3.54
Women aged 15 – 49 years for last birth received 4 ANCs or more* (%)	51.2	58.1	100	5.24
U-5 MR/1000 live births*	49.7	41.9	25	8.45
NMR/1000 live births*	29.5	24.9	12	13.44
Children fully immunized* (%)	62	76.4	100	2.95
Institutional deliveries out of total deliveries reported* (%)	78.9	88.6	100	1.43
Number of TB cases notified/100,000 population^	188	217	242	1.29
HIV incidence per 1000 uninfected population#	0.07	0.05	0	0.01
People living with HIV and currently receiving ART among the detected number of adults and children living with HIV#	62	84	73	1.88
Malaria incidence per 1000 populationa	0.92	0.13	0	0.02
Dengue case fatality ratioa	0.22	0.06	0	0.01
The proportion of grade-2 cases among new cases of leprosy (per million population)[a]	4.46	1.96	0	0.25
Blocks reporting <1% kala-azar case per 10,000 Population out of total endemic blocksa (%)	78.34	97.47	0	12.18
The death rate due to road traffic accidents (per 1,00,000 population)	11.81	11.42	5.81	12.07
Mortality rate attributed to unintentional poisoning per 100,000 population	2.08	1.58	1.39	1.71
Suicide mortality rate (per 1,00,000 population)	10.6	10.4	3.5	24.64
Number of persons treated in de-addiction centers (in number)	146124	128572	194832	4.25
Budgetary allocation for the Department of Health Research (in Rs. Crore)[b]	1018.17	2100	3054.51	5.17
Total physicians, nurses, and midwives per 10,000 populationb	35.8	31.3	45	3.81
IHR core capacity indexb	75.1	77.6	100	2.80

Sources: *National Family Health Survey reports.
^Revised National TB Control Program (RNTCP) Survey.
#National AIDS Control Organization (NACO) annual reports.
[a]National Vector Borne Disease Control Programme (NVBDCP) annual reports.
[b]Public Health Division of Ministry of Health and Family Welfare.
Abbreviations: AARC: Average annual rate of change; ANCs: Antenatal checkups; ART: Antiretroviral treatment; HIV: Human immunodeficiency virus; IHR: International Health Regulations; MMR: Maternal mortality ratio; NMR: Neonatal mortality rate; SDG: Sustainable Development Goal; TB: Tuberculosis; U5MR: Under-five mortality ratio.

Similarly, concerted efforts are warranted to improve NMR and U5MR, necessitating strengthened vaccination coverage and comprehensive healthcare delivery. The study identifies road traffic accidents, suicides, and non-communicable diseases as key areas necessitating urgent attention, with states such as Haryana, Karnataka, and Odisha demonstrating promising strides toward reducing mortality rates. Furthermore, TB notification rates and HIV treatment coverage underscore the need for enhanced surveillance systems and expanded treatment access. Qualitative findings from the CRM reports complement quantitative analyses, emphasizing successful maternal and newborn healthcare strategies while pinpointing gaps in family planning services, disease surveillance, and non-communicable disease management. Moreover, the integration of the PM-JAY health assurance scheme highlights progress toward universal health coverage, albeit with challenges related to resource utilization and coverage gaps in certain states. Overall, the comprehensive synthesis of quantitative and qualitative findings (Table S1) underscores the multifaceted challenges and opportunities in India's healthcare landscape, necessitating targeted interventions

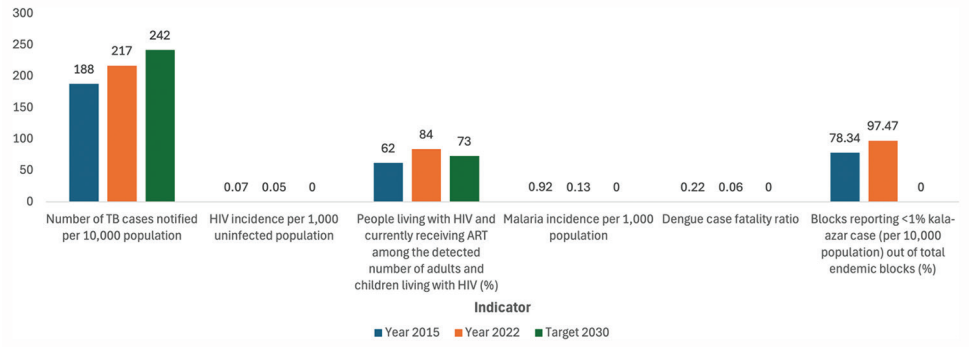


Figure 1. India's status toward achieving SDG-3 (communicable and non-communicable diseases) by 2030.
Abbreviations: ART: Antiretroviral treatment; HIV: Human immunodeficiency virus; SDG: Sustainable Development Goal; TB: Tuberculosis.

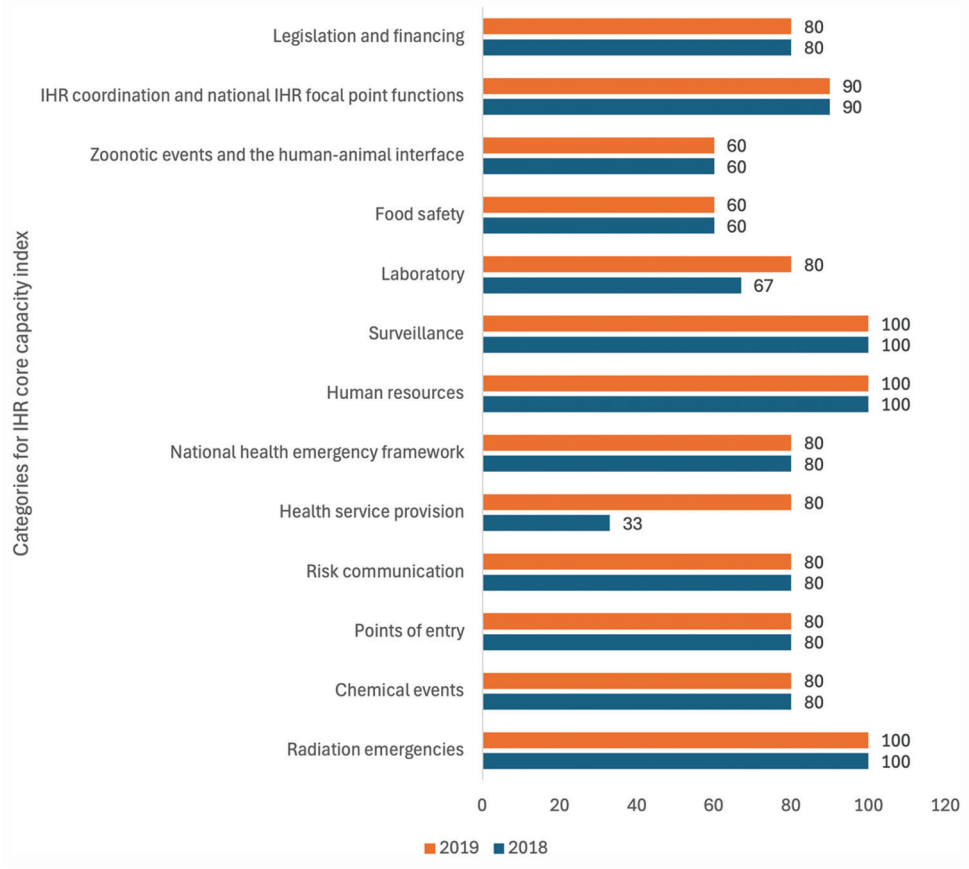


Figure 2. International Health Regulations core capacity index

and intersectoral collaborations to advance toward SDG-3 targets and achieve equitable health outcomes nationwide.

4. Discussion

Our analysis revealed that certain states within India, including Kerala, Tamil Nadu, Telangana, Karnataka, and Sikkim, will be able to achieve the SDG-3 targets in terms of outcome variables like MMR, NMR, and U5MR at the current AARC. Nevertheless, some Empowered Action Group and North-Eastern states like Bihar, Jharkhand, Assam, MP, and Rajasthan will not be able to achieve the SDG-3 targets until 2030 at the current pace of reducing mortalities and morbidities (Seidman, 2013).

The overall findings (Table 3) demonstrate that the indicators vary enormously among the states, and to achieve the SDG-3 targets, India needs to focus on

increasing AARC for several key indicators, including: percentage of currently married women (15 – 49 years) who use any modern family planning methods; percentage of women aged 15 – 49 years who received four ANCs or more for their last birth; number of TB cases notified per 100,000 population; and percentage of people living with HIV currently receiving ART among the detected number of adults and children living with HIV, by increasing the current AARC by 5.44%, 5.24%, 1.29%, and 1.88%, respectively (Singh *et al*., 2022). The study also highlighted the need for states to increase the AARC to achieve the required reduction in U5MR by improving the quality of immunization programs, particularly for measles and pneumonia, advancing the prevention and treatment of pneumococcal infections, and improving the overall nutritional and health status of children under 5 years of age is crucial. The opportunity and need for research that can alter life and livelihood are deeply felt across the country. Hence, exceptional focus and funding are necessary to create high-quality research-intensive institutions. For this, there is a need to increase the current annual budgetary allocation for the Department of Health Research by 5.17% to reach a yearly allocation of Rs 3054.51 crores (Table 3).

This study further highlighted that all the states and countries at the national level must prioritize non-communicable diseases, road traffic injuries, and suicide incidence to reduce mortalities to a greater extent to achieve the SDGs. State-specific data and planning are needed for this, which can be part of the Block Health Action Plan that feeds into district and state health action plans. Based on this, need-based planning should be done, considering the burden of various diseases and mortality rates (Mohandas, 2018).

Apart from health care services, preventive and health-promoting approaches targeting the community are essential to further reduce the burden of non-communicable diseases. Efforts should focus on raising awareness about mental health disorders and their common symptoms to reduce mortality due to suicides. Detailed planning for human resources and rational deployment of physicians and nurses at the state level is required to ensure an adequate workforce. Further, strengthening monitoring mechanisms and robust supportive supervision are needed at the state level (Our World in Data Team & Roser, 2023).

The study's emphasis on state-level planning for addressing non-communicable diseases, road traffic injuries, and suicide incidents is commendable. Still, the specific challenges and opportunities unique to each state are not extensively discussed. A more granular analysis of the contextual factors influencing healthcare outcomes could enhance the applicability of the recommendations. Moreover, the call for community-centric approaches and awareness campaigns for mental health disorders is essential. Hence, there is a need to study the potential cultural, social, and economic barriers that may impede the success of such initiatives in specific regions. Finally, while advocating for meticulous human resource planning and monitoring mechanisms, the study needs to provide frameworks or guidelines for implementing these recommendations. A more detailed exploration of best practices and potential challenges in executing these strategies would enrich the study's practical implications.

5. Conclusion

This study offers a nuanced understanding of the dynamic landscape of healthcare in various Indian states concerning SDG-3 targets. The disparities highlighted between states achieving remarkable progress and those encountering persistent challenges underscore the need for context-specific interventions. The strategic focus on key indicators, such as family planning, antenatal care, tuberculosis, and HIV treatment, provides actionable insights to align efforts with SDG-3 objectives. Notably, the call for increased research funding and attention to research-intensive institutions signifies a commitment to evidence-based policymaking. The study's emphasis on state-level planning for addressing non-communicable diseases, road traffic injuries, and suicide incidents recognizes the diverse health challenges faced by different regions. The recommendation for community-centric approaches and heightened awareness campaigns for mental health disorders reflects a holistic perspective on public health that extends beyond healthcare services. Furthermore, the study advocates for meticulous human resource planning and robust monitoring mechanisms to ensure the effectiveness of healthcare interventions. The proposed increase in the Department of Health Research's budgetary allocation underscores research's pivotal role in shaping comprehensive and impactful health policies.

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The authors declare that they have no competing interests.

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Data used in this work are available from the corresponding author on reasonable request.

References

Arora, N.K., Swaminathan, S., Mohapatra, A., Gopalan, H.S., Katoch, V.M., Bhan, M.K., *et al.* (2017). Research priorities in Maternal, Newborn, and Child Health and Nutrition for India: An Indian Council of medical research-INCLEN initiative. *The Indian Journal of Medical Research*, 145(5):611-622.

https://doi.org/10.4103/ijmr.IJMR_139_17

Banke-Thomas, A., Abejirinde, I.O.O., Ayomoh, F.I., Banke-Thomas, O., Eboreime, E.A., & Ameh, C.A. (2020). The cost of maternal health services in low-income and middle-income countries from a provider's perspective: A systematic review. *BMJ Global Health*, 5(6):e002371.

https://doi.org/10.1136/bmjgh-2020-002371

Creswell, J.W., & Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th ed. Cobalt Park: SAGE.

De Neve, J.E., & Sachs, J.D. (2020). The SDGs and human well-being: A global analysis of synergies, trade-offs, and regional differences. *Scientific Reports*, 10(1):15113.

https://doi.org/10.1038/s41598-020-71916-9

Department of Economic and Social Affairs, UN. (2022). *The 17 Goals|Sustainable Development*. Available from: https://sdgs.un.org/goals [Last accessed on 2025 Jan 10].

Dhakal, L. (2019). Cash flow statement analysis between commercial banks (With reference to Himalayan Bank Ltd. and Global IME Bank Ltd.). *American Journal of Industrial and Business Management*, 9(11):2025-2033.

https://doi.org/10.4236/ajibm.2019.911133

DHS. (2022). *National, State and Union Territory, and District Fact Sheets 2019-21 National Family Health Survey (NFHS-5)*. Available from: https://dhsprogram.com/publications/publication-of43-other-fact-sheets.cfm [Last accessed on 2025 Jan 10].

Doddamani, A., Ballala, A.B.K., Madhyastha, S.P., Kamath, A., & Kulkarni, M.M. (2021). A cross-sectional study to identify the determinants of non-communicable diseases among fishermen in Southern India. *BMC Public Health*, 21(1):414.

https://doi.org/10.1186/s12889-021-10376-w

Godau, R. (2004). Qualitative data analysis software: NVivo. *Qualitative Research Journal*, 4:66-78.

Hussain, Z. (2013). *Ritchie Qualitative Research Practice (1)*. Available from: https://www.academia.edu/42042948/ritchie_qualitative_research_practice_1 [Last accessed on 2025 Jan 10].

Joosse, I.R., Wirtz, V.J., Van Mourik, A.T., Wagner, B.A., Mantel-Teeuwisse, A.K., Suleman, F., *et al.* (2023). SDG indicator 3.b.3-an analysis of its robustness and challenges for measuring access to medicines for children. *BMC Health Services Research*, 23(1):574.

https://doi.org/10.1186/s12913-023-09554-w

Karan, A., Negandhi, H., Hussain, S., Zapata, T., Mairembam, D., De Graeve, H., *et al.* (2021). Size, composition, and distribution of health workforce in India: Why, and where to invest? *Human Resources for Health*, 19(1):39.

https://doi.org/10.1186/s12960-021-00575-2

México, V., Guégan, J.F., Suzan, G., Kati Coulibaly, S., Didier, N., Bonpamgue, *et al.* (2018). Sustainable development goal #3, "health and well-being," and the need for more integrative thinking. *Veterinaria Mexico*, 5:1-18.

https://doi.org/10.21753/vmoa.5.2.443

Mohandas, P. (2018). *Sustainable development goals (SDGs)-challenges for India. Indian Journal of Public Health Research and Development*, 9:1.

https://doi.org/10.5958/0976-5506.2018.00172.9

MoHFW. (2021). *14th Common Review Mission Report. National Health Mission*. Available from: https://nhm.gov.in/new_updates_2018/monitoring/14th_crm/14th_crm.pdf [Last accessed on 2025 Jan 10].

MoHFW. (2021b). *Release of NFHS-5 (2019-21)-Compendium of Factsheets-Ministry of Health and Family Welfare-GOI*. Available from: https://main.mohfw.gov.in/basicpage-14 [Last accessed on 2025 Jan 10].

MoHFW. (2022). *Annual Reports: Central TB Division*. Available from: https://tbcindia.gov.in/index1.php?lang=1&level=1&sublinkid=4160&lid=2807 [Last accessed on 2025 Jan 10].

NACO, MoHFW. (2022). *Reports National AIDS Control Organization MoHFW-GoI*. Available from: https://www.naco.gov.in/documents/reports [Last accessed on

2025 Jan 10].

Nath, A. (2011). India's progress toward achieving the millennium development goals. *Indian Journal of Community Medicine*, 36(2):85.

https://doi.org/10.4103/0970-0218.84118

Nordenstedt, H., & Rosling, H. (2016). Chasing 60% of maternal deaths in the post-fact era. *The Lancet*, 388(10054):1864-1865.

https://doi.org/10.1016/S0140-6736(16)31793-7

Our World in Data Team, & Roser, M. (2023). Ensure Healthy Lives and Promote Well-being for all at all Ages. *Our World in Data*. Available from: https://ourworldindata.org/sdgs/good-health-wellbeing [Last accessed on 2025 Jan 10].

Pandve, H. (2015). Health-related Millennium Development Goals: How Much India has progressed? *Archives of Medicine and Health Sciences*, 3(2):335.

https://doi.org/10.4103/2321-4848.171944

Paulson, K.R., Kamath, A.M., Alam, T., Bienhoff, K., Abady, G.G., Abbas, J., *et al.* (2021). Global, regional, and national progress toward Sustainable Development Goal 3.2 for neonatal and child health: All-cause and cause-specific mortality findings from the Global Burden of Disease Study 2019. *The Lancet*, 398(10303):870-905.

https://doi.org/10.1016/S0140-6736(21)01207-1

Registrar General of India. (2020). Sample Registration System-statistical Report. Vol. 1. SRS Annual Report. *Office of the Registrar General and Census Commissioner, India (ORGI)*, p.4. Available from: https://censusindia.gov.in/nada/index.php/catalog/42687 [Last accessed on 2025 Jan 10].

Ritchie, J., Lewis, J., Nicholls, C.M., & Ormston, R. (2003). *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. Cobalt Park: SAGE.

https://doi.org/10.5860/choice.41-1319

Seidman, G. (2013). Does SDG 3 have an adequate theory of change for improving health systems performance? *Journal of Global Health*, 7(1):010302.

https://doi.org/10.7189/jogh.07.010302

Serra, F.A.R., Martins, F.S., & Cunha, J.A.C. (2018). Secondary data in research-uses and opportunities. *Revista Ibero Americana de Estratégia*, 17(4):1-4.

https://doi.org/10.5585/riae.v17i4.2715

Setia, M.S. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology*, 61(3):261-264.

https://doi.org/10.4103/0019-5154.182410

Singh, L., Dubey, R., Singh, P.K., Nair, S., Rai, R.K., Rao, M.V.V., *et al.* (2022). Coverage of quality maternal and newborn healthcare services in India: Examining dropouts, disparity and determinants. *Annals of Global Health*, 88(1):39.

https://doi.org/10.5334/aogh.3586

Stevens, G.A., Alkema, L., Black, R.E., Boerma, J.T., Collins, G.S., Ezzati M., *et al.* (2016). Guidelines for accurate and transparent health estimates reporting: The GATHER statement. *The Lancet*, 388(10062):e19-e23.

https://doi.org/10.1016/S0140-6736(16)30388-9

United Nations Millennium Declaration. (2000). Available from: https://www.ohchr.org/en/instruments-mechanisms/instruments/united-nations-millennium-declaration [Last accessed on 2024 Oct 04].

WHO. (2022). International Health Regulations (IHR) Core Capacity Index. *Global Health Observatory*. Availabe from: https://www.who.int/data/gho/indicator-metadata-registry/imr-details/4824 [Last accessed on 2025 Jan 10].

Wickham, R.J. (2019). Secondary analysis research. *Journal of the Advanced Practitioner in Oncology*, 10(4):395-400.

https://doi.org/10.6004/jadpro.2019.10.4.7

ACCSCIENCE PUBLISHING

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BRIEF REPORT

AI chatbots and cybersecurity: What do they tell the public?

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Abstract

This study evaluates the performance of five large language model chatbots – ChatGPT, Copilot, Gemini, Claude, and Cohere – on topics related to cybersecurity, healthcare, and the environment. The chatbots were evaluated by asking five specific questions, and their responses were analyzed to determine how well they aligned with the cybersecurity principles outlined in the Paris Call. To assess the semantic similarity of their responses, 384-dimensional sentence embeddings from Hugging Face (HuggingFace.com) were used to calculate cosine distances, offering a quantitative measure of their alignment with the Paris Call principles. Repeated measures of analysis of variance (ANOVA) revealed no significant differences in how frequently the chatbots applied the nine Paris Call principles to individual questions, with similar application rates across the chatbots. However, a separate ANOVA across all five questions identified significant differences ($p = 0.011$) in the average use of these principles, suggesting that the chatbots likely rely on different datasets and did not consistently apply the principles across all questions. The study also found errors of omission, where certain key principles were left out of some responses. For example, several chatbots failed to mention critical elements, e.g. protecting the integrity of supply chains or ensuring accountability in technology use, highlighting gaps in their cybersecurity coverage. As a result, users may need to query multiple chatbots to gain comprehensive insights on these topics.

Keywords: Large language models; Artificial intelligence; Paris call for trust and security in cyberspace

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1. Introduction

Data security is crucial in healthcare as electronic health records (EHRs), data exchange, and interoperability becomes widespread (Cartwright, 2023; Javaid *et al.*, 2023; Kelly *et al.*, 2023). Patients and physicians need to access medical data securely in real-time to provide effective care (Chouhan *et al.*, 2023; Derecho *et al.*, 2024; Triplett, 2024).

Cyberthieves can exploit vulnerabilities in portals with weak security to commit crimes against individuals and institutions (Al-Hawamleh, 2023). Ransomware embedded in EHRs exposes patients' Social Security numbers and addresses, putting them at risk of cybercrime and identity theft (Dameff *et al*., 2023; van Boven *et al*., 2024).

The Paris Call for Trust and Security in Cyberspace was launched at the Paris Peace Forum in 2018, and it was supported by 81 countries (Bell & Mbaziira, 2023; Shull *et al*., 2019). It incorporates nine principles for international cybersecurity ("The 9 Principles," 2024). Although these principles have not been widely adopted in healthcare systems, they serve as a foundation for discussing cybersecurity standards. Hackers can gain access to protected health information and deploy malware in wearable devices that can directly impact patient health, including insulin pumps, continuous glucose monitors, pacemakers, and defibrillators (Badrouchi *et al*., 2020; George & George, 2023; Machal, 2023; Stergiopoulos *et al*., 2023).

Recently, two large corporations were the targets of cyberattacks. On February 21, 2024, ransomware was deployed on Change Healthcare's billing software, which is used by 900,000 doctors, 33,000 pharmacies, 5,500 hospitals, and 600 laboratories, making it one of the largest healthcare cyber thefts to date and prompting a federal investigation (Dyer, 2024). Similarly, on March 30, 2024, AT&T experienced a data breach affecting 8 million active users and 65 million former users (Ortiz, 2024). As stakeholders in Change Healthcare and AT&T, patients and physicians are increasingly concerned about such breaches.

With the rising prevalence of cybercrimes, several individuals whose identities have been compromised may turn to chatbots, such as ChatGPT, for answers. ChatGPT-3.5, a free and advanced large language model (LLM) launched by Open AI (San Francisco) on November 30, 2022, had more than 1 million users by December 4, 2022 (De Kok, 2024; Firat, 2023). Its natural language processing capabilities, powered by artificial intelligence (AI), enable it to auto-complete sentences and ideas (Pesl *et al*., 2023; Roumeliotis & Tselikas, 2023; Shen & Wang, 2023). Despite not being specifically designed for healthcare purposes, chatbots like ChatGPT are increasingly used by individuals for self-diagnosis and health-related queries, driven by performance expectancy and perceived benefits outweighing risks (Shahsavar & Chouhurry, 2023).

Physicians also turn to chatbots for information (Eppler *et al*., 2024; Tangadulrat *et al*., 2023; Temsah *et al*., 2023); however, several healthcare professionals and patients lack knowledge about cybersecurity and information technology. Therefore, the accuracy of the responses provided by the AI chatbots requires careful evaluation (Wasserman & Wasserman, 2022).

In the current era of global warming, both patients and physicians are becoming increasingly concerned about the environmental impact of cybersecurity on the planet (Alanazi & Alanazi, 2023). Blockchain technology, which plays a crucial role in cybersecurity systems, is known for its significant greenhouse gas emissions (Fernando & Saravannan, 2021). Despite these environmental concerns, there are no mandatory limits on greenhouse gas emissions for cybersecurity, only recommendations (Ratasha *et al*., 2024; Terán & Noelia, 2023). Cybersecurity's environmental impact has sparked discussions about sustainability in both the cybersecurity and healthcare sectors (Alshahrani *et al*., 2023; Kormiltsyn *et al*., 2023; Shi *et al*., 2023). Some academic institutions have proposed using consortia or groups to reduce the energy consumption of blockchain technology in healthcare cybersecurity (Fernando & Saravannan, 2021). On June 13, 2022, the American Medical Association advocated for carbon neutrality by 2050 and supported environmental policies as the climate crisis continues to affect global health (Jakubek, 2022).

There are currently no universally accepted cybersecurity standards (Table 1). In the United States, the National Institute of Standards and Technology (NIST) provides the NIST Cybersecurity Framework (CSF), which is designed to help organizations manage and reduce cybersecurity risks. The CSF comprises five core functions: Identify, Protect, Detect, Respond, and Recover.

Other risk management frameworks include ISO/IEC 27001, an international standard for information security management systems (ISMS), which offers a framework for establishing, implementing, maintaining, and improving ISMS with a focus on information security management. The Payment Card Industry Data Security Standard ensures the security of credit card information and sets requirements for companies that process, store, or transmit credit card data. The Center for Internet Security, a non-profit organization, develops best practices for cybersecurity, including controls and benchmarks.

For healthcare, the HITRUST Common Security Framework is a certified framework that offers a comprehensive, flexible, and efficient approach to regulatory compliance and risk management in healthcare information security.

1.1. Purpose

This study aims to evaluate AI-mediated LLM chatbot responses regarding general cybersecurity, healthcare cybersecurity, and the ecological footprint of cybersecurity.

Table 1. Brief overview of various industry standards

Standards	Descriptions	Focuses
ISO/IEC 27001	Int std, information security management	Information security management
NIST CSF	USA std: Five core functions: Identify, Protect, Detect, Respond, and Recover to manage CSR	CSR
COBIT	ISACA for IT governance	IT governance and management
PCI-DSS	Security of credit card info	Payment card information security
CIS	Best practice for CND	CND
GDPR	EU: data privacy of individuals	Data protection and privacy
OWASP	Efforts to improve software security	Web application security
HITRUST CSF	A framework for regulatory compliance/risk management	Healthcare information security
ISF	Investigates, clarifies, and resolves issues in information security	Information security best practices
Cyber Essentials	UK: Protect against cyber threats	Basic cybersecurity measures

Abbreviations: Int: International; Std: Standard; CSR: Cybersecurity risk management; ISACA: Information system audit and control association; CND: Cyber defense solutions; COBIT: Control objectives for information and related technologies; PCI-DSS: Payment card industry data security standard; GDPR: General data protection regulation; OWASP: Open web application security project; HITRUST CSF: Common security framework; ISF: Information security forum; IT: Information technology; NIST: National Institute of Standards and Technology.

2. Methods

Five questions were developed for the chatbot assessment: Question (Q1): What global standards exist for cybersecurity? Q2: How can cyberattacks on wearables for diabetic patients be prevented? Q3: Can blockchain technology play a role in cybersecurity and healthcare? Q4: What is the carbon footprint of blockchain technology in healthcare? Q5: What is the most eco-friendly cybersecurity system for EHRs?

The following five LLMs were chosen: ChatGPT 3.5, the free version of ChatGPT (Open AI, San Francisco); Copilot, formerly known as Bing Chat (Microsoft, Redmond); Gemini, which replaced Bard (Google, Mountain View); Claude, a B2B chatbot (Anthropic, San Francisco); and Cohere, another B2B chatbot (Cohere, Toronto). The chatbot responses were recorded in Google Docs for further analysis.

Table 1 lists the most common cybersecurity standards. No international standards are universally applied (Table 2). The nine principles of the Paris Call for Trust and Security in Cyberspace are listed verbatim below ("The 9 Principles," 2018) (Table 3). The exact wording was used later for semantic similarity analysis. The nine principles focus on enhancing cybersecurity and promoting responsible behavior in cyberspace. The principles are as follows:

- Principle 1: Protect individuals and infrastructure. Prevent and recover from malicious cyber activities that threaten or cause significant, indiscriminate, or systemic harm to individuals and critical infrastructure.
- Principle 2: Protect the Internet. Prevent activity that intentionally and substantially damages the general availability or integrity of the public core of the Internet.

Table 2. Q1

	ChatGPT	Copilot	Gemini	Claude	Cohere
ISO/IEC 27001	✓	✓	✓	✓	✓
NIST CSF	✓	✓	✓	✓	✓
COBIT	✓	✓		✓	✓
PCI-DSS	✓				✓
CIS	✓	✓		✓	:
GDPR	✓				
OWASP		✓			
HITRUST CSF				✓	
ISF					✓
Cyber Essentials					✓

Abbreviations: Int: International; Std: Standard; CSR: Cybersecurity risk management; ISACA: Information system audit and control association; CND: Cyber defense solutions; COBIT: Control objectives for information and related technologies; PCI-DSS: Payment card industry data security standard; GDPR: General data protection regulation; OWASP: Open web application security project; HITRUST CSF: Common security framework; ISF: Information security forum; NIST: National Institute of Standards and Technology.

- Principle 3: Defend electoral processes. Strengthen the capacity to prevent malign interference by foreign actors aimed at undermining electoral processes through malicious cyber activities.
- Principle 4: Defend intellectual property. Prevent information and communications technology-enabled theft of intellectual property, including trade secrets or other confidential business information, with the intent of providing competitive advantages to companies or commercial sector.

Table 3. The Paris Call/The 9 Principles

	ChatGPT	Copilot	Gemini	Claude	Cohere
(1) Prevent cyber activities that harm individuals	Q1, Q2, Q3	Q2, Q3	Q2, Q3	Q1, Q2	Q1, Q2, Q3
(2) Protect the accessibility of the Internet	-	-	-	-	-
(3) Defend the electoral process (elections)	-	-	-	-	-
(4) Prevent intellectual property/ICT theft	-	-	-	-	-
(5) Fight malware/malicious software	Q2, Q3	Q2, Q3	Q2, Q3	Q2	Q3
(6) Provide security of IOT, ICT	Q1, Q2, Q3	Q1, Q2, Q3	Q1, Q2	Q1, Q2, Q3	Q1, Q2, Q3
(7) Cyber hygiene education	Q2	Q2	Q2	Q2	Q2
(8) No retaliation, no hack backs	-	-	-	-	-
(9) Promote international implementation of responsible cyber behavior	Q1	Q1	Q1	Q1	Q1

Abbreviations: ICT: Information and communications technology; IOT: Internet of things.

- Principle 5: Non-proliferation. Develop ways to prevent the proliferation of malicious software and practices intended to cause harm.
- Principle 6: Lifecycle security. Strengthen the security of digital processes, products and services, throughout their lifecycle and supply chain.
- Principle 7: Cyber hygiene. Support efforts to strengthen advanced cyber hygiene for all actors.
- Principle 8: No private hackback. Take steps to prevent non-state actors, including the private sector, from hacking-back, for their own purposes or those of other non-state actors.
- Principle 9: International norms. Promote the widespread acceptance and implementation of international norms of responsible behavior as well as confidence-building measures in cyberspace.

The responses from each LLM were compared against the principles of the Paris Call's cybersecurity goals (Tables 2-8). Using Python, cosine distances were computed through a 384-dimensional sentence embedding vector from Hugging Face (huggingface.com) ("Sentence-transformers," n.d.). The cosine score is defined as the standard dot product between two vectors divided by their magnitude: $Cosine\,score(a,b)=\frac{a\cdot b}{\|a\|\cdot\|b\|}$ These embeddings were used to measure semantic similarity, with values closer to 1 indicating similar meaning and values closer to 0 implying unrelated content (Figure 1). Negative values suggest the sentences are related but likely convey opposite meanings.

3. Results

Using repeated measures analysis of variance (ANOVA), no significant differences were found in the average similarity scores for each of the Paris Call's principles per question, indicating that on average, the chatbots applied the principles at similar frequencies across individual questions (Figure 1). However, when performing repeated measures ANOVA to compare the average use of principles by each chatbot across all five questions, the analysis returned F = 2.78365 and p = 0.043184, suggesting significant differences. Thus, the five chatbots demonstrated differing emphases on the principles, which is likely due to aggregating data from varied sources.

Table 4. Average cosine score utilization across chatbots for each question

Principle	ChatGPT	Copilot	Gemini	Claude	Cohere
1	0.2981	0.29338	0.33782	0.33088	0.31794
2	0.25392	0.26942	0.25778	0.26904	0.28284
3	0.0848	0.09016	0.095	0.11826	0.091
4	0.27526	0.30572	0.27446	0.29684	0.29728
5	0.22764	0.24246	0.2463	0.27248	0.2303
6	0.31146	0.36688	0.33188	0.3511	0.36386
7	0.27238	0.27518	0.31402	0.30156	0.28854
8	0.12222	0.15424	0.13762	0.12384	0.112
9	0.15544	0.1556	0.17266	0.16382	0.17754

4. Discussion

The ISO/IEC 27001 standard is recognized globally, whereas the NIST CSF (National Institute of Science and Technology Cybersecurity Framework) is primarily used in the United States (ISO/IEC, 2022) (Table 2). The NIST CSF is freely accessible (Pascoe *et al.*, 2022), whereas ISO/IEC 27001 requires payment, limiting public access. None of the chatbots mentioned the risk of cyberattacks on insulin dosing and device functions, and the Health Insurance Portability and Accountability Act (HIPAA)

Table 5. Q2

	Chat GPT	Copilot	Gemini	Claude	Cohere
Secure design and development	✓	✓	✓	✓	✓
Software updates	✓	✓	✓	✓	✓
Authentication	✓	✓	✓		✓
Encryption	✓	✓	✓	✓	✓
User education	✓	✓	✓	✓	✓
Network security/secure communication	✓		✓	✓	✓
Privacy controls	✓	✓		✓	
Device management/monitoring	✓	✓			
Vendor risk management	✓				
Regulatory compliance		✓	✓	✓	✓
Standardization			✓		
Minimize data transmission			✓		
Secure data storage				✓	✓
Regular risk assessment				✓	✓
Collaboration between manufacturers and healthcare providers					✓

Table 6. Q3

	ChatGPT	Copilot	Gemini	Claude	Cohere
Immutable ledger	✓	✓	✓		
Cryptogenic hashing	✓		✓		✓
Permissioned access	✓		✓	✓	✓
Smart Contracts	✓	✓		✓	
Pseudonymity	✓	✓			✓
Zero-knowledge proofs	✓				
Track and trace	✓	✓	✓	✓	✓
Verification of authenticity	✓	✓	✓	✓	✓
Decentralization	✓	✓	✓	✓	
Secure Identity Management	✓			✓	✓
Interoperability	✓	✓		✓	✓
Clinical Trials	✓	✓	✓	✓	✓
Secure transactions		✓			
Reducing costs		✓			
Secure medical records		✓	✓	✓	✓
Streamlined communication			✓		✓

was scarcely referenced (Table 2). The lack of emphasis on HIPAA results in information asymmetry because it may be the only healthcare cybersecurity standard that the public is familiar with. Historically, LLMs have not been adequately trained in healthcare cybersecurity due to inadequate protections in the field (Wasserman & Wasserman, 2022). Cybersecurity in medicine is not a significant revenue generator and has often been neglected, gaining attention only after the high-profile cyberattacks in 2024.

In addition, many medical devices still rely on outdated communication methods, such as fax machines, CDs, and USB drives, which hinder the development of advanced cybersecurity protocols. In recent years, the healthcare sector has experienced major cyberattacks, including

Table 7. Q4

	ChatGPT	Copilot	Gemini	Claude	Cohere
Ecological impact of healthcare individually	✓		✓		✓
Ecological impact of Blockchain individually	✓	✓	✓	✓	✓
Blockchain in healthcare, no ecological impact		✓			
Ecological impact of Blockchain in healthcare				✓	✓

Table 8. Q5

	ChatGPT	Copilot	Gemini	Claude	Cohere
Energy efficiency	✓	✓	✓	✓	✓
Cloud-based solutions	✓		✓	✓	✓
Renewable energy usages	✓		✓		✓
Minimal hardware footprint	✓			✓	
Lifecycle management	✓			✓	
Optimized resource utilization	✓		✓	✓	
Continuous monitoring	✓				✓
Standards compliance	✓	✓			
E-waste reduction		✓	✓	✓	✓
Blockchain integration		✓			✓
Green smart contracts		✓			
Remote workforce enablement				✓	
Secure data sharing					✓
Cybersecurity training			✓		✓

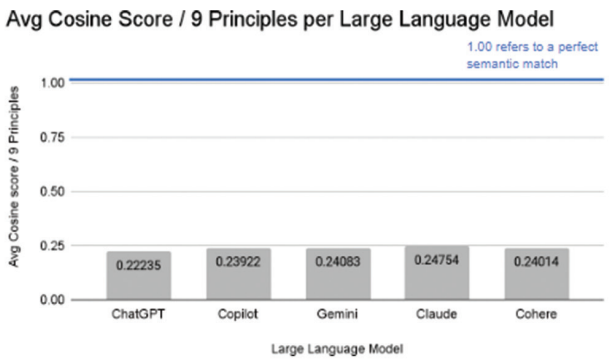


Figure 1. Average cosine scores over the Paris call principles per large language model

attacks against HCA Healthcare in 2023 and Change Healthcare in 2024. Between 2015 and 2020, there were 113 million cyberattacks in healthcare, and ransomware attacks increased globally by 102% from May 2020 to May 2021 (Minnaar & Herbig, 2021; Reddy *et al.*, 2023). Despite this, there is still a lack of widely adopted cyber hygiene standards within the healthcare community.

The Paris Call for Trust and Security in Cyberspace outlines nine principles aimed at all Internet users. As healthcare professionals, we must protect all stakeholders in the medical industry: Patients, physicians, nurses, hospitals, and ancillary healthcare providers. This includes safeguarding patient information, billing details, and credit card information.

LLMs, introduced with ChatGPT in November 2022, are relatively new developments. Healthcare cybersecurity and environmental impacts are topics that LLMs likely have not been adequately trained to address. This study highlights the limitations of LLMs in these areas.

Moreover, the environment itself is a crucial stakeholder. A healthy planet is essential for ensuring healthy lives and patients. Current cybersecurity rules and regulations do not factor the impact of cybersecurity on the environment. Maintaining AI chatbots is energy-intensive, and AI consumers are still in their infancy; thus, these systems are likely to "know" the extent of their environmental impact, which remains largely unknown.

5. Conclusion

The chatbots deliver a range of responses that contain useful information but also exhibit omissions. Users may need to consult multiple chatbots to obtain a comprehensive response.

If healthcare stakeholders – patients, doctors, and healthcare providers – repeatedly ask similar questions, chatbot responses will evolve to reflect those prompts. User queries essentially provide free training for these AI-powered systems. Notably, chatbot response improved from March 2023 to April 2024, with increased sophistication following the introduction of models, such as Google's PaLM 2 and Meta's LLama 2. Physicians and patients alike participated in the broader LLM experiment.

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Conflict of interest

The authors declare no conflicts of interest.

Author contributions

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Writing–review & editing: Gloria Wu, Adrial Wong, Milan Del Buono, Mary Nguyen, Hasini Namala

Ethics approval and consent to participate

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Consent for publication

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Availability of data

Data are available from the corresponding author upon reasonable request.

References

Alanazi, A.T., & Alanazi, A. (2023). Clinicians' perspectives on healthcare cybersecurity and cyber threats. *Cureus*, 15(10):e47026.

https://doi.org/10.7759/cureus.47026

AL-Hawamleh, A.M. (2023). Predictions of cybersecurity experts on future cyber-attacks and related cybersecurity measures. *International Journal of Advanced Computer Science and Applications*, 14(2).

https://doi.org/10.14569/IJACSA.2023.0140292

Alshahrani, H., Islam, N., Syed, D., Sulaiman, A., Al Reshan, M.S., Rajab, K., *et al.* (2023). Sustainability in blockchain: A systematic literature review on scalability and power consumption issues. *Energies*, 16(3):1510.

https://doi.org/10.3390/en16031510

Arsenault, A.C., Kreps, S.E., Snider, K.L., & Canetti, D. (2024). Cyber scares and prophylactic policies: Cross-national evidence on the effect of cyberattacks on public support for surveillance. *Journal of Peace Research*, 61(3):413-428.

https://doi.org/10.1177/00223433241233960

Badrouchi, F., Aymond, A., Haerinia, M., Badrouchi, S., Selvaraj, D.F., Tavakolian, K., *et al.* (2020). Cybersecurity vulnerabilities in biomedical devices: A hierarchical layered framework. *Internet of Things Use Cases for the Healthcare Industry*. Cham: Springer, p.157-184.

https://doi.org/10.1007/978-3-030-37526-3_7

Bell, N., & Mbaziira, A. (2023). Exploring a Diplomatic System of Cooperation in the Cyber Space through a Proposed Cyber Diplomacy Cooperation Framework. In: International Conference on Cybersecurity and Cybercrime. Vol. 10, p.7-11.

https://doi.org/10.19107/CYBERCON.2023.01

Biswas, S.S. (2023). Role of chat GPT in public health. *Annals of Biomedical Engineering*, 51(5):868-869.

https://doi.org/10.1007/s10439-023-03172-7

Cartwright, A.J. (2023). The elephant in the room: Cybersecurity in healthcare. *Journal of Clinical Monitoring and Computing*, 37(5):1123-1132.

https://doi.org/10.1007/s10877-023-01013-5

Choudhury, A., & Shamszare, H. (2023). Investigating the impact of user trust on the adoption and use of ChatGPT: Survey analysis. *Journal of Medical Internet Research*, 25:e47184.

https://doi.org/10.2196/47184

Chouhan, A.S., Qaseem, M.S., Basheer, Q.M.A., & Mehdia, A. (2023). Blockchain based EHR system architecture and the need of blockchain in healthcare. *Materials Today: Proceedings*, 80:2064-2070.

https://doi.org/10.1016/j.matpr.2021.06.114

Dameff, C., Tully, J., Chan, T.C., Castillo, E.M., Savage, S., Maysent, P., *et al.* (2023). Ransomware attack associated with disruptions at adjacent emergency departments in the US. *JAMA Network Open*, 6(5):e2312270.

https://doi.org/10.1001/jamanetworkopen.2023.12270

De Kok, T. (2024). ChatGPT for Textual Analysis? How to Use Generative LLMs in Accounting Research. SSRN.

https://doi.org/10.2139/ssrn.4429658

Derecho, K.C., Cafino, R., Aquino-Cafino, S.L., Isla, A. Jr., Esencia, J.A., Lactuan, N.J., *et al.* (2024). Technology adoption of electronic medical records in developing

economies: A systematic review on physicians' perspective. *Digital Health*, 10:20552076231224605.

https://doi.org/10.1177/20552076231224605

Dyer, O.(2024). US hospitals face collapse as cyberattack on UnitedHealth cuts revenue streams. *BMJ*, 384:q686.

https://doi.org/10.1136/bmj.q686

Eppler, M., Ganjavi, C., Ramacciotti, L.S., Piazza, P., Rodler, S., Checcucci, E., *et al*. (2024). Awareness and use of ChatGPT and large language models: A prospective cross-sectional global survey in urology. *European Urology*, 85(2):146-153.

https://doi.org/10.1016/j.eururo.2023.10.014

Fernando, Y., & Saravannan, R. (2021). Blockchain technology: Energy efficiency and ethical compliance. *Journal of Governance and Integrity*, 4(2):88-95.

https://doi.org/10.15282/jgi.4.2.2021.5872

Firat, M. (2023). How Chat GPT can Transform Autodidactic Experiences and Open Education? OSF Preprints.

https://doi.org/10.31219/osf.io/9ge8m

Fox, S., & Duggan, M. (2013). Health online 2013, p.1-55. Available from: https://www.pewresearch.org/internet/2013/01/15/health-online-2013 [Last accessed on 2024 Jul 08].

George, A.S., & George, A.H. (2023). The emergence of cybersecurity medicine: Protecting implanted devices from cyber threats. *Partners Universal Innovative Research Publication*, 1(2):93-111.

https://doi.org/10.5281/zenodo.10206563

Hugging Face. (n.d.). Available from: https://huggingface.co/sentence-transformers/all-minilm-l6-v2 [Last accessed on 2024 Jul 08].

ISO/IEC 27001:2022. ISO. (2022). https://www.iso.org/standard/27001 [Last accessed on 2024 Jul 08].

Jakubek, K. (2022). AMA Adopts New Policy Declaring Climate Change a Public Health Crisis. American Medical Association. Available from: https://www.ama-assn.org/press-center/press-releases/ama-adopts-new-policy-declaring-climate-change-public-health-crisis [Last accessed on 2024 Jul 08].

Javaid, M., Haleem, A., Singh, R.P., & Suman, R. (2023). Towards insighting cybersecurity for healthcare domains: A comprehensive review of recent practices and trends. *Cyber Security and Applications*, 1:100016.

https://doi.org/10.1016/j.csa.2023.100016

Kelly, B., Quinn, C., Lawlor, A., Ronan, K., & Burrell, J. (2023) Cybersecurity in healthcare. In: Trends of Artificial Intelligence and Big Data for E-Health. Germany: Springer Nature, p.213-231.

https://doi.org/10.1007/978-3-031-11199-0

Kormiltsyn, A., Udokwu, C., Dwivedi, V., Norta, A., & Nisar, S. (2023). Privacy-conflict resolution for integrating personal and electronic health records in blockchain-based systems. *Blockchain in Healthcare Today*, 6(2):6.

https://doi.org/10.30953/bhty.v6.276

Machal, M.L. (2023). An overview about connected medical devices and their risks. *Studies in Health Technology and Informatics*, 305:119-122.

https://doi.org/10.3233/SHTI230438

Minnaar, A., & Herbig, F.J.W. (2021). Cyberattacks and the cybercrime threat of ransomware to hospitals and healthcare services during the COVID-19 pandemic. *Acta Criminologica*: *African Journal of Criminology and Victimology*, 34(3).

https://hdl.handle.net/10520/ejc-crim_v34_n3_a10

Ortiz, A. (2024). AT and T Resets Millions of Passcodes after Customer Records are Leaked. The New York Times. Available from: https://www.nytimes.com/2024/03/30/business/att-passcodes-reset-data-breach.html [Last accessed on 2024 Jul 08].

Pascoe, C., Quinn S., & Scarfone K. (2024). The NIST Cybersecurity Framework (CSF) 2.0. NIST Cybersecurity White Papers (CSWP).

https://doi.org/10.6028/NIST.CSWP.29

Pesl, R.D., Stötzner, M., Georgievski, I., & Aiello, M., (2023). Uncovering LLMs for Service-composition: Challenges and Opportunities. In: International Conference on Service-Oriented Computing, p.39-48.

https://doi.org/10.18419/darus-3767

Ratasha, M.A.B., Ismail, M.S.B., Aziz, A.S.A., Williams, G., & Rees, E. (2024). Towards Net Zero-better Decision Making for Enterprise Level Green House gas (GHG) Emission Management and Accounting. In: International Petroleum Technology Conference, D021S052R005.

https://doi.org/10.2523/IPTC-23574-MS

Reddy, J., Elsayed, N., ElSayed, Z., & Ozer, M. (2023). A review on data breaches in healthcare security systems. *International Journal of Computer Applications*, 184(45):1-4.

https://doi.org/10.5120/ijca2023922333

Roumeliotis, K.I., & Tselikas, N.D. (2023). Chatgpt and open-ai models: A preliminary review. *Future Internet*, 15(6):192.

https://doi.org/10.3390/fi15060192

Sallam, M, Salim, N.A., Barakat, M., & Al-Tammemi, A. (2023). ChatGPT applications in medical, dental, pharmacy, and public health education: A descriptive study highlighting the advantages and limitations. *Narra J*, 3(1).

https://doi.org/10.52225/narra.v3i1.103

Shahsavar, Y., & Choudhury, A. (2023). User intentions to use ChatGPT for self-diagnosis and health-related purposes:

Cross-sectional survey study. *JMIR Human Factors*, 10(1):e47564.

https://doi.org/10.2196/47564

Shen, C., & Wang, Y. (2023). Concerned or apathetic? Exploring online public opinions on climate change from 2008 to 2019: A comparative study between China and other G20 countries. *Journal of Environmental Management*, 332:117376.

https://doi.org/10.1016/j.jenvman.2023.117376

Shi, X., Xiao, H., Liu, W., Lackner, K.S., & Stocker, T.F. (2023). Confronting the carbon-footprint challenge of blockchain. *Environmental Science and Technology*, 57(3):1403-1410.

https://doi.org/10.1021/acs.est.2c05165

Shull, A., Boysen, A., Holland, B., Hathaway, M., Fay, R., Desai, N., *et al.* (2019). Governing Cyberspace During a Crisis in Trust. Centre for International Governance Innovation. Available from: https://www.cigionline.org/publications/governing-cyberspace-during-crisis-trust [Last accessed on 2024 Jul 08].

Stergiopoulos, G., Kotzanikolaou, P., Konstantinou, C., & Tsoukalis, A. (2023). Process-aware attacks on medication control of type-I diabetics using infusion pumps. *IEEE Systems Journal*, 17(2):1831-1842.

https://doi.org/10.1109/JSYST.2023.3236690

Tangadulrat, P., Sono, S., & Tangtrakulwanich, B. (2023) Using ChatGPT for clinical practice and medical education: Cross-sectional survey of medical students and physicians perceptions. *JMIR Medical Education*. 9(1):e50658.

https://doi.org/10.2196/50658

Temsah, M.H., Aljamaan, F., Malki, K.H., Alhasan, K., Altamimi, I., Aljarbou, R., *et al.* (2023). Chatgpt and the future of digital health: A study on healthcare workers perceptions and expectations. *Healthcare*, 11(13):1812.

https://doi.org/10.3390/healthcare11131812

Terán, M., & Noelia, H. (2023). Environmental sustainability and ICT: A look at impact factors. LUTPub. Available from: https://lutpub.lut.fi/handle/10024/165468 [Last accessed on 2024 Jul 08].

The 9 Principles. (2018) Paris Call. Available from: https://pariscall.international/en/principles [Last accessed on 2024 Jul 08].

Triplett, W.J. (2024). Cybersecurity vulnerabilities in healthcare: A threat to patient security. *Cybersecurity and Innovative Technology Journal*, 2(1):15-25.

https://doi.org/10.53889/citj.v2i1.333

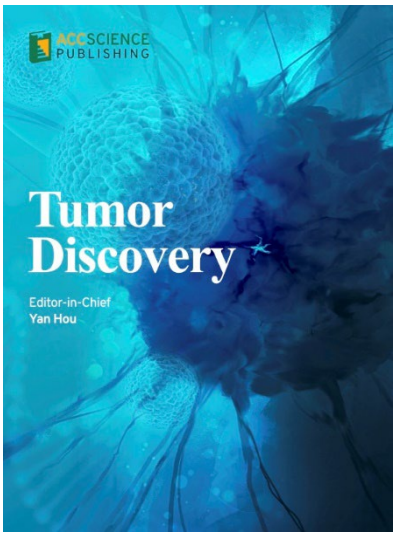
Van Boven, L.S., Kusters, R.W., Tin, D., Van Osch, F.H.M., De Cauwer, H., Ketelings, L., *et al.* (2024). Hacking acute care: A qualitative study on the health care impacts of ransomware attacks against hospitals. *Annals of Emergency Medicine*, 83(1):46-56.

https://doi.org/10.1016/j.annemergmed.2023.04.025

Wasserman, L., & Wasserman, Y. (2022). Hospital cybersecurity risks and gaps: Review (for the non-cyber professional). *Frontiers of Digital Health*, 4:862221.

https://doi.org/10.3389/fdgth.2022.862221

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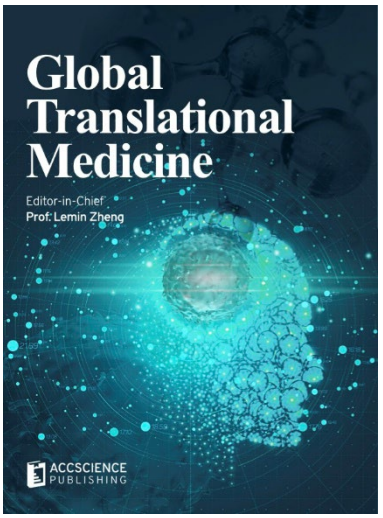


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