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REVIEW ARTICLE

Juvenile crimes and drugs: A review of structural and psychosocial determinants in the context of drug decriminalization

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Abstract

Drug-related juvenile crimes in refugee camps are a growing concern, shaped by structural vulnerabilities. This review synthesizes existing literature on drug-related juvenile crimes in refugee settings, focusing on how social disorganization, structural neglect, and psychosocial deprivation increase vulnerability among displaced children, and argues for a public health–oriented decriminalization approach to prevention and rehabilitation. Drawing upon international and regional studies published between 2017 and 2024, the paper highlights how poverty, forced migration, trauma, limited education, and exposure to drug trafficking networks contribute to youth delinquency in refugee camps. Using social disorganization, delinquent subculture, rational choice, and structural functionalism theories, the review identifies five key thematic drivers: economic marginalization, peer and gang influence, normalization of drug culture, lack of family supervision, and absence of rehabilitation services. In light of contemporary debates on drug decriminalization, the review argues that punitive approaches to drug-related juvenile offences often reinforce structural disadvantages, criminalize poverty, and hinder social reintegration. Instead, a public health-oriented decriminalization framework can mitigate these harms by shifting focus from punishment to rehabilitation, prevention, and community reintegration. The consequences of maintaining criminalization extend beyond individual harm, contributing to broader community insecurity, increased drug dependency, and undermined law and order. The paper concludes by recommending a multisectoral prevention and recovery framework that aligns with decriminalization principles, emphasizing community-based rehabilitation, psychosocial counseling, drug awareness education, and integrated child protection systems anchored in social work and public health models. Such an approach advances restorative justice and promotes long-term well-being for at-risk juveniles in fragile and displaced settings.

Keywords: Juvenile crime; Drug abuse; Drug decriminalization; Psychosocial distress; Social disorganization; Rehabilitation

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1. Introduction

The United Nations Convention on the Rights of the Child (UNCRC), adopted in 1989, defines a child as "any human being under the age of 18 unless the age of majority is attained earlier under national legislation." Countries that have ratified or acceded to this convention are legally bound by its provisions. The term juvenile generally refers to individuals under 18 years of age who have not yet attained adulthood, with minor exceptions based on jurisdiction. McFarlane *et al.* (2023) reported that the global population has reached eight billion, of which approximately 2.3 billion are under the age of 18. Juveniles represent the foundation of future leadership, innovation, and social progress. Turkay & Tirthali (2010) emphasized that leadership skills such as teamwork, civic engagement, determination, volunteerism, and a sense of collective responsibility are crucial for nurturing this potential.

However, the global reality is stark. Alkire *et al.* (2023), in the Global Multidimensional Poverty Index, noted that out of 6.1 billion people across 110 countries, 1.1 billion live in poverty, and among them, 566 million are under the age of 18. Juveniles are disproportionately vulnerable to abuse, neglect, delinquency, and a range of socioeconomic deprivations, which are often exacerbated in contexts of displacement, statelessness, and forced migration.

According to the United Nations High Commissioner for Refugees (UNHCR, 2023), over 100 million people have been forcibly displaced worldwide due to persecution, conflict, and human rights violations—an unprecedented figure in recorded history. Among the most complex and long-standing humanitarian crises is the Rohingya displacement, representing one of the world's largest stateless populations. Piper (1993) describes the Rohingya as descendants of a diverse lineage, including Moorish, Arab, and Persian traders, as well as Moghul, Turk, Pathan, and Bengali settlers who arrived between the ninth and 15th centuries.

Children and adolescents in refugee camps face conditions of structural deprivation, overcrowded shelters, food insecurity, poor sanitation, limited education, and restricted psychosocial support (Hossain *et al.*, 2021). These multidimensional hardships create fertile ground for the rise of juvenile delinquency and substance-related crimes. In recent years, humanitarian reports and independent studies have documented a worrying trend: the infiltration of drug trafficking networks and organized criminal gangs within and around refugee settlements. These groups exploit vulnerable children, using them as couriers, lookouts, or small-scale distributors of narcotic substances such as methamphetamine, heroin, and cannabis.

Drug abuse and trafficking have thus become deeply intertwined with juvenile crime in refugee environments. The American Bar Association (2023) and Together Free (2020) describe forced criminality as a form of exploitation where individuals, often minors, are coerced into committing crimes, including drug smuggling, production, and sale, under threats, manipulation, or false promises of financial gain. Emotional coercion, social pressure, and peer recruitment by adult offenders further blur the boundary between victim and perpetrator. Children involved in such acts are frequently misclassified as offenders rather than as victims of trafficking and exploitation.

The normalization of drug-related activities among juveniles in camps has broad social and public health implications. Besides introducing adolescents to criminal networks, it increases the risk of substance dependence, violence, and long-term psychological trauma. Juvenile involvement in drug trafficking also perpetuates the cycle of poverty, exclusion, and stigmatization, similar patterns observed in national rehabilitation studies such as Malaysia's *i-Pulih* model, where relapse and reintegration challenges are linked to social stigma, inadequate treatment continuity, and lack of structural support.

In this context, drug decriminalization emerges as a critical policy lens for rethinking how juvenile drug offences are conceptualized and managed. Instead of treating youth drug involvement purely as criminal behavior, decriminalization reframes it as a public health and social welfare concern, emphasizing prevention, rehabilitation, and harm reduction over punitive control. This approach aligns with the principles of the UNCRC, which calls for the protection, recovery, and reintegration of children in conflict with the law. By shifting from criminalization to decriminalization, governments can reduce incarceration rates, prevent the reinforcement of social marginalization, and provide community-based alternatives that address structural and psychosocial determinants of drug use.

Given these interrelated risks, this review synthesizes evidence on the causes and consequences of juvenile involvement in drug-related crimes in refugee camps. It also examines how systemic neglect, weak enforcement, and limited access to preventive and rehabilitative services contribute to the escalation of such crimes. Finally, the review proposes an integrated framework grounded in social work, public health, and decriminalization principles to support prevention, rehabilitation, and policy coordination for protecting juveniles from drug exploitation and associated criminality.

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1.1. Literature review

This review engages with relevant literature and draws on theories addressing the refugee crisis, with particular focus on juveniles and their exposure to drug-related risks. Hopkins *et al.* (1994) reported that Southeast Asian refugee juveniles often face severe mental health issues, academic failures, limited awareness of their migration history, lack of parental guidance, involvement in intra-community conflicts, and an absence of victim-offender rehabilitation programs. These conditions create a fertile environment for delinquent behavior, including substance abuse, as adolescents seek coping mechanisms for trauma, displacement, and social exclusion. Drug use among displaced juveniles, often beginning with inhalants and over-the-counter medications, is reported as both a symptom of distress and a pathway to deeper criminal involvement when manipulated by organized networks. Within this context, punitive drug policies tend to exacerbate vulnerability by criminalizing youth who require psychosocial care rather than incarceration. A shift toward drug decriminalization would instead allow for early intervention, rehabilitation, and social support consistent with human rights and child protection principles.

The Norwegian Refugee Council (NRC, 2018) outlined 10 significant challenges faced by refugee juveniles: (i) Difficulty obtaining legal recognition; (ii) lack of access to quality education, learning, and skills-building opportunities; (iii) cultural clashes; (iv) limited employment prospects; (v) gender-based discrimination and violence; (vi) inadequate psychosocial support; (vii) restricted freedom of movement and insufficient safety and security; (viii) vulnerability of unaccompanied minors; (ix) exclusion from decision-making processes; and (x) limited knowledge about refugee rights and services. Each of these vulnerabilities is closely intertwined with the escalating trend of drug trafficking and consumption in refugee settings. Limited education and employment prospects, for instance, push adolescents toward illicit economies such as drug peddling, while the lack of psychosocial support leaves them vulnerable to substance dependence as a form of escapism. The decriminalization of drug use provides an alternative framework to address these root causes by treating substance abuse as a public health issue and by integrating social services within refugee governance systems.

Mallick (2020) highlighted growing concerns about the long-term existence of refugee camps in Cox's Bazar, noting that their prolonged presence poses severe challenges to governance and social order. BBC News (2023) reported that drug smuggling and human trafficking gangs have turned life in Cox's Bazar into a nightmare for nearly one million Rohingya refugees who fled Myanmar in 2017. By mid-July 2023, 48 deaths had been recorded due to gang violence, surpassing the total fatalities reported in 2022. The report underscored the deteriorating security and the growing entanglement between organized crime and the narcotics trade. Armed groups, including the Arakan Rohingya Salvation Army, the Rohingya Solidarity Organization, and the Munna Gang, have been accused of abducting individuals for ransom, enforcing forced marriages, and recruiting children into drug trafficking and other illegal activities (Human Rights Watch, 2023). Such networks exploit the poverty and despair within camps, using juveniles as couriers, lookouts, and low-level distributors of narcotics, offering small monetary incentives in return. A decriminalization approach could help distinguish between traffickers and exploited juveniles, ensuring that the latter receive protection, counseling, and reintegration rather than punishment.

Sivan *et al.* (1999) observed that despite rising adolescent gang activity among Southeast Asian immigrants, there remains a paucity of research on gang recruitment and substance-related crimes among adolescent refugees. Adolescent refugees from Bosnia, Guatemala, and Haiti are particularly at risk of being targeted by criminal organizations involved in drug trading and cross-border smuggling. Prevention and intervention programs aimed at ensuring their reintegration and well-being remain severely limited, allowing the cycle of drug-fueled violence and juvenile delinquency to persist. Similarly, Ivert & Magnusson (2020) found that unaccompanied refugee minors across Europe are often exposed to high-risk environments that increase their susceptibility to substance abuse and criminal involvement. Many such children go unacknowledged in international policy frameworks; their untreated mental health issues, combined with chronic displacement and lack of supervision, heighten their risk of drug dependence and coercion into trafficking networks. Decriminalization policies could serve as an enabling mechanism to bridge these service gaps by directing resources toward psychosocial treatment, harm reduction, and community rehabilitation, rather than penalization.

Orr & Ajzenstadt (2020) analyzed the discursive process of criminalization of African asylum seekers in Israel, demonstrating how marginalized social groups are constructed as criminal threats and subsequently subjected to heightened surveillance. The same logic applies to displaced juveniles who become entangled in drug-related offences not as primary perpetrators, but as visible symbols of social disorder. Criminalization of adolescent asylum seekers is facilitated by their portrayal

as "infiltrators" beyond state control. This rhetoric connects border violations with drug-related criminality and violence, emphasizing their perceived potential for deviance while ignoring structural neglect and trauma. Lane (2018) further argued that the causes, consequences, and effective responses to juvenile crime, particularly when linked to drugs and forced criminality, remain overlooked by the broader research community. The principles of drug decriminalization challenge this punitive paradigm by recognizing that many juvenile offenders are, in fact, victims of structural violence, coercion, and systemic neglect.

In summary, the reviewed literature reveals that drug-related juvenile crimes in refugee contexts stem from a convergence of structural, psychosocial, and economic determinants. Persistent marginalization, peer influence, and the normalization of narcotics within informal economies perpetuate cycles of delinquency. The absence of sustainable rehabilitation frameworks and psychosocial interventions exacerbates these challenges. Incorporating drug decriminalization into juvenile protection strategies would align legal systems with human rights norms, reduce incarceration, and promote a coordinated, multisectoral approach integrating social work, public health, and community-based recovery to mitigate the drug–crime nexus among refugee juveniles.

1.2. Conceptual framework

This review draws on four key theoretical perspectives: Social disorganization, delinquent subculture, rational choice, and structural functionalism. These frameworks collectively explain the structural and psychosocial underpinnings of juvenile crimes and provide a foundation for re-evaluating punitive drug policies through the lens of drug decriminalization.

The social disorganization theory, introduced by Shaw & McKay (1942), posits that environmental factors, particularly residential location, are stronger predictors of criminal behavior than individual traits. According to this theory, deteriorating physical environments, poverty, and high levels of ethnic heterogeneity contribute significantly to criminal activity, especially among youth. The breakdown of community-based control mechanisms, coupled with rapid migration into fragile contexts and the normalization of deviant values, facilitates juvenile delinquency. Within the context of drug-related offenses, social disorganization is further intensified in refugee settings where weak institutional oversight and a lack of social capital enable the spread of drug trafficking networks. The theory supports the argument that decriminalization policies, by shifting emphasis from punishment to community rehabilitation, can help restore social cohesion and strengthen informal social controls.

The delinquent subculture theory, proposed by Cohen (1955), suggests that juvenile gangs arise as a collective response to shared frustrations and socio-economic marginalization. These subcultures are non-utilitarian, negativistic, and often malicious in nature, offering limited material benefit to members. Instead, they provide emotional solidarity and a means to assert identity and resistance. Economic injustice is a key driver of youth gang formation and perpetuation. In refugee contexts, adolescents often internalize deviant subcultural norms as adaptive responses to exclusion and despair. Drug decriminalization, when paired with targeted psychosocial interventions, can disrupt this cycle by reducing stigmatization and reintegrating youth into constructive community roles. Rather than reinforcing criminal identities through incarceration, decriminalization offers opportunities for rehabilitation, education, and social reintegration.

The rational choice theory, initially articulated by Moffitt, (1993) and later adapted for use in criminology, posits that individuals make rational decisions by weighing the potential benefits and consequences of their actions. In the context of juvenile crime, however, this theory is somewhat limited, as children often lack the cognitive maturity to fully assess risks and rewards. Their decisions are heavily influenced by environmental pressures, peer influence, and adult manipulation. Nevertheless, the theory remains relevant in understanding how punitive systems often fail to deter juvenile offenders who perceive minimal alternatives for survival or belonging. The decriminalization approach acknowledges this limitation by prioritizing prevention and harm reduction over deterrence. Removing harsh penalties for minor drug offenses redirects focus toward creating rational incentives for youth participation in education, skill-building, and social rehabilitation.

Structural functionalism, as formulated by Parsons (1951), views society as a system composed of interrelated elements, such as customs, norms, institutions, and traditions, that function together to maintain order. Structural functionalists in the field of criminal justice argue that law enforcement and judicial institutions serve to uphold social cohesion by delineating acceptable and unacceptable behavior (Browning, 2015). However, in settings where punitive drug laws disproportionately affect marginalized juveniles, the system may lose its integrative function and instead perpetuate exclusion. Through the lens of drug decriminalization, structural functionalism supports the restoration of institutional balance where health, education, and social welfare systems function alongside justice mechanisms to rehabilitate rather than penalize young offenders.

These theories have been supported and applied in various studies. For example, Nielsen *et al.* (2005) utilized the social disorganization theory to examine patterns of criminality in selected refugee zones in the United States. A. Islam (2021) employed the delinquent subculture theory to understand refugee-related crimes in Estonia. Gul (2009) demonstrated the cross-disciplinary application of the rational choice theory among criminologists, sociologists, and psychologists. Phillimore (2021) drew on elements of structural functionalism to analyze the well-being of refugees affected by social disorder.

The incorporation of these theoretical perspectives in the present study is well-aligned with existing scholarly literature and provides a strong conceptual foundation for understanding how drug decriminalization can serve as a structural reform mechanism to address the root causes of juvenile crime.

1.3. Study objectives

This review examines the major factors that contribute to juvenile involvement in drug-related and forced criminal activities within refugee camps, with particular attention to how structural deprivation, psychosocial distress, and weak governance systems shape these behaviors.

It also assesses the broader social, psychological, and security consequences of juvenile participation in drug-related offences across refugee settlements, highlighting the interplay between organized crime, drug dependency, and community instability.

Finally, this review proposes evidence-based policy recommendations that promote a shift from punitive control to restorative and public health approaches through drug decriminalization, community-based rehabilitation, psychosocial support, and regional cooperation.

2. Data and method

2.1. Study design

The study design outlines a systematic process aimed at developing a comprehensive understanding of the relationship between juvenile delinquency, forced criminality, and drug-related involvement in refugee camps. Emphasizing the review-based approach, this study consolidated and interpreted previous research to identify recurring patterns, theoretical perspectives, and intervention gaps related to drug-fueled juvenile crime among displaced populations. It also critically explored how drug decriminalization frameworks can reshape existing responses to juvenile drug offences from punitive control toward public health, social protection, and rehabilitation.

Creswell (2014) conceptualized research design as a staged and iterative process that guides data collection, analysis, and the establishment of reliability and validity in pursuit of research objectives. In line with this, the present research adopted a narrative review approach, which synthesizes academic, policy, and grey literature rather than collecting primary field data. The review aims to uncover thematic connections between structural deprivation, psychosocial distress, and the proliferation of drug-related activities among juveniles in refugee settings. In addition, it analyses how criminalization versus decriminalization policies influence the treatment, rehabilitation, and social reintegration of juveniles involved in drug-related crimes.

The theoretical foundation of this review is informed by social disorganization, delinquent subculture, rational choice, and structural functionalism, each of which provides a lens for interpreting how environmental instability, socioeconomic hardship, and weak social control mechanisms drive youth involvement in crime and substance use. These theoretical perspectives also guide the discussion on how decriminalization policies may strengthen community-based rehabilitation, restore informal social controls, and reduce the stigmatization associated with drug use among displaced juveniles.

To ensure a comprehensive and balanced synthesis, peer-reviewed journal articles, institutional reports, and policy papers published between 2017 and 2024 were systematically reviewed. The selection emphasized studies focusing on drug trafficking, substance abuse, juvenile delinquency, forced criminality, and drug policy reform, particularly those examining the transition from punitive to decriminalized frameworks. Major databases, including Scopus, Web of Science, SpringerLink, Taylor & Francis Online, and Google Scholar, were consulted, along with publications from UNHCR, the United Nations Children's Fund, the United Nations Office on Drugs and Crime, the International Organization for Migration (2016), and Human Rights Watch.

This systematic and interpretive design allowed for a multidimensional understanding of juvenile crime in refugee contexts while evaluating the potential of drug decriminalization as a transformative policy pathway for reducing vulnerability, promoting rehabilitation, and strengthening social reintegration among at-risk juveniles.

2.2. Literature selection and inclusion criteria

Following Braun & Clarke's (2006) thematic synthesis framework, this review incorporated both empirical and conceptual studies to capture the multidimensional nature of juvenile drug-related crimes in refugee contexts. The inclusion criteria were guided by five key parameters.

The first was topical relevance, focusing on studies addressing juvenile delinquency, forced criminality, or drug-related issues within refugee or displaced populations. The review covered publications from 2017 to 2024, reflecting the post-migration escalation of organized crime and narcotics trade in refugee settlements (BBC News, 2023; Human Rights Watch, 2023). The types of sources included were peer-reviewed journal articles, reports from non-governmental organizations, government policy documents, and assessments from international agencies, to ensure a comprehensive understanding across various sectors. The language criterion restricted the review to English-language publications to maintain analytical consistency.

The final parameter, theoretical contribution, emphasized works offering insight into criminological, psychological, or social work approaches to rehabilitation, prevention, and the evolving discourse on drug decriminalization as an alternative to punitive control. Studies focusing solely on adult criminality, non-refugee contexts, or unrelated health issues were excluded. Employing a narrative synthesis approach enabled a deeper interpretation of cross-cutting themes, integrating macro-level policy debates, such as the shift toward decriminalization, with micro-level psychosocial dynamics that shape juvenile vulnerability and resilience within refugee environments.

A total of 112 documents were initially identified. After screening titles and abstracts, 68 sources met the inclusion criteria. These consisted of 41 peer-reviewed journal articles, 17 reports from non-governmental organizations or humanitarian agencies, and 10 government or policy documents. Of these, 29 sources specifically addressed refugee camps or displaced youth, while 14 publications discussed drug policies, harm reduction, or decriminalization. Making these categories explicit strengthens methodological transparency and addresses concerns regarding the "black box" nature of the review.

2.3. Data collection and management

Instead of conducting field interviews, data for this review were collected through a systematic literature retrieval and content extraction process. Using Preferred Reporting Items for Systematic Reviews and Meta-Analyses-informed screening procedures to enhance transparency, articles were screened through title and abstract review, followed by full-text evaluation. Each selected document was coded according to recurring themes such as drivers of juvenile drug use, organized criminal exploitation, psychosocial stressors, rehabilitation models, and policy frameworks. Particular attention was given to literature discussing the implications of drug criminalization and decriminalization on juvenile treatment, rehabilitation, and reintegration within refugee settings.

The review emphasized identifying common push-and-pull factors such as poverty, social exclusion, peer influence, and exposure to narcotic networks that contribute to juvenile involvement in drug peddling and consumption. Sources from Human Rights Watch (2023), the NRC (2018), and the United Nations Office on Drugs and Crime (2020) were cross-referenced to triangulate data reliability and strengthen interpretive validity.

In accordance with best practices in qualitative synthesis (Azman *et al.*, 2019; Creswell, 2014; Hung *et al.*, 2023; Yusof *et al.*, 2022; Azman *et al.*, 2020; Singh *et al.*, 2019; Rashid *et al.*, 2023), data were managed using ATLAS.ti software (version 25) to code textual content, identify patterns, and consolidate thematic findings. Codes were refined iteratively to highlight emerging interconnections between drug-related vulnerabilities, the structural conditions of refugee camps, and evolving policy discourses surrounding drug decriminalization as a framework for reducing harm and promoting rehabilitation among at-risk juveniles.

A total of 112 records were identified, 81 remained after duplicates were removed, 68 were screened in full text, and 54 were included in the final synthesis. Each source was coded using a structured template capturing location, population focus, type of drug risk, theoretical relevance, and policy implications.

2.4. Reliability and validity

Cypress (2017), Rashid *et al.*, (2020), and Singh *et al.*, (2023) emphasized the importance of ensuring process-oriented reliability and validity in qualitative and review-based studies. To maintain methodological rigor, the present review adhered to several key validation steps. Cross-source triangulation was employed to verify consistency across multiple data sources, including academic studies, government reports, and publications from non-governmental organizations. Peer-reviewed bias minimization was ensured by prioritizing literature published in indexed journals to strengthen scholarly credibility. Transparency and traceability were maintained through detailed documentation of inclusion and exclusion criteria, ensuring auditability and replicability of the review process. Conceptual coherence was upheld by ensuring that all findings and interpretations aligned with the theoretical lenses applied and with the broader analytical framework of drug decriminalization, which situates juvenile drug involvement within a rehabilitative and public health paradigm rather than a punitive one.

Internal consistency was further strengthened through inter-textual comparison (Sarstedt *et al.*, 2019). For example, recurring references to juvenile participation in methamphetamine distribution (BBC News, 2023) were cross-checked with reports on organized recruitment of youth by militant groups and narcotics syndicates (Human Rights Watch, 2023; Ivert & Magnusson, 2020). This triangulated approach enhanced reliability while enabling a nuanced understanding of how structural deprivation, coercion, and punitive legal responses interact, reinforcing the relevance of drug decriminalization as a framework for reforming juvenile justice and protection in refugee settings.

2.5. Data analysis

Kerrigan (2014) described qualitative analysis as a deliberate and systematic process of interpreting text through categorization and the identification of recurring patterns. Guided by this approach, all sources included in this review were carefully read and coded using thematic analysis, which involved iterative reading, the extraction of key phrases, and the synthesis of insights under broader analytical categories. The analysis was organized around five core themes: (i) Socioeconomic and structural drivers of drug involvement; (ii) psychosocial and cultural enablers of juvenile delinquency; (iii) drug trafficking as a mechanism of forced criminality; (iv) the impact of these issues on community safety, health, and rehabilitation; and (v) preventive, policy, and decriminalization frameworks relevant to drug control and youth empowerment.

Each theme was validated through multi-source convergence, ensuring that findings reflected both empirical evidence and theoretical perspectives. The analysis highlighted how punitive approaches to drug control often intensify structural vulnerability, perpetuating cycles of exclusion and criminalization among refugee juveniles. Conversely, the integration of drug decriminalization within policy discourse emerged as a transformative framework repositioning drug use and juvenile involvement in narcotic networks as symptoms of systemic neglect rather than individual moral failure. This interpretive lens aligns with the social justice and harm reduction principles central to public health and social work paradigms, advocating for rehabilitation, community reintegration, and preventive intervention over punishment.

Each document was coded through a three-stage process: (i) Open coding of key concepts, (ii) axial coding linking structural, psychosocial, and policy dimensions, and (iii) selective coding to consolidate the five overarching themes. This explicit process clarifies how patterns were derived and removes ambiguity regarding how the review informed the proposed framework.

3. Results

The reviewed studies collectively emphasize that refugee adolescents, especially those residing in protracted camp settings, are highly vulnerable to delinquent behavior, including substance use and drug trafficking. Across Southeast Asian, Middle Eastern, and African contexts, researchers consistently highlight the convergence of deprivation, trauma, and exposure to organized criminal networks as primary catalysts of juvenile crime (BBC News, 2023; Hopkins *et al.*, 1994; Human Rights Watch, 2023; Ivert & Magnusson, 2020; NRC, 2018). These vulnerabilities are amplified by poor living conditions, limited access to education, psychosocial instability, and weak law enforcement capacity in camps.

The synthesis reveals that drug-related criminality has become an increasingly central feature of juvenile delinquency in refugee populations. Adolescents are exploited as couriers and small-scale dealers of narcotics, most commonly methamphetamine (Yaba), heroin, and cannabis, driven by economic need, peer pressure, and coercion from adult-led syndicates (BBC News, 2023; Human Rights Watch, 2023). In contexts where punitive laws dominate, such adolescents are often treated as offenders rather than victims of structural exploitation. The literature, therefore, reinforces the need to reconsider current criminalization practices and move toward drug decriminalization frameworks that emphasize rehabilitation, protection, and harm reduction over punishment.

3.1. Structural and socio-economic drivers of juvenile drug involvement

Refugee adolescents, particularly those living in long-term camp settings, are highly susceptible to drug-related delinquency due to overlapping structural and economic vulnerabilities. Widespread deprivation, poverty, and the lack of basic needs such as food, shelter, and education compel many to seek alternative livelihoods through drug trafficking and smuggling (BBC News, 2023; Hopkins *et al.*, 1994; NRC, 2018). Limited humanitarian aid from agencies such as the World Food Programme and UNHCR often fails to meet the growing needs of displaced populations, while the absence of vocational training and livelihood opportunities reinforces dependency and frustration. Under a drug decriminalization framework, such behaviors are better interpreted as socioeconomic survival responses, calling for livelihood interventions and skill development programs rather than punitive sanctions.

3.2. Psychosocial distress, peer influence, and the pathways to addiction

Psychosocial distress is another major catalyst for juvenile drug involvement. Exposure to war, displacement, and family separation can contribute to trauma, anxiety, and depression and, in the absence of counseling, may increase the likelihood of drug use as a coping mechanism (Hopkins *et al.*, 1994; Ivert & Magnusson, 2020). Social isolation, peer influence, and the lure of monetary gain or revenge further pull juveniles into drug networks (Ali *et al.*, 2022; Human Rights Watch, 2023). Punitive incarceration tends to deepen this cycle, while decriminalization-oriented approaches emphasize trauma-informed care and diversion to rehabilitation. Low participation in civic and moral education (NRC, 2018), combined with idleness resulting from limited recreational opportunities (Oke *et al.*, 2024), fosters environments where substance use becomes both entertainment and an escape.

3.3. Organized exploitation and cross-border drug networks

The infiltration of organized criminal and militant groups into refugee camps intensifies the crisis. Adolescents are frequently recruited into drug trafficking, extortion, and smuggling operations, often under coercion or threat (BBC News, 2023; Human Rights Watch, 2023). Camps located near porous borders, such as those in Cox's Bazar, face heightened exposure to cross-border narcotics flows (Oke *et al.*, 2023). Within punitive systems, these adolescents are criminalized despite being victims of manipulation. In contrast, decriminalization frameworks recognize them as exploited individuals who require protection, psychosocial rehabilitation, and social reintegration. This perspective realigns policy responses with humanitarian and child protection principles by distinguishing between traffickers and trafficked victims.

3.4. Consequences and policy implications in the context of decriminalization

The consequences of juvenile drug-related crime are far-reaching. Drug proliferation destabilizes camp governance, erodes law and order, and fuels violence (Human Rights Watch, 2023). Families experience fear, trauma, and social stigma (Ivert & Magnusson, 2020; Oke *et al.*, 2022), while substance misuse leads to health crises such as sexually transmitted diseases, overdoses, and untreated mental illness (United Nations Office on Drugs and Crime, 2022). Furthermore, juvenile participation in the narcotics trade undermines regional peace and security by facilitating transnational smuggling networks. Orr & Ajzenstadt (2020) argue that criminalization reflects systemic failure to protect vulnerable youth. By contrast, drug decriminalization aligns with human rights and child welfare mandates by reframing juvenile offenders as victims of structural neglect rather than moral deviance. It encourages community-based rehabilitation, preventive education, and restorative justice as key pathways toward reducing harm, promoting recovery, and rebuilding resilience among displaced youth.

4. Discussion

This discussion interprets the reviewed evidence on refugee juveniles' involvement in forced criminality and organized crimes, with a specific focus on drug exposure, use, and trafficking. It connects these patterns to broader policy, socioeconomic, cultural, environmental, legal, and political contexts, while also aligning the analysis with four theoretical lenses: social disorganization, delinquent subculture, rational choice, and structural functionalism. The section concludes by considering how a drug decriminalization framework could address structural vulnerabilities, support rehabilitation, and enhance regional security and juvenile well-being.

Across the literature, refugee juveniles are consistently shown to navigate long-standing poverty, disrupted education, and social exclusion (Hopkins *et al.*, 1994). These conditions, often intensified in congested camps with limited access to essential services, are directly linked to elevated risks of substance use and coercion into narcotics markets. The Global Multidimensional Poverty Index highlights that material deprivation and constrained opportunities act as push factors into informal, high-risk economies, including drug couriering, small-scale distribution, and other forms of "forced criminality" (American Bar Association, 2023; NRC, 2018; Together Free, 2020). From a policy standpoint, this underscores the limitations of punitive responses and supports the adoption of drug decriminalization measures that reframe drug involvement as a socioeconomic and public health issue requiring structural intervention, rather than punishment.

The social disorganization theory provides a powerful lens to explain why drug-related crimes are concentrated in refugee environments where formal and informal control mechanisms are weakened. Community disruption, overcrowding, and rapid in-migration correlate with higher juvenile exposure to narcotic networks and lower collective efficacy to prevent recruitment. Evidence from displacement contexts demonstrates that poverty, fragile institutions, and political volatility amplify these risks (Doğan, 2024; Hossain *et al.*, 2021). Reports of drug smuggling, gang violence, and trafficking in and around camps (BBC News, 2023; Human Rights Watch, 2023) illustrate how systemic disorganization facilitates narcotics

supply chains that actively target adolescents. By contrast, decriminalization policies that promote harm reduction and community-based rehabilitation can strengthen social cohesion and empower local structures to disrupt recruitment networks through inclusion rather than exclusion.

The delinquent subculture theory further illuminates how youth subcultures emerge as collective responses to blocked opportunities. Refugee adolescents facing unemployment, scarce education, and limited recreation often form peer bonds around shared frustration, using drugs as a means of coping and belonging (I. Islam & Naing, 2023; NRC, 2018). While these subcultural dynamics are evident, the literature also shows that juveniles are frequently exploited by adult traffickers and militant groups, indicating manipulation more than voluntary deviance (Human Rights Watch, 2023). Hence, drug decriminalization frameworks can be seen as complementary to subcultural insights, as they shift the response from stigmatization to rehabilitation, emphasizing psychosocial support, mentorship, and skill development to redirect peer solidarity toward pro-social goals.

The explanatory power of the rational choice theory appears limited in this setting. Although small financial gains from drug couriering may seem "rational" under extreme scarcity, the literature reveals that many juveniles act under manipulation, coercion, or misinformation (Abdul Rahman *et al.*, 2022; Hopkins *et al.*, 1994; Human Rights Watch, 2023). Emotional trauma and untreated mental health conditions further constrain their capacity for reasoned decision-making (Ivert & Magnusson, 2020). The decriminalization paradigm responds to this by recognizing the bounded agency of juveniles, acknowledging that rational decision-making is compromised by survival pressures and psychosocial stressors, and prioritizing diversion programs, psychosocial counseling, and community-based treatment over incarceration.

From a structural functionalist perspective, persistent breakdowns in formal institutions, such as education, child protection, and justice systems, alongside weakened informal norms, like community guardianship, erode the social equilibrium necessary for youth safety. In many host states, legal and moral panics construct displaced adolescents as "criminal others" or "infiltrators" (Orr & Ajzenstadt, 2020), legitimizing punitive interventions that reinforce cycles of marginalization. Conversely, drug decriminalization restores the integrative role of institutions by aligning justice, health, and welfare systems around restorative and rehabilitative functions. It ensures that juveniles apprehended in drug contexts are treated as victims of exploitation, entitled to recovery and reintegration (American Bar Association, 2023; Khuda, 2019).

The literature also exposes under-recognized harms associated with the drug economy, such as sexual exploitation, coercion, forced marriages, and intra-group violence, all of which are intensified by substance dependency and trafficking disputes (BBC News, 2023; Hossain *et al.*, 2021; Human Rights Watch, 2023). These dynamics fuel fear, erode social trust, and spread insecurity beyond camps, threatening broader peace and stability. Lane (2018) observes that scholarship still under examines the intersections between drugs, displacement, and juvenile crime, leaving significant policy gaps in prevention and rehabilitation.

Emerging debates around local integration and rights-based decriminalization point toward sustainable solutions. Expanding refugees' access to education, legal documentation, and safe employment can mitigate drug-driven recruitment by creating legitimate opportunities (London School of Economics and Political Science, 2021). Simultaneously, decriminalization policies offer a pragmatic middle ground, reducing the harms of incarceration, destigmatizing drug use, and investing in community-based recovery models that align with UNCRC principles. As the evidence suggests, effective reform requires a balanced approach that couples rights-based inclusion and harm reduction with robust child protection, anti-trafficking enforcement, and socioeconomic investment.

The discussion affirms that juvenile drug-related crime in refugee settings is not merely a product of individual deviance but a manifestation of structural deprivation, psychosocial distress, and institutional failure. Integrating drug decriminalization within regional and national strategies offers a transformative pathway, one that humanizes policy responses, strengthens social systems, and enhances both individual recovery and collective security across South and Southeast Asia. The contribution of this review lies in synthesizing three previously disconnected strands of scholarship: forced criminality among refugee juveniles, structural and psychosocial determinants of drug-related behavior, and the emerging discourse on drug decriminalization. While each strand has been studied independently, this review integrates them within a unified analytical framework that highlights how displacement-specific vulnerabilities interact with drug markets and punitive policy environments. This integrated perspective is not present in prior literature and forms the basis for a broader research agenda on drug harm reduction in displacement settings.

Taken together, the evidence indicates that juvenile drug involvement in refugee settings is a systemic outcome rooted in social disorganization, exploitation, and service deficits rather than an aggregate of individual moral failings. Addressing this complex issue requires multi-level coordination that integrates the principles of drug decriminalization within prevention, protection, and rehabilitation frameworks. At the preventive level, psychosocial support, drug awareness and life skills education, safe recreation, and family-strengthening initiatives are essential to reduce vulnerability and promote resilience (Hopkins *et al.*, 1994; Ivert & Magnusson, 2020; NRC, 2018).

Within the justice system, child-sensitive legal mechanisms, including access to legal aid, diversion programs, and treatment-based alternatives, should replace punitive sentencing for drug-involved juveniles, while anti-trafficking laws must be enforced rigorously against adult exploiters (American Bar Association, 2023; Khuda, 2019; Orr & Ajzenstadt, 2020). On the supply side, coordinated action is needed to disrupt drug and trafficking networks operating in and around refugee camps, with a focus on border management and prevention of youth recruitment (BBC News, 2023; Human Rights Watch, 2023). Over the long term, sustainable solutions depend on expanding education, vocational training, and governance reforms that are consistent with inclusion and safe mobility frameworks, thereby reducing the structural opportunity for juvenile drug recruitment (Hossain *et al.*, 2021; London School of Economics and Political Science, 2021). By shifting from punitive control to rehabilitative, rights-based, and decriminalized approaches, refugee governance systems can more effectively protect juveniles, rebuild community resilience, and address the intertwined challenges of addiction, exploitation, and insecurity.

Existing literature, including the 14 articles related specifically to drug issues, shows no evidence of any fully implemented or successful drug decriminalization model within refugee camps. While studies consistently document widespread deprivation, coercion, organized criminal activity, and psychosocial distress among refugee juveniles, none describe a structured decriminalization framework being applied in these settings.

The argument for a decriminalization-oriented approach in this paper is therefore not based on claims of existing success within camps. Instead, it arises from three central insights identified in the review: (i) Punitive drug policies frequently exacerbate harm by criminalizing juveniles who are acting under exploitation, fear, or trauma; (ii) public health and harm reduction models have shown effectiveness in other fragile contexts, and their principles are relevant to the vulnerabilities observed in refugee environments; and (iii) the review highlights a clear gap in current interventions, which remain largely punitive and do not address the structural drivers of juvenile involvement in drug networks.

Accordingly, the support for a decriminalization-oriented framework in this manuscript is forward-looking and conceptual. It reflects a rights-based, child protection perspective that responds to the mismatch between punitive approaches and the complex vulnerabilities documented in the literature. The intention is to propose a policy direction that prioritizes rehabilitation, protection, and diversion rather than punishment, without implying that effective decriminalization programs currently operate in refugee camps.

5. Conclusion

The reviewed literature positions social disorganization as the primary explanatory framework for understanding juvenile drug involvement in refugee settings, with delinquent subculture and constrained rational choice theories offering complementary insights, and structural functionalism clarifying how institutional deficits perpetuate the drug–crime nexus. Social disorganization accounts for the collapse of community structures, poverty, and weak social control that allows drug networks to thrive among displaced populations. The delinquent subculture theory explains how marginalized youth develop coping identities and group norms that normalize drug use and trafficking, while the rational choice theory reveals the constrained agency of juveniles making survival-based decisions in coercive environments. Structural functionalism underscores how the erosion of education, justice, and health institutions sustains systemic vulnerability. Collectively, these perspectives reinforce that juvenile drug involvement is not a result of individual moral failure but a structural consequence of displacement, deprivation, and policy neglect. Addressing this crisis requires an integrated strategy grounded in drug decriminalization, one that prioritizes protection and rehabilitation, strengthens community and institutional guardianship, and disrupts narcotics markets that prey on displaced youth. By reframing drug use as a public health and social welfare concern rather than a criminal act, decriminalization offers a pathway to rebuild trust, promote inclusion, and restore social order within refugee communities.

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Conflict of interest

The authors declare that they have no competing interests.

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ACCSCIENCE PUBLISHING

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PERSPECTIVE ARTICLE

Ageism in the workplace from Singapore to Canada: A translational perspective

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Abstract

This perspective piece tackles transnational ageism in the workplace by focusing on the Singapore case and national context while making connections to timely observations in Canada. Following existing studies, our review finds that although cultural circumstances of Confucian filial piety (in Singapore and East Asia) lead to higher degrees of implicit rather than explicit age discrimination, ageism is equally serious, and similarly intense, across contexts. Our discussion challenges the oversimplification of cultural differences between "East" and "West" in how societies are thought to address aging and age discrimination, as well as how ageism in various settings of daily life manifests. By analyzing policies, workplace practices, and social attitudes in Singapore, then situating these in global trends such as in Canada, we reveal common anxieties faced by older adults regarding financial insecurity and access to re-employment. This transnational lens underscores the importance of delving deeper into the culturally specific ways ageism manifests while simultaneously working toward the creation of effective international strategies. Deeper shifts are needed in the hearts and minds of people for significant changes to occur. In our view, shifting global demographics and rapid workplace changes necessitate a move beyond stereotypes and toward intergenerational cooperation, especially but not just in the workplace. We emphasize the importance of addressing ageism at all levels, relationally and transnationally, interpersonally to institutionally, to promote age-inclusive societies and secure a more dignified future for aging populations. Both authors' perspectives are anchored in lived experiences as Singapore citizens. In what follows, we weave together our academic and community-engaged practitioner expertise in Singapore's context of workplace ageism in light of ongoing community and social gerontology trends. We offer some observations in Canada for a comparative lens by way of gesturing to future transnational research directions for population studies.

Keywords: Cross-cultural ageism; Age discrimination; Workplace; Canada; Singapore

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1. Background: Anxious aging, precarious futures, and age discrimination

As a world society, we are poised to become more defined by age than any other social identity. A joint perspective on ageism in the workplace and social institutions, such as we illustrate from Canada and Singapore, is timely because in the current frame of understanding population behavior, cultural differences between "East" and "West" tend to be overdrawn (*e.g.*, Marcus, 2022). For the field of population studies, the concurrent convergences of unprecedentedly low fertility rates, rapidly aging populations (leading to the continuous pushing back of retirement ages), and startling readjustments/changes to the workforce composition and skills training landscape – exacerbated by the exponential growth of Artificial Intelligence tools – necessitate transnational frameworks for ageism in the family and society (Ng, 2025). Combining our respective academic expertise on understandings of "reproductive ageism," which refers to processes that reproduce elderly marginalization and the sidelining/downplaying of older adults' needs and perspectives in family care planning from East Asia to North America (Ng, 2023), as well as community-engaged gerontological and nursing home experience in Singapore (Dayanandan & Mehta, 2022), we present a global comparative perspective of ageism in the workplace; a crucial complement to existing studies on healthcare settings that tend to dominate discussion of ageism. From our perspective, broader commonalities of ageism in the workplace across large cultural differences are a most pressing domain for this journal to address in light of global population woes and aged dependency concerns.

Cultural values have, and always will, shape people's perceptions and treatment of older workers. A unique social norm in Singapore, as well as its East Asian neighbours of Hong Kong, Taiwan, South Korea, and Japan, is the strong social stigma of elderly institutionalization in nursing homes (Ng, 2023; Rozario & Hong, 2019). This prevailing norm alludes to certain well-recognized cultural circumstances of family care norms, namely Confucian filial piety that manifests in Singapore's particular migrant-in-the-family model of eldercare to allow for aging-in-place (at home or at least in a comfortable, familiar community environment). From critical social gerontology perspectives, we gather that these already existing attitudes and norms regarding appropriate eldercare arrangements at an interpersonal level bleed into, and mediate, institutional processes and structural outcomes of age-related discrimination in the workforce (North, 2022). In other words, communal-oriented societies with familialist foundations of family care in which adult children have an automatic obligation of parental care, contrast starkly with individualist social orientations where seniors may dislike, but nonetheless are resigned to, the possibility of sending oneself to a home. In light of these observations, we might expect the strong influence of familial values in Singaporean workplaces—social norms of "respect your elders–" to bring about greater respect for senior employees in contrast to elsewhere. However, as cross-country surveys have shown (North, 2022), ageism in the workforce can be equally, if not more, serious in degree and scope in Confucian cultural settings. As mentioned above, its signs may manifest in an implicit or subtle (*e.g.*, unconscious biases of patronizing speech acts in Maulod & Lu, 2019) rather than an explicit fashion that reflects socially accepted standards of deferent and polite behavior toward elders (North & Fiske, 2021).

Canada is typically associated with an individualist liberal social attitude toward issues of aging, where the emotional and physical struggles of older adults tend to be rationalized as part of individual resilience and responsibility. Older adults in North America may see institutionalization in the long term as an inevitable, albeit undesired, outcome that one is resigned to (*e.g.*, Herron *et al.*, 2021). In contrast, in Singapore, where Confucian cultural norms of filial piety (expectations of aging-in-place at home) prevail, sending one's elderly parents to a nursing home is still socially stigmatized—often perceived as an unfilial act, and associated with negative feelings of abandonment, estrangement, and isolation (Ng, 2023). The intense public stigma associated with elderly institutionalization in this context, where hiring foreign domestic workers for live-in care is a popular (if not default) arrangement for middle-income households (Rozario & Hong, 2019), is a unique social phenomenon that stands out relative to their Canadian counterparts. In Singapore's context, Confucian cultural preferences of filial piety in the form of aging-in-place (stay-at-home) care arrangements are still a strong social norm and often attributed to collectivist or familial model types of care. This societal perspective significantly influences caregiving decisions, often placing immense pressure on families to provide direct home-based support despite growing care complexities (Basu, 2016). Consequently, the decision to opt for institutional care typically arises from acute necessity rather than a preferred choice, revealing a profound tension between ideals and realities. It is important to note that filial piety beliefs and practices are diverse and dynamic among Singapore's multiracial and age-diverse population. However, the common understanding tends to be overshadowed by dominant Chinese ethnic claims in and beyond the Southeast Asia region, which the Singapore state strategically taps into for economic and political projects of nationhood, including family building. Before we outline this unique situation, we situate our transnational lens of ageism in the workplace in critical social gerontology perspectives.

2. Theoretical positioning in Singapore's community and critical social gerontology

In contrast to conventional gerontology approaches, which focus on the biological or psychological aspects of aging, critical social gerontology foregrounds the role of power relations, social norms, and policy environments on the lived experiences of older adults. Its perspectives draw on formative and contemporary work in the sociology of aging, political economy, and qualitative anthropology, all of which underscore the importance of understanding aging within its specific social context and recognizing the centrality of ideology, stratification, and global forces (Buffel & Phillipson, 2018; Katz, 2019). Hence, critical social gerontology provides a robust framework for understanding ageism beyond individual experiences of aging, such as in medical or healthcare settings where discussions of elderly abuse tend to cohere, by alluding to the wider cultural, structural, and institutional forces that shape older adults' lives yet escape one's individual agency or control (Holstein & Minkler, 2003). Community gerontology, a complementary perspective and practitioner toolkit (Dayanandan & Mehta, 2022), prioritizes community-engaged local expertise and collective action in supporting older adults. It focuses on intergenerational support mechanisms in the family and grassroots initiatives as crucial elements of positive aging experiences and resilience building (Chan, 2017; Ma, 2020; Mehta, 2020). Collectively, these frameworks encourage multifaceted power-attentive analyses that consider macro-level structural forces, meso-level community dynamics, and micro-level interpersonal relationships.

This integrated and holistic approach of ageism and its associated processes as well as settings, is particularly relevant to Singapore, where our perspective is anchored. Singapore is one of the world's most rapidly aging societies with a strong emphasis on values of filial piety, the family unit, and the community's role as primary pillars of social support (Chan, 2017; Ng, 2023). The nation-state's aging policies, blueprints, and masterplans are deeply rooted in an integrated intergenerational resource pooling mechanism, and informed by customary norms of family obligation, responsibility, and involvement in caring for one's aging parents (Rozario & Hong, 2019). By 2030, almost one in four residents will be aged 65 years or older; the city-state's demographic trajectory necessitates culturally sensitive approaches that pay heed to the population's multi-religious and multi-racial nature (Koh, 2025). Government initiatives have for long promoted integrated health and social services, active engagement through community programs, and aging-in-place facilities (TOUCH Elderly Group, 2023). These national initiatives include the construction and expansion of Active Ageing Centers (AACs), lifelong learning programs, intergenerational volunteering to foster inclusive age-diverse environments, and challenging age stereotypes. As of 2025, Singapore has more than 220 AACs, each providing a range of social, physical, and skills learning activities/workshops to support senior engagement and wellbeing (Koh, 2025). In that vein, the community gerontology landscape thus provides an essential lens for analyzing aging as a social construct and lived experience in and beyond Singapore, challenging oversimplified binaries of culture, policy, and community in aging outcomes.

Crucially, ageism is compounded for diverse marginalized population groups, such as women, ethnic/racial minority groups, and disabled individuals, which highlight the need for intersectional frameworks that account for overlapping social identities and positionalities of power and privilege that confer structural (dis) advantages in not always linear ways (Dayanandan & Mehta, 2022; Higgs & Gilleard, 2020). Life-course perspectives of reproducing society further enrich intersectional awareness by drawing attention to how ageist attitudes and practices can, and do, evolve across one's working life to influence hiring, promotion, training, and retirement decisions. Integrated critical and community gerontology informs Singapore's recent anti-ageist legislation, which includes the Workplace Fairness Act (passed in 2025) that reflects the population's growing demand and need for robust protections against incriminating forms of age discrimination (Chih & Chang, 2025). The Act prohibits employers from making decisions based on age and other associated characteristics at all stages of employment, and is complemented by the Retirement and Re-employment Act, which raises the statutory retirement age to 65 years by 2030 (Ministry of Manpower, 2023). Yet as we reflect below, applying these conceptual frameworks to actually existing scenarios of workplace ageism throws up both persistent challenges and promising avenues for fruitful intervention. Ageism is still the most common form of workplace discrimination in Singapore despite recent reports of its decline; one 2023 survey found an almost 6% and 22% decrease in the number of employees who reported experiencing age discrimination compared to 2021 and 2018, respectively (Ministry of Manpower, 2023). Nonetheless, older adult workers—especially those aged 40 and above—are the most affected and least likely to self-report, whereas age-based discrimination also impacts younger generations and remains an intergenerational dilemma (Ma, 2020; Randstad Singapore). We outline our comparative perspective of such issues before turning to enforcement challenges.

3. Comparative approach, context, and perspectival lens

Crucial case differences are important to unpack for a contextual perspective, yet as we note, our transnational framework for understanding ageism is situated in broader commonalities. A key case in point is the ongoing global trajectory of extended work-life agenda, where regardless of the cultural, social, and political context of planning for retirement and later life care, older adults are increasingly being coerced to delay retirement and compete with younger colleagues in arenas (*e.g.*, digital skill sets) that they lack formative exposure to (Maulod & Lu, 2019). Across the globe, older adult workers are expressing heightened anxieties, concerns, and worries about longer-term financial insecurity and struggles to access meaningful re-employment opportunities. The Singapore government has a stronger whole-of-nation hold on an eldercare strategy that places "the family" at the front and center. In Canada too, private households bear the brunt and cooperate informally to keep up with aging parents' needs. But as we explain below, Singapore's systematic implementation of an intergenerational resource pooling mechanism (in the form of a nationally enforced savings scheme for family members of all ages) remains unparalleled in its scope of application and universal efficiency. Still, while Singapore has policies and initiatives to support older adults, age discrimination nonetheless persists in various forms, particularly in the workplace. Less often is ageism discussed beyond its explicitly obvious zones of concentration, namely, nursing homes, long-term care homes, and other eldercare institutions. Yet as populations globally are forced to contend with age diversity in the workforce, it is all the more crucial to investigate its banal, mundane aspects that, at least on the surface, may appear neutral or even harmless. For instance, in skills upgrading/retraining courses, patronizing speech acts and unconscious biases often emerge (*e.g.*, having a "senior moment") that deserve greater interrogation for their negative assumptions (Maulod & Lu, 2019).

In a global context of an extended work-life agenda, we find that regardless of the cultural, social, and political context of planning for retirement and later life care, older adults increasingly exhibit common anxieties, concerns, and worries about financial insecurity and struggles to access meaningful re-employment opportunities. Ageism in Singapore is a growing concern as the population ages rapidly (Michael Page Singapore, 2023). While Singapore has policies and initiatives to support older adults, age discrimination persists in various forms, particularly in the workplace. Locally and globally, perceptions of reduced productivity, adaptability, and tech-savviness among older workers negatively impact their access to employment, advancement, and professional development (Ng & Feldman, 2021). Singapore's Central Provident Fund (CPF) serves as a cornerstone of retirement planning, encompassing various accounts for housing, healthcare, and compulsory retirement savings that every working citizen and their employers contribute to (Yeo & Lee, 2022). While the Retirement Sum Scheme (formerly the Minimum Sum Scheme) provides monthly payouts (Leong, 2024), it is crucial to acknowledge the evolving landscape of re-employment for older adults. Continued CPF contributions during re-employment are beneficial; however, the reality of part-time or contract work, coupled with reduced employer contributions for older workers, can significantly impact retirement adequacy. This backdrop of socially engineered intergenerational resource pooling mechanism, which materially ties family members across the age spectrum together in a network of reciprocal financial transfers (Ching, 2023; Lim & Koh, 2021), exerts significant influence on public attitudes, expectations, and understanding of retirement pensions as well as deservedness vis-à-vis Canadian counterparts.

A growing number of older adults face precarious employment, such as in low-paying blue-collar work in service industries or gig work, leading to inconsistent CPF contributions and heightened financial vulnerability. Consequently, supplementary retirement planning becomes essential to bridge the gap between CPF payouts and the rising cost of living to ensure a more secure future (Yeo & Lee, 2022). In light of these challenges, intergenerational resource pooling has emerged as a vital strategy for the city-state's finances (Zhan & Huang, 2023). From the government's perspective, this concept emphasizes the collective support of families and communities to bolster the financial well-being of older adults. It can encompass intergenerational transfers by way of allowances, caregiving, and shared living arrangements, effectively complementing CPF payouts, particularly for those in precarious re-employment or involuntary retirement. Furthermore, community organizations and government programs offer valuable resources, providing some safety net for older adults (Lim & Koh, 2021). That said, a holistic approach that combines CPF payouts with proactive intergenerational support is necessary to address the financial precarity faced by many older adults in Singapore. This approach must not only acknowledge the challenges but also promote actionable solutions, ensuring a more secure and dignified retirement for all.

4. Age discrimination in the workplace: A view from Singapore to Canada

At a national level, Singapore's Workplace Fairness Legislation (Chih & Chang, 2025) is expected to be enacted in 2026 or 2027 and aims to protect workers from age discrimination. However, it remains to be seen how effectively this legislation will address the deeper issues. In this local context, implementation gaps exist between in-principle promises and the ongoing realities. A major challenge is the burden of proof (evidence of age discrimination) and enforcement challenges. The hurtful truth is that if an employer decides your time is up and they want you gone, termination can happen without due notice or even compensation. While there may be significant differences across small to large-sized companies in terms of implementation capacity, ageism remains an unconscious bias that is hard to quantify and objectively call out. Whether in Canada or Singapore, older adults tend to be more vulnerable to corporate loopholes that allow ageist hiring practices because navigating legal processes can be daunting, especially if one lacks the legal knowledge or financial resources (De Stefano, 2021; Government of Canada, 2024). Transforming workplace mindsets, in other words, is easier said than done. More often than not, complaints boil down to a murky "he/she said, they said" scenario that manifests in implicit biases during hiring, promotion, and occupational development decisions, all of which are difficult to prove where the role of age attitudes is concerned (Bae & Choi, 2023; Lahey, 2020).

Older workers in financially precarious positions may fear retaliation if they proceed further with formal complaints, leading to underreporting of discriminatory practices. Ultimately, much of effective enforcement requires adequate resources for investigation and adjudication of employee claims, and the capacity of existing mechanisms for redress to handle a potential surge of age-related cases remains to be seen (Ng & Feldman, 2021). Legislation may induce significant incentives to change behavior, but it is a lot harder to change deep-seated stereotypes in people's hearts and minds (North, 2022; North & Fiske, 2021). Negative stereotypes about older workers' capabilities prevail and persist despite legal protections and institutional commitments to equitable opportunities (Burnes et al., 2020; Marcus, 2022). As we gather, employers may find ways to circumvent the rules by creating job descriptions that implicitly favor younger candidates, among other strategies. Ongoing awareness and education campaigns that draw on intergenerational collaborations, in that vein, to increase exposure to age diverse perspectives are needed to transform workplace culture.

In essence, Singapore's Workplace Fairness Legislation is a vital step, but its success hinges on robust enforcement and sustained efforts to change workplace culture. It will be very important to monitor the implementation of this legislation to see how effective it will be in practice. This step is a positive sign for anti-ageist advocates and supporters, yet it does not significantly improve the later life prospects of many aging adults and senior citizens who have depleted the majority of their savings through CPF spending: housing, education, and healthcare spending. Many older adults are asset-rich but cash-poor. Singapore has some of the highest property values in the world. While this builds equity, it also means a significant portion of wealth is tied up in housing, often leaving limited cash for daily expenses or retirement. Singaporean parents prioritize education and often invest heavily in their children's schooling, tuition, and even overseas education. This can strain finances and reduce cash reserves. Another contributing factor is healthcare expenses, which increase with age. Medisave, a component of CPF, can be used for medical expenses, which again draws down on retirement savings (Koh et al., 2021). The same can be said of Canada's existing anti-ageist stance, which disproportionately relies on the charitable goodwill of individual employers rather than strict legal enforcement. Similar to their Singaporean counterparts, the Canadian workforce is slowly but surely laboring beyond the traditional retirement age of 65 years. Today, an increasing number (at least one in five older Canadians) are delaying retirement plans and/or maintaining part-time work arrangements for financial or aspirational reasons (Government of Canada, 2024). Despite an undeniable age diversity in the modern workforce, people have not dealt with ageist attitudes and prejudice adequately, allowing these outdated views to continue acting as barriers to participation.

Another key legislation in Singapore is the Retirement and Re-employment Act (Retirement and Re-employment Act [RRA], 2017). This act primarily deals with the process of retirement and re-employment, not necessarily discrimination in other aspects of employment. It sets the minimum retirement age (currently 63) and requires employers to offer re-employment to eligible employees who have reached this stage, up to the age of 68 years. The RRA ensures that older workers can continue working beyond the initial retirement age, providing some protection against outright dismissal due to age. However, it does not prevent discrimination in hiring, promotions, training, or other workplace developmental opportunities before retirement age or for those above 63. In sum, there is reason to pursue broader agendas of increasing age diversity awareness and our seemingly universal desire to age-in-place (at home or in a comfortably familiar

setting) while being validated and recognized for our social contributions, regardless of cultural background and geopolitical environment. Cities, including but not limited to ones across the United States, Canada, England, China, India, Brazil, and Singapore (Kuper & Jivraj, 2022), are implicated in an international context of confusing social changes in age distribution and urbanization that challenge the sociocultural infrastructures of aging and older adults.

Rather than a workplace-specific legislation, Canada's Human Rights Act outlaws age discrimination in all aspects of employment: decisions about recruitment, retrenchment, job scope allocation, promotion opportunities, training resources, and benefit entitlements. The Government of Canada maintains an official stance through federal, provincial, and territorial (FPT) statements against ageism: "the stereotypes (how we think), prejudice (how we feel), and discrimination (how we act) toward others or oneself based on age." (Government of Canada, 2024, p. 4). Although research on ageism in workplace interactions remains limited, the available data strongly suggest that age stereotypes persist to the detriment of older adults' life opportunities. Positive and negative stereotypes are at play, with the former including perceptions of higher loyalty and reliability and the latter usually implying "decreased performance activity" and less capacity to adapt "especially to new technologies" (Lagacé et al., 2022: 2). In Canada, as in Singapore, starting from as soon as 45 years old, people report receiving lower callback rates on job applications and fewer training or upskilling opportunities, which are worse for women and ethnic minority groups in particular (Ching, 2023; Firzly *et al.*, 2021; Maulod & Lu, 2019). Ongoing research underscores the importance of combining legal safeguards with cultural awareness and changes in consciousness, organizational innovation, and community engagement initiatives to address the complex, intersectional nature of how ageism manifests in workplace interactions (Randstad Singapore, 2023; Higgs & Gilleard, 2020). By grounding policy and practice in critical and community gerontology, Singapore and its transnational counterparts can harness more contextually relevant and nuanced strategies for fostering age-inclusive workplaces in highly age-diverse societies.

5. Future directions: Uncovering (and combating) transnational ageism

As a field of study, systematic reviews find that experiences of age discrimination tend to rely on self-reporting methods, which raises the likelihood of over/underreporting across people and contexts. Measurement tools for ageism in social institutions and the wider public, such as those compiled by Wilson *et al.* (Wilson *et al.*, 2019: 79-80) from almost 1060 print articles, reveal that 17 out of 25 indexes have no associated studies. Among the remaining eight tools that were deployed in research outputs, the majority of studies use convenience sampling and survey questionnaires, which yield drastically varying results from context to context. For instance, slightly below half of a 2013 sample of 816 South Korean older persons reported experiencing ageist behavior from others, while more than 90% among 375 Canadian older persons did so in a 2001 survey (in Wilson *et al.*, 2019: 82). Population researchers of aging and ageism, then and now, agree that there is a need to go beyond small convenience samples—as informative and useful as narrative stories are—to develop reliable trackers of age-identified discrimination at broader national scales. Social analysts in the moment are aware of ageist attitudes, prejudice, and unfair outcomes related to others' and their own age identity, but compared to other topics, measurement tools for ageism are nascent and as yet unable to yield significant results that can inform country or occupation-level decisions.

While there is some evidence to suggest that Eastern cultures have a positive bias toward older adults than Western cultures, we suggest that in a rapidly modernizing world and especially in workplace interactions, cross-cultural frameworks of age discrimination are an urgent, timely direction to direct future studies toward. Globally, regardless of national context, older persons aged 50 and above face prolonged struggles to access meaningful employment opportunities vis-à-vis their younger counterparts (Rudman & Aldrich, 2021: 5). From current trends, we gather that the bulk of emphasis tends to be on instrumental, mechanical processes of retaining and/or regaining employment rather than substantial organizational efforts to meet older persons where they are. Older job seekers, as numerous studies find, tend to experience lower rates of appreciation for their so-called outdated skill sets, especially with regard to an (assumed) absence of digital literacy and comfort with technology. Such generational or cohort stereotypes about one's working habits and ingrained skill sets need to be unpacked and discussed collectively rather than pre-defined as an inherently positive or negative trait. The importance of addressing ageism from the interpersonal to institutional level goes beyond specific issues of digital usage in daily life, as broader dynamics of age relations, intergenerational relationships, and cooperating across age diversity in the population's imminent future are at stake.

The field of research on ageism within population studies appears to be evolving. While there seems to be a growing recognition of ageism's potential impact on health, well-being, and economic participation, further research

may be needed to fully understand the complexities of age-based discrimination across diverse cultural contexts. Studies might also explore the intersection of ageism with other potential forms of discrimination, such as gender and race, to provide a more comprehensive perspective (Kuper & Jivraj, 2022). In addition, there could be a need for more research to examine the effectiveness of potential interventions aimed at combating ageism and promoting age-inclusive societies (Burnes et al., 2020). The term "aging of aging" is commonly used to refer to the exponentially growing numbers of "advanced aging" persons aged 80 or over in the world population, which will triple by 2050 (Wilson et al., 2019: 78). In the Asia-Pacific region where Singapore is located, 59% of the total population will cross this life stage mark by 2050. Despite being a young nation, Singapore is the world's second-fastest aging society, poised to become superaged by 2030; almost one-quarter of the city-state's population will be 65 years or older (Ching, 2023: 3). In Canada, centenarians are already the fastest growing sub-population followed by those aged 85–99 years.

In many cases, ageism in the family, society, and institutions is a form of social death (*e.g.*, Herron et al., 2021). We have drawn on a local example of age discrimination from an underrepresented location in mainstream acknowledgements of ageist behavior in population studies to suggest that researchers should unpack existing cultural assumptions of positive bias toward older adults in Eastern cultures, which are, in all likelihood, overblown. In an increasingly liberal marketized world order, the workforce composition is changing faster than the pace of human skills adaptation and education programs can. This dizzying rate of shifting occupational landscapes and prerequisites on the job in a digital era provides strong reason to foster intergenerational creativity through careful cooperation rather than falling back on simplistic age, cohort, or generation stereotypes that reduce peoples' complex individuality. On that note, there are broader trends of competitive, individualizing imperatives of coping with increasing precarity in the labor market that can also be observed in collective and familial-oriented cultural contexts of family care in East Asia (Bae & Choi, 2023; Marcus, 2022; North, 2022). From this relational (and transnational) perspective, inquiring into the deeper psychological underpinnings of ageist attitudes—in which encourage a society to endorse individual solutions to structural constraints of age discrimination—is a necessary next step to improving current understandings of ageism by way of strategizing to combat its pitfalls.

Keeping in mind that there can be no one-size-fits-all solution, we suggest that policymakers strive toward culturally appropriate and attentive approaches to address ageism. Singapore's approach to an aging population reflects its decades-long pragmatic governance in a complex landscape where explicit respect of elders (social norm) coexists with implicit workplace discrimination in a broader cultural emphasis on economic productivity. Although varying in degree, both implicit and explicit ageism are present from Singapore to Canada, which warrants more holistic, integrated strategies that strike an optimal balance between intangible norms and tangible outcomes. At the bare minimum, employers and policymakers must move beyond legal formality alone and implement culturally informed, multi-layered positive interventions to foster age inclusivity. These include investing in lifelong learning and digital literacy programs that pay special attention to the creeping aspects of patronizing speech to counter stereotypes about older adults' adaptive capacity, and flexible working arrangements that recognize diverse caregiving responsibilities and family circumstances. In this sense, upcoming enforcement plans such as Singapore's Workplace Fairness legislation must be complemented by a range of safeguards, including but not limited to: accessible complaint channels; company-wide investigation resources; compulsory age-diversity training in corporate progression and/or organizational development; and protection against retaliation (*e.g.*, retrenchment). In wider society, public awareness campaigns should advocate for intergenerational collaboration and shared decision-making that foster collective action to challenge social constructs of older adults' dependency and/or decline. Such steps will go a long way toward embedding age equity as a relational and institutional goal.

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RESEARCH ARTICLE

A machine learning approach in predicting poverty in the poorest region of Luzon, Philippines

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Abstract

Poverty is a complex and multidimensional issue that is difficult to measure accurately. While multiple studies have employed traditional econometric methods to analyze poverty, they often overlook the critical roles of electricity, Internet, and cell phone access – factors our study incorporates alongside machine learning to provide deeper and more accurate insights. This study examines the associations between Internet, cell phone, and electricity access and poverty in the poorest region of Luzon, Philippines, aiming to foster connectivity among households to support poverty alleviation. Using probit regression and estimation analyses, we found significant socioeconomic disparities, with many households living below the poverty line. While most households have electricity and cell phones, many lack Internet access. This indicates challenges in infrastructure and digital connectivity that affect living standards and economic opportunities. The analysis reveals important causal relationships between Internet access, cell phone ownership, electricity availability, household size, and the likelihood of being in poverty. Interestingly, the lack of these essential services is linked to higher poverty rates. These results highlight the need for targeted interventions to tackle the root causes of poverty, particularly in bridging the digital divide and improving access to essential services. Machine learning algorithms were employed to effectively predict poverty outcomes based on the results of econometric modeling, where variables with significant coefficients served as a priori inputs. The findings indicate that Extreme Gradient Boosting achieved the lowest mean square error and the highest R^2 value among all regression models. Meanwhile, the random forest classifier demonstrated the best overall performance with the highest classification accuracy. The outlined policies support energy affordability, cell phone access, and Internet connectivity through financial aid, solar programs, device provisions, and broadband expansion. Addressing infrastructure gaps and technology access is key to sustainable economic growth, guiding policy makers toward equitable, resilient solutions.

Keywords: Poverty; Internet access; Cell phone; Electricity; Probit; Community-based monitoring system; Philippines

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1. Introduction

1.1. The complexity of poverty

Poverty represents a widespread challenge globally, presenting a vast and intricate issue that afflicts societies in a seemingly unending cycle (Buck & Deutsch, 2014). It is described as a complete absence of opportunities coupled with severe hunger, undernourishment, lack of education, physical and mental health problems, emotional fragility, social seclusion, and a sense of despair regarding the future. In addition, it is defined as a persistent deficiency in economic, social, and political involvement that confines individuals to societal exclusion, hindering their access to the advantages of economic and social progress and thereby constraining their cultural advancement (Belghith *et al*., 2022; Wagle, 2002). Poverty is multidimensional and has been explored in the Philippines through many indicators and socioeconomic deprivations (Onsay & Rabajante, 2024a; Sobreviñas, 2020). However, there are still unexplored variables, as a lack of money is not the only factor involved. Aspects of poverty include not only not having access to education or health care but also being unwell and unable to receive it. Different definitions of poverty have been proposed, and the nature of poverty varies over time and between geographic locations. Most people strive to escape poverty. It is, therefore, a call to action – for both the wealthy and the poor – to reshape the world in a way that ensures broader access to education, health care, decent shelter, food, protection from violence, and a meaningful voice in community decisions (Inam, 2015; Onsay & Rabajante, 2024a). Developing a better local-level understanding of poverty determinants and how household-level factors and broader national policies affect household welfare will assist policy makers and development practitioners in improving livelihoods and welfare in rural areas (Okwi *et al*., 2007). The movement in and out of poverty is caused by several demographic, economic, and natural factors that are within and outside the control of the household (Hossain *et al*., 2006).

1.2. Literature reviews on poverty driven by essential services

The complexity of poverty is often underappreciated by countries and global institutions, leading to poor policies (Edelman, 2006; Foxley, 2004; Haveman, 2013), exacerbated by the exclusion of low-income urban voices from the governance process (Benson *et al*., 2014). Rural poverty, characterized by restricted income, employment, inputs, credit, and market access (Khan, 2000), is a result of interrelated factors such as policy, gender, and culture (Khan, 2001). Rural household welfare is determined by family size (lower dependency ratios can improve well-being) and the age of the household head, balancing experience with adjustment hurdles (Eyasu, 2020; Onsay & Rabajante, 2024b). Access to electricity fuels poverty reduction through economic growth, health, and education (González-Eguino, 2015), and its absence reinforces underdevelopment (Rarasati *et al*., 2019). Poverty measurement should go beyond income levels (Onsay, 2022) to encompass basic needs shortages and lack of access in decision-making (Sobreviñas, 2020).

Internet poverty, or the inability to pay for fundamental services (10 Mbps speed, 1 GB data) without spending more than 10% of discretionary income, limits access to basic activities such as email, news, and e-government services (Cuaresma *et al*., 2022). Rural–urban inequalities continue, with lower rates of connectivity in rural areas worsening educational disadvantages for low-income students (Afzal *et al*., 2023). The nexus between electricity, mobile technology, and Internet penetration is vital to poverty reduction, especially in areas such as Bicol, Philippines. Electricity boosts productivity, education, and health, supporting income-generating activities (Ravago *et al*., 2018). Mobile technologies enhance financial inclusion and alleviate information asymmetry, empowering low-income families (Barrantes, 2010; Llorito, 2020). Internet penetration enhances economic development and social inclusion by improving infrastructure, expanding access to educational resources, and creating job opportunities (Hjort & Tian, 2021; World Bank, 2022). Together, these technologies address multidimensional poverty by improving access to resources, services, and participation in broader economic networks.

Infrastructure deficits in Luzon's poorer regions, including unreliable electricity and Internet access, perpetuate poverty and widen the digital divide, exacerbated by profit-driven underinvestment in rural areas (Cuaresma *et al*., 2021; Faiella & Lavecchia, 2021; Wise, 2014). Machine learning (ML) enhances poverty analysis by integrating electricity access, Internet connectivity, and cell phone ownership data, enabling accurate predictions beyond income metrics (Aiken *et al*., 2023; Muñetón-Santa & Manrique-Ruiz, 2023). Electricity access correlates with economic activity and quality of life; satellite-derived nighttime light data combined with ML effectively predicts socioeconomic conditions (Gonzalez-Briones *et al*., 2019; Hall *et al*., 2023; Lee *et al*., 2022). Internet connectivity facilitates poverty alleviation through access to information and opportunities, with ML models using penetration data to map poverty for targeted interventions (Alsharkawi *et al*., 2022; Sundsøy *et al*., 2016; Xu *et al*., 2019). Cell phone ownership, a socioeconomic indicator, aids real-time poverty prediction through ML analysis of usage patterns

(Aiken *et al*., 2022; Solís-Salazar & Madrigal-Sanabria, 2022). An integrated ML approach combining electricity, Internet, and cell phone data improves prediction accuracy, guiding tailored anti-poverty strategies (Muñetón-Santa & Manrique-Ruiz, 2023). Policy makers must prioritize rural electrification (e.g., renewable microgrids) and affordable Internet to foster inclusive growth. Collaboration between the government and communities is critical to address infrastructural gaps, leveraging technology's role in enhancing economic opportunities, education, and quality of life in Luzon. Sustained research and targeted interventions are vital for sustainable poverty reduction (Muñetón-Santa & Manrique-Ruiz, 2023).

1.3. Frameworks

In examining the influence of electricity, cell phone access, and Internet connectivity on poverty, our study draws upon five key theoretical frameworks:

1.3.1. Capabilities approach

Developed by Sen (2008), this framework emphasizes that poverty extends beyond income levels to include individuals' capabilities in leading fulfilling lives. Our study applies this approach to explore how access to electricity, cell phones, and the Internet enhances individual capabilities, improving access to education, health care, and economic opportunities (Sen, 2008).

1.3.2. Social capital theory

This framework highlights the role of social networks in achieving economic and social outcomes. Our research examines how access to communication technologies facilitates social connections, ultimately providing people experiencing poverty with better opportunities to access essential information and resources (Nahapiet & Ghoshal, 1998).

1.3.3. Digital divide theory

This theory addresses disparities in technology access due to socioeconomic factors. Our study utilizes this framework to analyze the challenges of electricity, cell phones, and Internet access in rural regions, assessing how these limitations contribute to poverty levels (Lee *et al*., 2022; Van Dijk, 2006).

1.3.4. Energy justice framework

This framework explores the relationship between energy access and social equity, with a focus on fairness and transparency in energy policies. Our research applies this lens to examine how equitable access to electricity influences poverty, particularly among marginalized communities (Jenkins *et al*., 2016; Lee & Byrne, 2019).

1.3.5. Theory of change

The theory of change serves as a blueprint for understanding how specific interventions can lead to desired outcomes. Our study employs this framework to map the pathways through which technology access affects poverty alleviation, detailing the necessary conditions and interventions for success (Connell & Kubisch, 1998).

To further investigate these relationships, our research used a conceptual model to demonstrate the interaction of independent and dependent variables. A conceptual model is a visual or narrative representation of how variables work together within a particular context, reducing complicated concepts to a simple framework and informing research design and data analysis (Varpio *et al*., 2020). Our independent variables are electrical connection, cell phone ownership, Internet access, and household size (as a control variable), all of which are predicted to affect poverty outcomes, measured by an income indicator. Using descriptive statistics, econometric modeling, and predictions from ML, our research offers a systematic approach to poverty prediction using digital services. This method provides valuable insights into the effects of technological access change on poverty to inform policy advice for sustainable economic growth (Onsay & Rabajante, 2024c).

1.4. The unexplored poverty cases in the Philippines

The Philippines grapples with persistent poverty, particularly in rural and geographically isolated regions, driven by factors such as educational disparities, uneven resource distribution, and societal norms exacerbated by the archipelago's challenging geography and climate (Balisacan, 2010; Onsay & Rabajante, 2024d). Understanding poverty dynamics in this context requires analyzing access to essential and digital services, as these are pivotal for shaping strategies to alleviate deprivation. Poverty analysis hinges on defining thresholds. Nationally, a household with monthly earnings below PhP13,873 (≈236.23 USD) for a family of five is classified as poor. In comparison, the Bicol Region – Luzon's poorest area – uses a slightly higher threshold of PhP13,989 (≈238.21 USD) (Philippine Statistics Authority, 2023). The Bicol Region, historically among the nation's poorest, saw Camarines Sur Province reduce its poverty incidence from 38.7% in 2021 to 29.4% by 2023, though it remains deeply disadvantaged (Philippine Statistics Authority, 2021; 2023). This underscores the urgency of examining how access to electricity, mobile connectivity, and Internet services influences poverty. Electrification correlates with higher productivity, income growth, and improved education (Ravago *et al*., 2018), while mobile access strengthens

social networks and household consumption (Labonne and Chase, 2009). Similarly, Internet connectivity bridges economic gaps through digital education, health care, and financial inclusion (Asongu & Agyemang-Mintah, 2025; Leidig & Teeuw, 2015). Population studies highlight how socioeconomic conditions and service accessibility shape poverty trajectories (Gu *et al*., 2017; Paira & Ao, 2023; Yang & Wen, 2016; Zhang *et al*., 2024). Hence, this study investigates the interplay between energy, connectivity, and poverty in Bicol, emphasizing their role as catalysts for economic stability and empowerment. By synthesizing empirical data and regional statistics, it aims to inform policies that address systemic inequities and uplift marginalized communities, aligning with broader goals of poverty reduction and improved quality of life in the Philippines.

1.5. The problems, objectives, and research gap

Poverty remains a persistent and multidimensional issue in emerging economies (World Bank, 2022). As Sen (2008) argues, poverty encompasses not only low income but also poor health, limited education, inadequate living conditions, lack of empowerment, precarious employment, and heightened exposure to violence and environmental hazards. In the Philippines, these dimensions have been explored in impoverished communities (Onsay & Rabajante, 2024b), yet critical barriers, such as limited access to electricity, Internet, and mobile communication, remain largely unaddressed in empirical poverty analyzes.

While national and global strategies continue to emphasize data-driven approaches for poverty reduction (Min *et al*., 2022; Onsay, 2022), conventional poverty estimation methods often suffer from outdated or incomplete data, limited granularity, and transparency issues. These limitations constrain the ability of policy makers and stakeholders to design effective, targeted interventions. To bridge this methodological gap, this study employs ML tools to analyze poverty using granular household-level data from the Community-Based Monitoring System (CBMS), institutionalized under Republic Act No. 11315.

ML, a data-driven subfield of artificial intelligence focused on pattern recognition and predictive modeling (Burkov, 2019; Raschka and Mirjalili, 2019), has shown promise in forecasting poverty in various contexts – such as energy poverty prediction in India (Wang *et al*., 2021), poverty estimation through e-commerce data in Indonesia (Wijaya *et al*., 2022), and humanitarian targeting improvements (Aiken *et al*., 2021). However, ML's application to official household survey data for localized poverty assessment remains limited in the Philippine context.

This study addresses this research gap by applying ML algorithms to CBMS data from Goa, Camarines Sur, to examine the role of digital and energy access, specifically electricity, cell phone ownership, and Internet connectivity, in shaping poverty outcomes. Households are classified as poor based on per capita income thresholds consistent with official poverty lines (Albert & Collado, 2024; Onsay & Rabajante, 2024d). There are three study objectives:

(i) To empirically assess the relationship between electricity, cell phone, and Internet access and household poverty status.
(ii) To develop ML models that predict poverty outcomes based on statistically significant indicators.
(iii) To generate policy insights for local government units to address infrastructure gaps, promote digital inclusion, and reduce multidimensional poverty.

By focusing on a municipality within the poorest region of Luzon, this research contributes to localized and evidence-based poverty alleviation strategies aligned with Sustainable Development Goals 1 (No Poverty), 2 (Zero Hunger), 7 (Affordable and Clean Energy), 9 (Industry, Innovation, and Infrastructure), and 11 (Sustainable Cities and Communities). The study not only provides methodological innovation by integrating ML with econometric modeling but also offers practical pathways for enhancing household well-being and economic resilience in rural communities.

The multidimensional nature of poverty – encompassing education, health care, and employment gaps – aligns with Sen's (2008) framework, emphasizing interconnected challenges. Our research highlights electricity, cell phone usage, and Internet access as strategic levers for intervention. Targeted policies, such as solar energy programs in off-grid African regions or broadband expansion in rural India, can address energy affordability and digital divides (Baurzhan & Jenkins, 2016; Jain, 2014). A key innovation is the application of ML models such as Extreme Gradient Boosting (XGBoost) and random forest to predict poverty outcomes that are replicable in countries with data limitations. ML enables real-time estimation using household surveys or mobile data, as seen in Kenya's usage patterns or Indonesia's e-commerce analytics (Aiken *et al*., 2021; Wijaya *et al*., 2022). Localized data collection through CBMS can guide context-specific policies, such as renewable energy initiatives in Sub-Saharan Africa or digital literacy programs in South Asia. In Latin America, bridging digital gaps reduced disparities in Brazil and Colombia (Briceño *et al*., 2024; Ikejemba *et al*., 2017; Kass-Hanna *et al*., 2022; Reyes *et al*., 2007). By emphasizing data-driven, region-tailored strategies, this approach supports global efforts to align with the United Nations' Sustainable

Development Goals, offering actionable insights for equitable resource allocation and poverty reduction.

2. Data and methods

2.1. Study design, subject, and data sources

This study adopted a quantitative-causal approach, systematically analyzing numerical data to examine variables objectively. The study subjects were households in Goa, Camarines Sur Province, drawn from CBMS – a technology-driven framework for collecting and validating disaggregated data to inform local planning, program implementation, and community engagement (RA11315, 2018; Philippine Statistics Authority, 2023). Total enumeration was applied, with all households in the municipality serving as the sample. The unit of observation was the household, including all members, economic statuses, locations, and compositions, ensuring comprehensive representation in the analysis.

2.2. Measurements and econometric modeling

This study used probit regression to examine how households' electricity access, cell phone ownership, Internet connectivity, and size influence poverty outcomes in Luzon's poorest region. The dependent variable, poverty status, was measured by comparing a household's per capita income to the official regional poverty threshold for a family of five in the Bicol Region, which is approximately PhP 13,959/month (equivalent to USD 250 – 275, depending on exchange rates) (Philippine Statistics Authority, 2023). Independent variables included binary indicators for electricity, cell phone, and Internet access, with household size as a control. In this study, four key variables were examined to assess their influence on poverty outcomes in the Bicol region.

Electricity access is a binary indicator, where a value of 1 denotes that the household has access to electricity, and a value of 0 indicates no access. This was defined as having a legal and functional electrical connection, irrespective of the consistency of the electricity supply. Cell phone ownership is also a binary variable, where a value of 1 signifies that at least one member of the household owns a cell phone, and a value of 0 indicates no cell phone ownership within the household. The definition assumed that ownership is based on the presence of a cell phone owned by any household member, not necessarily all members. Similarly, Internet access is a binary variable indicating whether the household has Internet connectivity; a value of 1 means the household has Internet access (either through mobile data, broadband, or other means), whereas a value of 0 means there is no Internet access. Finally, household size was used as a control variable and referred to the total number of individuals living in the household, including both adults and children. It is a continuous variable that helps account for the potential influence of family composition on poverty outcomes, recognizing that larger households may face different economic challenges compared to smaller ones. These variables provided a comprehensive view of how technological access and household composition relate to poverty in the region. A multicollinearity test (variance inflation factor <5) confirmed stable coefficients. The probit model, grounded in methodologies from Onsay (2022), Onsay & Rabajante (2024b) and Parikh and Sen (2006), analyzed the probability of poverty, revealing how technological access and household composition shape economic status. The detailed specification of the econometric models used in this study, including the probit regression framework, is presented in the Supplementary File. This approach identified critical pathways for poverty alleviation interventions through models in Equations I and II:

$$\text{Model 1: PovO}=\beta_0 + \beta_1 Elecon + \beta_2 CelOwn + \beta_3 InterAcc + \beta_4 HoSize + \mu \quad \text{(I)}$$

$$\text{Model 2: PovI}=\beta_0 + \beta_1 Elecon + \beta_2 CelOwn + \beta_3 InterAcc + \beta_4 HoSize + \mu \quad \text{(II)}$$

where *PovO* is poverty outcomes, *PovI* is income-based poverty, *EleCon* is electrical connection, *CelOwn* is cell phone ownership, *InterAcc* is Internet access, *HoSize* is household size, β_0 is the coefficient of the constant, β is the coefficient of each independent variable, and μ is the error term.

The variables in Table 1 are selected through bidirectional selection by satisfying econometric diagnostic tests to ensure accuracy and reliability. This approach combines forward selection (adding variables) and backward elimination (removing variables) iteratively to determine the most relevant subset of features for a predictive model. It balances model complexity and predictive accuracy efficiently (Onsay & Rabajante, 2024d).

2.3. Prediction and performance evaluation

The variables validated by probit regression in Table 1 were utilized as a priori input in training and testing the datasets of the CBMS. We utilized six phases of poverty prediction modeling: (i) data collection, (ii) data preprocessing, (iii) econometric modeling and analysis, (iv) clustering, (v) ML modeling and analysis, and (vi) performance evaluation as illustrated in Figure 1 (Onsay & Rabajante, 2024b).

2.3.1. Data collection

Data were sourced from the CBMS of Goa, Camarines Sur Province, structured into four socioeconomic sectors:

Table 1. Variable descriptions

Variables	Variable abbreviations	Description	A priori expectations (expected sign of coefficients)
Dependent variables			
Poverty outcomes	PovO[b]	1 (Poor), 0 (non-poor)	
Income-based Poverty	PovI[b]	Income of a household (HH) per month in Philippine pesos	
Independent variables			
Electrical connection	EleCon[b]	1 (HH without connection), 0 (HH with connection)	Positive (+)
Cell phone ownership	CelOwn[b]	1 (HH without a cell phone), 0 (HH with a cell phone)	Positive (+)
Internet access	InterAcc[b]	1 (HH without access), 0 (HH with access)	Positive (+)
Household size	HoSize[a]	Total number of household members	Negative (−)

Notes: [a]Refers to data from the community-based monitoring system; [b]Refers to data from the community-based monitoring system that have been transformed/processed by researchers/enumerators.

Isarog (12 barangays – the smallest administrative district), Poblacion (10 barangays), Ranggas (five barangays), and Salog (seven barangays), each reflecting distinct socioeconomic conditions (Onsay & Rabajante, 2024b).

2.3.2. Data pre-processing

Datasets underwent cleaning, normalization, and transformation to meet econometric and ML assumptions, employing techniques such as feature scaling and model fitting methods (all-in, bidirectional elimination) (Table 1).

2.3.3. Econometric modeling

A total of 78 probit models (34 barangay-level, four sector-level, and one municipal-level) identified variables significantly influencing poverty, serving as a priori attributes for ML.

2.3.4. Clustering

K-means clustering segregated households into poor/non-poor groups, validating input attributes amid variable correlations (Table 1).

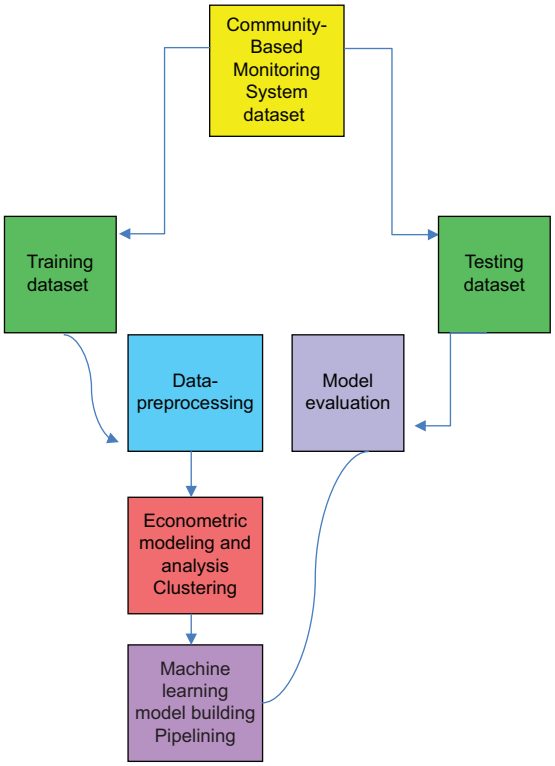

Figure 1. Poverty prediction using an essential services model, showing the training and test data and the development of the machine learning model with Pipeline (Δ)s (Onsay & Rabajante, 2024c)

2.3.5. ML modeling

We employed three regression algorithms to forecast continuous poverty outcomes and three classification algorithms to predict categorical poverty outcomes. These procedures were executed across two dimensions as outlined by Mujumdar & Vaidehi (2019):

(i) Prediction through ML algorithms: Datasets were randomly split into training/test sets. Algorithms were implemented using R version 4.3.1 (packages: rpart, Rfast, ElemStatLearn, e1071, catools, class, and ggplot2) and Python version 3.11.4 (libraries: scikit-learn, TensorFlow, Keras, PyTorch, XGBoost, LightGBM, CatBoost, statsmodels, and Pandas).

(ii) Prediction through Pipeline (Δ)Pipeline (Δ)s: Pre-set criteria Pipeline (Δ)s optimized algorithm accuracy. Models were fitted to the training data, followed by accuracy metrics comparison, and the most accurate model was selected through test dataset evaluation (Figure 1) (Mujumdar & Vaidehi, 2019).

2.3.6. Performance evaluation

The performance of regression and classification models was rigorously evaluated using established metrics. For regression, mean squared error (MSE) and root MSE

quantified the magnitude of prediction errors, whereas R^2 assessed the proportion of variance explained by the models (Choubey *et al.*, 2020; Min *et al.*, 2022). Classification models were evaluated through accuracy – reflecting correct predictions across all classes – and precision-recall metrics to address class imbalances in poverty identification. The confusion matrix provided granular insights into true positives, false positives, and false negatives, which are critical for understanding misclassification trends among poor and non-poor households. Precision emphasized the model's reliability by correctly identifying poverty, while recall reflected its ability to detect all relevant cases. The F1-score harmonized these metrics, balancing robustness and precision (Choubey *et al.*, 2020; Onsay & Rabajante, 2024c). These evaluations collectively underscored the models' effectiveness in capturing socioeconomic patterns, ensuring their utility in informing targeted poverty alleviation strategies. The performance evaluation metrics used to assess the accuracy and robustness of the regression and classification models are detailed in the Supplementary File.

2.4. Analytical strategies and approaches

2.4.1. Regression analysis

To model the relationships between poverty and key predictors (e.g., cell phone, electricity, and Internet access), we employed three regression approaches, each offering distinct advantages. Linear regression with lasso regularization provided a foundational understanding of linear relationships while performing feature selection by shrinking irrelevant coefficients to zero, enhancing interpretability (Hastie *et al.,* 2009; Muñetón-Santa & Manrique-Ruiz, 2023). However, its assumption of linearity may oversimplify complex socioeconomic dynamics. In contrast, XGBoost captured non-linear interactions and intricate patterns through gradient-boosted trees, leveraging regularization techniques, such as tree depth control and subsampling, to balance accuracy and overfitting (Chen *et. al.*, 2015 & 2016) Onsay & Rabajante, 2024b). Although less interpretable, its predictive performance often excels in high-dimensional settings. Finally, polynomial regression explored non-linear trends by extending linear models with higher-degree terms, offering flexibility to identify curvilinear relationships that simpler models might miss (Heiberger *et al.*, 2009; Ostertagová, 2012). However, its sensitivity to overfitting necessitates careful tuning of polynomial degrees. Collectively, these methods highlight a trade-off: Linear models prioritize interpretability, while XGBoost and polynomial regressions emphasize flexibility. Together, they provide complementary insights into poverty prediction, balancing simplicity with the capacity to uncover complex predictor-response dynamics. A detailed explanation of the ML regression techniques employed is provided in the Supplementary File.

2.4.2. Classification analysis

To predict poverty outcomes, we employed three robust classification methods, each chosen for their unique strengths in handling socioeconomic data. Gaussian Naïve Bayes (Aji *et al.*, 2023; Hastie *et al.*, 2009) provided a probabilistic framework for binary classification, leveraging its simplicity and efficiency with high-dimensional predictors such as cell phone ownership, electricity, and Internet access. Although it assumes that features are independent, its capacity to quickly estimate class probabilities provided useful initial insights into the likelihood of poverty. Logistic regression (Hastie *et al.*, 2009; Onsay & Rabajante, 2024c) was selected for its interpretability in modeling the linear relationships between predictors and the binary probability of poverty. By transforming predictor effects into log-odds, this method clarified how infrastructure access influences poverty, balancing simplicity with actionable insights for policy design. Finally, random forests (Onsay & Rabajante, 2024c; Schonlau & Zou, 2020) addressed the complexity of poverty determinants through ensemble learning. By aggregating multiple decision trees, it captured non-linear interactions among predictors while mitigating overfitting. Its ability to rank feature importance – highlighting variables such as electricity and Internet access – provided deeper insights into key drivers of poverty. Together, these methods complemented one another: Naïve Bayes for quick probabilistic estimates, logistic regression for interpretable linear associations, and random forests for capturing intricate, non-linear dynamics. This multi-method approach ensured a comprehensive analysis of infrastructure-related poverty predictors, aligning with our goal of informing targeted, data-driven interventions. The ML classification methods employed are described in detail in the Supplementary File.

2.5. Limitations and biases

Linear regression models with the lasso penalty can produce non-linear solutions in predictions due to coefficient shrinkage, while their sparsity-inducing property complicates interpretation and necessitates careful regularization parameter selection (Barocas *et al.*, 2023). XGBoost's complexity, regularization methods, and computational demands may lead to overfitting and require intensive hyperparameter tuning. Polynomial regression risks overfitting with higher degrees, increasing noise sensitivity, and reducing generalizability. Gaussian Naïve Bayes assumes unrealistic feature independence,

underperforming when correlations exist, while logistic regression's linearity assumption limits its ability to capture non-linear relationships and may struggle with multicollinearity or high-dimensional data (Eckart *et al*., 2021). Random forests lack interpretability due to their ensemble structure, hindering transparency in decision-making (Onsay & Rabajante, 2024a). The CBMS data from Goa, Camarines Sur, may face selection bias (e.g., overrepresentation of active participants) and measurement bias from variable collection methods. These were mitigated through full enumeration and standardization to enhance reliability. While residual biases remain, they guide critical evaluation of results.

2.6. Sensitivity analysis

To assess the robustness of our findings, we conducted a sensitivity analysis by examining the stability of regression coefficients and predictive performance across different model specifications and data partitions. First, we tested alternative econometric models, comparing probit regression results with logistic regression and random forest classification to evaluate consistency in poverty prediction. The core predictors – electricity access, cell phone ownership, and Internet connectivity – maintained their statistical significance across models, affirming their reliability in influencing poverty outcomes. Second, we applied k-fold cross-validation (k=10) to mitigate potential overfitting, ensuring that the model's accuracy remained stable across multiple training and test splits. Third, we examined the impact of multicollinearity by iteratively removing variables with high variance inflation factors (more than 5), confirming that no significant distortions affected coefficient estimations. Finally, to account for regional heterogeneity, we conducted sub-sample analyses at the barangay and sector levels, revealing consistent patterns in poverty determinants despite minor variations in effect sizes. These sensitivity checks collectively strengthen the validity of our findings, demonstrating that our methodological choices yielded robust and generalizable insights into poverty dynamics.

3. Results

Goa, a municipality in Camarines Sur Province, is located in the Bicol Region of the Philippines, an area characterized by significant economic challenges. The region, including Camarines Sur Province, has struggled with high poverty rates, with incidence rates reaching 38.7% in Camarines Sur Province based on the latest evaluations (Onsay & Rabajante, 2024b). This alarming figure underscores the pressing need to understand the multifaceted nature of poverty within the municipality. Poverty in Goa particularly affects a large portion of its population, with studies indicating that 82% of the indigenous people live in poverty, and 71% do not have access to sufficient food. Most multidimensional indicators have already been explored, but access to essential services has not yet been examined. These statistics reveal the extent of socioeconomic disparities faced by residents, emphasizing the urgent need for targeted interventions and policies aimed at poverty alleviation.

3.1. Poverty status and access to essential services among household populations

Figure 2 reveals the distribution of households under various conditions. Results provide important insights into the socioeconomic landscape of the region. A significant portion, 63.69% (8,930 households), was classified as poor, indicating that a large segment of the population is experiencing economic difficulties. In contrast, 36.31% (5,091 households) were considered non-poor, representing a smaller, more stable economic group within the total population of 14,021 households. Access to essential services is a crucial factor influencing household conditions. The distribution of household characteristics, including income conditions and access to essential services such as electricity, cell phone ownership, and Internet connection, is provided in Table S1.

An overwhelming majority, 95.59% (13,402 households), has an electrical connection, highlighting the widespread availability of this basic utility. However, 4.41% (619 households) do not have access to electricity, pointing to potential disparities in infrastructure that could affect living standards and opportunities. Cell phone ownership is also significant, with 67.27% (9,432 households) owning a cell phone. This high ownership rate indicates that communication technologies are commonly used, which may improve connectivity and access to information for many families. Nonetheless, 32.73% (4,589 households) do not own a cell phone, suggesting a digital divide that may impact communication, information access, and participation in the digital economy. Internet connectivity shows a marked disparity, with only 39.15% (5,489 households) having access while 60.85% (8,532 households) lack Internet connection. This gap raises concerns about digital inclusion and could limit educational, economic, and social opportunities for households without online access. The distribution of households based on income and access to essential services highlights the complexity of socioeconomic dynamics within the surveyed population. These findings stress the need to address disparities in infrastructure and digital access to create more equitable opportunities and improve overall well-being for households. This is consistent with the overarching trends of poverty in the Philippines. Recent studies indicate

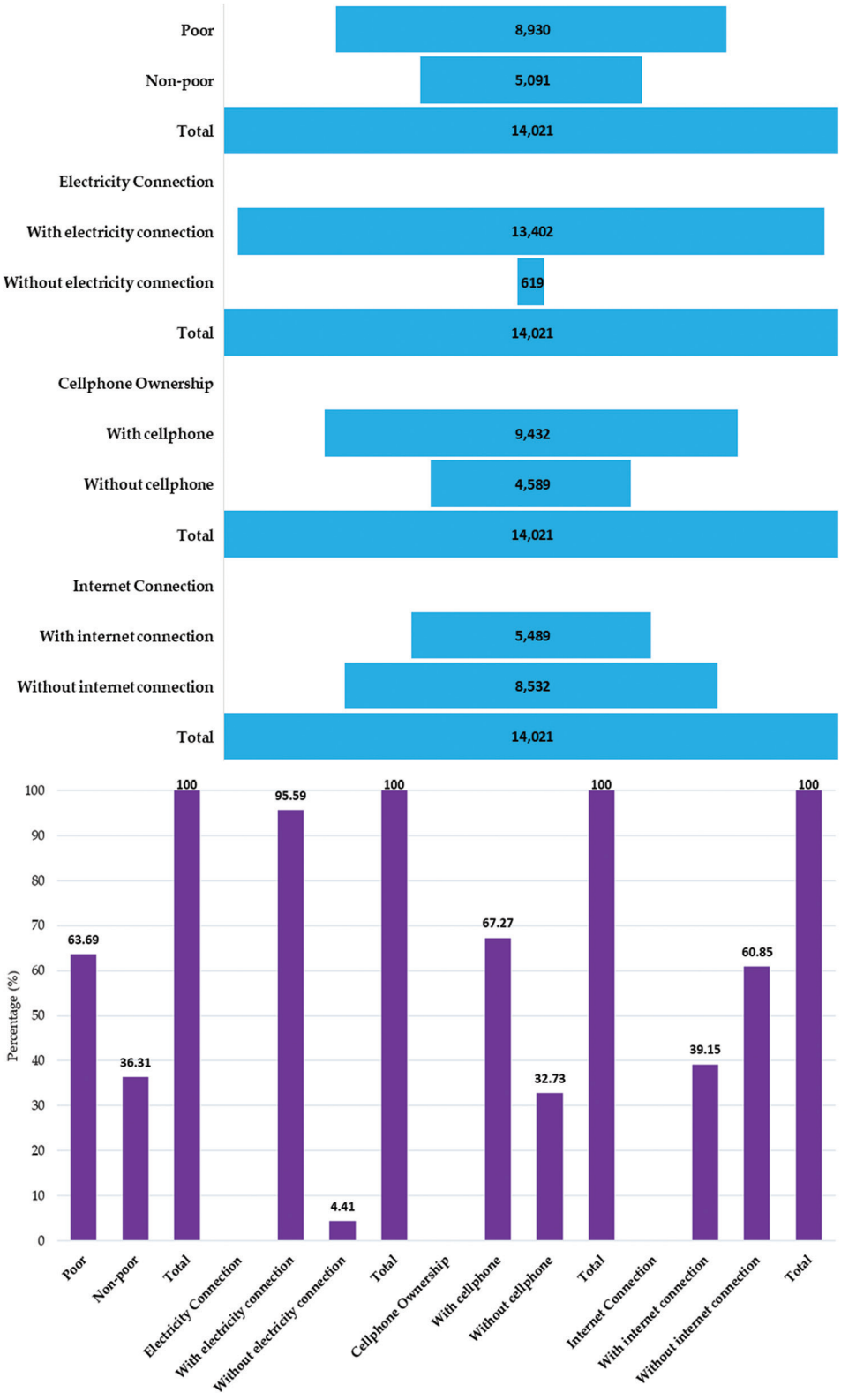

Figure 2. Frequency analysis and distribution of poverty and access to essential services among household populations

that nearly 60% of households nationwide lack access to the Internet, hampering their ability to benefit from digitalization and economic opportunities (Diop *et al.*, 2020; Onsay & Rabajante, 2024d). A substantial number of Filipinos continue to lack reliable Internet access, which restricts their participation in the digital economy and limits educational opportunities (Baticulon *et al.*, 2021; Giray *et al.*, 2022).

3.2. Factors affecting poverty outcomes driven by essential services

The results of the probit regression model unveil significant associations between key factors and poverty outcomes, as revealed by Table 2.

Internet connection, cell phone ownership, electricity access, and household size all exhibit notable impacts on poverty likelihood. Specifically, having no Internet connection, not owning a cell phone, and having no electrical connection are linked with increased probabilities of experiencing poverty, with coefficients of 0.2697, 0.2883, and 0.5768, respectively. Keeping other variables constant, a one-unit increase in no cell phone ownership corresponds to a 0.2883 increase in the likelihood of poverty, and a one-unit increase in no Internet connection corresponds to a 0.2697 probability of experiencing poverty. Whereas a one-unit increase in having no electrical connection is linked to a 0.5768 rise in the probability of poverty. Controlling for other variables, an increase in household size by one unit is associated with a 0.1457 increase in the likelihood of experiencing poverty.

Having no Internet connection can restrict access to information, online opportunities, education, and job prospects. In today's digital era, Internet access is vital for social and economic engagement. The coefficient illustrates how the absence of Internet access can impede one's ability to escape or prevent poverty. Cell phones serve not only as communication tools but also as gateways to services, job prospects, and information. Lacking a cell phone can isolate individuals from vital connections and resources, potentially heightening the risk of poverty. Conversely, electricity is indispensable for lighting, cooking, communication, and powering devices. Without electricity, daily tasks become arduous, economic opportunities shrink, and overall quality of life declines significantly. The significant coefficient underscores the deep impact of electricity deprivation on the likelihood of poverty. Conversely, a larger household size often leads to increased financial strain on limited resources. With more dependents to support, expenses for essentials such as food, shelter, and other necessities rise. This coefficient indicates that as household size expands, the likelihood of experiencing poverty also rises due to the additional financial burden. The constant term represents the baseline probability of poverty when all other variables are zero. These findings suggest that access to modern communication technologies and essential utilities might not only be indicators of economic well-being but also potentially influential factors contributing to poverty levels in the studied region. Addressing disparities in connectivity and household composition could play a crucial role in poverty alleviation efforts, emphasizing the importance of targeted interventions to improve access to these resources for vulnerable populations.

The findings of the probit regression model align with existing literature on the relationship between access to communication technologies, essential utilities, and poverty outcomes. Research indicates that Internet access is strongly associated with lower poverty levels, particularly in rural regions, where connectivity can significantly improve economic opportunities and access to information (Butcher & Curry, 2022; Garcia-Mora & Mora-Rivera, 2023). In addition, studies highlight that ownership of mobile phones and other technological tools not only facilitates better communication but also enhances economic activities, thereby contributing to poverty reduction (Kefela, 2011; Sullivan, 2008). Furthermore, the impact of household size on poverty likelihood is well-documented, as larger households often face greater financial strain due to increased resource demands, which can exacerbate poverty conditions. Taken together, these insights emphasize the necessity of addressing disparities in access to essential services and communication

Table 2. Results of probit regression on the influence of essential services on poverty outcomes

Poverty outcomes	Coefficient	Standard error	$p>z$	Robust		
				Coefficient	Standard error	$p>z$
Internet connection	0.2697	0.0744	0.0000	0.2697	0.0751	0.0000
Cell phone ownership	0.2883	0.0310	0.0000	0.2883	0.0305	0.0000
Electrical connection	0.5768	0.0407	0.0000	0.5768	0.0394	0.0000
Household size	0.1457	0.0053	0.0000	0.1457	0.0055	0.0000
Intercept (_cons)	−0.3827	0.0259	0.0000	−0.3827	0.0264	0.0000

technologies, as improving these resources could be pivotal in poverty alleviation strategies for vulnerable populations (Afzal *et al*., 2022). The absence of electricity not only keeps communities trapped in a cycle of poverty but also restricts children's educational prospects, as many schools lack the necessary facilities to operate effectively after dark (Diallo & Moussa, 2020; Ignacio *et al*., 2021; O'Sullivan *et al*., 2011).

3.3. Predicted probability on poverty outcomes and performance evaluation of econometric models

The probit regression model reveals how key variables such as electricity access, cell phone usage, Internet connectivity, and household size serve as significant predictors of poverty outcomes. The analysis shows that as access to these services increases, the predicted probability of a household being classified as poor decreases, indicating a non-linear but meaningful relationship between these factors and poverty status. This suggests that these variables not only influence poverty directly but also interact in ways that affect the model's predictive power. Despite potential limitations in initial econometric classification accuracy, integrating these predictors improves the precision of poverty estimation, especially when used as a priori input in subsequent ML applications. The model's robustness is further supported by the goodness-of-fit results. With 13,797 observations and 98 unique covariate patterns, the Pearson chi-square statistic is 147.12 with 93 degrees of freedom, yielding a statistically significant p=0.0003. This confirms that the model fits the data well and that the included predictors are significantly associated with poverty status, reinforcing their relevance for policy and practical application (Hagle & Mitchell, 1992; Kibria & Saleh, 2012).

Table 3 offers a breakdown of the classification results based on the model's predictions of poverty status. Out of a total of 13,797 household observations, 8,954 households were classified as poor, with 7,975 of them accurately falling into the poor category and 879 incorrectly classified as poor. In addition, 3,816 households were classified as non-poor, with 1,127 being correctly categorized and 2,689 misclassified. This classification breakdown underlines the model's performance in distinguishing between poor and non-poor households, shedding light on both its accuracy in predicting poverty outcomes and areas where misclassifications occur. The model demonstrates high sensitivity, correctly identifying 90.07% of households classified as poor and effectively capturing true positive cases. However, its specificity is comparatively lower at 22.80%, indicating challenges in accurately identifying non-poor households. The positive predictive value of 67.64% signifies that among those classified as poor, a substantial majority are indeed in poverty. Conversely, the negative predictive value of 56.18% indicates room for improvement in correctly identifying non-poor households. The false positive rate for true non-poor households stands at 77.20%, while the false negative rate for true poor households is 9.93%, suggesting areas where misclassifications occur. Moreover, the false positive rate for classified non-poor households is 32.36%, and the false negative rate for classified poor households is 43.82%, indicating instances where the model incorrectly predicted poverty outcomes. Finally, the model achieves an accuracy rate of 65.97%, highlighting the proportion of correctly predicted outcomes and pointing toward the need for potential refinements to enhance its predictive capabilities and reduce misclassifications. These results emphasize the importance of ML predictions in improving the validity and reliability of model fitting. There is a critical need to enhance accuracy and improve the applicability of the model to ensure its effectiveness.

3.4. ML regression for poverty prediction by essential services

We have implemented the procedures and applied all ML algorithms with caution and cross-validation as shown in

Table 3. Classification of performance metrics for poverty status prediction of household populations

Classification	Poor classification	Non-poor classification	Total
Classified as poor and actually poor	7,975		11,791
Classified as poor but actually non-poor	879		2,006
Classified as non-poor but actually poor		3,816	
Classified as non-poor and actually non-poor		1,127	
Total	8,854	4,943	13,797
Sensitivity	90.07%		
Specificity	22.80%		
Positive predictive value	67.64%		
Negative predictive value	56.18%		
False positive rate for true non-poor	77.20%		
False negative rate for true poor	9.93%		
False positive rate for classified as non-poor	32.36%		
False negative rate for classified as poor	43.82%		
Accurate classification rate		65.97%	

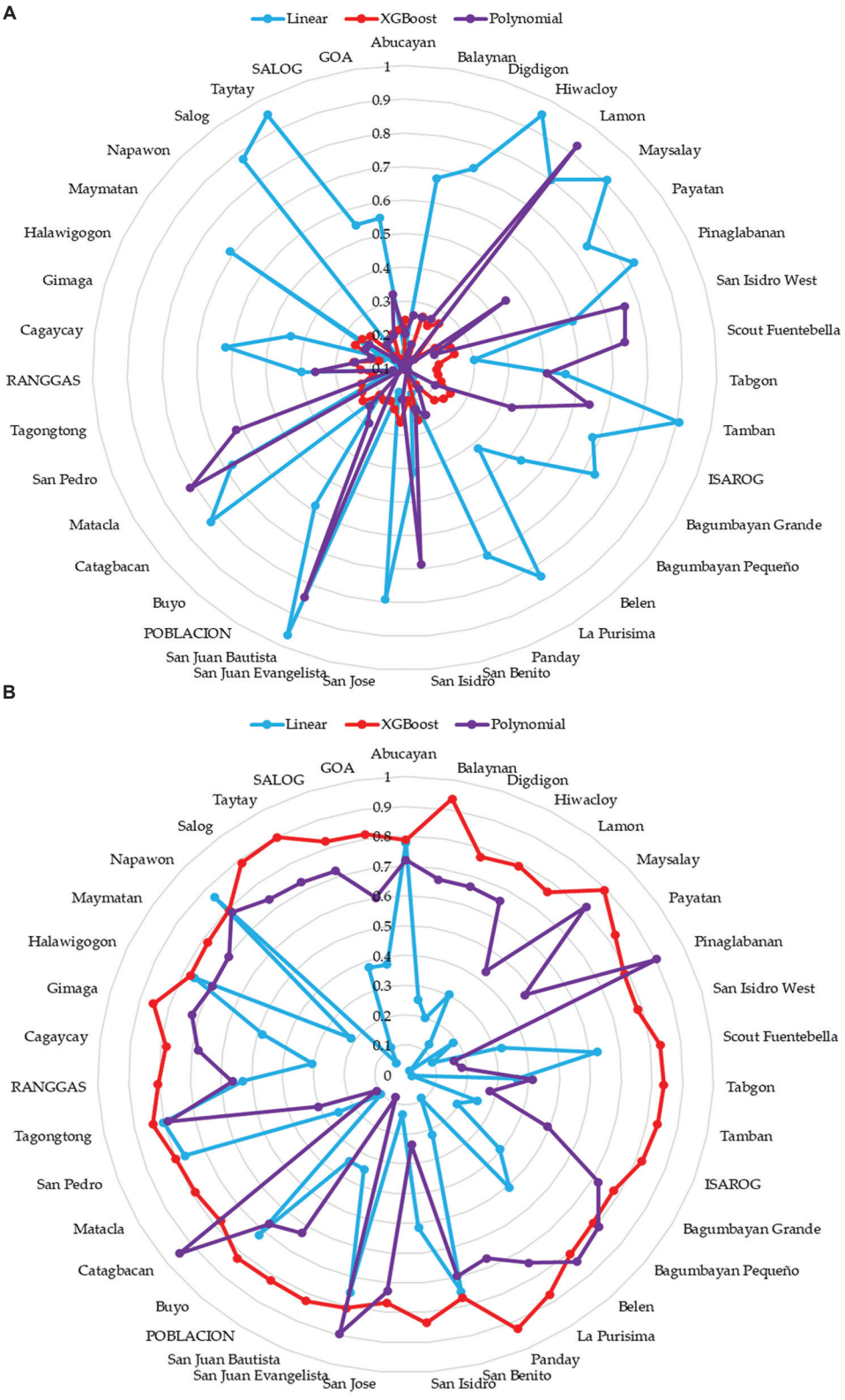

Figure 3. Model performance in poverty prediction using electricity and digital connection indicators. (A) Represents the average MSE, and (B) Represents the average $^{R}2$ of the ML regression models for both localities and sectors.
Abbreviations: XGBoost: Extreme Gradient Boost; MSE: Mean squared error.

Figure 3. For the regression analysis, the target value is the monthly income of households, supported by poverty gap and severity statistics. Three regression models were utilized in this work: linear, XGBoost, and polynomial. The datasets were clustered into 34 localities (barangays) and summarized into four sectors (Isarog, Ranggas, Salog, and Poblacion). By disaggregating the data into various configurations, we ensured that the accuracy of the ML models was maintained. Different localities exhibited varying characteristics; thus, multiple ensemble methods were beneficial for this analysis. The ML algorithms we employed aimed to inform policies and programs from a microeconomic perspective relevant to local sectors. A total of 238 runs of poverty predictions were conducted for the 34 localities, 28 runs for the four sectors, and seven runs for the entire municipality of Goa, Camarines Sur Province, utilizing data on electrical connections, cell phone ownership, Internet access, and household size. Figure 3 presents the average MSE (Figure 3A) and average R^2 (Figure 3B) of the ML regression models for both localities and sectors. The linear regression model generally performed moderately well across the local areas, with MSE values ranging from approximately 0.15 to 0.95, demonstrating better performance in locales such as San Benito, San Pedro, and Tagongtong. Conversely, the XGBoost regression model produced varying results, with MSE values ranging from about 0.09 to 0.26, performing effectively in Balaynan, Bagumbayan Pequeño, and Salog. The polynomial regression model showed mixed results, with MSE values ranging from 0.06 to 0.93, yielding better outcomes in areas such as Bagumbayan Pequeño, Belen, and San Juan Evangelista. The choice of regression model considerably influenced prediction accuracy, with different regression models excelling in specific local contexts. Overall, XGBoost achieved the lowest average MSE, followed by the polynomial and linear regression models. The average MSE values of the regression models for poverty prediction, categorized by electrical connection, cell phone ownership, and Internet access, are provided in Table S2.

Figure 3 shows the average R^2 and MSE values for various ML regression models used in predicting poverty based on electrical connection, cell phone ownership, and Internet access. The metrics reflect the models' predictive accuracy across these key indicators.

Regarding the average root MSE, the XGBoost algorithm demonstrated a root MSE of 0.3012. The linear regression model achieved R^2 values ranging from approximately 0.02 to 0.86 across various barangays, performing relatively well in barangays such as Abucayan, San Pedro, and Tagongtong. The XGBoost regression model varied in performance, with R^2 values between approximately 0.77 and 0.93, excelling in barangays such as Balaynan, Panday, and Taytay, where it attained higher R^2 values compared to the other regression models. The polynomial regression model exhibited mixed performance as well, with R^2 values ranging from 0.08 to 0.95, showing improved results in barangays such as Catagbacan, San Juan Evangelista, and Napawon. The choice of regression model notably influenced the model's predictive performance, with each regression model performing best in different barangays. The linear regression model provided more consistent performance, while the XGBoost and polynomial regression models demonstrated greater variability in their outcomes. Overall, XGBoost performed admirably, achieving the highest R^2 value, indicating it has the lowest error score and provides the best fit to the regression line (Supplementary File). These results differ from some studies on poverty prediction. However, our findings align with previous research showing that gradient boosting also exhibits strong performance, consistent with the studies of Solís-Salazar & Madrigal-Sanabria (2022) and Zixi (2021). Moreover, our results support the assertion made by Li *et al.* (2022) that XGBoost outperforms linear models in poverty prediction. The average R^2 values of the ML regression models for poverty prediction, categorized by electrical connection, cell phone ownership, and Internet access, are presented in Table S3.

3.5. ML classification for poverty prediction by essential services

Figure 4 reveals the results of the logistic regression, random forest, and Gaussian Naive Bayes classifiers for predicting poverty based on electricity access, cell phone ownership, and Internet connectivity in different barangays. The logistic regression model achieved classification accuracies ranging from approximately 0.66 to 0.89 across the various barangays. It performed well in barangays such as Balaynan, San Isidro West, and Tabgon, where it attained higher accuracy levels. The random forest algorithm demonstrated accuracies ranging from about 0.70 to 0.93, excelling in barangays such as Balaynan, San Isidro West, and Tabgon and showing consistently high performance across these areas. The Gaussian Naive Bayes classifier exhibited accuracies between approximately 0.66 and 0.89 across the barangays, similarly performing well in Balaynan, San Isidro West, and Tabgon, where it achieved elevated accuracy levels. Overall, the random forest algorithm outperformed the other algorithms in terms of classification accuracy in most barangays. Logistic regression and Gaussian Naive Bayes also displayed competitive performance, though with greater variability across different regions. Electricity access, cell phone

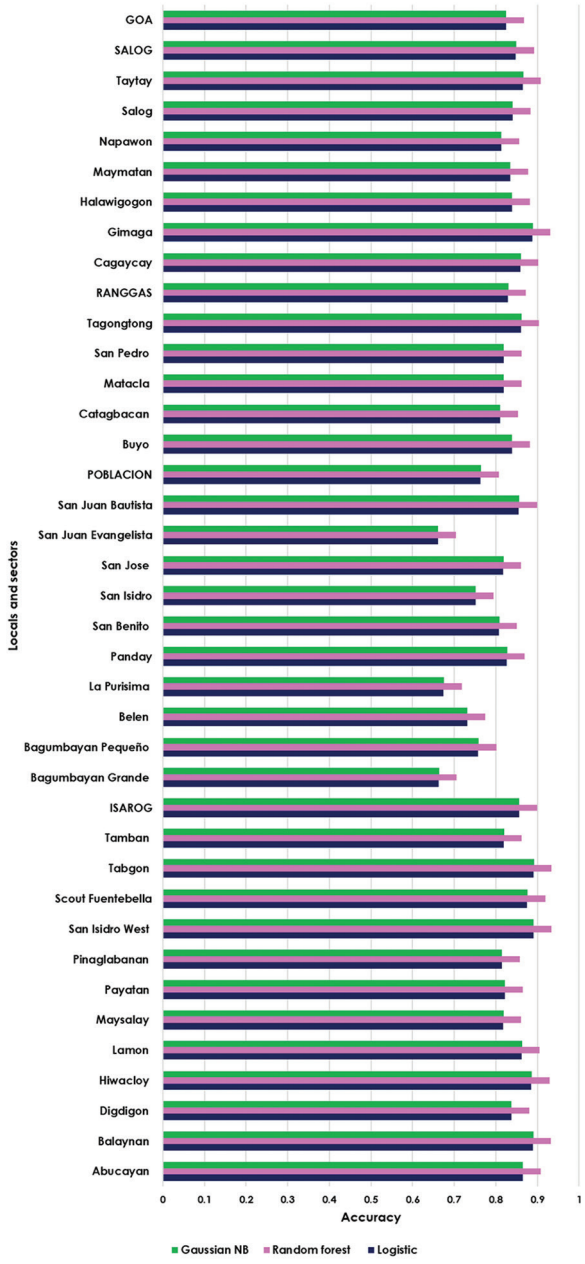

Figure 4. Classification accuracies of machine learning algorithms for poverty prediction based on electricity availability, cell phone ownership, and Internet access, evaluated with random variables Abbreviation: NB: Naïve Bayes.

ownership, and Internet connectivity play a significant role in predicting poverty levels, with these ML algorithms offering valuable insights into the relationship between these factors and poverty. These results align with the study by Min *et al.* (2022), which claims that random forest regression demonstrated the best performance in predicting poverty among Costa Rican households. In addition, random forests yielded the highest accuracy in poverty prediction in Colombia (Muñetón-Santa & Manrique-Ruiz, 2023). The classification accuracies of the ML algorithms for poverty prediction, categorized by electrical connection, cell phone ownership, and Internet access, are detailed in Table S4.

Figure 5 illustrates the classification accuracies of logistic regression, random forest, and Gaussian Naïve Bayes for predicting poverty based on the availability of electrical connections, cell phone ownership, and Internet access in different barangays at Pipeline (Δ). Prediction through Pipeline (Δ)s involved using pre-set criteria to optimize the accuracy of the algorithms. The models were first fitted to the training data, after which their accuracy metrics were compared. The most accurate model was then selected based on its performance during evaluation with the test dataset (Figure 1) (Mujumdar & Vaidehi, 2019). The logistic regression model achieved classification accuracies ranging from approximately 0.71 to 0.93 across the various barangays at Pipeline (Δ). It performed particularly well in barangays such as Balaynan, San Isidro West, and Tabgon, attaining higher accuracy levels in these areas. The Random Forest algorithm exhibited accuracies ranging from about 0.72 to 0.95 across the barangays at Pipeline (Δ). It excelled in barangays such as Balaynan, San Isidro West, and Tabgon, consistently demonstrating high performance in these locations. The Gaussian Naïve Bayes classifier showed accuracies between approximately 0.71 and 0.93 across the barangays at Pipeline (Δ). Similar to the logistic regression model, it also performed well in Balaynan, San Isidro West, and Tabgon, achieving elevated accuracy levels. Consistent with the findings presented in Figure 3, the random forest algorithm generally outperforms the other algorithms in classification accuracy in most barangays at Pipeline (Δ). While logistic regression and Gaussian Naïve Bayes also displayed competitive performance, their results exhibited some variability across different areas. The availability of electrical connections, cell phone ownership, and Internet access remains significant in predicting poverty levels at Pipeline (Δ). The ML algorithms employed in this study provide valuable insights into the relationship between these factors and poverty in this specific region. This observation aligns with the study by Browne *et al.* (2021), which claims that the random forest regression model is effective in poverty prediction and malnutrition analysis. In addition, Hu *et al.* (2022) utilized random forest regression for poverty prediction at the village level. Liu *et al.* (2012) applied random forest regression to identify spatial poverty determinants in rural China. Furthermore, the Light Gradient-Boosting Machine framework has proven to be an effective tool in predicting poverty in Jordan (Alsharkawi *et al.*, 2021). This analysis

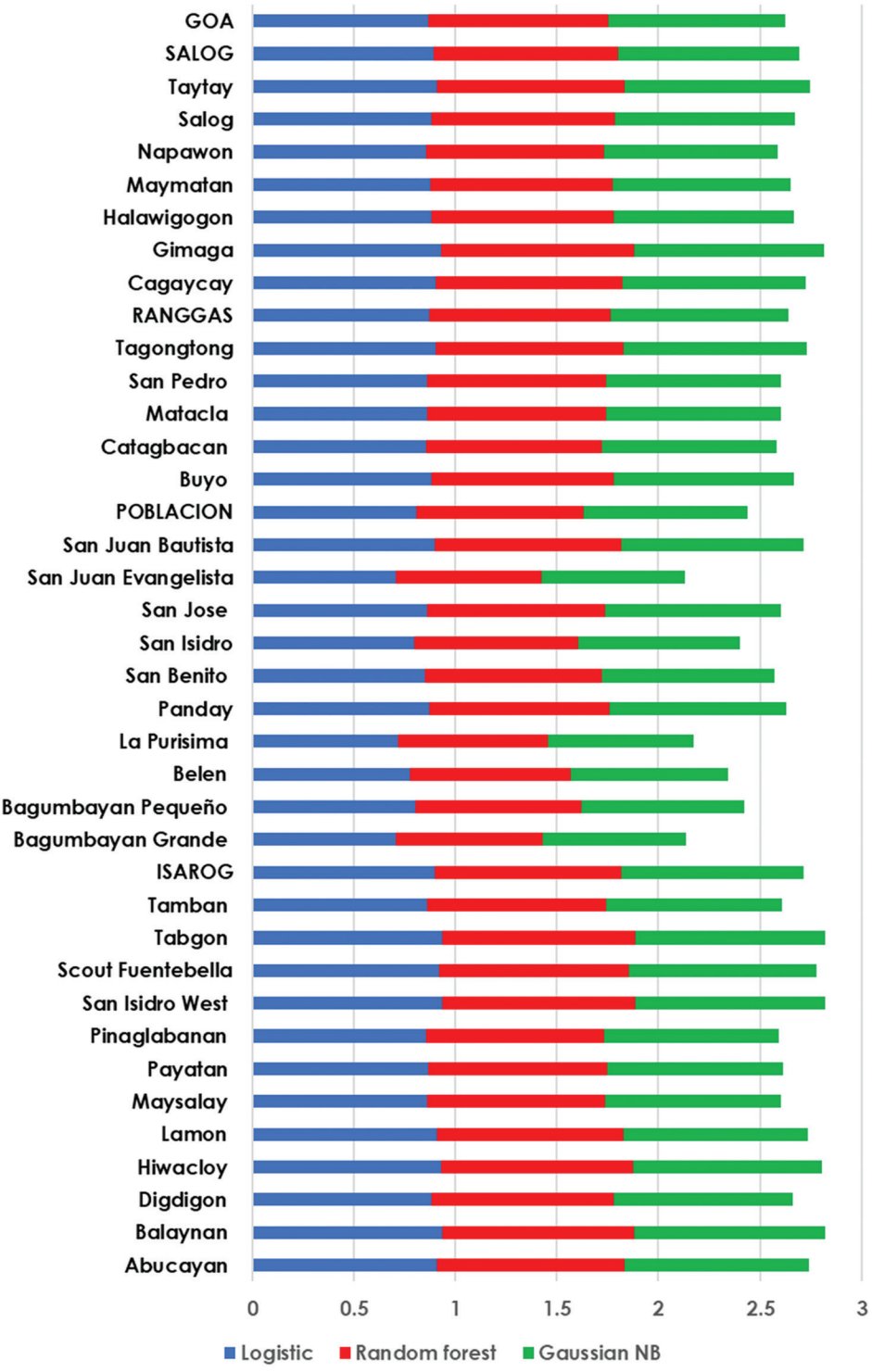

Figure 5. Classification accuracies of machine learning algorithms for poverty prediction based on electricity, cell phone ownership, and Internet access at Pipeline (Δ)
Abbreviation: NB: Naïve Bayes.

highlights how different ML algorithms perform in predicting poverty based on the presence of electrical connections, cell phone ownership, and Internet access across various barangays at Pipeline (Δ), emphasizing their classification accuracies as indicators of predictive success. The classification accuracies of ML algorithms for poverty prediction, categorized by electrical connection, cell phone ownership, and Internet access at Pipeline (Δ) (Δ), are detailed in Table S5.

3.6. Policy proposals in addressing poverty through essential service access

We have detailed essential interventions designed to alleviate poverty by enhancing access to critical services. These strategies play a crucial role in overcoming obstacles related to resources such as electricity availability, cell phone ownership, and Internet connectivity, which are essential for enhancing living standards and mitigating poverty risks. Our approach involved thorough focus group discussions and key informant interviews with government officials and residents of both municipal and barangay levels. Focus group discussions were conducted across 34 barangays within the municipality to gather insights and inputs on pertinent issues. In addition, we sought expertise in digital technologies and electricity economics. The proposals presented in Table 4 are indispensable for policy makers and organizations, offering a pathway to uplift communities and enhance socio-economic conditions. Informed by econometrics and ML analyses, these interventions are data-driven and customized to effectively combat poverty. By integrating insights from these fields, the interventions in Table 4 are grounded in evidence and aimed at bridging the digital gap, empowering individuals, and fostering economic opportunities in alignment with empirical studies on poverty alleviation.

The interventions presented in Table 4 are designed to address poverty linked to essential services such as electricity, cell phone ownership, and Internet access. These strategies were formulated through consultations with crucial stakeholders in the economic ecosystem of the region facing extreme poverty. The data informing these interventions was gathered through focus group discussions and key informant interviews to better understand the community's needs and challenges. By incorporating local perspectives and insights, these programs aim to create targeted solutions that resonate with the concerns and realities of the population experiencing poverty. The collaborative approach taken in developing these interventions underscores a community-driven and participatory effort to tackle poverty and enhance access to vital services in the region. By establishing programs that offer financial assistance for electricity bills, providing energy efficiency upgrades, and implementing off-grid solar initiatives, communities can ensure consistent access to clean and reliable electricity. In addition, promoting the reuse of mobile devices, supplying free phones to those in need, and offering affordable upgrade options can enhance connectivity and communication for vulnerable groups. Moreover, supporting the creation of community-owned broadband networks, advocating for municipal investments in broadband infrastructure, and issuing digital vouchers for discounted Internet services address

Table 4. Proposed interventions in addressing poverty through essential service access

Essential services	Intervention programs
Electrical connectio$_n$	• Establish programs that provide financial assistance to low-income households for paying electricity bills. • Offer energy efficiency upgrades and weatherization services to reduce electricity costs. • Implement off-grid solar power initiatives in rural and distant areas without access to the main electricity grid. • Provide affordable solar home systems or mini-grids to increase access to clean and reliable electricity. • Introduce energy subsidy programs targeted at vulnerable populations to ensure affordable access to electricity. • Implement tiered pricing structures to make electricity more affordable for low-income households. • Memorandum of Agreement with the Camarines Sur Electric Cooperative). • Conditionality services programs for energy consumption.
Cell phone ownership	• Free phone for vulnerable groups. • Establish programs that collect and refurbish used mobile phones, making them available at reduced prices for poor individuals. • Promote sustainable practices by encouraging the reuse of mobile devices and donations to poor households. • Introduce trade-in programs where individuals can exchange old devices for discounts on new cell phones. • Partner with manufacturers and retailers to offer affordable upgrade options for poor customers in the locality.
Internet connection	• Support the development of community-owned broadband networks to provide affordable and high-speed Internet access to underserved areas. • Encourage local municipalities to invest in broadband infrastructure for the benefit of residents. • Issue digital vouchers to poor households that can be redeemed for discounted Internet services or devices. • Collaborate with Internet service providers to offer special packages tailored to voucher recipients.

the digital divide, providing affordable and high-speed Internet access to underserved areas. These interventions not only improve access to essential services but also have broader implications for socioeconomic development. Enhanced access to electricity, connectivity, and communication technologies can empower individuals, facilitate educational opportunities, enable access to health-care services, and foster economic growth within marginalized communities. Furthermore, collaboration with stakeholders such as electric cooperatives, manufacturers, retailers, and Internet service providers can lead to more effective and sustainable implementation of these interventions. The focus on affordability, sustainability, and inclusivity in these programs reflects a commitment to addressing the specific needs of vulnerable populations and promoting equitable access to essential services. Overall, these strategies possess the potential to bridge existing gaps in access to essential services while also contributing to the overall well-being and development of underserved communities. Policy makers can leverage the insights from probit analysis to implement measures that address these critical variables, ultimately contributing to more effective poverty alleviation strategies such as renewable energy, efficient Internet infrastructure, and durable cell phones (Jaeger *et al*., 2007; Rani & Schmid, 2007; Velasco & Chang, 2024). This study's findings offer global relevance for poverty alleviation, particularly in developing regions such as Sub-Saharan Africa, South Asia, and Latin America, where rural areas face high poverty rates linked to limited Internet access (World Bank, 2022).

4. Discussion

Our study highlights significant economic disparities among the 14,021 surveyed households in Goa, Camarines Sur Province, Philippines, with 63.69% classified as poor and 36.31% as non-poor. Access to essential services—electricity, cell phone ownership, and Internet connectivity – emerges as a critical determinant of poverty outcomes. While electricity access is widespread (95.59%), 4.41% of households remain excluded, reflecting localized disparities that exacerbate inequalities in living standards. Similarly, 67.27% own cell phones, yet 32.73% do not, signaling a persistent digital divide that hinders connectivity and participation in digital platforms (Diop *et al*., 2020; Onsay & Rabajante, 2024d). Internet connectivity is markedly unequal, with only 39.15% having an Internet connection compared to 60.85% without, limiting educational, economic, and social opportunities for unconnected households. These disparities align with national trends, where ~60% of Filipino households lack Internet access, restricting benefits from digitalization and stifling engagement in the digital economy and education (Baticulon *et al*., 2021; Giray *et al*., 2022). Addressing infrastructure and digital inclusion gaps is critical to fostering equitable socioeconomic progress (Jenkins *et al*., 2016; Sen, 2008).

The probit regression model confirms significant relationships between service access and poverty status. Lack of Internet connection (coefficient: 0.2697), cell phone ownership (0.2883), and electricity access (0.5768) are strongly linked to higher poverty probabilities, while a one-unit increase in household size elevates poverty risk by 0.1457, reflecting resource strain (Table 2). These findings align with Sen's Capabilities Approach, as limited access to electricity and digital technologies restricts individuals' ability to enhance education, health care, and economic opportunities (Sen, 2008). Internet access serves as a poverty-alleviation tool, particularly in rural areas (Butcher & Curry, 2022; Garcia-Mora & Mora-Rivera, 2023), while mobile ownership facilitates economic participation (Kefela, 2011; Sullivan, 2008). Electricity deprivation perpetuates poverty by limiting education and economic activities (Diallo & Moussa, 2020; Ignacio *et al*., 2021; O'Sullivan *et al*., 2011). Larger households face compounded challenges due to resource dilution (Afzal *et al*., 2022), underscoring the need for targeted interventions to enhance digital inclusion and utility access.

ML models further strengthen these findings. Among tested models, XGBoost achieved the lowest average MSE (0.09 – 0.26) and highest R^2 (0.77 – 0.93), outperforming linear and polynomial regression models (Figure 3). This aligns with studies highlighting gradient boosting's efficacy in poverty prediction (Li *et al*., 2022; Solís-Salazar & Madrigal-Sanabria, 2022; Zixi, 2021). While random forest excelled in classification (accuracy: 0.70 – 0.93) (Min *et al*., 2022; Muñetón-Santa & Manrique-Ruiz, 2023), XGBoost's superiority in localized contexts underscores its utility for tailored policy design. Electricity access, cell phone ownership, and Internet connectivity emerged as key predictors, reinforcing their role in socioeconomic disparities (Alsharkawi *et al*., 2021; Browne *et al*., 2021; Hu *et al*., 2022; Liu *et al*., 2012). These results align with the social capital theory, as digital access fosters social connections for resource acquisition (Nahapiet & Ghoshal, 1998), and the digital divide theory, which highlights barriers to technological benefits (Lee & Byrne, 2019; Van Dijk, 2006). The Energy Justice Framework contextualizes electricity disparities, advocating equitable policies for marginalized groups (Jenkins *et al*., 2016). Meanwhile, the theory of change provides a roadmap for interventions such as broadband expansion and renewable energy initiatives to enhance accessibility (Connell & Kubisch, 1998). Collaboration with stakeholders – electric cooperatives,

Internet service providers, and manufacturers – can ensure sustainable, inclusive programs (Jaeger *et al.*, 2007; Rani & Schmid, 2007; Velasco & Chang, 2024). Policy makers must leverage these insights to bridge service gaps and promote equitable access, aligning with broader poverty alleviation strategies for vulnerable populations.

5. Conclusion

The complexity of poverty in the poorest region of Luzon, Philippines, underscores the profound socioeconomic challenges faced by a significant portion of the population. This study reveals stark disparities in access to essential services such as electricity, cell phones, and the Internet, highlighting their critical role in shaping poverty outcomes. Through probit regression analysis, we demonstrated that access to modern communication technologies and basic utilities significantly influences economic well-being, serving as either a catalyst for poverty alleviation or a barrier to progress. These findings emphasize the urgent need for equitable access to these resources as a cornerstone of poverty reduction strategies. A key contribution of this study lies in its innovative application of ML to predict poverty outcomes. By evaluating various regression models and classifiers, we found that XGBoost consistently outperformed linear and polynomial regression models in predictive accuracy, while random forest achieved the highest classification accuracy compared to logistic regression and Gaussian Naive Bayes. These results not only validate the reliability of ML algorithms such as XGBoost and random forest in poverty prediction tasks but also underscore their potential to inform targeted, data-driven interventions. The study's methodological approach offers a replicable framework for other regions seeking to leverage technology for poverty analysis and policy design. The implications of this research extend far beyond the Philippines. By identifying specific areas where interventions can have the greatest impact, the study provides actionable insights for addressing digital and energy poverty in other developing countries and impoverished regions. The proposed policies – ranging from financial assistance for electricity bills and off-grid solar programs to community-owned broadband networks and digital voucher systems – offer scalable solutions tailored to the unique needs of underserved communities. These strategies emphasize the importance of collaborative, participatory approaches to poverty alleviation, ensuring that interventions are both inclusive and sustainable. Moreover, this study contributes to the broader discourse on poverty by aligning its findings with global development goals, particularly the United Nations' Sustainable Development Goals related to poverty eradication, affordable energy, and infrastructure development. The research highlights the interconnectedness of energy access, digital connectivity, and economic stability, offering a multidimensional perspective on poverty that transcends traditional income-based metrics.

Looking ahead, this study opens several avenues for future research. Longitudinal studies could assess the long-term impact of implemented interventions, while further exploration of the socio-economic effects of energy and digital poverty could deepen our understanding of these complex dynamics. In addition, policy impact analyses on energy access could provide valuable insights for crafting more targeted and effective interventions in similar contexts. Finally, this study not only advances our understanding of poverty in the Philippines but also offers a robust framework for addressing similar challenges globally. By addressing infrastructure gaps and enhancing access to essential services, the findings and proposed interventions pave the way for sustainable economic development and improved well-being in impoverished regions worldwide. The study's emphasis on data-driven, community-centered solutions underscores the importance of tailored strategies that reflect the unique needs of each context, ensuring that no one is left behind in the pursuit of progress.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Author contributions

Conceptualization: All authors
Data curation: Emmanuel A. Onsay
Formal analysis: All authors
Funding acquisition: All authors
Investigation: Emmanuel Onsay
Methodology: All authors
Project administration: All authors
Resources: All authors
Software: Kevin C. Baltar
Supervision: Kevin C. Baltar
Validation: All authors
Visualization: Emmanuel Onsay
Writing – original draft: Emmanuel Onsay
Writing – review & editing: Kevin C. Baltar

Ethics approval and consent to participate

The study received approval from the Partido State University and the University of the Philippines, Los Baños. The Goa, Camarines Sur Local Government Unit approved the dissemination, use, management, analysis, and application of the processed data outputs. Researchers carried out data analysis and procedures voluntarily and independently, without being part of an experiment. The human data used in this study are of a secondary, indirect, and socioeconomic nature, devoid of any laboratory experimentation, hence obviating the need for ethical clearances. In addition, the research excludes animal testing, direct involvement of human volunteers, or the use of data sourced from social media platforms.

Consent for publication

Not applicable, the study utilizes secondary data that are publicly available and anonymized.

Availability of data

The dataset used in this study can be accessed through this cited Mendeley Data deposition:

Onsay, Emmanuel; Rabajante, Jomar, "Dataset on Measuring the Unmeasurable Multidimensional Rural Poverty for Economic Development: Analysis from the Poorest District of the Poorest Province in the Poorest Region of Luzon, Philippines", Mendeley Data, V1, doi: 10.17632/s76nh7dm4v.1 (2023).

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RESEARCH ARTICLE

Factors associated with secondary school attendance in Lesotho, 2018

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Abstract

In 2018, the adjusted net attendance ratio for secondary schools in Lesotho was 56.1%, with males accounting for 45.5% and females 67.2%, a rate falling short of the 80% target set by the United Nations Sustainable Development Goals. This study explores the individual, household, and community factors influencing secondary school attendance among youth aged 13 – 17 in Lesotho. The study utilized data from the Lesotho 2018 Multiple Indicator Cluster Survey to examine the factors associated with secondary school attendance. A three-level logistic regression model was employed to assess these associations, with separate analyses conducted for male and female respondents. The study's findings revealed that at the individual level, the relationship to the household was a significant factor for both genders. For males, additional factors included age, herding of animals, and maternal education, whereas for females, age at first marriage was significant. Among males, household factors accounted for the largest share (79.3%) of the explained variation in school attendance, followed by individual factors (14.8%), and community factors (5.9%). For females, household and community factors each explained 43% of the variation, with individual factors accounting for 14.6%. Based on the findings, it is concluded that for males, individual and household factors were the primary factors influencing their school attendance, explaining at least 80% of the total explained variation. For females, household and community factors were the most significant factors. The study recommends that there should be interventions addressing household and individual factors for males, and household and community factors for females. Specifically, addressing issues such as animal herding for boys and teenage marriage for girls could significantly improve their school attendance. In addition, poverty reduction or subsidizing secondary education could enhance attendance rates for both genders, as financial constraints were identified as a barrier.

Keywords: Child marriage; Lesotho Multiple Indicator Cluster Survey; Multivariate analysis; Secondary school attendance; Sustainable Development Goals

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1. Introduction

Lesotho's education system consists of eight levels, namely pre-primary or kinder garden (level 0), elementary or primary school (level 1), secondary education including junior

(level 2), senior high school (level 3), post-secondary education including vocational and technical schools (level 4), and tertiary or higher education (levels 5, 6, and 7). The present study focuses on investigating the student's attendance in institutes encompassed under the levels 2 and 3 education system. The official school-going age for this level ranges from 13 to 17 years.

Lesotho conducted two Voluntary National Reviews (VNR) for the implementation of the United Nations (UN) Sustainable Development Goals (SDGs), the first in 2019 (Lesotho Government, 2019) and the second in 2022 (Lesotho Government, 2022). Both reviews primarily focused on goal 4, using school attendance as one of the indicators to measure progress. Based on the two reviews, the boys accounted for 71.7% while the girls 69.5% in the net intake into schools of primary education, which is mandatory in the country, whereas the attendance rate in secondary education was low, with adjusted secondary net attendance ratio of 45.5% for boys and 67.2% for girl (Ministry of Education and Training, 2019). The long-established characteristic of Lesotho where generally education outcomes, in particular adult literacy, are in favor of females relative to their male counterparts continues to be supported by recent figures (Bureau of Statistics, 2019; 2023). To come up with strategies, plans, and policies to address SDG 4, there is a need to investigate problems surrounding secondary education particularly factors associated with attendance among other problems that need investigating. The present study is intended to investigate factors associated with secondary school attendance, to contribute to the literature and aid in perfecting strategies for addressing SDG 4.

In Lesotho, females are more educated than their male counterparts, which are a prevailing phenomenon that has persisted since Lesotho's political independence in 1966 (Makatjane, 1981), partly attributed to the legacy of labor migration. Until the early 1980s, the South African mining industry was the main employer of Basotho men. Since education was not a prerequisite for employment in the mining industry, mining work was the low-hanging fruit for most uneducated Basotho men, while the history of labor migration demonstrates how Lesotho was turned into a labor reserve. Recent studies continue to demonstrate better education outcomes for Basotho females compared to their male counterparts (Bureau of Statistics, 2019).

The incompatibility between schooling and the economic roles of boys is another contributor to lower literacy rates among Basotho men compared to their female counterparts. At age five and above, boys are considered "old" enough to participate in male-oriented economic activities such as livestock herding. On the contrary, at ages 5 – 13, girls are regarded as too young to cope with female-oriented economic activities beyond household chores such as fetching water or collecting firewood. Except in rare circumstances – such as when herding livestock is shared among several households on alternate days – boys who take livestock herding as a full-time job find it incompatible with school attendance. On the other hand, girls can fetch water before or after school, making their activities more compatible with schooling (Makatjane, 1981). According to the Njau (2016) and Lesotho Multiple Indicator Cluster Survey (MICS) (2018), among children aged 7 – 14, 51.5% of boys were involved in herding animals compared to 3.6% of their girls' counterparts (Bureau of Statistics, 2019). Previous studies have also demonstrated the negative impact of livestock herding on school attendance of boys in Lesotho (Lekhetho, 2018).

Poverty is probably at the heart of this problem, as boys are often hired to look after livestock to earn money for their siblings' education and other household needs. The expectation to care for others (Vera-Sanso & Hlabana, 2023), which is at the core of boys' socialization among the Basotho, partly contributes to the lower literacy rates among males in Lesotho. Studies conducted in other contexts have also reported that caregiving responsibilities, traditionally assigned to male members of society, place a significant burden on them.

1.1. Background of the study

The high value that Basotho attached to education can be traced back to the colonial era. Moshoeshoe I (1786 – 1870), the first King of the Basotho, played a crucial role in the introduction of formal education in Lesotho. He invited missionaries to establish schools, leading to the introduction of formal education in 1838 following the arrival of the Paris Evangelical Missionary Society in 1833 (Lekhetho, 2018). In addition, he incorporated an education levy into the hut tax that Basotho men paid during the colonial era. To this day, education remains highly valued among the Basotho. However, available literature suggests that teenage pregnancy or marriage is among the leading barriers for girls to access secondary education in Lesotho (Mosaase, 2004). This challenge manifests in two interrelated ways. First, a girl who becomes pregnant is often expected to drop out, either due to school policies or because of stigma and discrimination from peers and staff. Second, the hostile attitude and lack of support from teachers and peers make it difficult for young mothers to continue their education (UNICEF, 2021). As a result, many girls ultimately leave school.

King Moshoeshoe I's invitation of the missionaries to establish schools in the country shaped the ownership of

the schools such that the majority of secondary schools are owned by churches. According to the 2017 Education Statistical Bulletin, about two-thirds (62%) of secondary schools were owned by churches while about a third (27%) were owned by the government (Ministry of Education and Training, 2019). One significant implication of this is the challenge it poses for the government in introducing and implementing policies that may conflict with religious principles (Khama, 2018). For instance, as Christianity opposes pre-marital sex, pregnant girls are often required by school authorities to drop out. Stigma, discrimination, and condemnation from peers and staff for pregnant girls (UNICEF, 2021) are unavoidable, as students are socialized to view premarital pregnancy as unacceptable.

As indicated earlier, the situation in Lesotho is different from what prevails in most countries, where girls are typically disadvantaged in education outcomes. Most recent education outcomes for Lesotho continue to demonstrate that boys face greater educational disadvantage than their female counterparts. According to Lesotho MICS, 2018, only a third (30.2%) of boys completed secondary education, compared to almost half (46.4%) of girls. The adjusted secondary net attendance ratio was 45.5% for boys and 67.2% for girls (Bureau of Statistics, 2019).

While near-universal primary education has been achieved, net enrolment for secondary school was below the 80% target, with a completion rate of 44% for lower secondary and 32% for upper secondary.

For effective policy formulation, it is essential to consider the key factors associated with secondary attendance. Both 2019 and 2022 VNR have indicated the need for more work if the country is to achieve UN SDG 4 in relation to secondary education. SDG 4 aims to ensure inclusive and equitable quality education while promoting lifelong learning opportunities for all. This goal is crucial for fostering a sustainable and equitable global society.

Achieving compliance with SDG 4 has numerous tangible benefits that extend beyond meeting a global target. In the context of Lesotho, compliance would significantly reduce gender disparities in education, especially at the secondary education level, where boys currently face disadvantages. Furthermore, ensuring inclusive and equitable quality education would yield some concrete gains such as:

1. Economic growth and poverty reduction. Improved education outcomes foster a more skilled workforce, which directly contributes to economic growth. This is particularly critical for Lesotho, where enhancing the employability of youth could help reduce poverty and unemployment rates.
2. Improved health outcomes. Education, particularly for boys who are currently disadvantaged, is strongly linked to improved health outcomes. Literate individuals are more likely to access healthcare services, adopt healthier lifestyles, and contribute to the well-being of their families and communities.
3. Social equity and stability. By addressing the educational imbalance, compliance with SDG 4 would promote social cohesion and equity, helping to mitigate the long-term effects of systemic inequalities. This, in turn, would contribute to greater social stability.
4. Fostering sustainable development. Education equips learners with the skills and knowledge necessary to promote sustainable practices, drive innovation, and contribute to addressing global challenges, such as climate change and economic inequality.
5. Global competitiveness. A well-educated population would position Lesotho as a competitive participant in the global economy, fostering partnerships, trade, and investments that benefit the nation.

This contextualization underscores the broader importance of compliance with SDG 4 by demonstrating its potential to transform not only the education systems but also the socioeconomic and developmental landscape of Lesotho.

Hence, this would help in identifying significant factors over other factors. Despite the valuable insights provided by previous studies on secondary school attendance, most were case studies with limited generalizability to the broader Lesotho context. Moreover, no multivariate analysis was carried out to identify factors associated with secondary school attendance while accounting for other influencing variables. A comprehensive multivariate that incorporates all factors as suggested by prior research would help isolate the most significant determinants of school attendance. This, in turn, would enable policymakers to design targeted interventions addressing the key barriers to secondary education.

Within this context, the present study attempts to investigate barriers to secondary education that may hinder Lesotho from attaining the UN SDG 4, which calls for, among other targets, ". secondary education leading to relevant and effective learning outcomes."

The objective of the study is twofold. First, it aims to investigate factors associated with secondary school attendance. Second, it seeks to measure the amount of variation explained by each factor influencing school attendance. Assessing the variation explained not only helps identify factors associated with attendance but also highlights their relative significance. Given that the factors influencing attendance may differ between male

and female respondents – for example, livestock herding disproportionately affecting boys – the analysis was conducted separately for males and females.

2. Data sources and materials

In this section, we present the data description, data source, and materials used in the study.

2.1. Data sources

Lesotho 2018 MICS served as the primary data source for this study, specifically utilizing responses from mothers or primary caretakers of children aged 5 – 17. The MICS was conducted over 6 months, from April to September 2018. A two-way stratified sampling design was used to select households using the 2016 Lesotho Census of Population and Housing sampling frame. A total of 8847 households were successfully interviewed out of 9227 occupied households, resulting in a response rate of 95.9%. A detailed description of the sampling methodology is available in the Lesotho 2018 MICS main report (Bureau of Statistics. 2019).

2.1.1. Target population

The secondary school-aged individuals (13 – 17 years) were the target population for this study. The final sample size for analysis included 1840 respondents.

2.1.2. Response variable

The response variable for this study was secondary school attendance, computed from the survey question "Was the respondent attending school during the calendar year of data collection?" Responses were recorded as "Yes" and "No". The response variable was coded as "1" if the respondent was attending secondary school during the survey year and "0" otherwise.

2.1.3. Individual-level variables

Individual-level variables included respondent age, sex, relationship with the household head, maternal education, orphanhood status, engagement in livestock herding, firewood collection, childcare responsibilities, and age at first marriage (for female respondents). A detailed description of these variables is presented in Table 1.

Table 1. Description and categories of variables

Variable	Description	Category
Age of respondent	The reported age of respondents categorized into 5-year age groups	15 – 19
		20 – 24
Sex of respondent	The reported sex of the respondent	Male
		Female
Relationship with the household head	Relationship of the respondent to the household head	Child of head
		The head or the spouse
		Grandchild
		Son- or daughter-in-law
		Another relative
		Not related
Orphanhood status	Based on two questions: "Is father alive?" and "Is mother alive?" The responses were "Yes," "No," and "Do not know."	No information
		Father alive
		Mother alive
		Double orphan
		Not an orphan
Engagement in herding animals	Based on the question "Engaged in herding animals?"	Yes
		No
Engagement in collecting firewood	Based on the question "Engaged in collecting firewood?"	Yes
		No
Engagement in caring for children	Based on the question "Engaged in caring for children?"	Yes
		No
Age at first marriage	The reported age at first marriage for respondents married currently or previously.	Never married
		<18

(Cont'd...)

Table 1. *(Continued)*

Variable	Description	Category
Maternal education	The highest educational level of respondent	Primary or none
		Secondary
		Beyond secondary
Respondent's mass media exposure	Respondents who could read a newspaper, listen to the radio, or watch television at least less than once a week or at least once a week were considered exposed.	Not exposed
		Exposed
Education of the household head	Highest educational level of household head	Primary or none
		Secondary
		Beyond secondary
Sex of the household head	The reported sex of the household head	Male
		Female
Age of the household head	The reported age of the household head	<50
		≥50
Mother's or father's residential status	Based on whether the mother or father is alive and their residential status. The "No information" category indicates respondents with no information to these questions.	No information
		Mother/father lives abroad
		Mother/father lives elsewhere in Lesotho
		Mother/father lives in the household
		Mother/father is dead
Under five in the household	Number of children aged 0 – 4 in the household	0
		1
		≥2
Children aged 5 – 17	Number of children aged 5 – 17 in the household	1
		2
		≥3
Cattle owned by the household	Number of cattle owned by the household	0
		≥1
Educated males in the household	Number of males with secondary education or higher within the household	0
		≥1
Educated females in the household	Number of females with secondary education or higher within the household	0
		≥1
Literate males in the household	Number of literate males within the household	0
		≥1
Literate females in the household	Number of literate females within the household	0
		≥1
Community mass media exposure	The proportion of males or females in the community who read a newspaper listen to the radio, or watch television at least less than once a week or at least once a week.	Low
		High
Community literacy	The proportion of literate males or females in the community	Low
		High
Community education	The proportion of males or females in the community with education beyond primary level	Low
		High
Community condoning GBV	The proportion of males or females in the community condoning GBV	Low
		High

Abbreviation: GBV: Gender-based violence.

2.1.4. Household-level variables

Household-level variables included age, sex, and education of the household head, household wealth index, residential status, the number of males and females in the households with education beyond the primary level, as well as the number of children aged <5 years in the household (Table 1).

2.1.5. Community-level variables

Community-level variables included rural-urban residence, district, and zone. Other than these three variables, Lesotho 2018 MICS did not collect data on the characteristics of the community. However, by equating a community to a survey cluster, community variables were created by aggregating individual population characteristics within clusters (Tassew *et al.*, 2019). The aggregates were computed as the average proportions of the population in each category of a given variable. Based on the overall mean values, we categorized the aggregate values into "low" (values less than the mean) and "high" (values equal to the mean or higher). Several community-level variables were computed this way, including community literacy (male and female), community education (male and female), and community media exposure (male and female) (Table 1).

2.2. Statistical analysis

Three levels of analysis were employed: univariate, bivariate, and multivariate. Univariate analysis was used to present the profile of the study population. At the bivariate level, we used a binary logistic regression to identify variables associated with the response variable. In this study, bivariate logistic regression serves as a powerful tool for identifying associations between multiple binary response variables and predictors while accounting for their joint distribution. This method enhances our understanding of complex relationships in data where outcomes may influence each other (Srimaneekarn *et al.*, 2022). The association between the response variable and each explanatory variable was investigated using crude odds ratio (COR). Variables with a $p < 0.05$ were considered significantly associated with the response variable. According to Harrell (2015), the COR is a valuable tool for investigating associations between binary response variables and explanatory variables. It provides clear insights into how changes in predictors may influence outcomes, making it an essential component in statistical analyses, particularly in fields such as epidemiology, public health, and social sciences. However, it is important to note that while CORs provide useful initial insights, they do not account for potential confounding variables. Therefore, further analysis using adjusted models may be necessary to draw more robust conclusions.

At the multivariate level, analysis was done in three steps using Models I, II, and III. These models were used to determine individual-, household-, and community-level factors associated with the response variable. Model III further determined the key factors associated with the response variable by incorporating significant predictors identified in Models I and II. Only factors that were significantly associated with the response variable at the bivariate level were included in the regression analysis for Models I, II, and III (Custodio-Mendoza *et al.,* 2019). The intra-class correlation coefficient was computed and found to be less than 0.05 for both males (0.211) and females (0.138), suggesting that multilevel logistic analysis was unnecessary. Across all models, forward stepwise multiple logistic regression was used to identify factors that were significantly associated with the response variable while controlling for other factors. Multicollinearity among independent variables was assessed using the variance inflation factor (VIF) and all predictor variables had VIF value below 3, indicating the absence of a significant correlation among the explanatory variables.

2.3. Ethical clearance

The use of Lesotho MICS 2018 data does not require ethical clearance, as the data are publicly available on the MICS official website[1].

3. Results and discussion

3.1. Profile of participants

Table 2 presents the profile of respondents. At the individual level, more than half (51.4%) of respondents were children of the household head, while boys constituted half (50.7%) of the sample. The average age of respondents was 14.95 years with a standard deviation of 1.45. Less than a tenth (4.3%) of females got married before the age of 18. More than half (54.2%) of respondents were not orphaned, while a third (27.7%) were engaged in herding animals. More than a fifth (22.6%) of respondents were engaged in collecting firewood while <3rd (27.1%) were engaged in childcare responsibilities. Furthermore, 58.8% of respondents were children of mothers with primary or no formal education.

At the household level, 53.3% of respondents resided in male-headed households. More than half (52.6%) resided in households where the head aged less than 50 years, and a third (33.4%) resided in households where the head had attained secondary education or higher. Four in ten (41.1%) respondents resided in rich households while less than one in ten (6.7%) respondents resided in households with at least two children aged <5 years. More than half

[1] http://mics.unicef.org/surveys

Table 2. Profile of the study population

Factor	Category	% (N)
Age	13 – 15	60.6 (1115)
	16 – 17	39.4 (725)
Sex	Male	50.7 (934)
	Female	49.3 (906)
Relationship with the household head	Child of head	51.4 (946)
	The head or the spouse	2.5 (46)
	Grandchild	23.1 (425)
	Another relative	20.0 (367)
	Not related	3.0 (55)
Orphanhood status	No information	5.1 (93)
	Father alive	6.4 (117)
	Mother alive	23.2 (428)
	Double orphan	11.2 (205)
	Not an orphan	54.2 (996)
Age at first marriage	Never married	48.2 (437)
	No information	42.9 (389)
	<18	4.3 (39)
	Inconsistent response	4.8 (42)
Engagement in herding animals	Yes	27.7 (511)
	No	72.1 (1327)
	No response	0.1 (2)
Engagement in collecting firewood	No	77.3 (1422)
	Yes	22.6 (415)
	No response	0.1 (3)
Engagement in caring for children	No	72.8 (1340)
	Yes	27.1 (489)
	No response	0.1 (1)
Maternal education	Primary or none	58.8 (1082)
	Secondary or higher	35.1 (647)
	No information	5.7 (105)
	Do not know	0.3 (6)
Mother's residential status	No information	1.0 (19)
	Mother lives abroad	15.4 (283)
	Mother lives elsewhere	17.0 (313)
	Mother lives in the household	47.8 (880)
	Mother is dead	18.7 (345)
Father's residential status	No information	5.8 (107)
	Father lives abroad	13.6 (251)
	Father lives elsewhere	17.4 (321)
	Father lives in the household	28.7 (528)
	Father is dead	34.4 (634)
Wealth index	Poorest	20.3 (374)
	Second	18.2 (336)
	Middle	21.3 (391)
	Fourth	19.8 (365)
	Richest	20.3 (374)
Education of the household head	Primary or none	66.3 (1220)
	Secondary or higher	33.4 (614)
	No response	0.3 (5)
Sex of the household head	Male	53.3 (981)
	Female	46.7 (859)
Age of the household head	<50	52.6 (967)
	≥50	47.4 (873)
Under five in household	0	67.5 (1243)
	1	25.7 (474)
	≥2	6.7 (123)
Children aged 5 – 17 in household	1	46.6 (857)
	2	31.4 (578)
	≥3	22.0 (406)
Educated males	0	84.2 (1550)
	≥1	15.8 (290)
Educated females	0	45.5 (837)
	≥1	54.5 (1003)
Cattle owned by the household	0	64.3 (1184)
	≥1	35.7 (657)
Ecological zone	Lowlands	64.5 (1187)
	Foothills	8.4 (155)
	Mountains	19.3 (355)
	Senqu River Valley	7.8 (143)
District	Botha-Bothe	5.8 (107)
	Leribe	16.7 (307)
	Berea	12.4 (228)
	Mafeteng	10.7 (196)
	Mohale's Hoek	8.3 (152)
	Quthing	4.4 (81)
	Qacha's Nek	3.5 (65)
	Mokhotlong	5.1 (94)
	Thaba-Tseka	6.6 (121)
	Maseru	26.6 (489)
Rural or urban residence	Urban	36.7 (676)
	Rural	63.3 (1164)
Male community education	Low	51.5 (948)
	High	48.5 (892)
Female community education	Low	38.2 (702)
	High	61.8 (1138)

(Cont'd...)

Table 2. *(Continued)*

Factor	Category	% (N)
Male community media exposure	Low	42.6 (783)
	High	57.4 (1057)
Female community media exposure	Low	44.0 (810)
	High	56.0 (1030)
Male community literacy	Low	43.9 (808)
	High	56.1 (1032)
Female community literacy	Low	40.5 (745)
	High	59.5 (1095)
Community males condoning GBV	Low	62.2 (1144)
	High	37.8 (696)
Community females condoning GBV	Low	58.2 (1071)
	High	41.8 (769)

Notes: % denotes the percentage of respondents; N denotes the number of respondents.
Abbreviation: GBV: Gender-based violence.

(54.5%) of respondents resided in households with at least one female member with education beyond the primary level, whereas more than one in ten (15.8%) respondents resided in households with at least one male member with education beyond the primary level. Regarding the residential status of parents, 47.8% of mothers lived in the household compared to 28.7% of fathers. More than a third (35.7%) of households owned cattle.

At the community level, we found that at least six in ten (63.3%) respondents lived in rural areas while two-thirds (64.5%) lived in the lowlands, with the least representation in Senqu River Valley (7.8%). Nonetheless, our results showed that Maseru was the most populous district accounting for 26.6% of respondents, followed by Leribe at 16.7%, while Qacha's Nek had the smallest population share (3.5%). At least half of respondents resided in communities characterized by low male (51.5%) and high female (61.8%) education levels, high male (57.4%) and female (56.0%) media exposure, and high male (56.1%) and female (59.5%) literacy rates. Furthermore, 62.2% of respondents lived in communities where a low proportion of males condoned gender-based violence (GBV), compared to 58.3% in communities where a low proportion of females condoned GBV.

3.2. The prevalence of secondary school attendance and their associated COR

The COR was used to identify factors associated with the response variables. Overall attendance among males was 46.5% compared to 67.5% for females. The COR was used to establish the association between factors and outcome variables. Table 3 presents the results of this analysis.

3.2.1. Male respondents

At the individual level, bivariate analysis identified six factors significantly associated with secondary school attendance among male children. These factors included engagement in herding animals and collecting firewood, age of the respondent, relationship with the household head, orphanhood status, and maternal education. At the household level, we identified ten factors that were significantly associated with secondary attendance among male respondents. These included the residential status of the mother and father, household wealth, the number of children aged 5 – 17 within the household, the education and age of the household head, the presence of educated males and females within the household, male literacy levels, and ownership of cattle. At the community level, eleven factors associated with the response variable were identified. These factors included rural-urban residence, ecological zone, district, male and female community education levels, male and female community mass media exposure, male and female community literacy levels, and male and female community attitudes towards condoning violence (Table 3).

3.2.2. Female respondents

At the individual level, five factors were significantly associated with the response variable. These included engagement in caring for children and collecting firewood, age at first marriage, relationship with the household head, and maternal education. At the household level, we identified ten factors. They were the residential status of the mother and father, household wealth, the number of children under five and those aged 5 – 17 within the household, the education level of the household head, the presence of literate males and females, the presence of educated females, and ownership of cattle. At the community level, eleven factors were found to be associated with the response variable. These factors included rural-urban residence, ecological zone, district, male and female community education levels, male and female community mass media exposure, male and female community literacy levels, and male and female community attitudes towards condoning violence (Table 3).

3.3. Logistic regression for identifying factors at different levels (Models I, II, and III)

This section presents the results of Models I, II, and III, which examine individual, household, and community factors associated with secondary school attendance. Each model accounts for variables found to be significant at the bivariate level (Table 2), assessing their effects net of other factors within the same group. The models used a stepwise method to eliminate insignificant factors while

Table 3. Prevalence of secondary school attendance and the associated COR (Model I)

Variable	Categories	Males				Females			
		Attendance (%)		COR (CI)	Sig	Attendance (%)		COR (CI)	Sig
		No	Yes			No	Yes		
Age of respondent	13 – 15	57.8	42.2	1.6 (1.2, 2.0)	0.001	33.8	66.2	1.2 (0.9, 1.6)	0.291
	16 – 17	46.8	53.2	-	-	30.4	69.6	-	-
Relationship with the household head	Child of head	35.3	64.7	-	-	25.2	74.8	-	-
	The head or the spouse	12.1	87.9	3.6 (1.3, 10.1)	0.014	33.3	66.7	-	-
	Son or daughter-in-law	69.0	31.0	0.2 (0.1, 0.6)	0.001	71.4	28.6	-	-
	Grandchild	50.2	49.8	0.5 (0.4, 0.7)	0.000	36.3	63.7	-	-
	Another relative	44.0	56.0	0.7 (0.5, 0.9)	0.007	80.0	20.0	-	-
	Not related	80.6	19.4	0.1 (0.1, 0.2)	0.000	30.7	69.3	-	-
Engagement in herding animals	Yes	68.5	31.5	-	-	28.6	71.4	-	-
	No	37.6	62.4	3.6 (2.7,4.7)	0.000	32.5	67.5	0.8 (0.4, 1.9)	0.671
Engagement in collecting wood	Yes	68.0	32.0	-	-	48.1	51.9	-	-
	No	50.2	49.8	2.1 (1.5, 3.0)	0.000	26.8	73.2	2.5 (1.9, 3.4)	0.000
Engagement in caring for children	Yes	50.7	49.3	0.9 (0.6, 1.3)	0.468	40.3	59.7	-	-
	No	54.1	45.9	-	-	27.3	72.7	1.8 (1.4, 2.4)	0.000
Age at first marriage	Never married	-	-	-	-	23.4	76.6	-	-
	<18	-	-	-	-	67.6	32.4	0.2 (0.1, 0.3)	0.000
	No information	-	-	-	-	40.1	59.9	0.5 (0.3, 0.6)	0.000
Maternal education	Primary or none	65.2	34.8	-	-	38.2	61.8	-	-
	Secondary or higher	34.6	65.4	2.8 (2.2, 3.5)	0.000	20.0	80.0	1.8 (1.4, 2.3)	0.000
Orphanhood status	No information	74.1	25.9	0.3 (0.2, 0.6)	0.001	38.5	61.5	0.6 (0.3, 1.1)	0.109
	Father alive	68.8	31.3	0.4 (0.2, 0.7)	0.003	46.3	53.7	0.4 (0.2, 0.7)	0.002
	Mother alive	47.0	53.0	1.1 (0.8, 1.5)	0.679	36.9	63.1	0.6 (0.4, 0.7)	0.005
	Double orphan	71.1	28.9	0.4 (0.2, 0.6)	0.000	40.4	59.6	0.5 (0.3, 0.8)	0.005
	Not an orphan	48.7	51.3	-	-	26.5	73.5	-	-
Mother's residential status	No information	66.7	33.3	0.3 (0.1, 1.2)	0.089	25.0	75.0	1.0 (0.2, 5.3)	0.993
	Mother lives abroad	55.6	44.4	0.6 (0.4, 0.8)	0.004	38.5	61.5	0.6 (0.4, 0.8)	0.006
	Mother lives elsewhere in Lesotho	63.3	36.7	0.4 (0.3, 0.6)	0.000	35.6	64.4	0.6 (0.4, 0.9)	0.019
	Mother is dead	72.4	27.6	0.3 (0.2, 0.4)	0.000	40.9	59.1	0.5 (0.3, 0.7)	0.000
	Mother lives in the household	42.2	57.8	-	-	25.8	74.2	-	-
Father's residential status	No information	72.7	27.3	3.1 (1.6, 5.8)	0.001	38.1	61.9	2.9 (1.3, 6.3)	0.008
	Father lives abroad	46.8	53.2	2.1 (1.1, 3.9)	0.021	17.5	82.5	1.1 (0.5, 2.2)	0.856
	Father lives elsewhere in Lesotho	56.5	43.5	2.2 (1.2, 4.1)	0.007	35.8	64.2	1.0 (0.5, 1.9)	0.937
	Father is dead	54.8	45.2	2.9 (1.6, 5.2)	0.001	38.0	62.0	1.4 (0.7, 2.8)	0.306
	Father lives in the household	48.6	51.4	-	-	29.5	70.5	-	-
Wealth index	Poor	-	-	-	-	-	-	-	-
	Middle	-	-	-	-	-	-	-	-
	Rich	-	-	-	-	-	-	-	-
Under five in the household	0	53.3	46.7	1.5 (0.8, 2.7)	0.169	26.5	73.5	2.1 (1.3, 3.6)	0.005
	1	51.8	48.2	-	-	43.3	56.7	1.0 (0.6, 1.7)	0.978
	≥2	61.0	39.0	-	-	43.8	56.3	-	-

(Cont'd...)

Table 3. ***(Continued)***

Variable	Categories	Males				Females			
		Attendance (%)		COR (CI)	Sig	Attendance (%)		COR (CI)	Sig
		No	Yes			No	Yes		
Sex of the household head	Male	52.7	47.3	1.1 (0.8, 1.4)	0.554	33.2	66.8	0.9 (0.7, 1.2)	0.608
	Female	54.5	45.5	-	-	31.6	68.4	-	-
Age of the household head	<50	48.8	51.2	1.5 (1.1, 1.9)	0.004	29.8	70.2	1.3 (1.0, 1.7)	0.064
	≥50	58.3	41.7	-	-	35.6	64.4	-	-
Education of the household head	Primary or none	62.0	38.0	0.5 (0.3, 0.9)	0.028	38.4	61.6	0.4 (0.3, 0.8)	0.005
	Secondary	33.3	66.7	1.6 (0.8, 3.1)	0.160	20.6	79.4	1.1 (0.6, 2.0)	0.782
	Beyond secondary	45.2	54.8	-	-	22.1	77.9	-	-
Educated males in the household	0	58.0	42.0	0.4 (0.3, 0.6)	0.000	32.9	67.1	0.8 (0.5, 1.3)	0.381
	≥1	35.6	64.4	-	-	28.4	71.6	-	-
Educated females in the household	0	65.0	35.0	0.3(0.3, 0.4)	0.000	52.1	47.9	0.3 (0.2, 0.4)	0.000
	≥1	38.3	61.7	-	-	22.5	77.5	-	-
Literate males in the household	0	55.0	45.0	0.8 (0.6, 1.1)	0.125	32.1	67.9	1.1 (0.8, 1.6)	0.580
	≥1	49.4	50.6	-	-	34.2	65.8	-	-
Literate females in the household	0	66.2	33.8	0.4 (0.3, 0.5)	0.000	47.7	52.3	0.4 (0.3, 0.6)	0.000
	≥1	44.8	55.2	-	-	28.1	71.9	-	-
Children aged 5 – 17 in the household	1	49.9	50.1	1.9 (1.3, 2.6)	0.000	28.2	71.8	2.0 (1.4, 2.8)	0.000
	2	49.8	50.2	1.9 (1.3, 2.7)	0.001	31.6	68.4	1.7 (1.1, 2.4)	0.008
	≥3	65.0	35.0	-	-	43.8	56.2	-	-
Cattle owned by the household	0	45.0	55.0	2.4 (1.8, 3.1)	0.00	29.2	70.8	1.6 (1.2, 2.1)	0.002
	≥1	65.0	34.0	-	-	39.4	60.6	-	-
Ecological zone	Lowlands	42.6	57.4	-	-	24.4	75.6	-	-
	Foothills	61.1	38.9	0.5 (0.3, 0.7)	0.001	49.2	50.8	0.3 (0.2, 0.6)	0.000
	Mountains	74.1	25.9	0.3 (0.2, 0.4)	0.000	50.0	50.0	0.3 (0.2, 0.5)	0.000
	Senqu River Valley	74.1	25.9	0.3 (0.2, 0.4)	0.000	46.8	53.2	0.4 (0.2, 0.6)	0.000
District	Botha-Bothe	56.6	43.4	0.6 (0.3, 1.2)	0.136	27.8	72.2	1.1 (0.6, 2.1)	0.777
	Leribe	42.9	57.1	1.1 (0.7, 1.6)	0.644	21.7	78.3	1.5 (0.9, 2.4)	0.086
	Berea	43.9	56.1	1.1 (0.7, 1.7)	0.788	25.6	74.4	1.2 (0.7, 2.0)	0.458
	Mafeteng	51.6	48.4	0.8 (0.5, 1.3)	0.313	39.2	60.8	0.6 (0.4, 1.1)	0.081
	Mohale's Hoek	65.4	34.6	0.4 (0.3, 0.7)	0.002	33.3	66.7	0.8 (0.5, 1.5)	0.524
	Quthing	67.4	32.6	0.4 (0.2, 0.8)	0.008	43.2	56.8	0.6 (0.3, 1.1)	0.098
	Qacha's Nek	64.7	35.3	0.5 (0.2, 1.0)	0.041	41.9	58.1	0.6 (0.3, 1.3)	0.207
	Mokhotlong	72.0	28.0	0.3 (0.2, 0.7)	0.001	54.5	45.5	0.4 (0.2, 0.7)	0.002
	Thaba-Tseka	77.5	22.5	0.2 (0.1, 0.5)	0.000	55.1	44.9	0.3 (0.2, 0.6)	0.001
	Maseru	45.7	54.3	-	-	29.3	70.7	-	-
Rural or urban residence	Urban	34.9	65.1	-	-	22.7	77.3	-	-
	Rural	62.3	37.7	0.3 (0.2, 0.4)	0.000	39.4	60.6	0.4 (0.3, 0.6)	0.000
Male community education	Low	65.3	34.7	0.3 (0.3, 0.4)	0.000	43.1	56.9	0.4 (0.3, 0.5)	0.000
	High	38.3	61.7	-	-	23.0	77.0	-	-
Female community education	Low	73.9	26.1	0.2 (0.2, 0.3)	0.000	52.3	47.7	0.3 (0.2, 0.4)	0.000
	High	38.6	61.4	-	-	22.2	77.8	-	-

(Cont'd...)

Table 3. ***(Continued)***

Variable	Categories	Males				Females			
		Attendance (%)		COR (CI)	Sig	Attendance (%)		COR (CI)	Sig
		No	Yes			No	Yes		
Male community literacy	Low	66.4	33.6	0.2 (0.2, 0.3)	0.000	45.5	54.5	0.4 (0.3, 0.5)	0.000
	High	42.2	57.8	-	-	23.3	76.7	-	-
Female community literacy	Low	67.4	32.6	0.3 (0.3, 0.4)	0.000	38.9	61.1	0.6 (0.5, 0.8)	0.001
	High	43.6	56.4	-	-	28.3	71.7	-	-
Male community media exposure	Low	67.7	32.3	0.3 (0.3, 0.4)	0.000	45.7	54.3	0.4 (0.3, 0.5)	0.000
	High	41.8	58.2	-	-	23.8	76.2	-	-
Female community media exposure	Low	69.6	30.4	0.3 (0.2, 0.4)	0.000	43.3	56.7	0.4 (0.3, 0.6)	0.000
	High	39.5	60.5	-	-	24.7	75.3	-	-
Community males condoning GBV	Low	50.2	49.8	0.3 (0.2, 0.4)	0.000	29.6	70.4	0.7 (0.5, 1.0)	0.000
	High	59.1	40.9	0.7 (0.5, 0.9)	0.000	36.9	63.1	-	-
Community females condoning GBV	Low	49.1	50.9	-	-	27.9	72.1	-	-
	High	59.3	40.7	0.7 (0.5, 0.9)	0.002	39.3	60.7	0.6 (0.5, 0.8)	0.000
Total		53.5	46.5	-	-	32.5	67.5	-	-

Notes: % denotes the percentage of respondents; COR denotes crude odds ratio; CI denotes 95% confidence interval; Sig denotes *p*-value for COR analysis.
Abbreviation: GBV: Gender-based violence.

retaining those with meaningful associations. The results are presented in Table 4.

3.3.1. Male respondents

After controlling for other individual-level factors, the following remained significantly associated with school attendance: engagement in herding animals, age, relationship with the household head, orphanhood status, and maternal education. At the household level, factors that continued to be associated with attendance included household wealth, the number of educated males and females within the household, cattle ownership, the age and education level of the household head, the mother's residential status, and the number of literate males in the household. At the community level, female community education, female media exposure, and male community literacy remained significant predictors of attendance.

3.3.2. Female respondents

For female respondents, secondary school attendance remained associated with age at first marriage, engagement in collecting firewood and caring for children, relationship with the household head, and maternal education at the individual level. At the household level, significant factors included household wealth, the number of educated females, the father's residential status, and the children aged 5 – 17 and under 5 years old in the household. At the community level, key factors associated with attendance included female community education, male and female community literacy, and ecological zone.

3.4. Individual, household, and community factors associated with secondary school attendance (Model IV)

This section presents the results of Model IV, which examines the influence of individual, household, and community factors on secondary school attendance, highlighting the key determinants and their statistical significance. Model IV corresponds to the final analysis of the study, which takes into consideration all the significant variables in Model I, II and III.

3.4.1. Male respondents

Table 5 presents factors associated with secondary school attendance. After controlling for household and community factors, the following individual factors remained significantly associated with school attendance: engagement in herding, age, and maternal education. Respondents not engaged in herding were more likely to attend school than their counterparts engaged in herding (adjusted odds ratio [AOR] = 1.9; confidence interval [CI]: 1.3, 2.7). Each additional year of age increased the likelihood of attending school by 30% (AOR = 1.3; CI: 1.2, 1.5). Boys whose mothers had education beyond secondary school had significantly higher odds of attending

Table 4. Factors associated with secondary school attendance within the same variable group (Model II)

Variable	Categories	Males		Females	
		AOR (CI)	Sig	AOR (CI)	Sig
Age of respondent	16 – 17	1.7 (1.1, 1.4)	0.000	-	-
Relationship with the household head	Child of head			-	-
	The head or the spouse	1.6 (0.7, 3.6)	0.216	0.7 (0.0, 12.2)	0.789
	Son or daughter-in-law			0.1 (0.0, 0.5)	0.002
	Grandchild	1.0 (0.1, 19.8)	0.996	0.7 (0.5, 1.1)	0.128
	Another relative	1.5 (0.7, 3.4)	0.333	0.0 (0.0, 0.1)	0.000
	Not related	0.7 (0.3, 1.6)	0.384	0.7 (0.5, 1.2)	0.180
Engagement in herding animals	Yes	0.4 (0.3, 0.5)	0.000	-	-
	No	-	-	-	-
Engagement in collecting wood	Yes	-	-	-	-
	No	-	-	2.0 (1.4, 2.9)	0.000
Engagement in caring for children	Yes	-	-	-	-
	No	-	-	1.4 (1.0, 2.0)	0.035
Age at first marriage	Never married	-	-	-	-
	<18	-	-	0.4 (0.1, 1.1)	0.076
	No information	-	-	0.4 (0.3, 0.6)	0.000
Maternal education	Primary or none	0.3 (0.2, 0.4)	0.000	-	-
	Secondary or higher	-	-	2.1 (1.5, 3.1)	0.000
Orphanhood status	No information	0.4 (0.2, 0.9)	0.026	-	-
	Father alive	0.5 (0.3, 0.9)	0.023	-	-
	Mother alive	1.2 (0.8, 1.8)	0.332	-	-
	Double orphan	0.6 (0.3, 1.0)	0.070	-	-
	Not an orphan	-	-	-	-
Mother's residential status	No information	0.6 (0.2, 2.5)	0.494	2.0 (0.3, 12.3)	0.458
	Mother lives abroad	0.8 (0.5, 1.3)	0.340	0.6 (0.4, 1.0)	0.032
	Mother lives elsewhere in Lesotho	0.5 (0.3, 0.8)	0.003	0.7 (0.4, 1.1)	0.120
	Mother is dead	0.3 (0.2, 0.4)	0.000	0.6 (0.4, 0.9)	0.010
	Mother lives in the household	-	-	-	-
Father's residential status	No information	0.4 (0.2, 0.9)	0.016	1.3 (0.6, 3.0)	0.472
	Father lives abroad	1.2 (0.7, 2.0)	0.485	2.3 (1.3, 4.2)	0.007
	Father lives elsewhere in Lesotho	1.0 (0.6, 1.5)	0.835	0.8 (0.5, 1.3)	0.335
	Father is dead	1.3 (0.8, 1.9)	0.255	0.8 (0.6, 1.3)	0.439
	Father lives in the household	-	-	-	-
Wealth index	Poor	-	-	-	-
	Middle	-	-	1.5 (1.0, 2.2)	0.053
	Richest	-	-	2.1 (1.5, 3.1)	0.000
Under five in the household	0	-	-	-	-
	1	-	-	0.4 (0.3, 0.6)	0.000
	≥2	-	-	0.4 (0.2, 0.7)	0.003
Children aged 5 – 17 in the household	1	-	-	-	-

(Cont'd...)

Table 4. ***(Continued)***

Variable	Categories	Males		Females	
		AOR (CI)	Sig	AOR (CI)	Sig
	2	-	-	0.9 (0.6, 1.2)	0.397
	≥3	-	-	0.5 (0.3, 0.8)	0.002
Age of the household head	<50	0.7 (0.5, 0.9)	0.020	-	-
	≥50	-	-	-	-
Education of the household head	Primary or none	-	-	-	-
	Secondary	2.0 (0.9, 4.2)	0.086	-	-
	Beyond secondary	3.0 (1.4, 6.4)	0.005	-	-
Educated males in the household	0	0.5 (0.3, 0.7)	0.000	-	-
	≥1	-	-	-	-
Educated females in the household	0	0.5 (0.4, 0.8)	0.000	-	-
	≥1	-	-	3.7 (2.7, 5.2)	0.000
Cattle owned by the household	0	1.9 (1.4, 2.6)	0.000	-	-
	≥1	-	-	-	-
Ecological zone	Lowlands	-	-	-	-
	Foothills	-	-	0.4 (0.3, 0.8)	0.004
	Mountains	-	-	0.7 (0.5, 1.1)	0.128
	Senqu River Valley	-	-	0.6 (0.4, 1.2)	0.150
Female community education	Low	0.4 (0.3, 0.5)	0.000	-	-
	High	-	-	3.4 (2.2, 5.3)	0.000
Male community literacy	Low	0.6 (0.5, 0.9)	0.003	-	-
	High	-	-	1.6 (1.1, 2.2)	0.009
Female community literacy	Low	-	-	-	-
	High	-	-	1.6 (1.1, 2.4)	0.018
Female community media exposure	Low	0.5 (0.4, 0.7)	0.000	-	-
	High	-	-	-	-

Notes: AOR denotes adjusted odds ratio; CI denotes 95% confidence interval; Sig denotes *p*-value for AOR analysis.

school (AOR = 5.0; CI: 1.6, 16.2) compared to those whose mothers had primary education or none.

After adjusting for individual and community factors, the following household factors were significantly associated with school attendance: household wealth index, mother's residential status, the presence of educated males and females, the presence of literate males, and the education and age of the household head. Boys from the wealthiest households had more than three times the odds of attending school compared to those from the poorest households (AOR = 3.3; CI: 1.6, 6.3). Living in a household with at least one male with education beyond primary significantly increased school attendance odds (AOR = 6.6; CI: 2.7, 15.8), as did living in a household with at least one female with education beyond primary (AOR = 1.6; CI: 1.1, 2.3). Boys in households headed by individuals with education beyond secondary school were over six times more likely to attend school than those in households where the head had primary education or none (AOR = 6.3; CI: 2.1, 19.6). Households headed by individuals aged 50 or older were also associated with increased attendance odds (AOR = 1.6; CI: 1.1, 2.3). Having at least one literate male in the household significantly boosted school attendance (AOR = 4.5; CI: 2.0, 4.2). Boys whose mothers lived elsewhere in Lesotho (AOR = 0.4; CI: 0.2, 0.7) or whose mothers were dead (AOR = 0.3; CI: 0.2, 0.4) had lower odds of attendance compared to those whose mothers lived in the household.

After adjusting for individual and household factors, the following community factors remained significantly associated with school attendance: female community education, male community literacy, and female community media exposure. Boys residing in communities with high female community education, high male community

Table 5. Individual, household, and community factors associated with secondary school attendance (Model III)

Factor	Category	Males		Females	
		AOR (CI)	Sig	AOR (CI)	Sig
Engagement in herding animals	No	1.0	-	-	-
	Yes	1.9 (1.3, 2.7)	0.001	-	-
Age of respondent	16-17	1.3 (1.2, 1.5)	0.000	-	-
Age at first marriage	Never married	-	-	-	-
	<18	-	-	0.7 (0.2, 2.3)	0.543
	No information	-	-	0.5 (0.3, 0.8)	0.002
Mother's education	Primary or none	1.0	-	-	-
	Secondary	1.9 (1.1, 3.3)	0.024	-	-
	Beyond secondary	5.0 (1.6, 16.2)	0.007	-	-
Mother's residential status	No information	0.4 (0.1, 2.0)	0.276	-	-
	Mother lives abroad	0.7 (0.4, 1.1)	0.149	-	-
	Mother lives elsewhere	0.4 (0.2, 0.7)	0.000	-	-
	Mother is dead	0.3 (0.2, 0.4)	0.000	-	-
	Mother lives in household	1.0	-	1.0	
Father's residential status	No information	-	-	0.9 (0.4, 2.4)	0.886
	Father lives abroad	-	-	2.3 (1.2, 4.6)	0.015
	Father lives elsewhere	-	-	0.9 (0.5, 1.7)	0.687
	Father is dead	-	-	0.9 (0.5, 1.5)	0.562
	Father lives in household	-	-	-	-
Relationship with the household head	Child of head	-	-	-	-
	The head or the spouse	-	-	0.5 (0.0, 10.0)	0.662
	Son- or daughter-in-law	-	-	0.1 (0.0, 0.6)	0.009
	Grandchild	-	-	0.7 (0.4, 1.2)	0.217
	Another relative	-	-	0.1 (0.0, 0.2)	0.000
	Not related	-	-	0.8 (0.5, 1.5)	0.511
Wealth index	Poorest	1.0	-	-	-
	Poor	1.2 (0.7, 2.1)	0.453	-	-
	Middle	1.2 (0.7, 2.1)	0.474	-	-
	Rich	1.7 (0.9, 3.0)	0.095	-	-
	Richest	3.2 (1.6, 6.3)	0.001	-	-
Under five in the household	0	-	-	-	-
	1	-	-	0.4 (0.3, 0.6)	0.000
	≥2	-	-	0.4 (0.2, 0.9)	0.014
Educated males	0	1.0	-	1.0	-
	≥1	6.6 (2.7, 15.8)	0.000	-	-
Educated females	0	1.0	-	-	-
	≥1	1.6 (1.1, 2.3)	0.018	3.0 (1.9, 4.6)	0.000

(Cont'd...)

Table 5. ***(Continued)***

Factor	Category	Males		Females	
		AOR (CI)	Sig	AOR (CI)	Sig
Literate males	0	1.0	-	-	-
	≥1	4.5 (2.0, 10.2)	0.000	-	-
Age of the household head	<50	-	-	-	-
	≥50	1.6 (1.1, 2.3)	0.012	-	-
Education of the household head	Primary or none	1.0	-	-	-
	Secondary	7.8 (2.5, 24.1)	0.000	-	-
	Beyond secondary	6.3 (2.1, 19.6)	0.001	-	-
Ecological zone	Lowlands	-	-	-	-
	Foothills	-	-	0.3 (0.1, 0.6)	0.001
	Mountains	-	-	0.6 (0.4, 1.0)	0.054
	Senqu River Valley	-	-	0.5 (0.2, 0.9)	0.029
Female community education	Low	1.0	-	1.0	-
	High	1.5 (1.0, 2.2)	0.061	3.3 (2.0, 5.6)	0.000
Male community literacy	Low	1.0	-	-	-
	High	1.5 (1.0, 2.1)	0.027	-	-
Female community media exposure	Low	-	-	-	-
	High	1.5 (1.0, 2.2)	0.047	-	-
Female community literacy	Low	-	-	-	-
	High	1.7 (1.1, 2.6)	0.021	0.6 (0.3, 0.9)	0.013

Notes: AOR denotes adjusted odds ratio; CI denotes 95% confidence interval; Sig denotes *p*-value for AOR analysis.

literacy, and high female community media exposure were respectively associated with higher odds of attending school compared to those residing in communities with low female community education (AOR = 1.5; CI: 1.0, 2.3), low male community literacy (AOR = 1.5; CI: 1.0, 2.0), and low female community media exposure (AOR = 1.5; CI: 1.0, 2.2), respectively.

3.4.2. Female respondents

After controlling for household and community factors, the following individual factors remained significantly associated with school attendance: age at first marriage and relationship with the household head. Respondents without information on age at first marriage were associated with lower (AOR = 0.5; CI: 0.3, 0.9) odds of attendance compared to those who had never married. Daughters-in-law (AOR = 0.1; CI: 0.0, 0.6) and other relatives (AOR = 0.1; CI: 0.0, 0.2) were significantly less likely to attend school compared to children of the household head.

After adjusting for individual and community factors, the following household factors were significantly associated with school attendance: the father's residential status, the presence of educated females, and the number of children under five in the household. Respondents residing in households where the father was abroad were two times more likely to attend school compared to those whose fathers lived in the household (AOR = 2.3; CI: 1.2, 4.6). Residing in households with at least one female with education beyond primary level and in households with no children under five were more likely to attend school compared to respondents residing in a household with no females with education beyond primary level (AOR = 3.0; CI: 1.9, 4.6) and in a household with at least two children aged less five (AOR = 2.2; CI: 1.2, 4.3), respectively.

After adjusting for individual and household factors, the following community factors remained significantly associated with school attendance: ecological zone, female community education, and female community literacy. Girls residing in communities with high female education levels were more than three times as likely to attend school compared to those in communities with low female education (AOR = 3.3; CI: 3.0, 5.6). Residing in communities with low female literacy was associated with higher odds of attendance compared to communities with higher female literacy (AOR = 1.8; CI: 1.1, 2.9).

3.5. Importance of factors in explaining variation in secondary school attendance

Among male respondents, household factors accounted for the largest percentage (78.8%) of the total variation in school attendance, followed by individual factors (15.3%) and community factors (5.9%). The age of respondents explained the highest proportion (45.0%) of the variation within individual factors, followed by engagement in herding (40.0%); maternal education had the smallest contribution (15.0%). The household wealth index explained the highest proportion (60.7%) of the variation within household factors, followed by the mother's residential status (18.5%) and the number of literate males (4.6%). Education and age of the household head and the number of males and females with education beyond primary level each explained less than 5%. Female community education explained the highest proportion (52.2%) of the variation within community factors, followed by male community literacy (30.4%) and female community media exposure (17.4%). Overall, the top five factors – household wealth (47.8%), mother's residential status (14.6%), age of respondent (6.9%), number of females with education beyond primary level (6.9%), and engagement in herding animals (6.1%) – explained more than three quarters (82.4%) of the total variation in school attendance among male respondents.

For female respondents, household factors explained 52.4% of the total variation in school attendance, followed by individual factors (27.4%) and community factors (20.2%). The number of females with education beyond primary explained the highest proportion (75.4%) of the variation in household factors while the number of children under five in the household accounted for 16.1%. The relationship with the household head explained 88.0% of the variation in individuals while the age at first marriage explained the remaining 12.0%. Female community education explained 68.7% of the variation in the community factors while female community literacy explained 12.2%. Overall, the top five factors – the number of household females with education beyond primary level (37.4%), relationship with the household head (24.1%), female community education (15.8%), number of children under five in the household (8.0%), and ecological zone (4.4%) – explained more than three quarters (89.7%) of the total variation in school attendance among female respondents.

4. Discussion

This study aimed to investigate factors associated with secondary school attendance among children aged 13 – 17 in Lesotho. Lesotho 2018 MICS was the source of the data for this investigation. The findings revealed that individual, household, and community factors significantly affected secondary school attendance for both male and female respondents. Overall, secondary school attendance was 57% (47% for males and 68% for females).

Age of respondent, engagement in herding animals, and maternal education were individual factors associated with attendance among male respondents while age at first marriage and relationship with the household head were among the factors for female respondents. Association between age and school attendance has been established by prior studies in Africa (Pezzulo *et al.*, 2022). The observed increase in attendance with age suggests that boys start primary school later than girls. One likely contributor to this delay is the early engagement of boys in herding animals, which not only postpones their schooling but also reduces their chances of attending secondary school. For instance, more than half (58.7%) of male children aged 13 – 17 were involved in herding animals, with 44.1% of them still in primary. At the age of 5 – 11 years, more than two-thirds (69.9%) were already involved in animal herding (Bureau of Statistics, 2019). Research has consistently highlighted the negative impact of animal herding on boys' education (Lekhetho, 2018). Meanwhile, the role of maternal education in promoting children's schooling has been well-documented (Pezzulo *et al.*, 2022).

Among female respondents, non-biological children were less likely to attend school compared to children of the household head. This result is similar to the findings of previous studies (Huisman & Smits, 2015; Kazeem & Jensen, 2017). The odds of attendance for females married before age 18 were not statistically different from those of never-married females. This contradicts findings from earlier studies in Lesotho and elsewhere (Mosaase, 2004; Molapo *et al.*, 2014; Nkosi & Pretorious, 2019, UNICEF, 2021). The discrepancy may be due to the lack of information on age at first marriage among respondents.

The high HIV prevalence in Lesotho has left a sizable percentage (40.7%) of secondary school-aged children being orphaned, which can negatively affect school attendance (Nyabanyaba, 2009; Fleisch *et al.*, 2012; Kazeem & Jensen, 2017). However, according to the findings of the present study, orphanhood was only significant at the bivariate level. This is probably due to the Lesotho government's financial assistance to vulnerable children.

Household wealth was associated with elevated odds of attendance among male respondents. The role of financial constraints as a barrier for the majority of children in accessing education has been well documented (Tuoane *et al.*, 2001; Duflo, *et al.*, 2021; Pezzulo *et al.*, 2022).

Residing in households with at least one child aged less than five was associated with decreased odds of school attendance among female respondents. Previous research has corroborated the importance of the child dependency ratio on school attendance, as competition for limited financial resources among siblings can hinder educational opportunities (Pezzulo *et al.*, 2022). On the other hand, residing in households with educated females was associated with elevated odds among both female and male respondents. This finding aligns with previous studies suggesting that household literacy creates a conducive environment for children to attend school (Barman, 2010; Onyedikachim & Ezekiel-Hart, 2021).

Residing in communities with high male community education was associated with elevated odds of school attendance among male respondents, whereas female community education was significantly linked to attendance among female respondents. These findings reinforce the role of education in creating a conducive environment for children to access education (Pezzulo *et al.*, 2022). The importance of female community education among female respondents has also been documented by other researchers (Kamanda *et al.*, 2016). In addition, high female community media exposure was associated with increased school attendance among male respondents.

The negative relationship between the number of children under five and school attendance among male respondents further underscores the competition for limited financial resources among siblings within the household. This factor reinforces financial resources as a barrier for children to access secondary education. Previous research has corroborated these findings (Duflo *et al.*, 2021). Pezzulo *et al.*, 2022). Other studies have established that poverty negatively affects attendance due to a lack of sanitary pads (Montgomery *et al.*, 2012; Alam *et al.*, 2017) or the absence of school feeding programs (Remmelzwaal, 2018).

This study highlights the necessity of recognizing and addressing the distinct educational needs of males and females at the community level. By promoting gender-specific educational programs, communities can foster greater engagement, empowerment, and overall development. This approach not only benefits individuals but also strengthens the social fabric and economic resilience of the community as a whole. Elimination of current gender disparities – where male children face greater disadvantages in accessing education – could lead to increased male community education. This, in turn, would create a conducive environment for school attendance among secondary school-going-aged boys. Since the majority (61.7%) of males are household heads and primary decision-makers, ensuring their education during their school-going years would have long-term benefits. Higher male education levels in a community are linked to improved school attendance among children, emphasizing the broader societal advantages of investing in education for both genders.

The early engagement in herding animals among boys likely contributes to their delayed start in primary and low secondary school attendance. For instance, more than half (58.7%) of male children aged 13 – 17 were involved in herding animals and 44.1% of them were still in primary school. At the age of 5 – 11 years, more than two-thirds (69.9%) were already involved in animal herding (Bureau of Statistics, 2019).

The findings of this analysis indicate that household factors have the greatest influence on school attendance, followed by individual factors, while community-level factors play a comparatively smaller role. However, to address barriers to secondary school attendance, interventions should consider individual, household, and community-level factors collectively.

4.1. Limitations of the study

This study has several limitations that should be considered when interpreting the findings. First, the use of cross-sectional data from the Lesotho MICS limits the ability to establish causal relationships between individual factors and secondary school attendance. Longitudinal studies would provide better insights into changes over time. Second, reliance on self-reported information may introduce biases, such as social desirability bias or recall bias, potentially affecting the accuracy of the data. Third, while MICS aims for representative sampling, certain subgroups (e.g., remote communities) may be underrepresented, limiting the generalizability of the findings. In addition, the analysis focused on specific individual, household, and community factors, but other important variables, such as school quality, peer influence, and health issues, were not included in the model. While the household wealth index was used to assess financial barriers, it may not fully capture economic challenges faced like unexpected expenses or cultural attitudes toward education. Finally, the study did not account for temporal factors, such as changes in educational policies or external events (e.g., natural disasters or economic fluctuations), which could impact school attendance rates over time.

4.2. Implications of the study

The findings of this study have several important implications for policy, practice, and future research. In terms of policy interventions, targeted programs for

boys and girls are necessary. For boys, policies should address barriers such as animal herding, while for girls, early marriage and community support structures require attention. Economic support is crucial, as financial constraints significantly impact school attendance. Policies that provide financial assistance, subsidies, or poverty alleviation programs can help increase school attendance rates for both genders.

Educational programs could also play a significant role. Programs that engage community leaders and members can help change cultural norms that hinder school attendance. Increasing maternal education has been shown to positively influence male attendance, highlighting the need for programs that educate parents, particularly mothers, on the long-term benefits of schooling.

School-based initiatives are essential as well. For boys involved in herding, flexible schooling options or integrating educational programs into their daily activities could help them balance responsibilities. For girls, providing support for teenage mothers and promoting delayed marriage through awareness programs could reduce dropout rates.

Community development is another critical area. Economic development programs that improve overall economic conditions can indirectly boost school attendance by alleviating some of the economic pressures that force children out of school. In addition, improving infrastructure, such as roads and transportation, would enhance school accessibility, particularly in rural areas.

Future research should utilize longitudinal study models to better understand the causal relationships between various factors and school attendance. Expanding research to include variables, such as school quality, peer influences, and health issues, would provide a more comprehensive understanding of the factors affecting school attendance.

5. Conclusion

The analysis, based on the Lesotho 2018 MICS and a three-level logistic regression model, indicates different factors influencing secondary school attendance for males and females. For males, individual and household factors, such as age, animal herding, and maternal education, are paramount, explaining over 80% of the total variation associated with school attendance. For females, household and community factors, including age at first marriage, are equally crucial, also accounting for at least 80% of the total variation.

The findings suggest that interventions to improve school attendance should be gender-specific. For boys, addressing barriers such as animal herding and providing targeted support at the household level can significantly enhance educational access. For girls, focusing on reducing teenage marriages and strengthening community support structures is essential. In addition, poverty reduction measures and subsidies for secondary education can alleviate financial barriers, increasing school attendance for both genders.

Overall, this study underscores the importance of targeted and multifaceted strategies to improve secondary school attendance in Lesotho. By addressing the identified individual, household, and community barriers, stakeholders can develop targeted interventions to improve school attendance rates. This, in turn, will contribute to achieving the UN SDG and fostering a more educated and prosperous society in Lesotho.

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Conflict of interest

The authors declare that they have no conflict of interests.

Author contributions

Conceptualization: Katleho Makatjane, Mamoeletsi Mojalefa
Investigation: Katleho Makatjane
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Writing – original draft: Tiisetso Makatjane
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Ethics approval and consent to participate

The use of Lesotho MICS 2018 data does not require ethical clearance, as the data are publicly available.

Consent for publication

Only publicly available data were used in the analysis.

Availability of data

The data used in this study is available at http://mics.unicef.org/surveys.

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ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Demographic diversity and social capital: A pathway to sustainable red durian cultivation in rural Indonesia

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Abstract

This study aims to investigate how demographic factors – education, income, and family size – interact with the core dimensions of social capital (trust, networks, and norms) to shape collective decision-making in Kemiren Village, Banyuwangi Regency, Indonesia, a rural area renowned for its culturally significant red durian cultivation. Using a mixed-method approach that integrates quantitative surveys (from 200 household heads within the local population) and qualitative interviews with community leaders, data were analyzed using principal component analysis and structural equation modeling. To contextualize the results, we additionally synthesize evidence from four recent rural-agriculture studies in Thailand, Vietnam, and the Philippines, highlighting both convergent and divergent demographic–social-capital pathways. Interview questions explored socio-economic contexts, stakeholder collaboration, and community norms, providing deeper insight into local governance structures. The findings reveal that higher education enhances trust in community institutions, stable incomes facilitate participation in social networks, and larger family sizes reinforce adherence to shared norms. These demographic-social capital interactions significantly influence community decisions regarding red durian cultivation, with educated and wealthier households more likely to support sustainable practices and larger families serving as social anchors. Notably, these results underscore the economic dimension of sustainability, as households with greater financial capacity can invest in improved farming techniques and marketing strategies. While grounded in a single case study, the insights offer potential lessons for other rural communities in Southeast Asia, emphasizing the importance of integrating social capital-building initiatives into rural development strategies to promote collective action, cultural preservation, and sustainable agriculture. Policymakers are encouraged to implement context-specific education and income-support programs while fostering inclusive community networks. Nevertheless, the study's single-site design suggests a need for broader comparative research, including additional demographic variables, to fully capture cross-cultural nuances and longitudinal dynamics.

Keywords: Social capital; Demographic diversity; Indonesia; Rural development; Collective decision-making; Sustainable agriculture

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1. Introduction

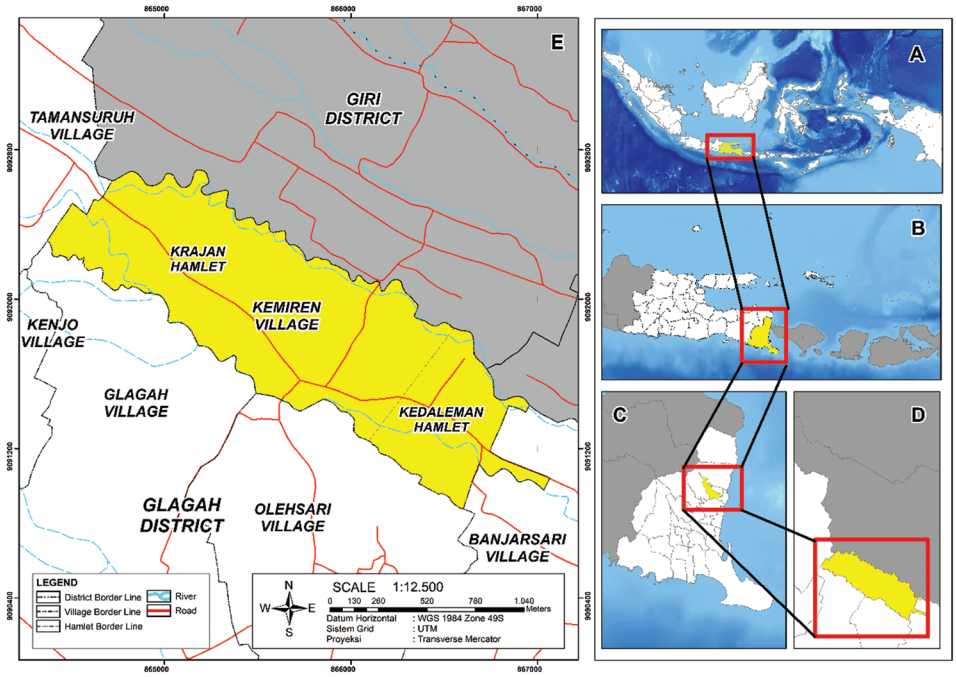
Rural agricultural development is deeply intertwined with the interplay of social capital and demographic factors, especially in a single-case setting such as Kemiren Village, Indonesia, where indigenous crops hold both economic and cultural significance. Social capital, encompassing trust, networks, and norms are a foundational element in facilitating collaboration, resource sharing, and innovation among rural communities (Heliawaty *et al*., 2021; Jia & Xu, 2021; Qurniati *et al*., 2017; Ren *et al*., 2022; Ruslan & Khalid, 2023; Wang *et al*., 2022; Zhang *et al*., 2020). Trust plays a pivotal role as the foundation for robust social networks and shared norms, which enable collective action. Higher levels of trust have been shown to enhance participation in agricultural initiatives, influence economic outcomes, foster sustainable practices, and strengthen overall community collaboration (Heliawaty *et al*., 2021; Qurniati *et al*., 2017; Zhang *et al*., 2020). Building on these insights, we contrast Kemiren with comparable village studies from Southeast Asia to illustrate where social-capital mechanisms converge – or diverge – under differing cultural and institutional contexts.

Indigenous crops, such as the red durian, are emblematic of the rich cultural heritage and income-generating potential of Southeast Asian rural communities (Aziz *et al*., 2017; Low *et al*., 2021; Mahlangu *et al*., 2020). These crops hold profound cultural significance, often embedded in local myths and traditions, symbolizing a region's identity and legacy (Low *et al*., 2021). Economically, indigenous crops like red durian provide vital sources of food security, income, and livelihoods for rural households, contributing significantly to their overall well-being (Aziz *et al*., 2017; Mahlangu *et al*., 2020). Although this study focuses on one local context, the potential of these crops to drive sustainable development depends on the effective mobilization of community resources, which is inherently shaped by the interplay of social capital and demographic diversity.

Demographic factors, including education, income, and family size, play a crucial role in shaping rural decision-making processes. Education equips individuals with the knowledge and skills necessary for informed participation in community governance and agricultural innovation (Xu *et al*., 2010). Similarly, income levels determine households' financial capacity to invest in both collective endeavors and new farming technologies, while family size influences the strength and extent of kinship networks, which are essential for fostering community norms and cohesion (Alexander *et al*., 2023; Xu *et al*., 2010). Notably, the relative influence of these demographic factors can vary across cultural contexts, where collectivist values and kinship networks may outweigh individual attributes in shaping decisions (Alexander *et al*., 2023). Furthermore, the interplay between these demographic factors and community social capital is critical for understanding rural tourism innovation in Indonesia, as it highlights how local communities leverage their social networks and collective resources to enhance tourism development, ultimately creating a more sustainable and inclusive economic environment that benefits all members of the community (Wafa *et al*., 2024).

Despite the growing recognition of these dynamics, significant gaps remain in cross-cultural understanding. To bridge this, we introduce a comparative lens – drawing on evidence from Thailand (Mahaarcha & Sirisunhirun, 2023), Vietnam (Hua & Brown, 2024), and the Philippines (Intong *et al*., 2022) – that illuminates both shared and divergent patterns between social capital and demographic attributes. Moreover, limited attention has been paid to generalizing findings beyond a single locale, as current research has largely focused on the individual dimensions of social capital – trust, networks, or norms – without adequately exploring their interdependence and combined impact on agricultural outcomes (Wu *et al*., 2022). Our study responds by juxtaposing Kemiren's pathways with these regional cases, thereby uncovering how cultural norms, market structures, and decentralized governance shape social-capital formation.

In rural settings like Kemiren Village, multiple stakeholders – including farmers, local government agencies, non-governmental organizations (NGOs), and community leaders – play an equally pivotal role in shaping social capital dimensions. These stakeholders collaborate through shared norms and trust-based networks to achieve sustainable cultivation of culturally significant crops such as red durian. By examining how education, income, and family size intersect with stakeholder interactions, this study offers insights into effective strategies for broader rural contexts in Southeast Asia. Kemiren Village in Indonesia offers a unique opportunity to investigate these complex dynamics. Renowned for its cultivation of red durian, a culturally significant crop, the village represents an ideal context for examining the interplay of social capital and demographic factors in guiding community-level agricultural decisions. This study explores how education, income, and family size interact with the core dimensions of social capital – trust, networks, and norms – to influence community collaboration and decision-making. To clarify these pathways, we present a causal flow-diagram (Figure 1) that maps the direction and relative strength of each demographic-to-social-capital link, providing a visual anchor for subsequent comparative



1 Map of Kemiren Villag

Figure 1. Study-site maps: (A) Indonesia → (B) East Java → (C) Banyuwangi Regency → (D) Glagah District; (E) detailed village boundary showing hamlets sampled

discussion. By addressing these interrelationships, this research contributes to a deeper understanding of how the integration of social capital and demographic diversity can support sustainable agriculture while preserving cultural heritage. While the findings are localized, they may serve as a basis for wider empirical explorations. Ultimately, it provides insights for policymakers, researchers, and community leaders to design interventions that align with economic, cultural, and environmental goals in rural agricultural development.

1.1. Literature review

1.1.1. Theoretical frameworks for analyzing social capital in rural development

Theoretical frameworks serve as essential tools for understanding the dynamics of social capital in rural development. One of the most widely used frameworks is Putnam's conceptualization, which defines social capital as comprising three core dimensions: trust, networks, and norms (Heliawaty *et al.*, 2021; Jia & Xu, 2021; Qurniati *et al.*, 2017; Ren *et al.*, 2022; Ruslan & Khalid, 2023; Wang *et al.*, 2022; Zhang *et al.*, 2020). These dimensions collectively influence community collaboration, broader socio-economic resilience, and the adoption of sustainable practices. Comparative works from Thailand, Vietnam, and the Philippines show that these same dimensions recur but vary in strength: in Thailand's multi-level irrigation system, trust is the dominant driver of farmer participation (Mahaarcha & Sirisunhirun, 2023); in Mekong-Delta cooperatives, dense *networks* outweigh trust in predicting organizational resilience (Hua & Brown, 2024); while among livelihood programs for rural women in Mindanao, adherence to *norms* is the critical pathway to food-security gains (Intong *et al.*, 2022). For instance, trust fosters mutual respect and reduces transactional uncertainty, enabling community members to work collaboratively toward shared goals (Heliawaty *et al.*, 2021; Qurniati *et al.*, 2017). Networks enhance connectivity among individuals, local government agencies, NGOs, and groups, facilitating the exchange of resources, market information, and support systems necessary for agricultural development (Ren *et al.*, 2022; Zhang *et al.*, 2020). Norms act as informal regulations that align individual behaviors with collective interests, promoting inclusivity and sustainability in rural initiatives (Jia & Xu, 2021; Ruslan & Khalid, 2023).

Another relevant perspective is the embeddedness theory, which explores how social capital is deeply integrated into the social and cultural fabric of rural communities (Ruslan & Khalid, 2023; Tregear & Cooper, 2016). Cross-country evidence suggests that the *depth* of embeddedness is sensitive to land-tenure regimes and local governance. For example, strong customary tenure in Vietnam's cooperative villages reinforces internal norms (Hua & Brown, 2024), whereas Thailand's state-

managed irrigation layers require formal trust in agencies (Mahaarcha & Sirisunhirun, 2023). Education is also known to increase economic growth in Southeast Asia. Education can significantly improve Thailand's economy by increasing labor productivity, promoting social mobility, addressing structural challenges, taking advantage of demographic dividends, and adjusting public policies to meet growing educational needs (Michel, 2015). Recent studies in Southeast Asia highlight that embedding social capital practices in local contexts can drive more inclusive community-based resource management, fostering both ecological protection and livelihood enhancement (Gurney *et al*., 2019). These foundations frame how social-capital dimensions operate in culturally specific contexts, including the cultivation of red durian in Indonesia.

1.1.2. The influence of education and income on leadership and participation

Education and income are pivotal demographic factors that influence leadership and participation in rural community initiatives. Higher educational attainment equips individuals with critical thinking skills, knowledge, and confidence, enabling them to assume leadership roles and actively participate in decision-making processes (Anang & Yeboah, 2019; Xu *et al*., 2010). In agricultural contexts, educated farmers are more likely to adopt sustainable practices, leverage advanced technologies, and engage in cooperative ventures, fostering community-level resilience (Xu *et al*., 2010). Comparative evidence shows mixed patterns: while tertiary education predicts active committee membership in Thai irrigation districts (Mahaarcha & Sirisunhirun, 2023), Vietnamese cooperative leaders attribute their influence more to extensive kinship networks than to formal schooling (Hua & Brown, 2024). Well-designed training programs can amplify these benefits by providing technical skills and capacity-building resources.

Income levels likewise shape the breadth of social networks: households in Mekong cooperatives with higher surplus capital provide bridging loans that expand inter-village ties (Hua & Brown, 2024), whereas Mindanao livelihood groups rely on pooled micro-savings from low-income members but compensate through strong norm-based reciprocity (Intong *et al*., 2022).

Similarly, income levels determine households' financial capacity to contribute to collective projects and access critical resources, such as agricultural inputs or market opportunities (Anang & Yeboah, 2019). Wealthier households tend to have broader social networks and a higher degree of influence within their communities, enabling them to lead or support development initiatives (Xu *et al*., 2010). For example, in certain high-value crop systems in Indonesia, higher-income farmers have been found to drive community-led marketing strategies, thereby improving overall local economic growth and poverty reduction in developing countries (Mariyono, 2019). However, the role of education and income may be moderated by traditional kinship networks and collectivist values, which often dominate decision-making in rural contexts. In such settings, social capital may supersede individual demographic attributes as a determinant of leadership and participation (Alexander *et al*., 2023; Xu *et al*., 2010).

1.1.3. The role of family size in maintaining cultural norms and collective action

Family size is a significant yet complex demographic factor in rural settings. Larger families often function as custodians of cultural norms and traditions, playing a crucial role in preserving community values and fostering intergenerational knowledge transfer (Abdurezak *et al*., 2021; Niu *et al*., 2023). These families may have extensive kinship networks that enhance social cohesion and collective action, particularly in culturally significant agricultural practices like red durian cultivation (Alexander *et al*., 2023).

However, larger family sizes can also pose challenges, particularly in resource-constrained rural settings. Economic limitations may restrict their ability to actively participate in community projects or adopt innovative practices, potentially reducing their influence on collective decision-making (Abdurezak *et al*., 2021). Conversely, smaller families may demonstrate greater agility in decision-making but may lack the extensive social ties necessary for maintaining cultural norms and fostering long-term collaboration (Alexander *et al*., 2023; Xu *et al*., 2010). As seen in other Southeast Asian communities, smaller households sometimes focus on off-farm income sources, which can limit direct involvement in traditional agriculture (The World Bank, 2021). Understanding these dynamics is essential for designing interventions that leverage family structures to promote sustainable rural development.

1.1.4. Effective methods for measuring the impact of social capital on agricultural sustainability

The impact of social capital on agricultural sustainability has been studied using both quantitative and qualitative methodologies. Quantitative approaches, such as surveys and econometric modeling, allow researchers to assess relationships between social capital dimensions (trust, networks, and norms) and agricultural outcomes, including the adoption of sustainable practices, participation in cooperatives, and income generation (Heliawaty *et al*.,

2021; Jia & Xu, 2021; Ren *et al*., 2022; Ruslan & Khalid, 2023; Wang *et al*., 2022; Zhang *et al*., 2020). These methods can also account for economic dimensions, such as cost-benefit analysis and market access, thereby clarifying how social capital contributes to the profitability of crops like red durian.

Qualitative methods, including interviews and case studies, complement quantitative analyses by providing deeper contextual understanding of the mechanisms through which social capital operates (Nugraha *et al*., 2022; Tregear & Cooper, 2016). For instance, interviews with community leaders and farmers can reveal how trust and shared norms shape collective decision-making and resource allocation in agricultural initiatives. In addition, participatory rural appraisal techniques have been successfully employed to capture localized knowledge and cultural practices, elucidating how social capital fosters adaptive resilience in the face of market fluctuations (Antriyandarti *et al*., 2024; Chambers, 1994). Case studies can illustrate successful examples of social capital utilization in promoting sustainable practices, offering replicable models for other rural contexts (Tregear & Cooper, 2016).

Integrating quantitative and qualitative approaches yields a more comprehensive understanding of the complex dynamics between social capital and agricultural sustainability. In addition, engaging multiple local stakeholders in both data collection and interpretation can enrich findings and enhance their applicability beyond a single region. This mixed-methods approach is particularly relevant for examining culturally and economically specific agricultural practices, such as red durian cultivation, where both statistical trends and contextual insights are critical for formulating effective development strategies.

2. Data and methods

2.1. Study area

This study was conducted in Kemiren Village, Banyuwangi Regency, Indonesia, a rural area renowned for its rich cultural heritage and unique agricultural practices. Banyuwangi Regency is located on the easternmost tip of Java Island, Indonesia. The village is characterized by its cultivation of red durian, a crop deeply embedded in local traditions and economic systems. The predominantly agrarian economy of Kemiren is supplemented by small-scale tourism, which highlights the community's distinctive osing cultural heritage. The focus on red durian cultivation in this study provides a unique context to explore the interplay of demographic attributes and social capital dimensions in shaping community decision-making and sustainable agricultural practices. Kemiren Village borders Tamansuruh Village to the west, Olehsari Village to the south, Banjarsari Village to the east and borders Jambersari Village, Giri District to the north. To aid global readers, an additional inset map of Indonesia was prepared to indicate the precise location of Kemiren Village within Banyuwangi Regency (Figure 1).

2.2. Demographic variables and social capital dimensions

The study operationalized demographic variables as education, income, and family size to examine their interactions with the core dimensions of social capital: trust, networks, and norms. Education was categorized into primary, secondary, and tertiary levels, reflecting differences in knowledge and capacity for decision-making. For clarity, the total population of Kemiren Village is approximately 1,100 households, thus contextualizing the educational distribution. Income levels were grouped into low, medium, and high, based on regional medians, to capture variations in financial capacity and resource allocation. At the time of data collection, the low-income category referred to monthly earnings below IDR 500,000 (≈ USD 35), medium from IDR 500,001 to 1,500,000 (≈ USD 35 – 105), and high above IDR 1,500,000 (≈ USD 105). Family size was categorized as small (1 – 2 members), medium (3 – 4 members), and large (5 or more members), representing the potential for kinship-based networks and norm reinforcement.

The dimensions of social capital were defined according to Putnam's framework, which identifies trust, networks, and norms as essential components. Trust was measured through indicators of interpersonal and institutional confidence, while networks were assessed based on the frequency and diversity of interactions within the community. Norms were captured through adherence to shared values and collective rules, particularly those related to red durian cultivation and sustainable agricultural practices.

2.3. Sampling design

The study employed a random sampling technique to ensure diverse representation of educational backgrounds, income levels, and family sizes within the Kemiren Village population. Based on the approximate 1,100 households in the village, 200 respondents represent about 18% of the total household population, including both male and female household heads. This sample size was chosen to balance statistical rigor and logistical feasibility, meeting the minimum recommendations for structural equation modeling (SEM) analyses. The sampling design also aimed to reflect the demographic diversity of the village, ensuring the inclusion of marginalized groups and variations across socioeconomic strata. Furthermore, care was taken to

include households from different hamlets within the village to capture any geographic variation in social capital dimensions.

2.4. Data collection

Data were collected using a mixed-method approach that combined quantitative surveys with qualitative interviews. The structured surveys were designed to measure the demographic variables and social capital dimensions, adapting items from established social capital assessment tools to ensure reliability and cultural relevance. These surveys included Likert-scale items to assess trust, network participation, and adherence to norms. In total, 20 semi-structured interviews were conducted with a purposive sample of village leaders, cooperative members, red durian farmers, and local government representatives, ensuring diverse perspectives on community collaboration. The interviews focused on understanding the mechanisms through which demographic factors influence social capital and community decision-making, particularly regarding red durian cultivation. Interview questions covered themes such as institutional trust, cultural norms, collaborative networks, and perceived barriers to sustainable agricultural practices.

2.5. Measurements

To ensure the robustness of our findings, and guided by existing literature, we included 21 variables in the analysis: 12 related to trust, seven to social networks, and two to social norms. All items were assessed using five-point Likert-type scales, with coding schemes tailored to the nature of each question. For variables related to trust and social norms, we used an agreement-based scale ranging from strongly disagree (coded as 1) to strongly agree (coded as 5). For social network variables, a frequency-based scale was employed, ranging from never (coded as 1) to very often (coded as 5).

The 12 trust-related items captured various dimensions of interpersonal and institutional trust. Specifically:

- $X_{1.1}$ assesses confidence that a neighbor would return borrowed money or goods.
- $X_{1.2}$ captures the belief that community interactions are guided by mutual respect.
- $X_{1.3}$ gauges perceptions of honesty among community members.
- $X_{1.4}$ reflects expectations of cooperation in communal activities.
- $X_{1.5}$ measures the respondent's sense of social acceptance.
- $X_{1.6}$ evaluates belief in neighbors' willingness to help during emergencies.
- $X_{1.7}$ – $X_{1.10}$ assess trust in family members, relatives, neighbors, and friends, respectively.
- $X_{1.11}$ measures confidence in the transparency of the Kemiren village government.
- $X_{1.12}$ captures trust in local organizations, such as farmer groups or religious institutions.

The seven social network items focus on the frequency of interpersonal exchanges and social contacts:

- $X_{2.1}$ records how often a household provides food to non-household members.
- $X_{2.2}$ logs the frequency of offering lodging to non-relatives.
- $X_{2.3}$ captures how often respondents accompany non-relatives to medical appointments.
- $X_{2.4}$ and $X_{2.5}$ measure the frequency of visiting friends and neighbors, respectively.
- $X_{2.6}$ notes how often friends visit the respondent's household.
- $X_{2.7}$ reflects the breadth of regular monthly contacts within the village.

Finally, two variables assess adherence to social norms:

- $X_{3.1}$ evaluates the respondent's understanding of shared village values and rules.
- $X_{3.2}$ measures the extent to which these values are practiced in daily life.

2.6. Analytical methods

The study employed principal component analysis (PCA) to identify and reduce the multiple indicators of social capital into core components. This technique allowed for a clearer interpretation of the underlying dimensions of trust, networks, and norms, which were influenced by demographic diversity. PCA is particularly effective in distilling complex datasets into meaningful components while retaining essential variance, ensuring robust analytical outcomes (Ahlborg *et al.*, 2022; Coppe *et al.*, 2022; Rui *et al.*, 2015).

Hypothesized relationships between demographic variables and social capital dimensions were tested using SEM. A summary path-diagram derived from the final SEM (Figure 2) visually depicts the standardized effect sizes and highlights the causal chain Education → Trust, Income → Networks, and Family Size → Norms. The model's fit was assessed using standard indices, including the root mean square error of approximation (RMSEA), comparative fit index (CFI), and goodness-of-fit index (GFI). In addition, multiple-group SEM analyses were conducted to check whether these pathways held consistently across income and education strata.

2.7. Validation and reliability

To ensure the reliability and validity of the research instruments, Cronbach's alpha was computed for each

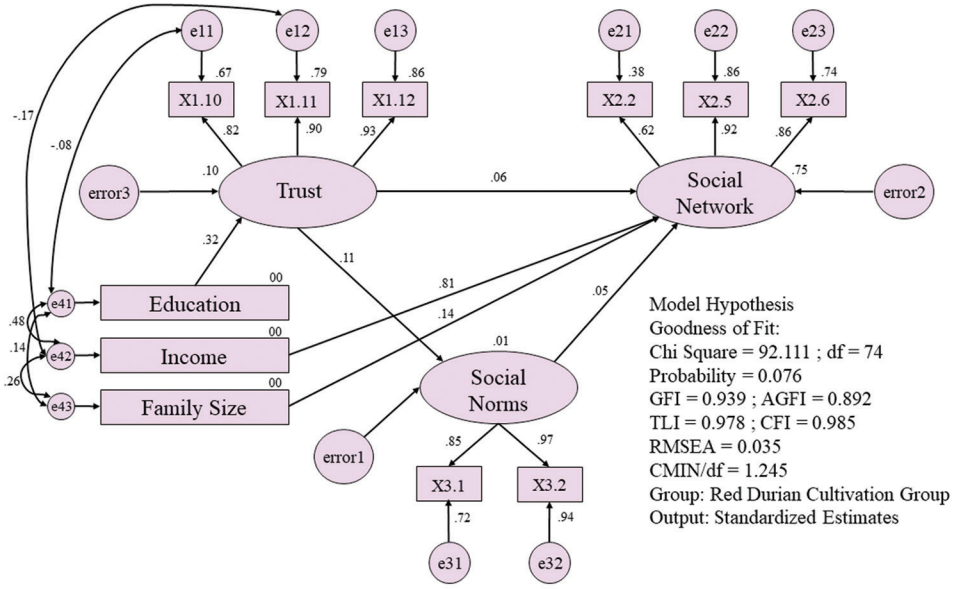


Figure 2. The corresponding path-diagram in Kemiren Village

dimension of social capital to assess internal consistency. Convergent and discriminant validity were evaluated through SEM measurement models. A pilot test of the survey was conducted with 15 villagers (not included in the final sample) to refine questions related to trust and norms, ensuring clarity and cultural appropriateness. Pre-testing of the survey instruments was conducted in collaboration with local informants to ensure cultural appropriateness and minimize bias. Feedback from community leaders and experts was incorporated to refine the measurement of trust, networks, and norms.

2.8. Ethical considerations

Ethical approval for the study was obtained from relevant authorities, ensuring compliance with ethical guidelines for research involving human participants. Informed consent was secured from all respondents, who were informed of their right to withdraw from the study at any point. Data confidentiality was maintained throughout the research process, and findings were anonymized to protect participants' identities. All respondents, including interviewees, received detailed information on the study objectives, data handling procedures, and potential benefits to community development.

This methodological approach, integrating both quantitative and qualitative techniques, provided a comprehensive understanding of how demographic attributes interact with social capital dimensions to influence community decisions. The use of PCA and SEM ensured robust analytical rigor, while the qualitative components enriched the interpretation of findings within the cultural and social context of Kemiren Village. In particular, triangulating survey data with interview insights allowed for a deeper exploration of stakeholder roles, trust-building processes, and the socioeconomic implications of red durian cultivation.

3. Results

3.1. Demographic profile of respondents

The demographic characteristics of the study participants in Kemiren Village provided crucial insights into the community's socio-economic landscape. When compared with recent surveys in rural Thailand and Vietnam, Kemiren shows a noticeably higher share of primary-educated farmers (59.5% vs. 44 – 48%), but a similar proportion of low-income households (<USD 70 month). This contextual comparison strengthens the external relevance of our subsequent social-capital analysis (Table 1).

3.2. Social capital dimensions across demographic groups

Education demonstrated a significant influence on trust, a core dimension of social capital. Education demonstrated a significant influence on trust, a core dimension of social capital. This mirrors findings from multi-level irrigation districts in Thailand, where tertiary schooling likewise predicts higher institutional trust (Mahaarcha & Sirisunhirun, 2023), yet contrasts with Mekong-Delta cooperatives – there, trust hinges more on kinship than formal education (Hua & Brown, 2024). Respondents

with tertiary education reported higher levels of trust in community institutions and leaders compared to those with only primary or secondary education. This finding aligns with studies suggesting that higher education levels foster a better understanding of institutional functions and enhance perceptions of impartiality (Batlang & Wilford, 2017; Charron & Rothstein, 2016). However, insights from interviews indicated that some tertiary-educated participants expressed skepticism toward local governance, reflecting broader socio-political concerns (Hakhverdian & Mayne, 2012). Interview data also indicated that educated villagers often demanded greater transparency in resource allocation, suggesting an evolving dynamic in local leadership expectations.

Income levels were closely linked to participation in social networks. Higher-income households were more active in community organizations, cooperatives, and cultural events, indicating that financial stability facilitates engagement in social and civic activities. This finding resonates with prior research emphasizing the role of income in enabling broader social interactions and participation (Curvers *et al*., 2018; Feng *et al*., 2020). However, this relationship was not entirely linear; some higher-income individuals reported time constraints as a barrier to participation, consistent with findings in other rural contexts (Oinas *et al*., 2020). Parallel evidence from Vietnam confirms that surplus capital expands bridging ties (Hua & Brown, 2024), whereas a Philippine livelihood study stresses norm-based reciprocity among low-income women's groups (Intong *et al*., 2022).

Family size influenced adherence to community norms and collective action. Larger families were more likely to adhere to traditional values and participate in community-driven initiatives, reinforcing cultural cohesion. However, economic constraints among larger households limited their ability to contribute consistently to collective projects, highlighting the tension between kinship networks and resource allocation (Abdurezak *et al*., 2021; Niu *et al*., 2023). Smaller families, on the other hand, demonstrated greater flexibility in decision-making but were less embedded in the extensive social networks that sustain communal norms.

Table 1. Demographic profiles of respondents

Variable	Category	Percentage
Education	Primary	59.5
	Secondary	27.5
	Tertiary	13.0
Income (IDR)	≤500,000 (~USD 33)	33.0
	500,001 – 1,000,000 (~USD 33 – 67)	38.5
	1,000,001 – 2,000,000 (~USD 67 – 133)	15.5
	>2,000,000 (~USD 133)	13.0
Family size	1 – 2 members	64.0
	3 – 4 members	35.0
	≥5 members	1.0

3.3. Structural relationships between demography and social capital

SEM revealed significant relationships between demographic attributes and social capital dimensions. A visual path-diagram (Figure 2) summarizes the standardized effects and uses line-weight coding to underscore the strongest link (Income → Networks). Education exhibited a strong positive effect on trust, with a standardized regression weight of 0.309 (p<0.001), supporting the hypothesis that higher educational attainment enhances confidence in community leaders and institutions. Income was positively associated with participation in social networks, yielding a regression weight of 0.812 (p<0.001), indicating the critical role of financial resources in facilitating engagement. Family size contributed positively to the reinforcement of norms, although to a lesser extent than income, with a regression weight of 0.140 (p=0.002). Multiple-group SEM analysis indicated that these relationships held similarly across different age brackets, suggesting that generational differences did not significantly alter the influence of education, income, and family size on social capital dimensions. These findings confirmed that each demographic factor exerts a unique yet interconnected influence on social capital dimensions (Table 2).

3.4. Community decision-making for red durian cultivation

Table 2. Structural equation modeling results for Kemiren village

Path	Standardized coefficient	p-value	Interpretation
Education → Trust	0.309	<0.001	Significant positive effect
Income → Social Networks	0.812	<0.001	Strong positive effect
Family size → Norms	0.140	0.002	Positive but weaker effect
Trust → Decision-Making	0.457	>0.001	Mediates education and decision-making
Social Networks → Decision-Making	0.376	>0.001	Mediates income and decision-making
Norms → Decision-Making	0.219	0.015	Moderates family size influence

The interplay between demographics and social capital dimensions played a decisive role in shaping community decisions about red durian cultivation. Educated respondents were more inclined to support initiatives promoting sustainable farming practices and biodiversity preservation, citing awareness of their long-term benefits. Local government and NGO-led workshops further motivated these educated households to take leadership roles in organizing training sessions for best cultivation practices. Wealthier households contributed resources to collective efforts, such as funding for agricultural inputs and marketing activities. Larger families acted as social anchors, fostering communal participation in red durian projects, while smaller families adopted targeted approaches, focusing on individual-level innovations.

Respondents with lower education levels or limited incomes expressed hesitancy in supporting such initiatives due to financial insecurity and a lack of information. This highlights the importance of addressing socio-economic disparities to ensure inclusive participation in community-driven agricultural development.

3.5. Key statistical insights

PCA confirmed that trust, networks, and norms are the principal components of social capital, explaining 64.9% of the variance (Table 3). Trust emerged as the most influential dimension, accounting for 40.3% of the variance, underscoring its foundational role in fostering community collaboration. The dominance of trust (40.3% variance) aligns with Thai and Filipino studies, whereas the Vietnamese cooperative case shows networks as the leading component – reinforcing the contextual nature of social-capital structure. SEM fit indices, including RMSEA = 0.036, CFI = 0.991, and GFI = 0.956, validated the robustness of the proposed model and its alignment with theoretical assumptions. When interpreting these statistics, it is important to consider that culturally specific factors in Kemiren Village (e.g., red durian's heritage value) may not directly apply to other regions, although the fundamental role of social capital could be generalized. These statistical insights underscore the intricate linkages between demographic diversity and social capital dimensions, offering actionable evidence for leveraging these factors to enhance community decision-making and sustainable development in rural settings. By situating Kemiren alongside comparable Southeast-Asian evidence, we illustrate both shared pathways (Education → Trust) and notable divergences (income-network elasticity), offering nuanced guidance for region-specific policy design.

Table 3. Principal component analysis results for social capital dimensions

Component	Variance explained (%)	Key variables loaded
Trust	40.3	Trust in leaders, trust in neighbors
Social Networks	14.5	Network diversity, interaction frequency
Norms	10.2	Adherence to rules, cultural values

In summary, the results, augmented by qualitative feedback from key informants, demonstrate that demographic attributes – education, income, and family size – significantly shape the core dimensions of social capital in Kemiren Village. These dimensions, in turn, influence collective actions and decision-making processes, particularly in the context of red durian cultivation. By identifying these relationships, the study provides valuable insights into how social capital and demographic diversity can be harnessed to promote sustainable rural development. Although the findings stem from a specific local case, they offer broader lessons on the importance of aligning education, financial capacity, and family networks to strengthen trust, norms, and community participation in other rural settings.

4. Discussion

The findings of this study provide nuanced insights into the relationships between demographic factors and social capital dimensions in Kemiren Village, particularly in the context of red durian cultivation. By juxtaposing our results with recent evidence from Thailand, Vietnam, and the Philippines, we show both convergence (e.g., education-trust pathways) and divergence (e.g., income-network elasticity), thereby reinforcing the broader Southeast-Asian relevance of the Kemiren case. These results align with and expand upon existing literature while offering novel contributions to the understanding of how education, income, and family size interact with trust, networks, and norms to shape community collaboration and sustainable agricultural practices. In addition, the study highlights the economic significance of red durian as a culturally valuable crop, offering a potential model for other indigenous crops in Southeast Asia.

4.1. Demographic factors and social capital dimensions

Education was found to play a pivotal role in fostering trust in community institutions and leaders. This mirrors findings from Thailand's multi-level irrigation districts (Mahaarcha & Sirisunhirun, 2023) but contrasts with Vietnamese cooperatives where kinship-based familiarity supersedes formal schooling in generating trust (Hua & Brown, 2024). This observation aligns with prior research

indicating that higher education levels can enhance individuals' understanding of institutional functions and their perceptions of impartial governance (Batlang & Wilford, 2017; Charron & Rothstein, 2016). However, the study also highlights that this relationship is context-dependent. In Kemiren Village, where institutional transparency may vary, some tertiary-educated respondents expressed skepticism toward local governance. This finding resonates with studies suggesting that in contexts of perceived poor governance, education may lead to more critical evaluations of institutional effectiveness (Hakhverdian & Mayne, 2012). These insights underscore the dual role of education as both a driver of trust and a catalyst for critical engagement, emphasizing the need for improving institutional transparency and accountability to fully harness the potential of education in building trust. Enhanced local governance mechanisms could thus bridge the gap between educated citizens' expectations and the existing institutional framework.

Income emerged as a key determinant of participation in social networks. Comparable evidence from the Mekong Delta shows that surplus income boosts bridging ties (Hua & Brown, 2024), whereas a Philippine livelihood study highlights how low-income women compensate through norm-based reciprocity (Intong *et al.*, 2022). Consistent with existing literature, higher-income households in Kemiren Village were more actively engaged in community organizations and social activities, reflecting the enabling role of financial resources in fostering social connectivity (Curvers *et al.*, 2018; Feng *et al.*, 2020). However, the non-linear nature of this relationship was evident, as time constraints and perceived self-sufficiency limited participation among some wealthier individuals. These findings suggest that while income facilitates social engagement, complementary strategies, such as time-flexible community programs and incentivized participation, may be necessary to maximize network inclusivity.

Family size demonstrated a complex relationship with adherence to community norms and collective action. Larger families were more likely to maintain traditional values and contribute to communal efforts, which are consistent with the role of kinship networks in fostering collective cohesion (Alexander *et al.*, 2023; Xu *et al.*, 2010). However, economic constraints within larger households limited their ability to sustain active participation in resource-intensive initiatives, a dynamic also noted in prior studies (Abdurezak *et al.*, 2021; Niu *et al.*, 2023). Conversely, smaller families exhibited greater agility in decision-making but lacked the extensive social ties necessary for maintaining cultural traditions. These findings highlight the need for tailored interventions that support both large and small families in overcoming their unique barriers to community participation.

4.2. Policy implications for leveraging social capital

Our SEM-based path-diagram (Figure 2) can serve as a diagnostic tool for policymakers. For example, Income → Networks indicate leverage points for targeted interventions such as revolving-fund cooperatives, while Family Size → Norms highlight areas requiring culturally sensitive facilitation. Strategies aimed at strengthening community-level trust, networks, and norms are essential. Capacity-building workshops, participatory governance platforms, and trust-building exercises can reinforce these social capital dimensions, facilitating collective action and knowledge sharing. Second, integrating social capital into agricultural development programs can enhance their effectiveness. For instance, farmer cooperatives and community-based resource management systems could be designed to harness existing social networks while fostering inclusivity. These collaborations can also support the economic dimension of red durian cultivation by pooling resources for marketing and distribution, ultimately improving profit margins for local farmers. Such initiatives would also help address disparities in social capital formation by creating opportunities for marginalized groups to participate in decision-making processes.

Educational and economic empowerment programs are particularly critical in addressing inequalities in social capital formation. Expanding access to education and vocational training can enhance individuals' understanding of community governance and their ability to engage critically and constructively. Similarly, policies aimed at increasing household incomes, such as microfinance schemes or market access programs, can enable broader participation in social networks and cooperative ventures. However, these interventions must be context-sensitive, taking into account cultural norms and values that influence how demographic factors interact with social capital dimensions.

4.3. Contributions to literature and future research directions

This study contributes to the literature by providing empirical evidence of how demographic diversity influences the dimensions of social capital in a culturally specific agricultural context. By embedding a comparative lens, we extend the "contextual social-capital" debate (Perkins *et al.*, 2023) and demonstrate that the dominance of any single dimension (trust, networks, or norms) is contingent on national governance structures and market orientation. In addition, it underscores the importance of integrating social capital into sustainable agricultural

development strategies, particularly in contexts involving culturally significant crops like red durian. While these insights are drawn from a single case study, they may inform rural development initiatives in similar cultural settings, especially where heritage crops play pivotal roles in local economies.

Future research should build on these findings by exploring cross-cultural variations in the relationships between demographics and social capital. Panel data from multiple Southeast-Asian sites would allow testing of the feedback loops hypothesized in Figure 2 (e.g., improved income → stronger networks → cooperative growth). Comparative studies could provide insights into how these dynamics vary across different socio-cultural and institutional contexts. Longitudinal research is also needed to examine the evolving nature of these relationships over time, particularly in response to changes in governance, economic conditions, and cultural practices. Further, mixed-method approaches combining quantitative surveys with in-depth qualitative analyses can provide a more comprehensive understanding of the mechanisms underlying these interactions. Finally, exploring the role of other demographic variables – such as gender, age, and ethnicity – would enrich the understanding of how social capital formation is influenced by diverse individual and household characteristics. The findings of this study also showed that education and social capital can increase economic growth on a wider scope. As is known, in general, countries in Southeast Asia have similar characteristics, especially in agriculture, which is in line with the findings that the level of secondary and higher education enrollment contributes to the economic growth of ASEAN-5 countries (Singapore, Thailand, Malaysia, the Philippines, and Indonesia). This condition is assessed at the individual and regional levels in Southeast Asia (Maneejuk & Yamaka, 2021). However, it is still necessary to address this gap, and it will be important to generalize the findings beyond one location and ensure wider application to other rural communities in Indonesia and Southeast Asia.

5. Conclusion

This study demonstrates the significant role of demographic attributes – education, income, and family size – in shaping the core dimensions of social capital (trust, networks, and norms) and confirms, through a comparative lens, that these pathways resonate with patterns observed in rural Thailand, Vietnam, and the Philippines. The findings from Kemiren Village illustrate that higher education enhances institutional trust, financial stability facilitates active participation in social networks, and larger family structures reinforce adherence to community norms. These interconnections ultimately guide collective actions, such as the cultivation and promotion of culturally significant crops like red durian, which hold economic, cultural, and environmental value.

The study's findings have important policy implications. Strengthening social capital through education, economic empowerment, and community-based initiatives can enhance collaboration, resource sharing, and sustainable agricultural practices. Since the income-network pathway shows the greatest effect size, revolving-fund cooperatives and market-access programs should be prioritized. Local government, NGOs, and cooperative groups can work synergistically to implement these interventions, thereby ensuring more comprehensive community engagement. Addressing disparities in social capital formation and integrating social capital considerations into development programs can create more inclusive and effective rural development strategies.

Future research should explore the dynamics between demographics and social capital in diverse cultural and geographical contexts. Multi-site panel studies across Southeast Asia would allow testing of the feedback loops hypothesized in Figure 2 (e.g., income gains strengthening networks, which in turn raise household earnings). Longitudinal and mixed-method studies could provide deeper insights into the evolving relationships between these factors and their implications for sustainable development. This research contributes to the understanding of how leveraging social capital and demographic diversity can support inclusive and sustainable rural development while preserving cultural heritage.

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Conflict of interest

The authors declare no conflicts of interest.

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Ethics approval and consent to participate

Informed consent was obtained from all subjects involved before their participation in the study.

Consent for publication

Written informed consent has been obtained from the farmers to publish this paper.

Availability of data

The questionnaire used in gathering the data as well as the data sets used in the analysis that support the research findings are available from the corresponding author on reasonable request.

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ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Building bridges of intercultural communication: Overcoming barriers and enhancing multicultural education in Indonesia through meaningful contact

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Abstract

This study aims to investigate how Papuan students studying in Surabaya – the second largest city in Indonesia – face and overcome various cultural barriers during their adaptation process in Java. The main focus of this study is how they break down stereotypes and prejudices against Javanese society, and how they adapt to local culture through meaningful social contact to be able to live their academic lives smoothly. This study uses a qualitative approach with a phenomenological method. Data were collected through semi-structured interviews and observations of 25 new Papuan students studying at five universities in Surabaya and then analyzed using thematic analysis techniques. The results of the study showed that Papuan students are able to find various effective adaptation strategies in a new environment that is different from their initial expectations. One of the keys to successful adaptation is their ability to identify and utilize meaningful contact zones, namely, social spaces where they can establish positive and in-depth interactions. Some important strategies used to find and build these contact zones include: understanding the character of the person they are talking to, avoiding communication that is too long and indirect, building an open and friendly self-image, being active in the community, and following the social and cultural developments in the city where they live.

Keywords: Papua; Multicultural education; Meaningful contact; Cultural barriers; Stereotypes; Intercultural communication

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1. Introduction

As an archipelagic country, Indonesia is blessed with biodiversity and cultural and ethnic diversity. It is recorded that Indonesia has no <478 ethnic groups and around 742 languages/dialects (Kominfo, 2013). On the one hand, this is a priceless wealth. However, on the other hand, this fact is a challenge for the world of education in Indonesia. Even though so far, Indonesia has been considered capable of uniting ethnic groups within the country because of the unobstructed assimilation of vocabulary, terms, and concepts in both foreign and regional languages (Antara, 2022), the gap between cultures in various fields remain largely unaddressed.

In the education sector, for example, there are still problems related to differences in the quality of education on Java and outside Java (Mustofa *et al*., 2019), which are not resolved at this time, whereas education is one of the most essential elements for developing human resources (Hanushek & Woessmann, 2020). Until now, Java Island, which is the main and most populous island in Indonesia and is a development concentration area, government center, and economic center (Salsabila, 2022), is usually the top-choice schooling destination where most parents living outside Java to send their children to. This shows that the equalization of the quality of education in Java and outside Java has not been achieved properly.

Further issues in this context often take the shape of prejudice and stereotype issues, which are the main barriers to adaptation (Rahmanda, 2023). In addition, the large number of students from outside Java who come from different social and cultural backgrounds in Javanese society has given rise to a culture shock that makes it difficult for them to adapt to the learning model and social environment in Java (Hasgimianti *et al*., 2018). Even though some educational institutions in the region have embraced multicultural education programs, most of these students often hold prejudice and misconception about other parties when they step into the region, a hindrance to their assimilation into the Javanese society. This will usually influence their learning activities.

Indeed, under many circumstances, the numerous shortcomings of new students in adapting to their surroundings cause acculturative stress, and they have mental difficulties or pressure as a result of the contrasts they encounter (Xia, 2009). This syndrome is an individual reaction to life events based on acculturation experiences, in which the student struggles to adapt to a new environment and culture (Wei *et al*., 2007). If not resolved effectively, such adaptation struggles will definitely translate into stress and mental health deterioration (Berry *et al*., 2002).

This research project attempts to investigate how students from Papua Indonesians who study in Surabaya (Indonesia's second-largest city) struggle to overcome numerous cultural hurdles throughout their time in Java. Papuan students were chosen since there are already many Papuan students studying on the Java Island and who have successfully overcome cultural barriers without experiencing acculturative stress. In this study, we investigated how the Papua Indonesian students break down prejudices about the Javanese tribe and how they adjust to a new culture to ensure a smooth schooling process. The researchers hope that this study will serve as an example for people across the world to learn how to adapt to multicultural educational circumstances by suppressing stereotypes and prejudices.

1.1. Prejudice and stereotypes in intercultural communication

In the context of intercultural communication, stereotypes are closely tied to prejudice. Stereotypes are activated by prejudice, and prejudice strengthens stereotypes (Stratton *et al*., 2006). Prejudice is an antipathetic attitude based on an incorrect and rigid approach to generalizing (Zuma, 2014). Prejudice is defined as a negative attitude aimed toward a person or group in comparison to oneself (Bergh & Brandt, 2023; Katz, 1960). Prejudice is typically manifested as sentiments that diminish the worth of a group (Aschauer, 2020). This feeling is typically expressed by disparaging ethnic minorities, religious minorities, women, individuals with impairments, and others (Abrams *et al*., 2016).

Meanwhile, stereotypes are judgments about someone based solely on the group into which that person can be classified (Robbins & Judge, 2010). Stereotypes typically emerge spontaneously to reduce difficult issues and are commonly employed to make quick decisions (Desi *et al*., 2020). Stereotypes are typically the most difficult barrier in an intercultural communication process since they are allegations or prejudices made against other people from different cultural backgrounds (Lubis & Buana, 2020). Aside from media exposure (Tabassum & Nayak, 2021), stereotypes are formed through the influence of people closest to them, such as parents, teachers, and peers (Gunderson *et al*., 2012). Parents and close family members are the primary sources of information, teaching, and reinforcing stereotyped views in children, which are eventually carried over into adulthood (Brink & Nel, 2015).

Prejudice and stereotypes often serve as underlying factors that shape public perceptions and policy responses toward migrant populations (Ullah & Chattoraj, 2024). These preconceived notions, frequently rooted in fear or misunderstanding, can lead to social exclusion and hinder effective intercultural communication (King & Raghuram, 2013). Addressing such biases requires not only institutional reforms but also opportunities for meaningful contact and dialogue that promote mutual understanding and trust. Instead of being instigated by one party toward the other, prejudice and stereotypes are challenges that must be faced by both migrants and local communities; therefore, it is important to make a joint effort to build effective and inclusive cross-cultural communication (Ullah & Azizuddin, 2018).

1.2. Multicultural education

Multicultural education is a teaching and learning technique that promotes cultural heterogeneity in the classroom by

incorporating democratic values (Bennett, 2001). This is a shared commitment to attaining educational equity, creating curricula that promote understanding of ethnic groups, and eliminating repressive practices (Karacsony *et al*., 2022). Multicultural education is also sometimes referred to as a reflection of a "caring" and understanding mentality or as the politics of acknowledgment for persons from minority groups (Masruroh *et al*., 2022).

Multicultural education promotes awareness, appreciation, and appreciation of one's own culture, as well as respect and curiosity about the ethnic cultures of others (Shonfeld, 2020). This includes evaluating other people's cultures, not in the sense of agreeing with all features of these cultures, but rather of attempting to understand how a certain culture might represent values for its members (Blum, 2001). Multicultural education is critical for Indonesia as a multi-ethnic country, especially to reduce the possibility of conflict (Suradi, 2018). Multicultural education will assist in the empowerment of varied and heterogeneous communities so that people understand and appreciate one another and create characteristics that are open to differences (Slamet *et al*., 2021).

2. Data and methods

This study employed a qualitative research design with phenomenological approaches that focus on the study of individual life experiences, the organization of experiences in human consciousness, and the structure of experiences in the world (Neubauer *et al*., 2019). This research was carried out by involving fresh students from Papua in an in-depth study of the issue to look for information or gain a new understanding of the subject. It is envisaged that this research will be able to fully and effectively convey the significance of the subjects' experiences (Teherani *et al*., 2015).

As inquiry methods, semi-structured interviews and observation were used to collect data in this study (Abbey, 2020). This study was conducted for a duration of 6 months, from November, 2023 to April, 2024. The informants selected were 25 students from four provinces in Papua who volunteered as informants at several universities in Surabaya. The number of students at various campuses in Surabaya is shown in Table 1. All informants came from outside Java and were new to Surabaya. They were students who had lived in Surabaya for more than a year as students. Each interview with the informants lasted 30 – 60 min. Thematic analysis was used to examine interview data, and interview transcripts were categorized and organized based on appropriate themes and meta-themes (Creswell, 2003). Following that, the researcher evaluated and investigated the theory in depth (Braun & Clarke, 2023).

Table 1. Classification of informants

Informants	Province	University in Surabaya
I.1	West Papua	Surabaya State University
I.2	West Papua	Surabaya State University
I.3	South Papua	Surabaya State University
I.4	Papua	Surabaya State University
I.5	South West Papua	Surabaya State University
I.6	West Papua	Airlangga University
I.7	Papua	Airlangga University
I.8	Papua	Airlangga University
I.9	South Papua	Airlangga University
I.10	South West Papua	Airlangga University
I.11	Papua	Ciputra University
I.12	West Papua	Ciputra University
I.13	West Papua	Ciputra University
I.14	Papua	Ciputra University
I.15	South West Papua	Ciputra University
I.16	Papua	Dr. Sutomo University
I.17	Papua	Dr. Sutomo University
I.18	South Papua	Dr. Sutomo University
I.19	West Papua	Dr. Sutomo University
I.20	West Papua	Dr. Sutomo University
I.21	Papua	Petra University
I.22	South West Papua	Petra University
I.23	Papua	Petra University
I.24	West Papua	Petra University
I.25	Papua	Petra University

3. Results

3.1. Wrong stereotypes

In general, the informants were unaware of the fact that Java is made up of various tribes with distinct personalities and cultures. In fact, in addition to the Javanese ethnic group, the island of Java is home to several other ethnic groups, including the Sundanese, Betawi, and Madurese. The Javanese ethnic group itself is made up of people with various habits and customs. Those who live in the inland of Java (Jogyakarta, Surakarta, and surrounding areas, for example) have very soft speaking habits and tend to keep their feelings hidden, whereas those who live in the coastal areas of Java (Surabaya, Semarang, and the North Coast of Java) tend to speak in harsh words, in a loud tone and a straightforward manner (as is).

Many students believe that all Javanese people are the same and are already categorized as having a smooth and welcoming personality. This astonished them when they

first arrived in Surabaya because the people were Javanese with different personalities than the Javanese they had expected. Surabaya's Javanese inhabitants, as a coastal community, tend to speak matter-of-factly and do not utilize polished Javanese language.

> *When I first met Javanese in Surabaya, I was astonished to see that they shouted and liked to curse. Even though I had previously assumed that all Javanese people were gentle.* [I.7]

On the other hand, Javanese people are also often prejudiced against by those from outside of Java. During their initial meetings, they discovered that many Javanese people were kind and there was no evident prejudice against those from outside Java. They discovered that the people of Surabaya were quite nice and respected them as migrant students during their contact with the people of Surabaya. There is no rejection or gestures that degrade or ignore them.

> *I had previously assumed that because we were physically different from them, they would reject or at the very least shun us.* [I.6]

This stereotype occurs because they live in their place of origin and encounter Javanese people from Central Java or inland Java who speak softly. Before conversing, there is usually a barrier in the shape of unpleasant suspicions or prejudices toward other parties in an intercultural communication process (Bergh & Brandt, 2023). They must properly understand Javanese people (who will become interlocutors) in daily interactions.

To overcome the problem of stereotypes, Papuan students took several important reflective and adaptive steps in the process of cultural adjustment. One of the most important was realizing that Java is not a culturally homogeneous region, but rather consists of various ethnic groups with different personalities, languages, and customs, including differences between inland and coastal Javanese communities such as in Surabaya. This understanding emerged along with their direct interaction with local communities which turned out to be inconsistent with previous stereotypes.

Subsequently, they began to open themselves to learning directly through social experiences, observing the straightforward and assertive communication style of the Surabaya community as part of the coastal culture, not as a form of hostility or impoliteness. In addition, they also made adjustments in the way they think and interact, by not directly judging people's attitudes based on limited experience or information received in their home areas (Ullah & Azizuddin, 2018). In addition, they also corrected personal prejudices, such as the assumption that they would be rejected because of physical differences, by accepting the fact that many Surabaya residents are open and respect their existence as students. This process is an important part of intercultural communication competence, which requires a willingness to deconstruct stereotypes and replace them with more accurate and inclusive understandings (King & Ruiz-Gelices, 2003).

3.2. Culture shock in the initial phase of intercultural contact

Culture shock is a phenomenon in which people feel confused, nervous, anxious, and uneasy when they visit or live in a new social context that is drastically different from their regular scenario (Rese, 2018). People often experience culture shock and feel uncomfortable, apprehensive, and restless when confronted with a new environment that is vastly different from their previous circumstances (Mundeza, 2021). Papuan students encountered various culture shocks when they initially arrived in Java to study. In truth, they experienced a great deal of culture shock, but in this study, we will focus on the five most common culture shock events reported by our informants (Table 2).

Language is a barrier for students from outside of Java who come to Surabaya. Of course, every Javanese can communicate fluently in Indonesian. However, most of them choose to communicate in Javanese in everyday or social situations (Table 2). Only official meetings or events are held in Indonesian.

> *… not Indonesian. In Surabaya, everyone speaks Javanese everywhere. It is not just a dialect; it's authentic Javanese.* [I.12]

Not only did it reach the point of perplexity, but the inability to speak Javanese also often resulted in a

Table 2. Papuan student's culture shock experiences

No.	Culture shock type	Explanation
1.	Indonesian is not the main language	In Surabaya almost everytime and everywhere people speak Javanese. Indonesian is only used in official forums.
2.	Not all Javanese people are friendly	Surabaya people rarely greet each time they meet new people. They tend to wait to be greeted first.
3.	Individualistic	Surabaya residents tend not to care about other people and focus more on their personal interests.
4.	Not all Javanese dare to get close to Papuans	It turns out that it's not only Papuans who are afraid to start interactions. Surabaya people also have the same fear.
5.	Javanese people do not speak direct	Javanese people start a conversation with small talk first, then get to the heart of the matter.

Source: Researcher elaboration.

withdrawal from social activities. When people feel alone, the easiest option is to withdraw from social connections (Santini *et al*., 2020). To avoid these negative consequences, practically all our informants immediately began studying Javanese. They even attempted to learn straight from the neighborhood where they dwell so that they can comprehend Javanese terms rapidly and force themselves to socialize in the surroundings using Javanese, but often becoming the laughing stock themselves.

Abbott & Silles (2016) highlight the importance of a shared language in facilitating student mobility. The presence of a common language between the home and destination city can reduce communication barriers and help students adapt to the local culture. However, if students feel alienated because of language differences, this can reinforce negative stereotypes and hinder social integration.

The absence of hospitality in Surabaya is the second type of cultural shock encountered by students from Papua. According to the informants, welcoming strangers is common among Papuans and is considered a form of goodwill. This is contradictory in Surabaya, where greetings do not seem like a commonplace to do and are not usually done.

> *When I first walked into the boarding house, I envisioned myself in a community; however, this did not occur. We don't even know who each other because we never greet each other.* [I.8]

The individualism of the majority of Surabayans is also a culture shock for Papuan students. Most Javanese students in Surabaya are individualistic, which is (of course) a characteristic of urban society as a result of modernization (Rubin & Morrison, 2014). This circumstance, however, surprised students from Papua, who have a strong collective cultural past. The Papuans truly value culture and fraternity (Bayuseno & Windiani, 2020). They were not used to meeting persons who were mutually apathetic or indifferent to one another in their previous environment.

Another culture shock was that apparently, Surabaya people too not dare to approach and communicate with students from Papua. The biggest barriers to their contact with local people are physical differences, accents, and habits. Apart from this (according to informants), local communities' feelings of superiority also create poor interactions that are built with local communities in Surabaya. There is always a popular notion that the Papuan people lag behind other.

The Javanese practice of making small conversations in every interaction is the next culture shock. In every interaction, they always never address the fundamental point they wish to make directly (Table 2). There is a propensity to loop around to various trivial topics before getting to the main point. This is in stark contrast to the lives of Papuans, who are known for being plain, matter-of-factly, and forthright.

In dealing with culture shock in Surabaya, especially in terms of language and social-cultural differences, Papuan students take several strategic steps to adapt. First, they try to improve their ability to speak good and correct Indonesian, so that they can communicate more easily and be understood by the local community while reducing negative stereotypes. Second, they build a solid internal community as a safe space to support each other and share experiences, which also becomes a place to learn about the local social norms.

> *The role of the Papuan community really helps us in overcoming culture shock. With them, we can be open and strengthen each other.* [I.8]

Third, Papuan students actively participate in campus activities and cross-regional organizations in an effort to open up space for dialogue and bridge differences, especially in dealing with individualistic tendencies and the lack of greeting habits in Surabaya society. Finally, they apply a patient and persuasive approach in interacting, to overcome feelings of superiority that are sometimes felt by the local community, while slowly showing their potential and positive contributions in the campus and social environment.

3.3. Social construction and personal branding

Informants consider the campus in Surabaya appealing because it contains an "open-minded" collection of people who incorporate multicultural ideals into the teaching and learning process. As a result, the campus becomes a haven for people who are open-minded, pleasant, and extremely intelligent. A multicultural campus promotes and enables camaraderie among students, lecturers, and present educational staff (Shonfeld, 2020). This was felt by new Papuan students who engaged with various parties on campus on multiple occasions.

> *This is a place where everyone is very competent and naturally interesting to work with. They don't care who we are or where we come from. [I.9]*

The campus encourages students to establish a common identity based on ostensibly similar personalities to break down social and spatial barriers amongst students from varied cultural and social backgrounds. The multicultural education applied on campus also eliminates the binary social structure that has been emerging, specifically between Javanese and those originating from outside

Java. So far, Java has always been associated with progress, whereas everything else is connected with backwardness (Bhinadi, 2009). Fortunately, this binary construction is not developed and there is no distinction rule for Javanese and non-Javanese students in college. All students are treated equally and have equal rights.

> *I couldn't locate any university policies or treatment that differed between Javanese and non-Javanese students. Even in terms of money, there is no difference.* [I.4]

Apart from that, Papuan students recognize the significance of constructing themselves in the same way as Javanese people do. Of course, not physically, but more as an effort to construct positive personal branding to remove the bad notions that Javanese people have developed regarding Papuans. They have taken several important steps in developing personal branding in Surabaya, beginning with the elimination of stereotypes that have been proven to be false, moving on to not judge people based on their gender, social status, or ethnicity, becoming accustomed to being open-minded, and remaining active in their social environment (Figure 1). This is done to improve their self-image, which has been unfairly judged by other members of society.

> *We recognize it is merely physical; our soul remains the same. Thus, we strive to create a positive personal brand so that our friends don't hesitate to be friends with us.* [I.11]

3.4. Maximization of the meaningful contact zone

The existence of communities on and off campus, according to the informants, made it simpler for them to adjust to their new surroundings (Figure 2). These communities can serve as their contact zone, which is equitable and extremely beneficial throughout their transition to a new university. They engage with the meaningful contact zones that can increase their interactions, and participate in activities that can effectively build attachment and relationships between them if these zones are used correctly (Litt *et al.*, 2020). Internal communities can take the shape of student activity units and student clubs that are developed based on the interests and hobbies of the students. Most of the informants were aware of the significance of these groups' existence because of their potential to unify students from varied origins and provide numerous occasions for them to welcome one another (Abacioglu *et al.*, 2023).

> *The presence of groups or clubs on campus implies that we have several opportunities to meet and speak with other students.* [I.16]

Generally, clubs have no formal hierarchy and are attended by people of all levels, *i.e.*, common people. Regular club meetings, in addition to improving connections among members, indirectly increase social interaction inside the group (Borek & Abraham, 2018), and, at the same time, break down primal ethnic barriers. Despite having distinct ethnic or cultural identities, they are connected and equalized by the club's identity through ties and casual talks with one another. Their identity as a member of the club becomes more visible as they trade knowledge and skills to work collaboratively within the club, but their other identities (ethnic, religious, cultural, social, and economic) are not as visible or veiled (Juang *et al.*, 2021).

Mentoring is also a means of developing meaningful contacts for Papuan students on campus. This normative behavior, introduced in some Indonesian Universities, allows students to overcome their knowledge gaps (Venktaramana *et al.*, 2023). Across mentors, students can learn about campus issues, adjust to the campus environment, and understand the university's principles and culture. Mentors are people who new students can discuss their complaints with and act as a source of reference for

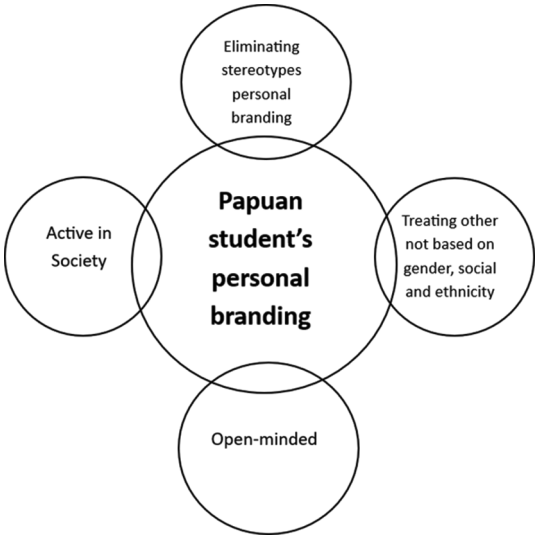

Figure 1. Papuan students' branding
Source: Researcher elaboration.

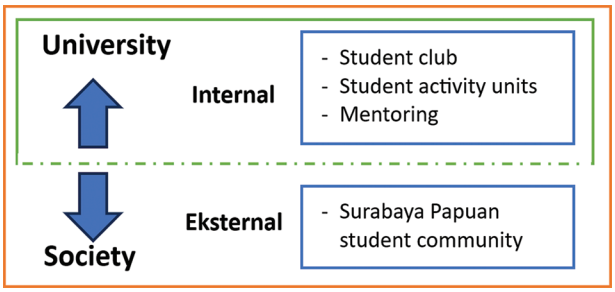

Figure 2. Meaningful contact zone for Papuan students
Source: Researcher elaboration.

how they should act when faced with challenges (Tenorio-Lopes, 2023). They also actively push new students to get more involved in campus social life. Mentors are a true representation of multicultural education since they care about and desire to understand the requirements of new students (Salako, 2026), particularly those from outside Java.

> *Mentors are extremely valuable to us. We rely heavily on them while we adjust to learning and socializing on campus.* [I.15]

Papuan students have made maximum use of the mentoring program provided by the campus as a means to adapt to the new academic and social environment. Across this activity, they not only receive academic guidance but also make mentoring an initial meaningful contact zone – a space for deep and meaningful interaction – that helps them build self-confidence, expand their network of friends, and strengthen their sense of belonging to the campus community.

Outside the university, the Papuan students have a community that caters to their interests and needs while in Surabaya. This community made a significant contribution to Surabaya's adaption process and provides a window for the incoming Papuan students to evaluate the difficulties that are commonly encountered and what the best remedies are to prevent even worse incidents (McNamara *et al*., 2021). In the community, they shared a lot of information about the innovative efforts made by the Surabaya city government and the city's ecology department in solving various difficulties and improving the quality of life of its people. This is, of course, critical for new Papuan students in Surabaya to create and pursue significant social ties with their new companions.

> *We frequently confide in one another and share stories about our unique interactions with Java students. Usually, people will comment and supply us with really important information.* [I.21]

4. Discussion

According to the testimony of the informants, it is apparent that their greatest strength in developing relationships in multicultural education is decreasing incorrect stereotypes and prejudices. According to Papuan students, they have stereotypes about Javanese people and assume that Javanese people must have false prejudices about themselves. In fact, after seeing it for themselves (by traveling to Surabaya), they discovered that this was incorrect. Stereotypes are the biggest barrier to Papuan students to integrate and swiftly adapt to their new surroundings in Surabaya. This is understandable because stereotypes are essentially generalizations about other people with different cultural origins (Jussim, 2012) that simplify truly complex judgments.

As a result, incoming students from Papua must control their prejudices effectively so that they do not become counter-productive. The main objective is to prevent the Papuan students from engaging with or entertaining the stereotypes they have of other people, especially if they are not even true. This, of course, applies to both parties: both the Papuan students and the students and the local community. Both parties must break down these negative judgments for the successful formation of connectivity and interaction (Amodio & Cikara, 2021).

Papuan students studying in Java experience identity transformation and increased cross-cultural understanding, but they also face challenges in the form of changing values, communication styles, and social expectations (King & Ruiz-Gelices, 2003). This is in line with the conditions of Papuan students who, when interacting with the culture of urban Javanese society in Surabaya, face pressure to adapt to more straightforward communication norms, a faster pace of life, and social expectations that may feel foreign or even contradict the values of their home culture (Ullah & Chattoraj, 2024).

Some culture shock may be unavoidable. However, culture shock must be followed with an openness to learning and opportunities to connect with locals, communities, and students (Mustafa, 2021). Several university-organized events and communities can be employed to decrease and reduce the shock felt (Pradita, 2016). Papuan students can share their stories and experiences there, as well as learn from seniors or other students about their experiences. This is significant because campus organizations, mentoring programs, and other activities can serve as excellent contact points for new students from Papua.

The established contact zone must be carefully utilized so that it does not simply become an area for chit-chat, but rather a space for meaningful communication. The contact zone, which is a meaningful relationship zone, can be used as a location for student interactions, activities, and shared experiences (Block *et al*., 2022). They can build attachments and pleasant interactions in it, which will positively and effectively contribute to their respective development (Hooker *et al*., 2020).

The university appears to be a welcoming environment for Papuan students, thanks to a multicultural education atmosphere. As is well known, multiculturalism education continues to attempt to remove the emerging binary social construction between Java and outside of Java. This amazing binary social construction will fade away

on its own when students from Java and outside of Java form genuine connections. Open interactions and strong linkages will demolish the binary architecture of Java–outside-Java automatically. The distinction between Javanese and non-Javanese students will become obsolete as time passes. This approach can foster an attitude of mutual understanding and respect develop a character that is open to diversity.

Building meaningful connections and engagement becomes crucial and relevant in this situation (Abacioglu *et al.*, 2023). In a university setting that embraces multicultural education, both parties (Papuan students and Javanese students) must nurture more than just interpersonal relations. Casual (reciprocal) conversations within the community and in daily contact that encourage informal knowledge sharing will considerably contribute to the development of meaningful engagement (Zannah & Sumadhinata, 2013). This not only promotes students' development during their studies, but also helps establish common relationships based on shared identity, which transcends gender, age, ethnicity, nationality, and culture.

Aside from that, comprehending the evolution of Surabaya itself is something that should not be overlooked. A thorough understanding of Surabaya's numerous public policies can substantially benefit incoming Papuan students' interactions. The numerous innovations that exist are the common subjects of discussion among students and must be understood or at least comprehended. The most recent information on Surabaya and its social trends is also presented. This is to avoid confusing the incoming Papuan students regarding the city of Surabaya and the social changes that are taking place.

This study discovered that Papuan students did several things, in general, to establish meaningful interaction, specifically (Figure 3): (i) properly understanding the person you are talking to (if you need to do research first, do not believe the stereotypes that are developing); (ii) avoid long and indirect conversations; start with light, communicative conversations to facilitate effective interactions (by making more use of local language/Javanese); (iii) build good personal branding (building yourself as someone open and easy-going to others); (iv) take advantage of the community (on campus and in the community); and (v) stay up-to-date on the latest happenings in the city you have just moved to.

Based on the contact intergroup theory proposed by Allport (1954), interactions between different groups can reduce prejudice and stereotypes if they occur under certain conditions: equal status, common goals, intergroup cooperation, and institutional support. The results of this research show that their interactions in Surabaya slowly fulfill these elements. When they began to interact with students and the local community through campus activities, mentoring, and community, meaningful contact occurred that helped correct the stereotypes (Ullah & Azizuddin, 2018) that they previously had about Javanese people. This contact became increasingly effective because

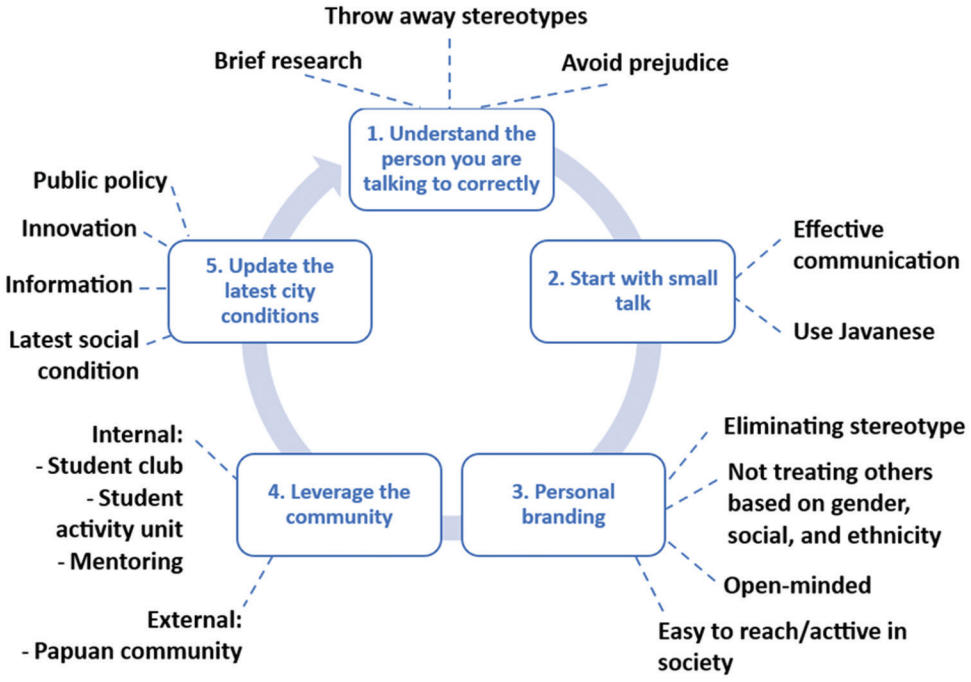

Figure 3. Papuan student's meaningful contacts
Source: Researcher elaboration

it took place in a relatively equal environment – as fellow students – and was supported by institutional programs that encouraged inclusion, such as orientation programs and organizational activities (King & Raghuram, 2013).

The initial stereotypes held by Papuan students, such as the assumption that Javanese people are always gentle or that local people will reject them because of physical differences, are forms of generalization that simplify cultural complexity. However, direct experience in the context of authentic interactions in Surabaya allowed them to break these assumptions (Ullah & Azizuddin, 2018). This is in line with Allport's main premise that proper contact can break down prejudice (Zuma, 2014). The experience of Papuan students also shows that changes in perception do not only occur one way – local people who may initially have had certain stigmas also begin to open up and build relationships based on similarities with fellow students (Aschauer, 2020). This process reflects the importance of equal status contact and common goals in creating intercultural bridges (Zuma, 2014).

The contact zone formed through campus activities, communities, and informal conversations becomes an effective space for building mutual understanding (Abbott & Silles, 2016). As Papuan students begin to familiarize themselves with local norms, build open personal branding, and actively participate in the social dynamics in Surabaya, they create connections that are not only social but also emotional and cognitive. This is the form of meaningful contact that Allport means: not just a physical meeting, but a meeting that allows empathy and appreciation for differences to grow (Zuma, 2014). In the context of multicultural education, educational institutions play an important role as facilitators of healthy cross-cultural social contact so that they can break the chain of stereotypes and form a more inclusive and harmonious campus society (Shonfeld, 2020).

4.1. Limitations

This study used a phenomenological approach that provides ample space to conduct in-depth observations of the subject's experiences, especially in the context of intercultural communication. However, the main limitation in implementing this study lies in the minimal opportunity to conduct direct observations. Most of the data were obtained through interviews without being supported by continuous situational observations. In fact, a phenomenological approach can enrich our understanding of the meaning formed in everyday interactions, especially in the dynamics of complex intercultural relations. Another limitation is that the research was conducted only in one city –Surabaya. Although Surabaya is one of the destination cities for Papuan students to study, this city is not the only center of education on the island of Java. Other cities such as Yogyakarta, Malang, and Jakarta also have significant Papuan student populations, with different social and cultural contexts. Therefore, the results of this study cannot be generalized widely to all Papuan students in Indonesia in terms of their intercultural communication experiences on the island of Java. These two limitations affect the depth and breadth of our findings and are important considerations for further research in the future.

4.2. Theoretical and practical implications

This study emphasizes the importance of meaningful intercultural contact as a primary entry point in intercultural communication and multicultural education theory. Theoretically, this study enriches the understanding of how honest and empathetic interactions can be an effective mechanism to reduce cultural tensions and facilitate positive attitude change. The findings support the concept that intercultural adaptation is not only a passive process of adjustment but also an active process involving identity negotiation and flexible attitude formation. Thus, this study adds a dynamic perspective to the literature on intercultural communication, especially in the context of multicultural education in Indonesia.

Practically, this study provides concrete guidance for Papuan students in facing new environments, such as the city of Surabaya. Meaningful intercultural contact through efforts to build positive personal branding, active participation in the community, and a deep understanding of socio-cultural dynamics is an effective and transformative adaptation strategy. This process allows students to maintain their cultural identity while developing an open and tolerant attitude toward differences.

Furthermore, this research underlines the importance of authentic interactions compared to shallow or small-talk communication, as honest and meaningful interactions not only help reduce cultural barriers but also strengthen social bonds and build more inclusive multicultural spaces. The practical implication of these findings for educational institutions is the need to create an environment that supports the formation of meaningful intercultural contact, involving all elements – students, teachers, and the surrounding community. Across this approach, intercultural learning experiences in Indonesia can develop into a process that not only is academically educational but also serves as a means of character development and continuous improvement of cross-cultural understanding.

5. Conclusion

In the context of multicultural education in Indonesia, intercultural communication plays a crucial role in

supporting the adaptation process of students from different cultural backgrounds, including Papuan students studying in Surabaya. Research shows that the main challenges in cultural transition come not only from differences in values and social norms but also from previously formed stereotypes, both from the newcomers and the local community. Therefore, successful adaptation is not enough to rely on ordinary social interactions, but requires meaningful contact – that is, interactions built on openness, curiosity, and a willingness to understand each other deeply.

For Papuan students, meaningful intercultural contact is an important entry point to reduce cultural tensions and encourage changes in attitudes, both in how they view the local community and in responding to different social expectations. Active efforts such as building positive personal branding, participating in the local community, and understanding the social and cultural dynamics of the city of Surabaya are part of an adaptation strategy that is not only practical but also transformative. This process allows students to maintain their cultural identity while developing flexible attitudes toward the new environment – a characteristic of healthy intercultural adaptation.

Thus, honest and empathetic interactions – rather than shallow small talk – play a vital role in fostering attitudinal change and strengthening social connections. When Papuan students engage in such interactions consistently, they not only overcome cultural barriers but also help create a more inclusive multicultural space. If this approach is fostered by all parties in the educational environment, then the intercultural learning experience in Indonesia can develop into one that is not only academically educational but also character-building and enriching in cross-cultural perspectives.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

This work was approved by the Faculty of Communication Science and Media Business Ethics Committee (Approval ID: 006C/UC-COM/ST/II/2024). Informed consent was obtained from participants before their participation.

Consent for publication

Participants consented on the publication of their data.

Availability of data

Data are available from the corresponding author upon reasonable request.

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RESEARCH ARTICLE

Community context and third parity among ever-married women in Bangladesh: Insights from a nationally representative survey

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Abstract

Despite a significant decline in fertility over the past 30 years, Bangladesh's total fertility rate has stalled at 2.3 since 2011, indicating a period of stagnation in reproductive behavior. This situation raises important questions about the role of community-level factors, which may be critical but remain underexplored as determinants of the failure to reach replacement-level fertility. The present study investigates how various community-level and individual-level factors influence the transition to third parity among ever-married women in Bangladesh, utilizing comprehensive data from the 2022 Bangladesh Demographic and Health Survey. The analysis reveals that families with more than two children significantly impact third birth rates, particularly in communities with a high prevalence of larger families, where the rate reaches an alarming 76.5%. Furthermore, community-level illiteracy and poverty demonstrate complex effects on birth intervals, with higher levels of these factors associated with an increased likelihood of third births. To identify the key determinants influencing the timing of third births, we employed the Cox proportional hazards model, estimating parameters using the maximum likelihood approach. The findings indicate that community characteristics, especially the prevalence of larger families, significantly increase the hazard of transitioning from second to third births, with hazard ratios ranging from 1.55 to 4.01 across different models. Other important determinants include age at first marriage, educational attainment, and exposure to mass media, underscoring the intricate relationships between socioeconomic factors and reproductive behavior. These results highlight the crucial need for targeted interventions that consider community characteristics to effectively influence fertility decisions.

Keywords: Parity progression; Birth interval; Community factors; Bangladesh; Hazard model

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1. Introduction

Fertility rates fell below replacement levels in many developed countries during the late 20th century. By the early 21st century, over half of the global population resided in nations with below-replacement fertility (Lesthaeghe, 2020). The long-term decline in period fertility rates across developed and developing countries has been widely documented (Sobotka, 2017). However, many developing countries have still not reached replacement-level fertility. This has occurred for several reasons, such as cultural norms,

access to family planning, education levels, and, most notably, economic perspectives (Bongaarts & Casterline, 2018). In low- and middle-income countries (LMICs), replacement-level fertility holds particular significance due to various socio-economic and health factors. Beyond social services, economic development, and healthcare systems, transitioning to replacement-level fertility can create a "demographic dividend," where a larger proportion of the population is of working age, potentially boosting economic growth if accompanied by appropriate policies and investments (Reher, 2011).

Achieving replacement-level fertility is closely linked to a country's pattern of parity progression, as the ability to maintain population stability depends on the individuals' transitions from having fewer children to achieving a balanced family size, particularly in the context of declining fertility rates (Lesthaeghe, 2010). Analyzing parity progression is vital for understanding demographic trends and family dynamics, as it influences overall fertility rates and population growth. While the initial phase of the fertility transition is typically characterized by an increase in the age at first marriage, the long-term impact of adopting smaller family sizes will be significant in countries experiencing advanced transitions (Vignoli, 2006). Therefore, the shift from having a second to a third child is a key factor in fertility change, as the decline in third and higher-order births is essential for sustaining overall fertility reductions (Feeney & Wang, 1993). Understanding these patterns is crucial for policymakers, as they provide insights into future population structures, workforce dynamics, and resource needs.

Bangladesh is ranked as the eighth-most populous country in the world (United Nations, 2024). It has undergone a significant demographic transition since the 1970s, marked by sharp declines in both fertility and child mortality rates. Infant and under-five mortality rates fell dramatically – from 88 and 134 deaths per 1,000 live births in 1993 – 1994 to 27 and 32, respectively, by 2022 – reflecting improved health outcomes for children (NIPORT & ICF, 2024). During the same period, fertility rates also declined steadily, from a total fertility rate (TFR) of 6.3 in 1971 – 1975 to 5.1 in 1984 – 1988, and then to 3.3 in 1994 – 1996. After plateauing around 3.3 during the late 1990s, the TFR began to decline again in 2004, reaching 2.3 by 2011, where it remained stable (NIPORT & ICF, 2024). Bangladesh had aimed to achieve a replacement-level TFR of 2.1 by 2015 through improved access to health and nutrition services for poor and geographically marginalized populations (NIPORT & ICF, 2024). The reasons for this stagnation over the past decade have been investigated in multiple studies (Bora *et al*., 2023; Husain, 2022; Rahman, 2020).

However, very few studies have specifically analyzed birth intervals as part of parity progression to better understand fertility behavior in Bangladesh (Mahfuzur, 2021; Nisha *et al*., 2019). Birth intervals provide valuable insights into fertility patterns, inform family planning strategies, and highlight socio-economic influences on reproductive health (Islam *et al*., 2022). According to the Bangladesh Demographic and Health Survey (BDHS) 2022, the median interval for non-first births is 59.2 months (NIPORT & ICF, 2024), with over three-quarters (78%) occurring 36 months or more after the previous birth. While many studies have explored the determinants of birth intervals (Ahammed *et al*., 2019; De Jonge *et al*., 2014; Islam *et al*., 2022 Rabbi, 2012; Rabbi *et al*., 2013), only a few have linked these intervals to parity progression at higher birth orders (Mahfuzur, 2018). For example, Ahammed *et al*. (2019) found significant associations between third birth intervals and both proximate and background factors. Among the proximate determinants, contraceptive use, the present age of the mother, and the survival status of the previous child were found to be important predictors of interval length. In addition, several individual-level factors have been shown to influence birth intervals, including age at first marriage, mother's education, religion, employment status, and exposure to mass media. At the family level, variables, such as the sex of the household head and household wealth status have also been linked to parity progression and timing (Islam *et al*., 2003; Rabbi *et al*., 2013).

Beyond the individual and family context, community-level factors are increasingly recognized as critical influences on fertility behavior. Cultural evolutionary theory suggests that features such as the prevalence of larger families (more than two children), community-level illiteracy, and community-level poverty shape fertility preferences and decisions (Balk, 1994; Caldwell, 2001; Colleran *et al*., 2014). In a low-fertility setting, Colleran *et al.* (2014) found that community-level education accelerates fertility decline, and similar effects have been observed in high-fertility contexts (Kravdal, 2002). Broader structural factors such as administrative division and place of residence (urban/rural) also reflect community influences. Moreover, cultural norms around ideal family size may generate pressure on couples to progress to higher parities (Caldwell, 2001; Colleran *et al*., 2014; Dribe *et al*., 2017). While some evidence points to regional variations in fertility in Bangladesh driven by cultural traditions (Islam *et al*., 2003; Mahfuzur, 2018), detailed community-level analyses focusing on the prevalence of larger families remain limited. It is important to acknowledge the complexity involved in interpreting these community-level associations. The observed

clustering of larger families within certain communities may reflect persistent social norms, economic conditions, or differential access to reproductive health services, rather than simply aggregating individual fertility behaviors. Moreover, differences in marriage patterns across communities – such as timing and prevalence – may also affect fertility outcomes but could not be modeled due to data constraints. Nevertheless, conducting such analyses can enhance our understanding of how community contexts shape individual fertility behaviors and contribute to regional variations.

This study examined the transition from second to third birth among currently married women in Bangladesh, a critical phase in the country's ongoing fertility decline. We hypothesized that community-level fertility norms – reflected in the local prevalence of larger families – play a significant role in shaping individual reproductive behavior. To investigate this, we analyzed parity progression from second to third birth using nationally representative survey data, incorporating community-level indicators derived from respondents' primary sampling units (PSUs), alongside individual socio-economic and demographic factors. We also estimate the timing of third births using survival analysis to understand not only whether but also when the transition occurs, offering further insight into the pace of fertility across different community contexts. Although national fertility rates have plateaued, some communities continue to exhibit persistently high fertility. Understanding the drivers behind this divergence is critical for designing targeted family planning interventions and addressing uneven demographic transitions.

2. Data and methods

2.1. Data

This study utilized data from the BDHS. The Demographic and Health Survey (DHS) surveys are cross-sectional in nature and conducted nationally in over 85 LMICs. Authorized by the National Institute for Population, Research, and Training (NIPORT) under the Ministry of Health and Welfare Bangladesh, these surveys are funded by the United States Agency for International Development (NIPORT & ICF, 2024). The BDHS employs a two-stage stratified sampling design, covering both rural and urban areas across all eight divisions in the country. In the first stage, 675 enumeration areas (EAs) were selected with probability proportional to EA size. In the second stage, a systematic sample of 45 households per EA was selected to ensure statistically reliable estimates of key demographic and health variables for urban and rural areas separately, as well as for each of the eight divisions. Ever-married women aged 15 – 49 were considered eligible for individual interviews. Detailed descriptions of the sampling procedures are available in the BDHS documentation (NIPORT & ICF, 2024). The final BDHS 2022 sample included 30,078 ever-married women of reproductive age. However, only two-thirds of this sample was selected for detailed birth history data collection. Consequently, the number of (past) births recorded in the BDHS 2022 was 20,029.

2.2. Variables considered in the study

The outcome variable in this study is the time duration between a respondent's second and third births. Based on previous literature, we considered three groups of independent variables to explain parity progression ratios (PPRs) and the timing of the third birth. The five explanatory variables categorized as community-level variables are the administrative divisions, place of residence (urban or rural), community-level illiteracy, community-level poverty, and prevalence of families with more than two children in the community. The past three community-level variables were estimated using participants' individual-level data aggregated at the PSU level (considered as the community). These variables include education, wealth index, and the prevalence of having more than two children. Following previous literature, community-level illiteracy was measured by the proportion of women in the PSU who had not completed primary education. This was categorized as "low" (<25%), "moderate" (25 – 50%), and "high" (>50%) illiteracy (Mezmur *et al.*, 2017). A similar categorization was applied to community-level poverty, based on the proportion of individuals in the lowest category of the wealth index within each PSU. For the community-level prevalence of more than two children, the proportion of women in each PSU with more than two children was calculated and classified as "low" (<25%), "moderate" (25 – 50%), and "high" (>50%). These community-level indicators were not interpreted as independent causal predictors but rather as proxies for local fertility norms and contextual influences that may shape individual reproductive behavior. While we acknowledge that these aggregates are derived from the same dataset, we follow existing literature in treating them as meaningful contextual variables that reflect social environments beyond individual characteristics.

Among the individual-level variables, we considered (i) women's age at first marriage (categorized as <15 years, 15 – 19 years, and ≥20 years); (ii) education level (primary or lower and secondary or higher); (iii) religion (Muslims or non-Muslims); (iv) employment status at the time of survey (employed or unemployed); and (v) mass media exposure (exposed or unexposed). The variable mass media exposure was computed as a combination of three items – whether

the respondent listened to the radio, watched television, or read newspapers. Respondents were considered exposed to mass media if they engaged with any one of these media at least once per week. At the family level, we included the sex of the household head (male or female) and the wealth quintile (poorest, poor, middle class, rich, richest).

2.3. Estimation of TFR and PPRs

We estimated the TFR considering the standard DHS methodology (NIPORT & ICF, 2024). Mathematically,

$$TFR = 5\sum_{i=1}^{7}\frac{B_i}{W_i} \quad \text{(I)}$$

Where W_i represents the number of women in the i-th age group, and B_i is the number of births to women in that age group. These B_i/W_i values are age-specific fertility rates (ASFRs), measured in the 5-year age groups, such as 15 – 19, 20 – 24,…, and 45 – 49, comprising seven age groups. The DHS methodology involves calculating ASFRs based on detailed pregnancy histories provided by women for the 3 years preceding the survey. Detailed methodology is available from Croft *et al.* (2018).

We used PPRs to estimate the probability of a woman having another child, given that she has already had a certain number. The PPR from j-th parity to $j+1$-th parity is the proportion of a cohort who had at least j live births and went on to have at least one more. Symbolically,

$$PPR_{j,j+1} = \frac{P_{j+1}}{P_j} \quad \text{(II)}$$

Where P_j is the number of women with j children, and P_{j+1} is the number of women with $j+1$ children. For first births, Pj refers to the number of married women with no child, and P_{j+1} is the number of women from that cohort who had a first child.

2.4. Statistical analysis

Given that the major outcome variable in this study is the time duration between second and third births, both events (births) and censoring at the end of the follow-up period were expected for the respondents. Therefore, event history analysis, specifically the Cox proportional hazards model (Cox, 1972) was employed to assess the effects of community factors and other covariates on the length of the third birth interval. The dependent variable is defined as the number of months from the date of the second birth to either the date of the third birth or the date of the interview (if no third birth occurred). For each second child born at time $t = 0$, the (instantaneous) hazard ratio function at $t > 0$ was assumed to follow the form of the proportional hazard for the third birth:

$$\lambda(t, x) = \lambda_0(t)exp(x'\beta) \quad \text{(III)}$$

where, $\lambda(t,x)$ is the hazard function at time t for a given covariate vector x, $\lambda_0(t)$ is the baseline hazard function, and β is the vector of regression parameters. Kaplan–Meier survival curves were used to visualize survival data and to compare groups, which helps assess whether the proportional hazards assumption holds.

3. Results

3.1. Fertility rates by community factors

As the key variables of interest are community-level factors, we estimated the ASFRs and TFR across three community characteristics. Table 1 presents the findings. The analysis showed that in communities with a high prevalence of families having more than two children, the ASFR for the 15 – 19 age groups increased significantly,

Table 1. Age-specific and total fertility rates according to community factors in Bangladesh (Bangladesh Demographic and Health Survey 2022)

Community-level factors	Level of community characteristics				
	Age groups	Low	Moderate	High	National
Prevalence of families with>2 children in the community	15 – 19	86	93	113	92
	20 – 24	135	160	190	153
	25 – 29	102	128	164	121
	30 – 34	59	77	97	72
	35 – 39	16	26	43	24
	40 – 44	3	4	7	4
	45 – 49	1	1	6	1
	TFR	2.0	2.5	3.1	2.3
Community-level illiteracy	15 – 19	89	93	107	92
	20 – 24	153	152	157	153
	25 – 29	115	126	146	121
	30 – 34	71	74	63	72
	35 – 39	22	25	38	24
	40 – 44	3	3	14	4
	45 – 49	1	2	0	1
	TFR	2.3	2.4	2.6	2.3
Community-level poverty	15 – 19	90	91	95	92
	20 – 24	147	148	164	153
	25 – 29	114	112	135	121
	30 – 34	67	73	77	72
	35 – 39	22	20	29	24
	40 – 44	4	3	5	4
	45 – 49	0	1	2	1
	TFR	2.2	2.2	2.5	2.3

Abbreviation: TFR: Total fertility rate.

from 86 in low-prevalence areas to 113 in high-prevalence communities. The TFR followed a similar pattern, rising from 2.0 in low-prevalence communities to 3.1 in high-prevalence areas (compared to the national level TFR of 2.3). Community-level illiteracy shows a moderate effect on the present fertility level. The TFR increased from 2.3 in low-illiteracy communities to 2.6 in those with high illiteracy, indicating a relationship between education levels and reproductive choices. The influence of community-level poverty appeared minimal. Among women aged 15 – 19, the ASFRs ranged from 90 in low-poverty communities to 95 in high-poverty areas, and the TFR remained stable at approximately 2.3 across poverty levels. Present fertility levels by division and place of residence are available from BDHS 2022, along with other common background variables (NIPORT & ICF, 2024). Notably, the lowest TFR was observed in the Rajshahi division (TFR = 2.0) and in urban areas (TFR = 2.1). Small differences in fertility levels across educational attainment and wealth quintiles were also reported (NIPORT & ICF, 2024).

3.2. Parity progression by community factors and different background variables

The PPRs up to the third birth order among ever-married women in Bangladesh are presented in Table 2, based on data from the BDHS 2022. Among the 20,029 respondents, 17,214 had one child (parity 1), 12,986 had a second child (parity 2), and 10,380 had a third child (parity 3). The findings indicate that the prevalence of families with more than two children in the community has a significant variation on parity progression. In communities with a low prevalence, 35.3% of women with two children progressed to having a third child. This percentage increased to 57.7% in communities with moderate prevalence and rose to 76.5% in those with high prevalence. In communities with low illiteracy prevalence, 46.8% of mothers with two children had a third child, while this figure rose to 67.1% in communities with high illiteracy prevalence. In the Sylhet division, 64.6% of mothers with two children proceeded to a third birth. Parity progression to a third child was also higher among women residing in rural areas, those who married early (before age 15), Muslim women, and those in the poorest wealth quintile. Exposure to mass media continues to play a significant role, where 60.2% of unexposed mothers with two children went on to have a third child, compared to only 45.1% of exposed mothers.

3.3. Survival analysis

Given that our main outcome variable is the timing of the third birth, we conducted a survival analysis in this study. The probability distribution of intervals from marriage to first birth, from first birth to second birth, and from second birth to third birth are plotted below in Figure 1. All of these distributions are positively skewed; however, for the second and third birth intervals, the mode of the distributions shifts slightly to the right. The median duration from marriage to the first birth was 23 months, the median for the second birth interval was 46 months, and the median duration for the third birth interval was 47 months.

The Cox proportional hazards model was used to assess the effect of community factors and other demographic and socio-economic covariates on the timing of birth intervals. To assess the assumptions of the hazard model, we used the Kaplan–Maier estimator. The estimated survival curve based on Kaplan–Maier estimates for the variable "prevalence of families with more than two children in the community" is plotted below in Figure 2. The estimates showed a highly significant difference in survival probability among the three categories of this variable (low, moderate, and high).

A total of four models were considered in the survival analysis. The hazard ratios of all fitted models are shown in Table 3, along with 95% confidence intervals (CI) and levels of significance. The goodness of fit of the model is presented in terms of -2 log-likelihood for all models. The first model (Model-I) contains only the main covariate of interest – the prevalence of families with more than two children in the community of respondents. The findings suggest a strongly significant influence of this variable on the timing of the third birth interval. A hazard ratio of 2.05 (95% CI: 1.95 – 2.15) for the moderate group indicates that the risk of having a third child is about twice as high compared to the low prevalence group. This hazard was much higher for respondents from communities with a high prevalence of families with more than two children (hazard ratio: 4.01; 95% CI: 3.74 – 4.30), suggesting the risk is approximately four times higher than in the low prevalence group. Model-II contains all the community-level variables, all of which were found to be significant determinants of the length of third birth intervals. However, the hazard ratio for the prevalence of families with more than two children in the community declined slightly. Respondents from communities with a moderate prevalence of families with more than two children were 68% more likely to have a shorter birth interval than those in the low prevalence group, while the high prevalence group was 2.73 times more likely to experience such an event. Respondents from the Rajshahi division were more likely to have longer birth intervals (hazard ratio: 0.79; 95% CI: 0.72 – 0.87) compared to the reference group (Barishal division). Rural mothers were found to have shorter birth intervals than urban mothers.

Table 2. Parity progression ratios up to the third birth order among ever-married women in Bangladesh (Bangladesh Demographic and Health Survey 2022)

Background characteristics of the respondents	Parity 1 (17,214)	Parity 2 (12,986)	Parity 3 (10,380)
Prevalence of families with more than 2 children in the community			
Low	57.7	69.0	35.3
Moderate	58.6	76.2	57.7
High	59.6	82.0	76.5
Community-level illiteracy			
Low	58.3	72.6	46.8
Moderate	58.5	74.7	55
High	58.7	80.9	67.1
Community-level poverty			
Low	58.1	70.7	44.1
Moderate	58.7	74.4	53.0
High	58.2	77.1	57.8
Division			
Barishal	57.2	75.4	54.8
Chattogram	59.0	76.7	61.5
Dhaka	58.0	70.9	48.0
Khulna	58.7	72.6	41.1
Mymensingh	57.9	76.5	58.8
Rajshahi	58.2	72.7	42.8
Rangpur	59.1	75.7	51.4
Sylhet	57.7	76.5	64.6
Place of residence			
Urban	58.2	71.0	45.7
Rural	58.4	75.2	54.1
Age at first marriage			
<15	95.4	83.9	59.8
15 – 19	87.4	72.2	50.1
≥20	74.0	58.2	35.4
Education			
Up to primary	61.1	85.8	65.5
Secondary or higher	56.5	65.4	38.2
Religion			
Islam	58.4	74.8	53.2
Non-Muslim	58.2	70.7	39.3
Employment			
Unemployed	92.0	78.9	52.3
Employed	85.0	70.9	51.3
Mass media			
Unexposed	58.2	77.1	60.2
Exposed	58.5	71.8	45.1
Sex of the household head			
Male	58.1	73.9	52.0

(Cont'd...)

Table 2. *(Continued)*

Background characteristics of the respondents	Parity 1 (17,214)	Parity 2 (12,986)	Parity 3 (10,380)
Female	59.5	74.5	50.9
Wealth quintile			
Poorest	57.6	78.9	60.0
Poor	58.8	74.6	56.3
Middle	58.7	73.5	53.1
Rich	59.1	72.4	48.1
Richest	57.3	71.1	41.0

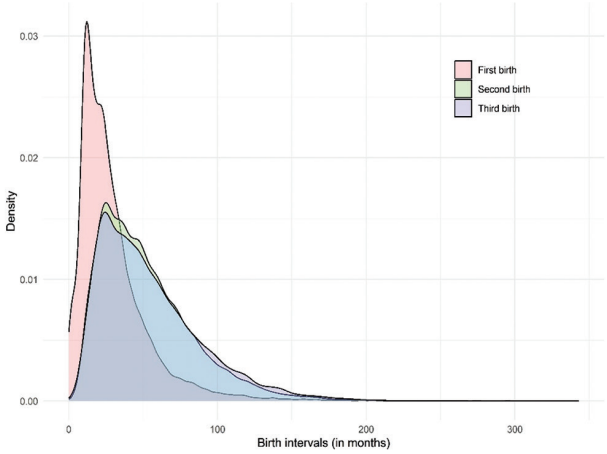

Figure 1. Distribution of birth intervals for the first three parities in Bangladesh (Bangladesh Demographic and Health Survey 2022)

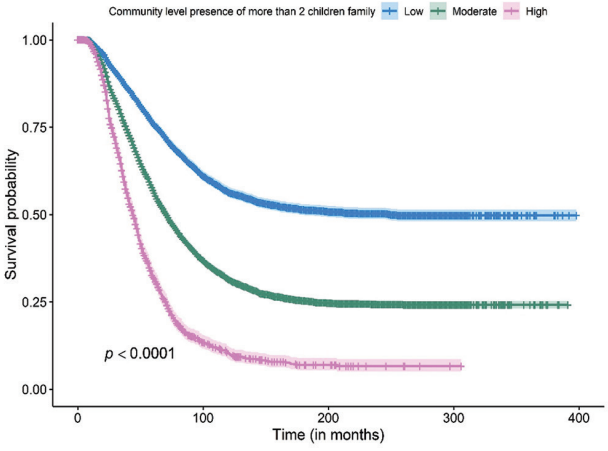

Figure 2. Kaplan–Maier estimate of third birth interval by community-level prevalence of families with more than two children in Bangladesh (Bangladesh Demographic and Health Survey 2022)

Model-III contains all the community-level and individual-level variables. Respondents from communities with a moderate prevalence of families having more than two children were 55% more likely to have a shorter birth interval than those in the low prevalence group, while the high prevalence group was 2.42 times more likely to have a shorter birth interval. Age at first marriage plays an important role in the duration of the third birth interval. Respondents who had their first marriage at age 20 or later were 33% less likely to have a shorter birth interval compared to mothers who married before age 15. Similarly, mothers with secondary or higher education were 36% less likely to have a third birth compared to mothers with primary or lower education. The full model (Model-IV) includes variables from all previous models as well as family-level variables (sex of household head and wealth status). Similar findings were observed for the community-level prevalence of families with more than two children. The division of respondents remained a significant covariate of the third birth interval. Mothers from Khulna, Rajshahi, and Rangpur divisions had lower hazard ratios than the reference group (Barishal), while mothers from other divisions had higher hazard ratios. Non-Mulsim mothers were 33% less likely to have a third birth compared to Muslim mothers. Mothers exposed to any form of mass media were 14% less likely to have a shorter birth interval compared to mothers who were not exposed (hazard ratio: 0.86; 95% CI: 0.82 – 0.91). Mothers from female-headed households were 19% less likely to have a third birth compared to mothers from male-headed households (hazard ratio: 0.81; 95% CI: 0.76 – 0.87). The duration of the third birth interval increased with higher wealth status according to the wealth index of the respondents.

4. Discussion

Our study explored variation in fertility level and parity progression to the third child, and the timing of the third birth interval among Bangladeshi women aged 15 – 49. It uniquely examined the effects of community-level prevalence families with more than two children on present fertility, parity progression to the third birth, and timing of the third birth interval, alongside other social and economic factors. The analysis showed that in communities with a high prevalence of families having more than two

Table 3. Hazard models of risk factors for the transition from second to third birth in Bangladesh (Bangladesh Demographic and Health Survey 2022)

Variables	Adjusted hazard ratio (95% CI)			
	Model-I	Model-II	Model-III	Model-IV
Prevalence of families with>2 children in the community				
Low	Ref	Ref	Ref	Ref
Moderate	2.05 (1.95 – 2.15)***	1.68 (1.59 – 1.77)***	1.55 (1.44 – 1.65)***	1.55 (1.44 – 1.65)***
High	4.01 (3.74 – 4.30)***	2.73 (2.51 – 2.98)***	2.42 (2.18 – 2.70)***	2.41 (2.16 – 2.68)***
Community-level illiteracy				
Low	-	Ref	Ref	Ref
Moderate	-	1.07 (1.02 – 1.13)**	0.98 (0.93 – 1.04)	0.97 (0.92 – 1.03)
High	-	1.15 (1.05 – 1.26)**	1.03 (0.93 – 1.15)	1.01 (0.90 – 1.13)
Community-level poverty				
Low	-	Ref	Ref	Ref
Moderate	-	1.11 (1.05 – 1.18)**	1.09 (1.01 – 1.18)**	1.06 (0.98 – 1.15)
High	-	1.20 (1.12 – 1.28)***	1.13 (1.04 – 1.23)**	1.07 (0.98 – 1.17)
Division				
Barishal	-	Ref	Ref	Ref
Chattogram	-	1.16 (1.06 – 1.25)**	1.25 (1.13 – 1.39)***	1.27 (1.15 – 1.41)***
Dhaka	-	1.05 (0.96 – 1.14)	1.04 (0.93 – 1.16)	1.03 (0.93 – 1.15)
Khulna	-	0.82 (0.75 – 0.90)***	0.76 (0.67 – 0.85)***	0.75 (0.67 – 0.84)***
Mymensingh	-	1.06 (0.97 – 1.16)	1.09 (0.98 – 1.21)	1.07 (0.96 – 1.19)
Rajshahi	-	0.79 (0.72 – 0.87)***	0.79 (0.71 – 0.89)***	0.77 (0.69 – 0.87)***
Rangpur	-	0.88 (0.80 – 0.96)**	0.86 (0.77 – 0.95)**	0.83 (0.75 – 0.93)**
Sylhet	-	1.33 (1.22 – 1.46)***	1.41 (1.26 – 1.57)***	1.41 (1.26 – 1.58)***
Place of residence				
Urban	-	Ref	Ref	Ref
Rural	-	1.08 (1.02 – 1.14)**	1.03 (0.97 – 1.10)	1.02 (0.96 – 1.09)
Age at first marriage				
<15	-	-	Ref	Ref
15 – 19	-	-	0.91 (0.86 – 0.96)***	0.91 (0.86 – 0.96)***
20 and above	-	-	0.67 (0.60 – 0.73)***	0.67 (0.61 – 0.74)***
Education				
Up to primary	-	-	Ref	Ref
Secondary or higher	-	-	0.64 (0.60 – 0.67)***	0.66 (0.62 – 0.70)***
Religion				
Islam	-	-	Ref	Ref
Non-Muslim	-	-	0.70 (0.63 – 0.77)***	0.67 (0.61 – 0.74)***
Employment				
Unemployed	-	-	Ref	Ref
Employed	-	-	1.04 (0.99 – 1.10)	1.05 (0.99 – 1.10)
Mass media				
Unexposed	-	-	Ref	Ref
Exposed	-	-	0.85 (0.81 – 0.90)***	0.86 (0.82 – 0.91)***

(Cont'd...)

Table 3. ***(Continued)***

Variables	Adjusted hazard ratio (95% CI)			
	Model-I	Model-II	Model-III	Model-IV
Sex of the household head				
Male	-	-	-	Ref
Female	-	-	-	0.81 (0.76 – 0.87)***
Wealth quintile				
Poorest	-	-	-	Ref
Poorer	-	-	-	0.95 (0.88 – 1.02)
Middle	-	-	-	0.90 (0.83 – 0.98)**
Richer	-	-	-	0.92 (0.84 – 1.00)
Richest	-	-	-	0.82 (0.74 – 0.90)***
Model summary				
−2 log-likelihood	187,009.24	180,300.41	113,401.33	113,344.60
Chi-square	1,762.10***	1,984.958***	1,889.54***	1,948.59***

Notes: *$p<0.05$, **$p<0.01$, ***$p<0.001$.
Abbreviations: CI: Confidence interval; Ref: Reference.

children, the ASFRs were higher. In addition, the TFR increased from 2.0 in low-prevalence communities to 3.1 in high-prevalence areas. This indicates a greater likelihood of early childbearing in such environments. We observed a higher PPR from the second birth to the third birth and a higher probability of having a third birth interval among respondents from communities with a high prevalence of families with more than two children. Our findings differ from those observed in low fertility scenarios (Dribe *et al*., 2017). Previously, it was observed that community has little to no effect on individual fertility behavior but may influence particular subgroups. This discrepancy likely arises because the context in Bangladesh, a higher fertility country, differs significantly from low fertility countries. In countries with lower fertility, individual behavior might be more constrained by broader social changes (e.g., economic development, changing gender roles, urbanization), while in high fertility contexts, such as Bangladesh, community norms might still play a dominant role in shaping fertility decisions, particularly in rural or less urbanized areas (Balk, 1994; Caldwell, 2001; Colleran *et al*., 2014). An in-depth analysis of this particular cluster of respondents from communities where the prevalence of families with more than two children is higher may provide further insights.

Previous studies have mentioned the influence of community-level education and poverty on fertility (Dribe *et al*., 2017). We did not find any significant impact in the full model. Similar findings were observed in the analysis of fertility; the TFR of respondents from clusters with higher illiteracy and poverty was slightly elevated compared to the national level. However, these factors play an important role in parity progression, as a higher percentage of these respondents proceeded to third parity. Similar findings were observed for place of residence. We did not find any significant impact of place of residence on the timing of the third birth interval, although TFR in rural areas was much higher than at the national level (NIPORT & ICF, 2024). Several studies have explained that cultural and social norms are responsible for this (Kulu, 2013); however, in Bangladesh, early marriage and childbearing have also long contributed to this pattern (Islam *et al*., 2022; Mahfuzur, 2021). On the other hand, significant regional variation was evident in our findings. Parity progression from second to third birth was higher in the Chattogram and Sylhet divisions, and their corresponding hazard ratios for terminating the third birth interval were also higher. Similar findings were reported in previous studies (Islam *et al*., 2010; Mahfuzur, 2021). Specific family planning policy interventions in Sylhet and Chattogram, aimed at ensuring gender equity, promoting female education, and delaying entry into marriage and childbearing, were proposed in previous research (Islam *et al*., 2010).

Bangladesh is noted for child marriage in numerous studies, and this cultural aspect is responsible for higher parity numbers (Islam *et al*., 2003; Mahfuzur, 2021). We also obtained similar findings. Those who were married later were less likely to have a third birth. In line with previous research, we have also seen that education is an effective tool for reducing fertility. The TFR for highly educated women was lower in Bangladesh (NIPORT & ICF, 2024), and we also observed that women with secondary or higher education are 34% less likely to have a third birth. These findings are similar to earlier studies as well (Islam

et al., 2003; Rabbi *et al*., 2013). Another implication of this finding is that community-level education has less impact on the timing of the third birth; however, individual-level education still guides individuals toward a longer birth interval before the third birth. Conversely, success in reducing fertility through education is also connected with the creation of employment opportunities for women (Rabbi *et al.*, 2013). We did not see any significant impact of women's employment on having a third birth in terms of PPR from the second birth to the third birth or the timing of the third birth. A more in-depth analysis of this may provide further insights.

Unlike many previous studies, we found a significant impact of religion on the timing of birth intervals and parity progression to the third birth. Non-Muslims were less likely to have a third birth and tended to have longer intervals before the third birth. McQuillan (2004) mentioned that religion plays an influential role when three conditions are satisfied: first, the religion articulates behavioral norms with a bearing on fertility behavior; second, the religion holds the means to communicate these values and promote compliance; and third, religion forms a central component of the social identity of its followers. These practices are more prevalent in the Sylhet and Chattogram divisions of the country (Islam *et al*., 2010). Mass media exposure played a significant role in reducing fertility in Bangladesh during the fertility transition by influencing the mass population on the effects of large population sizes and increased use of family planning techniques (Islam & Hasan, 2000). Rabbi *et al*. (2013) observed longer birth intervals among women who were more exposed to mass media compared to those who were unexposed. We obtained similar findings regarding mass media exposure and fertility in Bangladesh.

We considered two family-level variables in our analysis: the sex of the household head and wealth status. We did not observe a substantial difference in parity progression to the third birth; however, a longer birth interval was observed in households with a female head. It is possible that a female household head cannot go beyond the community norm of larger family size, but she can influence a longer birth interval for the sake of the mother's health. A more in-depth analysis may provide further insight into this. We observed an increased birth interval and lower parity progression among women from richer quintiles. These findings are similar to those obtained for the community level of poverty. Colleran *et al.* (2015) mentioned the role of wealth status in pre- and post-demographic transition contexts. Wealthy and high-status people typically have higher fertility than poorer and lower-status people before the demographic transition, while in transitioning and post-transition populations, the opposite becomes true. Our findings align with this.

5. Strengths and limitations

This study offers a detailed analysis by examining both parity progression to the third birth and the timing between births, providing a comprehensive understanding of fertility transitions. It uniquely incorporates community-level norms – specifically, the prevalence of larger families – which adds valuable insight into local social influences on reproductive behavior. In addition, the use of recent, nationally representative data ensures that the findings are relevant and reflective of present demographic patterns in Bangladesh.

However, one limitation of this study is the potential for endogeneity in community-level variables, as they are derived from the same individual sample. While this raises concerns about circularity, we interpret these variables as proxies for broader fertility norms rather than direct predictors of individual behavior, consistent with previous research that aggregates individual data to approximate community contexts. Another key limitation is the omission of marital status in our parity progression analysis. Given that marriage remains the primary pathway to childbearing in Bangladesh, community differences in marriage prevalence or timing may influence our findings—for instance, a community with higher third-birth rates might simply have more married women. Our model does not adjust for this selection effect, highlighting an important area for future research to better understand the relationship between marriage patterns and fertility behavior.

6. Conclusion

We examined the effect of community factors on fertility levels and parity progression to the third birth, including timing. Key community variables included the prevalence of families with more than two children, illiteracy, and poverty, alongside individual- and household-level factors. We observed an increase in TFR from 2.0 in low-prevalence communities to 3.1 in high-prevalence areas, compared to the national TFR of 2.3, highlighting the influence of community norms. In addition, community-level illiteracy and poverty showed complex effects on birth intervals, with higher levels linked to a greater likelihood of third births. Other important determinants were age at first marriage, education, and mass media exposure, emphasizing the complex interplay between socioeconomic factors and reproductive behavior. Overall, these findings highlight the significant role of community characteristics in shaping fertility patterns.

The practical implications of a high prevalence of families with more than two children likely reflect strong community pressures that encourage or even compel individuals to have a third child. However, there is limited scope in this study to fully explore this dynamic. Our analysis relies on a single cross-sectional dataset to examine community effects on fertility. Utilizing multiple DHS survey waves could provide deeper insights into these mechanisms. In addition, because this study is based on period data, it may be subjected to seasonal fluctuations. A longitudinal approach incorporating cohort perspectives would likely yield more robust findings. We also limited the number of explanatory variables in our analysis to avoid multicollinearity, which means alternative multivariable modeling techniques might reveal different relationships.

Community influences on fertility are likely driven by cultural expectations, social pressures, and economic considerations that encourage earlier and more frequent childbearing. High-fertility communities may have strong social networks that support larger families, such as extended family childcare and community programs that reinforce these norms. Understanding these factors is essential for designing culturally sensitive family planning interventions that educate individuals about reproductive health while respecting local values. Our findings highlight the persistence of high-fertility behaviors within certain communities, despite national-level declines, emphasizing the need to identify and target such clusters for effective reproductive health programs. Promoting women's education and economic empowerment emerges as a critical strategy to shift norms around family size and support informed reproductive choices.

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Conflict of interest

The author declares no conflict of interest.

Author contributions

This is a single-authored article.

Ethics approval and consent to participate

Data collection procedures for the 2022 wave of the Bangladesh Demographic and Health Survey (BDHS 2022) were approved by the Institutional Review Boards of the ICF International, Rockville, Maryland, United States of America, and the Bangladesh Medical Research Council, Dhaka, Bangladesh. Informed consent was obtained from all respondents before participation (this involved reading a written consent form aloud, followed by the respondent's signature or thumbprint). Consent was obtained separately before administering the survey and before collecting biomarker and anthropometric measurements. Respondents who did not provide consent were excluded from the analysis in the present study.

Consent for publication

This study used publicly available secondary data, for which informed consent was obtained by the original data collectors before publication.

Availability of data

The data used in this research are freely available from the Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MeasureDHS).

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ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Predictors of unintended pregnancy among adolescent schoolgirls during the COVID-19-induced school closures: The case of rural and underserved communities in Ghana

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Abstract

In Ghana, unintended pregnancies account for one in three births and are associated with adverse maternal and child health outcomes—a problem that appears to have worsened during the COVID-19 lockdown and school closures. Hence, this study examines unintended pregnancy and its predictors among adolescent schoolgirls within the context of COVID-19-induced school closures in rural and underserved communities in Ejisu municipality in Ghana. The sample comprised 310 adolescent girls aged 13–19 years who had a pregnancy during the COVID-19 lockdown. Data were collected using a structured questionnaire, and both bivariate and multivariate regression techniques were used to analyze the data. Of the total respondents, 227 (73.2%) had unintended pregnancies during the COVID-19 lockdown. The majority, 234 (75.5%), were aged between 16 and 19 years, 275 (88.7%) lived in rural areas, and 126 (40.6%) lived with only their mothers. Regression results demonstrated that girls who lacked knowledge of contraception (crude odds ratio = 0.691, 95% confidence interval [CI] = [0.479, 0.581]) and sex education (crude odds ratio = 0.209, 95% CI = [0.121, 0.362]), had multiple sex partners (adjusted odds ratio = 1.382, 95% CI = [0.289, 0.921]), and lived with only their mothers during the COVID-19 lockdown

were more likely to experience unintended pregnancy than their counterparts. Awareness of the predicting factors identified in this study can guide parental roles in reducing the likelihood of their children being lured sexually or victimized during disruptive occurrences like COVID-19-induced school closures.

Keywords: Unintended pregnancy; Adolescent girls; COVID-19; Rural and underserved communities; Ghana

1. Introduction

The outbreak of COVID-19 and its impacts on various aspects of life, including social, economic, cultural, educational, and health, continue to be felt around the world. One such impact is adolescent pregnancy (Okalo *et al.*, 2023). As defined by the United Nations Children's Fund (UNICEF), adolescent (or teenage) pregnancy generally refers to conceiving by girls between the ages of 13 and 19. In developing countries, an estimated 21 million adolescent girls aged between 13 and 19 years get pregnant while approximately 16 million give birth every year (Darroch *et al.*, 2016; UNICEF, 2018). A more concerning fact is that adolescent pregnancy is predicted to increase by 2030, with higher rates in sub-Saharan African (SSA) countries (Worldatlas, 2017). In the specific case of Ghana, estimates suggest that, in 2012 alone, 14% of adolescent girls in the country started childbearing, with approximately 11% live birth rate (Ghana Statistical Service [GSS] *et al.*, 2018).

Adolescence, defined by the ages of 13–19, is a distinct period in a person's life, forming a bridge between childhood and early adulthood. Ghana has a young population (United Nations Population Fund [UNPF], 2023). Currently, about 6.9 million Ghanaians are adolescents, representing about 22% of the total population of nearly 31 million (Amoah-Saah & Akosah, 2024; UNPF, 2023). Between 2016 and 2020, Ghana recorded 542,131 pregnancies among adolescent girls aged 15–19 years and 13,444 pregnancies among young adolescents aged 10–14 years (UNPF, 2023). A pooled analysis of national surveys estimated the prevalence of adolescent pregnancy in Ghana at 15.4%, with rural areas showing a higher prevalence (19.5%) compared to urban areas (10.6%), with some of the pregnancies being completely unintended (Mohammed, 2023).

An unintended pregnancy can be defined as a pregnancy that is either unwanted or mistimed (Nyarko, 2019). Although some adolescent pregnancies may be desired, estimates suggest that nearly 50% are not (Sully *et al.*, 2020). Global statistics revealed that about 85 million pregnancies were unintended in 2012 alone, of which 50% ended in unsafe abortion (Sedgh *et al.*, 2014). While the incidence of unintended pregnancy has declined globally over the last few years, its rate remains high in developing countries, including SSA (Okalo *et al.*, 2023). In Ghana, it has been discovered that around 37% of all pregnancies were unintended in 2018, which comprises 23% mistimed and 14% unwanted pregnancies (Nyarko, 2019).

Unintended pregnancy among adolescent girls is already high in Ghana even before the COVID-19 pandemic (Nyarko, 2019). In rural and underserved communities (RUCs) where child marriage and adolescent pregnancy are most prevalent, a higher rate of out-of-school girls, poor educational outcomes, economic poverty, and other cultural factors are among the leading predictors (Ampiah *et al.*, 2019; Dubik *et al.*, 2022). For instance, Dubik *et al.* (2022) found that parents' desire for grandchildren, multiple sexual partners, and poverty contribute to adolescent pregnancy in the rural communities in Ghana.

The COVID-19 pandemic could cause unprecedented harm to children, particularly girls, and put their lives at risk. Existing evidence already indicates gender-specific effects of school closures and lockdown during the COVID-19 pandemic (The Lancet Child Adolescent Health, 2020; UNICEF, 2022). Girls are particularly recognized as a vulnerable group during the COVID-19 pandemic (Hall *et al.*, 2020). For instance, estimates from World Vision Ghana (2020) indicate that in the Krachi West District, COVID-19 led to a nine-fold increase in adolescent pregnancies. Between March and May 2020, 51 girls were reported pregnant, compared to only six cases in all of 2018 (Baker, 2020). There are also concerns that school closures during the COVID-19 pandemic may exacerbate gender gaps in education and girl empowerment, dampening any progress made in Ghana (The Lancet Child Adolescent Health, 2020). Similarly, it is argued that most girls might not return to school due to spikes in adolescent pregnancies and other sexual and reproductive health (SRH) risks (Baker, 2020; Selbervik, 2020). The pandemic-induced closure of schools, isolation from school support networks, and rising poverty could worsen issues Ghana

was already struggling to address (Addae, 2021; The Lancet Child Adolescent Health, 2020; UNICEF, 2022).

The exacerbation of the adolescent pregnancy problem during the COVID-19 pandemic appears to be part of the vicious cycle affecting developing countries, such as Ghana, driven chiefly by income loss among poor populations. This financial strain has indeed taken a greater toll on low-income families. For instance, a decrease in household income can increase the likelihood of early marriage, especially in countries where bride price is usually exercised (UNICEF, 2018). This can, in turn, result in unintended pregnancies among adolescent girls. Also, apart from income constraints, the pandemic may affect access to and use of contraception, which can result in unintended pregnancy and unsafe abortions (Kumar & Singh, 2022). Similarly, the pandemic-induced worries may lead to a change in behavior against birth control measures, especially among adolescent girls who suffer from social disparities.

To combat the COVID-19 outbreak, countries around the globe took pragmatic measures, including the closure of schools (Addae, 2021; UNICEF, 2020). In Ghana, schools were closed for nearly a year (GSS, 2021). The consequences of the pandemic-induced school closures are that many functions performed by schools were compromised, exposing learners to potential social vices such as increased transactional sex, early marriages, and deepened adolescent pregnancies, as reported during the Ebola cases in Sierra Leone (Bah, 2014; Gettleman, 2014). Although the Ghana government implements policies to promote the educational well-being of students during the pandemic, the impacts of this policy response to school closures can be devastating, particularly for poor adolescent girls. Moreover, staying out of school can increase the exposure of adolescent girls to sexual activity or debuting sex arising from increased proximity and association among young people (Eduful & Eduful, 2022), which leads to the precipitation of physical contact of a sexual nature. As a result, the occurrence of unintended pregnancies, unsafe abortions, and maternal and infant mortality is increased.

Furthermore, the fear of contracting the COVID-19 virus at healthcare facilities may have also contributed to reduced use of contraceptives and other sexual and reproductive healthcare services. This is strongly supported by the previous study on the Ebola crisis in some African countries, where the use of condoms and other contraceptives considerably declined, causing a significant increase in unintended pregnancies among adolescent girls (Gettleman, 2014).

Adolescent pregnancy (either intended or not) is linked to higher risks of maternal problems (Cook & Cameron, 2017). Adolescent (or teenage) mothers usually suffer from complications such as unsafe abortions, hypertensive ailments, and urinary tract infections (Asare *et al.*, 2019). Other risks include instrument delivery (i.e., cesarean section), poor nutrition, and anemia (World Health Organization, 2016). Compared to their peers who delayed childbearing, teenage or adolescent mothers are more likely to experience poor educational outcomes and long-term poverty. As adults, they often face continued economic hardship. Their children, in turn, may also exhibit behavioral problems and face disadvantages in health and education. As indicated by Cook & Cameron (2017), the cycle of ten continues, with children of teenage mothers more likely to become teenage parents themselves.

Given the long-term impact of unintended adolescent pregnancy, this study investigates its predictors during the COVID-19 pandemic, focusing on adolescent girls in RUCs in Ghana. Notably, existing evidence on this issue in Ghana is largely limited to policy reports. The few empirical studies available are primarily descriptive (Okine & Dako-Gyeke, 2020; Addae, 2021). Thus, the policy relevance of this study cannot be overemphasized. Indeed, it is possible that many adolescent students, particularly girls, did not return to school after the pandemic, due to increased economic poverty and associated adolescent pregnancy issues. Moreover, evidence from previous pandemics in SSA revealed possible lasting adverse effects on adolescents, including widening inequality gaps in education and health outcomes, which may have detrimental consequences for adulthood. The findings of this study aim to inform policy for adolescent girls in Ghana as they recover from the socioeconomic shocks induced by the pandemic.

1.1. Literature review

This study relies on Bronfenbrenner's (1995) ecological systems theory to explain the proposed relationships. The theory provides explanations for the interaction and interdependencies that exist between people in a given environment (Johnson & Puplampu, 2008). Consequently, other researchers employed this theory to explain adolescent pregnancy among Portuguese adolescents (Araújo Pedrosa *et al.*, 2011). Among factors influencing adolescent pregnancy, the proponents of the theory give particular attention to sociodemographic characteristics, familial, and relational factors that could explain adolescent pregnancy. According to the theory, human capital is influenced by the relationships among different situations and bigger systems in which these situations are rooted (Salazar *et al.*, 2009). In addition, the theory postulates that an ecosystem comprises five interrelated systems, namely micro, meso, exo, macro, and chronosystem (Bronfenbrenner, 1979). The interactions

among these systems, the theory asserts, can impact the lives of adolescent students, particularly girls, in any given environment.

The applicability of the ecological systems theory to the current study is based on the fact that there are several interrelated factors influencing teenage pregnancies among adolescent girls in RUCs in Ghana (Okine & Dako-Gyeke, 2020). These communities are often underprivileged with heightened economic poverty, which could result in social vices, such as increased transactional sex, early marriages, and amplified adolescent pregnancies (Coast *et al.*, 2018). Teenage girls from socioeconomically disadvantaged families may not return to school, and hence, the prevalence of early marriage and adolescent pregnancies post-COVID-19 is a serious issue that needs an empirical investigation.

Empirically, a growing body of research has been conducted on COVID-19 and its impact on socioeconomic outcomes in both the global North and South. In the case of the global North, McCool-Myers *et al.* (2022) found that the COVID-19 crisis hindered access to contraceptive services in Georgia, USA, especially for people in rural areas. Those identified as engaging in homosexual behavior were likely to report experiencing negative judgments, discrimination, or confusion related to their sexual and reproductive health needs. About 21% of the study's respondents reported sexual abuse, which increased unplanned pregnancies. In addition, 45% of respondents reported income loss, while 16% reported loss of health insurance. The authors observed that approximately 18% reported having negative sexual experiences during the pandemic. In the global South, particularly in Jordan, Muhaidat *et al.* (2020) conducted a cross-sectional survey to investigate the accessibility of reproductive healthcare and the well-being of expectant mothers during the COVID-19 pandemic. Results showed a significant increase in the percentage of Jordanian pregnant women who did not receive sexual and reproductive healthcare services during the lockdown period, despite serious underlying medical conditions or complications that call for close antenatal attention.

Across SSA, Murewanhema (2021) found an indirect long-term effect of the pandemic on the vulnerability of young women to human immunodeficiency virus (HIV) infection through increased sexual activity. The author further predicted a possible increase in HIV-related deaths of over 500,000 in the region.

Talbot *et al.* (2023) also conducted an investigative study to determine the impact of COVID-19 on the prevalence of adolescent pregnancy among schoolgirls in Namibia. Based on a sample of 794 adolescent girls, the authors found that the pandemic constrained teenage girls' access to contraceptive services, thereby increasing the rates of unintended pregnancies during the pandemic. Furthermore, Musa *et al.* (2021) discovered that the closure of schools during the pandemic substantially increased the prevalence of early marriage in Nigeria. The study further reported that the pandemic negatively impacted government programs aimed at curbing early marriage in the country.

In addition, Shikuku *et al.* (2021) utilized data from the Kenya Health Information System for four months during the COVID-19 pandemic to investigate how the pandemic impacted sexual and reproductive health. Results showed that the pandemic exacerbated teenage pregnancy, as well as maternal and infant mortality in Kenya. Zulaika *et al.* (2022) also attempted to study the impact of COVID-19 on unintended pregnancy of teenagers, as well as school dropout in Kenya. Using a sample of 910 secondary school girls and employing a causal-comparative technique, the authors observed that the risk of getting pregnant during COVID-19 doubled among teen girls.

In Ghana, Owusu-Addo *et al.* (2023) analyzed factors that could have influenced sexual abuse during the COVID-19 period. Using a sample of 853 teenage girls aged between 13 and 19 years, results showed that the prevalence of sexual abuse was relatively heightened during the disruptive period, estimated at 32.5%. Similarly, Biney *et al.* (2023) investigated the relationship between COVID-19-induced lockdown and contraception behavior among emerging adults (i.e., those between 19 and 24 years old). The authors used a purposive sampling technique to select participants from several public universities in Accra. Their findings revealed that modern contraceptives, especially male condoms, were used during the lockdown period, but were generally obtained before the lockdown started. Furthermore, the authors noted that traditional methods were complementary. In addition, Koka *et al.* (2024) investigated the impact of COVID-19-induced lockdown on the health of mothers and children in Ghana. The authors focused on the Krobo Odumase and Ayawaso Wuogon districts. Employing a mixed-method approach, the results showed that treatment-seeking behavior for tuberculosis, Malaria, and HIV infections experienced a significant reduction. The authors noted the findings could be attributed partly to the fact that people exhibited worries since those illnesses have symptoms similar to those of COVID-19.

Although several studies have been conducted on the impact of the COVID-19 pandemic on sexual and reproductive health in Ghana, they primarily use descriptive analysis and tend to focus on data from urban communities in Ghana, while paying little attention to

the rural settings. Notably, one study conducted before the onset of COVID-19 by Krugu *et al.* (2017) focused on rural communities, where the authors showed that rural girls' motivation for sexual relationships is mostly "beyond love" but driven by economic factors. The current study also found that the COVID-19 pandemic may exacerbate such motivation. Again, much attention is devoted to the use of contraceptives among growing adults during the pandemic-induced lockdown.

Thus, in this study, we attempt to bridge the literature gap by utilizing the ecological systems theory to explore the impact of the COVID-19 pandemic on unintended pregnancy among adolescent schoolgirls in selected RUCs in the Ejisu Municipal District in Ghana.

2. Data and methods

2.1. Study setting

This study was conducted in the Ejisu Municipal Assembly, one of the 43 local government areas in the Ashanti Region, Ghana. Previously, it was part of the broader Ejisu-Juaben Municipal. However, a separation in 2018 led to the formation of the Ejisu Municipal Assembly. It is located in the central part of the Ashanti Region with Ejisu as its capital town (Figure 1). It is considered a municipality with significant rural areas, which make up 69.8% of its settlements (GSS, 2024; Owusu-Addo *et al.*, 2016). The five urban centers in the district only account for 30.2% of the total population (GSS, 2024).

The Ejisu-Juaben Municipal in the Ashanti Region was selected for this study because available data showed that cases of adolescent pregnancies were relatively high in the area (Mensah, 2021; Owusu-Addo *et al.*, 2016). Specifically, a study by Owusu-Addo *et al.* (2016) in the Ejisu Municipal Assembly that explored sexual and reproductive health experiences of adolescents found that about 58% of the 481 adolescent girls recruited in the study had been pregnant, while 37% had engaged in abortions. In addition, Ejisu Municipality was one of the local government areas highly impacted by COVID-19 and was affected by the lockdowns announced by the government, along with the Kumasi Metropolis. As a result, the schools in the municipality experienced an extended period of lockdowns between March 2020 and January 2021 (Ministry of Education, 2020).

2.2. Study design

To achieve the objective of this study, an institutional cross-sectional study design was used to gather information from adolescent girls who became pregnant during the COVID-19 pandemic in the Ejisu Municipal Assembly. An institutional cross-sectional design refers to a research design that collects data from a sample population at a single point in time (Seboka *et al.*, 2021). This type of research design enables data collection from participants at a specific institution, such as a school or a specialized hospital. The data collection employed both quantitative and qualitative approaches, in which the quantitative data were collected before or concurrently with the qualitative data, thus making the research design tend toward explanatory mixed methods (Creswell & Creswell, 2017).

2.3. Participants and sampling

The study's population includes adolescent girls aged 13–19 years who became pregnant during the COVID-19-induced school closures in the Ejisu Municipal Assembly. A stratified purposive sampling was used (Ames *et al.*, 2019; Nyimbili & Nyimbili, 2024; Patton, 2014; Rai & Thapa, 2015). This approach enables researchers to obtain information from participants by dividing the target population into subgroups, i.e., strata (Owusu-Addo *et al.*, 2023; Patton, 2014). In other words, the stratified purposive sampling ensures good representation from the different subgroups (i.e., in- and out-of-school adolescents) within our target population, leading to a more inclusive and balanced view on the impact of COVID-19-induced school closures on adolescent pregnancy in the Ejisu Municipal Assembly (Campbell *et al.*, 2020; Knotters & Brus, 2013; Neyman, 1992).

A total of 310 participants were recruited for the study, comprising 84 adolescent girls from the school settings and 226 adolescents from the hospital settings. Those from the school settings were selected from four community-based senior high schools (SHS) with urban to rural characteristics, including Achinakrom SHS, Bonwire Senior High Technical (STHS), Ejisuman SHS, and Onwe Community SHS, whereas the 226 adolescent mothers from the hospital settings were selected from the Ejisu government, Living Waters, and the Onwe government hospitals when they were accessing maternal health services. In both settings, the specific participants were recruited from girls who were available on the dates of data collection in the study sites. The survey was administered between April and July 2022, when schools had reopened and were in session, and hospitals were operating as usual.

For girls recruited from school settings, permission was obtained from school authorities to conduct the interviews during break periods to prevent disrupting their lessons. For girls recruited from hospital settings, after obtaining permission from hospital administrators, nurses helped select participants who attended the ante- and post-natal services and gave them a brief explanation of the study. Within the ante- and post-natal units, the interviews were performed in discreet, secure settings.

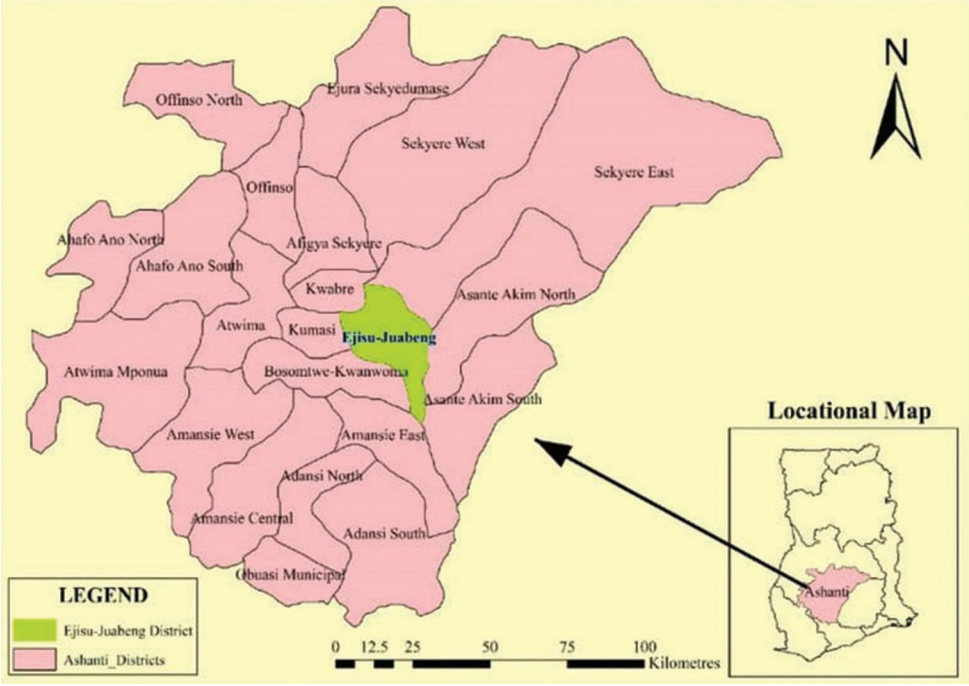

Figure 1. Ejisu-Juaben Municipal Assembly in the Ashanti Region
Source: Adapted from Asibey *et al.*, 2019.

It is imperative to note that a sample size of 310 is sufficient to obtain a 5% margin of error and a 95% confidence level for such studies, as reflected in previous studies (Cohen, 1998; Dell *et al.*, 2002; Singh & Masuku, 2014), which assumes an indeterminate population or one that could be up to 100,000 adolescent girls from both school and hospital settings.

In addition, for the qualitative component, other interviews were conducted on head teachers, teachers, parents, and community opinion leaders to capture a broader perspective on the factors accounting for adolescent pregnancy during the pandemic-induced school closures, as well as information relating to community girls who became pregnant within the period.

Before the study, permission in writing was requested and delivered by the research assistants to the management and/or authorities in each of the four community-based SHSs (Achinakrom SHS, Bonwire STHS, Ejisuman SHS, and Onwe Community SHS) as well as the three antenatal hospitals (Ejisu government, Living Waters, and the Onwe government hospitals). Upon delivering the letters, contact numbers were exchanged, and subsequent telephone calls were made to each institution to confirm their decision, as well as the time and date for the interviews. Accordingly, and in line with the previous studies (Agyapong *et al.*, 2024a, 2024b; Gyesaw & Ankomah, 2013; Krugu *et al.*, 2017; Owusu-Addo *et al.*, 2016), approval or consent was given verbally through telephone calls and personal visits to some proximate institutions.

2.4. Data collection procedure

A structured questionnaire and interview guide were used to collect data between April and July 2022. These instruments align with previous literature on adolescent sexual and reproductive health (McCool-Myers *et al.*, 2022; Nyarko, 2019). The questionnaire was administered through face-to-face interaction by five female research assistants who were recruited and trained for this purpose. The purpose was to create a conducive atmosphere for the female participants to be able to talk and express their sexual health experiences freely. The questionnaire was designed in English and administered in either English or Twi (a local Akan language), depending on the language the participants preferred, allowing them to express themselves freely. Nearly 50% of the participants completed the questionnaires themselves, while the remainder were completed with the assistance of the research assistants. Similarly, the interview guide was developed in English and translated into Twi for respondents. In all cases involving the interview guide, the research assistants recorded the responses from the respondents who spoke either English or the local dialect.

The translation of the approach and content of the questionnaire and interview responses into the local

dialect was part of the interviewers' training, where the team discussed and reached a common ground on specific words, phrases, and jargon for capturing consistent and uniform data. The questionnaire was pretested in the Juaben District Assembly, an adjoining district, where the adolescents have similar characteristics to those in the study area. The questionnaire was revised with the necessary corrections from the pretesting and field reviews before the main data collection campaign. The final revised questionnaire was then employed during the exercise, with each session lasting at least 40 minutes during the administration.

2.5. Data analysis, measures, and ethical considerations

The Statistical Package for Social Sciences (SPSS 26.0, IBM, United States) was used for the statistical analyses of the quantitative data. Both bivariate and multivariate regression techniques with adjusted odds ratio (AOR) were employed. Qualitative data were analyzed using a content analysis approach. The data were also analyzed using a simultaneous approach to ensure consistency in the findings (Creswell & Creswell, 2017).

In this study, the dependent variable is unintended adolescent pregnancy. In assessing whether an adolescent pregnancy was intended or unintended, we used a binary item with a "yes" or "no" response. In this case, participants were asked to indicate if the pregnancy was intended, aligned with previous studies (Ameyaw *et al.*, 2019; Okalo *et al.*, 2023; Wasswa *et al.*, 2020).

The study also controlled for sociodemographic characteristics, including age (in years), educational level, marital status, relationship with parents, fathers' and mothers' educational level, living arrangements, residence locality, as well as disability status and participation in girls' clubs or parties.

Regarding the qualitative analysis, the interviews were audio-recorded with the participants' permission. All recorded interviews were subsequently transcribed and saved on a personal computer. To ascertain privacy and confidentiality, the transcriptions used pseudonyms instead of the participants' original names. In addition, to ensure credibility, member checking and peer briefing were employed, as performed in the previous study (Okine & Dako-Gyeke, 2020). Subsequently, the transcribed interviews were numbered and matched to the participants appropriately.

Given the sensitive nature of the subject matter, we maintained the highest ethical standards in this research as is typically required of such studies. Thus, the participants were regularly notified and reminded about the sensitive nature of the subject being discussed. Aligned with proper research ethics, enumerators provided a brief background, highlighting participants' rights to choose whether or not to participate in the survey before the interviews commenced. Similarly, they were informed about their right not to respond to any question they felt uncomfortable answering. As a result, the average response rate to the questions is 93%. Safety protocols were duly upheld as data were collected face-to-face amidst the persistence of COVID-19. Complete anonymity and confidentiality were promised, tailored to the selection of interview sites and the data analysis.

3. Results

3.1. Quantitative results

As shown in Table 1, a total of 310 adolescent girls were surveyed in this study. The majority of the adolescent girls (73.2%) had unintended pregnancies during the COVID-19-induced school closures, whereas 83 girls (26.8%) had intended pregnancies. Regarding age, about 75.5% of the adolescent girls were between the ages of 16 and 19 years, while 24.5% were in their early adolescent stage (13–15 years). Also, a majority of the adolescent girls (75.2%) were in SHS, while the rest (24.8%) were in junior high school (JHS). Also, only 24.5% of the respondents were married. Concerning residence locality, more than two-thirds of the surveyed adolescent girls (88.7%) were living in rural areas.

Regarding sexual and reproductive health-related issues, 25.8% of adolescent girls reported having multiple partners during the COVID-19-induced school closure. About 73.5% of girls did not receive any form of sex education during the pandemic, while 74.2% did not have better knowledge about the use of contraception. In addition, a large majority of the surveyed adolescent girls (88.7%) reported having difficulty in discussing family planning-related matters with their parents or guardians. Therefore, it is not surprising that about 81.7% of adolescent girls who did not receive sex education during the pandemic indicated that their pregnancies were unintended. Similarly, 69.8% of those girls who could not freely discuss family planning-related issues with their parents had unintended pregnancies. A large number of those adolescent girls who did not know about contraception (63.9%) or did not think one-time sex could end in pregnancy revealed having unintended pregnancies during the period.

> I got pregnant after sleeping with him just once during the COVID-19 lockdown and school closures. Though it was not our intention, I refused to abort it as he [the boyfriend] suggested.

Table 1. Sociodemographic and pregnancy-related information of respondents

Variable	*n* (%)	Pregnancy	
		Intended, *n* (%)	Unintended, *n* (%)
Pregnancy	310 (100)	83 (26.8)	227 (73.2)
Age			
13–15 (early adolescence)	76 (24.5)	21 (27.6)	55 (72.4)
16–19	234 (75.5)	83 (35.5)	151 (64.5)
Level of education			
JHS	77 (24.8)	1 (1.3)	76 (98.7)
SHS	233 (75.2)	82 (35.2)	151 (64.8)
Marital status			
Married	76 (24.5)	41 (53.9)	35 (46.1)
Not married	234 (75.5)	42 (17.9)	192 (82.1)
Residence locality			
Rural	275 (88.7)	83 (30.2)	192 (69.8)
Urban	35 (11.3)	0 (0.00)	35 (100%)
Father's educational level			
No formal education	81 (26.1)	15 (18.5)	66 (81.5)
Primary	42 (13.5)	22 (52.4)	20 (47.6)
JHS	35 (11.3)	9 (25.7)	26 (74.3)
SHS	119 (38.4)	41 (34.5)	78 (65.5)
Tertiary	33 (10.6)	14 (42.4)	19 (57.6)
Mother's educational level			
No formal education	81 (26.1)	28 (34.6)	53 (65.4)
Primary	116 (37.4)	83 (71.6)	33 (28.4)
JHS	35 (11.3)	10 (28.6)	25 (71.4)
SHS	33 (10.6)	8 (24.2)	25 (75.8)
Tertiary	45 (14.5)	12 (26.7)	33 (73.3)
Living arrangement			
Stay with both biological parents	110 (35.5)	42 (38.2)	68 (61.8)
With mother only	126 (40.6)	41 (32.5)	85 (67.5)
With foster parent	74 (23.9)	35 (47.3)	39 (52.7)
Relationship with parents			
Very close	41 (13.2)	29 (70.7)	12 (29.3)
Close	68 (21.9)	23 (33.8)	45 (66.2)
Moderate	161 (51.9)	42 (26.1)	119 (73.9)
None	40 (12.9)	22 (55.0)	18 (45.0)
Disability			
Yes	68 (21.9)	36 (52.9)	32 (47.1)
No	242 (78.1)	83 (34.3)	159 (65.7)
Multiple partners during COVID-19			
Yes	80 (25.8)	26 (32.5)	54 (67.5)
No	230 (74.2)	95 (41.3)	135 (58.7)
Sex education during COVID-19			
Yes	82 (26.5)	42 (51.2)	40 (48.8)
No	228 (73.5)	41 (18.3)	187 (81.7)
Freely discussed family planning-related issues with parents during COVID-19			
Yes	35 (11.3)	9 (25.7)	26 (74.3)
No	275 (88.7)	83 (30.2)	192 (69.8)
Knowledge about contraceptives			
Yes	80 (25.8)	37 (46.3)	43 (53.7)
No	230 (74.2)	83 (36.1)	147 (63.9)
Belong to any girls' club			
Yes	76 (24.5)	14 (18.4)	62 (81.6)
No	234 (75.5)	83 (35.5)	151 (64.5)

Source: Authors' calculation using field data.
Abbreviations: JHS: Junior high school; SHS: Senior high school.

> My mother was mad at me and sacked me from the house but I relocated to his mother's house and continued my education after childbirth. (Adolescent school girl, aged 13–19, SHS A)

Also, the results of the crude odds ratio (COR) as depicted in Table 2 showed that the significant predictors or determinants of unintended pregnancy among adolescent girls during the COVID-19-induced school closures are sex education received during COVID-19 pandemic (COR = 0.209, 95% CI = [0.121, 0.362]), knowledge about the use of contraception (COR = 0.691, 95% CI = [0.479, 0.581]), girls in their late adolescence (16–19 years) (COR = 0.036, 95% CI = [0.187, 0.945]), adolescent girls whose mothers had JHS education (COR = 1.284, 95% CI = [0.242, 0.837]), and adolescent girls living with their mothers only (single parenting) (COR = 1.354, 95% CI = [0.503, 0.985]). In particular, the results from the crude model suggest that girls with a better understanding of the use of contraceptives are 30.9% less likely to experience unintended pregnancy during the COVID-19 lockdown and school closures compared to those with insufficient knowledge about contraception. Similarly, the odds of getting an unintended pregnancy are lower for girls in their late adolescence (16–19 years) compared to girls in their early adolescence (13–15 years). With regards to the living arrangements, the results revealed that respondents who were living only with their mothers had a 35.4% higher risk of getting unwanted pregnancies than their counterparts living with both parents during the COVID-19-induced school closures.

Table 2. Predictors of unintended pregnancy relative to the reference category

Predictors	COR (CI)	AOR (CI)
Multiple partners during COVID-19		
No	1.000	1.000
Yes	0.894 (0.521, 1.356)	1.382 (0.289, 0.921)**
Sex education during COVID-19		
No	1.000	1.000
Yes	0.209 (0.121, 0.362)***	0.528 (0.296, 0.940)**
Freely discussed family planning-related issues with parents during COVID-19		
No	1.000	1.000
Yes	0.522 (0.344, 1.389)	0.668 (0.456, 2.058)
Knowledge about contraceptives		
No	1.000	1.000
Yes	0.691 (0.479, 0.581)***	0.128 (0.687, 1.849)
Age		
13–15 (early adolescence)	1.000	1.000
16–19	0.036 (0.187, 0.945)**	0.137 (0.356, 1.784)
Level of education		
JHS	1.000	1.000
SHS	0.598 (0.154, 1.866)	0.456 (0.122, 1.454)
Marital status		
Married	1.000	1.000
Not married	1.254 (0.054, 4.517)	1.456 (0.215, 0.655)***
Residence locality		
Urban	1.000	1.000
Rural	0.247 (0.124, 1.668)	0.476 (0.422, 0.858)***
Father's educational level		
No formal education	1.000	1.000
Primary	1.034 (0.106, 7.021)	1.327 (0.215, 6.346)
JHS	0.770 (0.666, 2.654)	0.877 (0.512, 1.435)
SHS	2.098 (0.441, 7.414)	0.450 (0.548, 8.125)
Tertiary	2.056 (1.454, 6.546)	2.144 (1.330, 4.359)
Mother's educational level		
No formal education	1.000	1.000
Primary	0.585 (0.785, 5.151)	0.502 (0.349, 1.665)
JHS	1.458 (0.672, 3.231)	1.720 (0.632, 3.740)
SHS	1.284 (0.242, 0.837)**	1.575 (0.331, 5.154)
Tertiary	0.496 (0.188, 2.680)	1.125 (0.532, 3.248)
Living arrangement		
Stay with both biological parents	1.000	1.000
With mother only	1.354 (0.503, 0.985)***	1.020 (0.055, 1.155)
With father only	0.402 (0.114, 2.401)	0.556 (0.022, 1.289)
With foster parent	1.488 (0.177, 1.654)	2.022 (0.189, 2.335)
Relationship with parents		
Very close	1.000	1.000
Close	0.781 (0.085, 1.022)	0.155 (0.870, 2.356)
Moderate	0.474 (0.011, 1.322)	0.450 (1.541, 14.894)
None	0.177 (0.266, 4.014)	0.879 (0.556, 8.418)
Disability		
No	1.000	1.000
Yes	0.711 (0.021, 1.369)	2.414 (0.798, 2.986)
Belong to any girls' club		
No	1.000	1.000
Yes	1.748 (0.028, 7.633)	0.643 (0.477, 3.187)

Notes: ***, **, and * indicate that the coefficients are significant at 1%, 5%, and 10% level of error, respectively.
Abbreviations: AOR: Adjusted odds ratio; CI: Confidence interval; COR: Crude odds ratio; JHS: Junior high school; SHS: Senior high school.

In the AOR model (Table 2), the results indicate that adolescent girls who received sex education during the COVID-19 pandemic had a 47.2% lower risk of getting unintended pregnancy due to the COVID-19 lockdown and school closures compared to girls who did not receive such adolescent and reproductive health education (AOR = 0.528, 95% CI = [0.296, 0.940]). The results also showed that the odds of experiencing unintended pregnancy are approximately 38.2% higher for an adolescent girl with multiple sex partners during the COVID-19 lockdown and school closures compared to those with a single partner (AOR = 1.382, 95% CI = [0.289, 0.921]). The narrative of a girl in one of the hospitals mentioned that:

> Sometimes I visited my female friends. Other times, I visited my boyfriends who were also in town, even though they were far from my area. Yes, we did it [had sex] many times without the knowledge of my parents. I will say that each time, I was able to convince my mother, I went to their houses. (Adolescent school girl aged 16–19, Hospital C)

Furthermore, adolescent girls who were not married were 45.6% more likely to experience an unintended pregnancy than those who were married (AOR = 1.456, 95% CI = [0.215, 0.655]). Likewise, the results in this study revealed that the residence locality of girls was a significant predictor of unintended pregnancy among the respondents (AOR = 0.476, 95% CI = [0.422, 0.858]). More specifically, adolescent girls in urban areas had a 52.4% lower risk of experiencing unintended pregnancy during COVID-19 compared to girls in RUCs. In other words, the odds of experiencing an unintended pregnancy are higher for respondents in rural and underserved areas compared to their urban counterparts.

3.2. Qualitative results

The qualitative interviews generally support the findings that adolescent girls were at a higher risk of unintended pregnancy during COVID-19-induced school closures in the study area. In analyzing the evidence from the interviews, three key themes emerged, including proximity and association (Eduful & Eduful, 2021), precipitation of physical contact of a sexual nature, and failed attempts at preventing pregnancy and abortion. The evidence suggests that the pandemic and its resulting school closures made them vulnerable to the possibility of getting pregnant and subsequent delivery.

3.2.1. Proximity and association

The data show that school closures created an opportunity for adolescent girls to be closer to their male partners, which may not be the case if they were in school. The continued stay at home made them bored, and hence led them to escape the supervision of both parents and teachers and be closer to their partners. Once they became proximate, it was natural for them to start associating through verbal and non-verbal means, which possibly led to sexual advances.

> Yes, COVID-19 school closures and lockdown made it easy for me to visit some people that I would not have been able to visit if I were in school… I went home during the pandemic and got fed up staying at home. Because of that I started making things up to convince my mother to allow me to visit some friends. (Adolescent girl aged 16–19, SHS D)
>
> COVID-19 and the closure of schools actually exposed me [to reunite with old friends because the break was so long]… Most of the time I was telling my mother some lies. I was giving her excuses that would make her allow me to hang out… (Adolescent school girl aged 13-19, SHS B)

3.2.2. Precipitation of physical contact of a sexual nature

Once the adolescent became proximate and began to associate, our data suggest that it was within such moments that a precipitated physical contact of a sexual nature occurred. On occasion, such contacts may have been fueled by the watching of pornographic materials. Thus, among the victims of unintended adolescent pregnancy during the COVID-19 pandemic, staying at home and in the same community with their sexual partners precipitated such physical contact. In some cases, once the initial hurdle of physical contact or actual sex had been crossed, they tend to have sex multiple times in their subsequent meetings, thus making the act no longer unintentional, as shown in both the quantitative and qualitative data.

> Okay, so what happened was that honestly, before the lockdown or COVID-19 outbreak, I was already dating… while I was back home during the pandemic, I always go to his house to have fun. My mother always came back home in the evening around 5 pm, so I made sure I returned before her. So, I enjoyed myself during COVID-19. (Final-year girl, SHS A)

Watching of pornography too. Yes, it really got the better of me during the lockdown and school closures. One of my friends had a lot of them on her phone and she got pregnant eventually too. (Adolescent girl aged 16–19, Hospital B)

> …and I got pregnant but fortunately for me, we were still staying at home during the lockdown and school closures. When school reopened, I couldn't come early because I was about to be delivered. So, when I came back to school later, I told my friends that I was ill… Now I have a son who is being taken care of by my grandmother but nobody in the school knows about it. Considering my age, nobody can imagine it either. (19-year-old girl, SHS C)

3.2.3. Failed attempts at preventing pregnancy and abortion

In addition, the in-depth interviews indicate that some adolescent girls attempted abortion upon realizing they were pregnant. When asked if they tried to avoid pregnancy during sex, some noted that they attempted to prevent it by utilizing various birth control measures, but realized later it did not work, or may have worked, but subsequent times they had sex without the control might have led to the pregnancy.

> He didn't have a job and I also wanted to continue my education at the university level. So, he went to the pharmacy and bought [name withheld] which is a very powerful drug for abortion. But what makes me sad is that after he put me through severe pains and emotional trauma, he ended the relationship. (Adolescent girl aged 16–19, Hospital C)
>
> He was always giving me a lot of pills to take before sex. I realized that we were abusing it because we didn't follow the dosage. I also realized that it was affecting my menstrual cycle negatively. Anytime I refused to take the medicine, he abused me verbally. There was a time he threatened to slap me if I didn't take the pills. After doing all these, I still got pregnant. (Adolescent girl, out-of-school)
>
> Because of the lockdown and how it affects movement in this area, we couldn't get Postinor 2 to buy …We had money but the chemist said the shop was out of stock and he couldn't go to Kumasi to buy some because of the lockdown. So, we were using the withdrawal method but it obviously didn't help. (17-year-old girl, SHS B)

The above narrations are suggestive that the school closures made it possible for students to reach out to persons they could not initially meet because they were in school. In addition, most adolescent girls who were either dating or not before COVID-19 became vulnerable within such spaces of proximity and association, leading to physical contact with the consequences of engaging in actual sex with their partners during the lockdown and school closures. Once they were unsuccessful in preventing the pregnancies or causing an abortion, they had no choice but to carry the pregnancy to term. These responses generally conform to the quantitative findings, where only 26.8% of the sampled participants indicated that they got pregnant intentionally, compared to 73.2% who got pregnant unintentionally or accidentally.

4. Discussion

Given that adolescent pregnancy could have long-term impacts on the lives of adolescent mothers as well as their children who can potentially become adolescent parents themselves in the future (Baker, 2020; Cook & Cameron, 2017; The Lancet Child Adolescent Health, 2020; World Vision Ghana, 2020), this study investigated the predictors of unintended adolescent pregnancy during the COVID-19 pandemic, focusing on adolescent girls in RUCs in Ghana. The findings indicate that a large majority of girls (73.2%) had unintended pregnancies during the COVID-19-induced school closures, whereas 83 girls (26.8%) had intended pregnancies. More specifically, whereas more than half of the sampled rural girls (69.8%) had unintended pregnancies relative to 30.2% who had intended pregnancies, all urban girls (100%) reported that their pregnancies were unintended or accidental. This outcome is consistent with existing studies that argued that there is a high tendency for adolescent girls who are in or out of school to report a pregnancy as unintended (Mena-Meléndez, 2022; Ajayi *et al.*, 2021; Israel *et al.*, 2019). This is largely because such girls, particularly in-school girls, intend to further their education. Also, the higher proportion of unintended pregnancy among urban girls is in line with the study of Mena-Meléndez (2022), who found that rural women have lower odds of experiencing an unintended pregnancy and a pregnancy termination than urban women in Latin America and the Caribbean. The author argues that urban women claimed to have an understanding and good knowledge regarding contraceptive usage and, as a result, engage in multiple sexual activities. This tends to expose them to higher odds of experiencing unintended pregnancies compared to their rural counterparts. It is worth noting, however, that our findings are contrary to other researchers (Sutton *et al.*, 2019; Ikamari *et al.*, 2013) who discovered that the odds of unintended pregnancy are higher among women (or girls) who resided in rural areas compared to their urban counterparts. It can, therefore, be deduced that the extant literature on adolescent pregnancy and\or unintended pregnancy is yet to establish a universal consensus on whether rural girls have higher odds of experiencing unintended pregnancy than urban girls or vice versa.

Our findings further showed that over two-thirds of the respondents (88.7%) lived in RUCs, suggesting that the COVID-19 lockdown and school closures disproportionately exposed adolescent girls in RUCs to unintended pregnancy. This is consistent with the claims by ecological systems theory that there exist some interrelated factors influencing teenage pregnancies among adolescent girls in RUCs (Coast *et al.*, 2018; Okine & Dako-Gyeke, 2020). These communities, according to the theory, are often underprivileged with heightened economic poverty, which could result in potential social vices and other health risk behaviours such as increased transactional sex, early marriages, and amplified teenage pregnancies (Coast *et al.*, 2018). Adolescent girls from socioeconomically disadvantaged families may never return to school, and hence, the prevalence of early marriage and teenage pregnancies during the COVID-19 pandemic was bound to be huge, as discovered in this study. Likewise, our findings indicate that 73.5% of the girls did not receive any form of sex education during the pandemic. An estimated 74.2% did not have sufficient knowledge about contraception. Overall, evidence from this study revealed that unintended

pregnancies increased during the COVID-19 lockdown and school closures in Ejisu Municipality in Ghana.

Remarkably, our results showed that a large majority of girls (88.7%) do not have the freedom to discuss family planning-related matters with their parents and other family members. This could stem from the fact that most parents, especially in rural communities, tend not to discuss issues related to sexual and reproductive health with their children. Yet, both boys and girls continue to associate and intermingle with each other and, in some cases, experiment with pre-conceived ideas picked from the media and other fora, leading to early sex debuting. Therefore, we argue that early sex debuting in rural communities tends to be influenced by personal experimentations, societal and cultural conventions, rather than by parents' guidance (Mark & Wu, 2022). Indeed, strengthening parent-adolescent communication can raise awareness of contraception and good sexual and reproductive health practices among adolescents.

In addition, findings from the crude model showed that the odds of experiencing unintended pregnancy during the COVID-19 lockdown and school closures were lower for girls in their late adolescence (16–19 years), compared to those in their early adolescence (13–15 years). The findings suggest that, as early as 13 years of age, most girls in Ghana began childbearing. The COVID-19-induced school closures and the isolation of students from school support networks, as well as the associated rising poverty levels, escalated the adolescent pregnancy issues that Ghana has been struggling to address over the years. Even before the outbreak of the COVID-19 pandemic, teenage pregnancy had been high in Ghana (Addae, 2021). This finding corroborates the findings from GSS *et al.* (2014), which suggest that about 14% of adolescent girls aged 15 years and below started conceiving and childbearing, with approximately 11% live birth rate in Ghana. It is also consistent with Dubik *et al.*'s (2022) conclusions that poverty and parents' desire for grandchildren are the leading causes of teenage pregnancy in Ghana, especially in RUCs. As earlier discovered by Molla *et al.* (2022), the COVID-19 pandemic exacerbated the already difficult economic situation that poor Ghanaian families were facing, thus increasing the adolescent girls' vulnerability to unintended pregnancies during the COVID-19 lockdown and school closures. Previously, estimates by UNICEF (2018) also found that reduced household income increases the likelihood of early marriage by about 3%, especially in countries where bride price is a common practice.

Moreover, our results indicate that girls with a better understanding of the use of contraception are 30.9% less likely to experience unintended teenage pregnancy during the pandemic-induced school closures compared to those without access to contraceptives. This is consistent with Kumar & Singh's (2022) findings that the pandemic constrained most women's access to sexual and reproductive health services, including contraception. This, in turn, led to an increase in unintended pregnancies and unsafe abortions. Within this context, a finding by Biney *et al.* (2023) suggests that, although modern contraception, such as male and female condoms, was used during the COVID-19 lockdown and schools' closure, they were obtained before the lockdown. Again, the findings from the current study indicate that girls who were living with single parents, in particular, with their mothers only, had a 35.4% higher risk of getting an unwanted pregnancy than their counterparts living with both parents during COVID-19. One possible explanation could be that single mothers could be socioeconomically disadvantaged, thus pushing their adolescent daughters into early sex debut or marketable sexual activity. However, this can result in unintended pregnancies among these girls, especially in the absence of proper sex education and parent-adolescent communication.

Indeed, our findings from the adjusted model showed that adolescent girls who received sex education during the COVID-19 pandemic had a 47.2% lower risk of experiencing unintended pregnancy compared to girls who did not receive such adolescent and reproductive health education. This means that effective sex education could provide useful guidance to girls on possible ways to avoid unwanted pregnancies (Okalo *et al.*, 2023; Owusu-Addo *et al.*, 2023). However, as indicated earlier, in most families in Ghana, similar to other developing countries, girls usually have difficulties discussing sexual and reproductive health issues with their parents or guardians (Mark & Wu, 2022; Owusu-Addo *et al.*, 2023).

Similarly, we found that the odds of experiencing an unintended teenage pregnancy during the COVID-19 school closures were approximately 38.2% higher for girls with multiple sex partners compared to those with a single partner. This is likely because the adolescent girls gained more proximity and association with their male partners during school closures, leading to the precipitation of physical contact of a sexual nature. For instance, a participant mentioned that:

> Sometimes I visited my female friends during school closures. Other times, I visited my boyfriends who were also in town, even though they were far from my area. Yes, we did it [had sex] many times without the knowledge of my parents. I will say that each time, I was able to convince my mother, I went to their houses. (Adolescent girl, Hospital C)

Consistent with the quantitative results, our qualitative data revealed that COVID-19-induced school closures created opportunities for students to interact with individuals they previously could not access due to school attendance. This increased proximity and social interaction made many adolescent girls more vulnerable, leading to physical contact and, in some cases, sexual activity during the lockdown. These findings support the earlier idea that COVID-19-induced school closures led to a loss of school (parental/guardian) caring functions, exposing adolescents to potential social vices, including increased transactional sex, early marriages, and deepened teenage pregnancies as recorded during the Ebola cases in Sierra Leone (Bah, 2014; Gettleman, 2014). Our findings imply that staying out of school during the COVID-19 pandemic undoubtedly exposes adolescent girls to sexual activity or early debut of sex, which in turn increases unintended teenage pregnancies, unsafe abortions, and maternal and infant mortality.

Notably, the findings in this paper should be interpreted with some probable limitations. First, this paper utilized cross-sectional data and, therefore, does not establish a causal effect (Sandow *et al*., 2021; Sandow *et al*., 2022). Second, the analysis in this paper is based on data drawn from one local government area (municipality) in the Ashanti Region. As a result, while the findings in this study are useful, they cannot be generalized to the entire adolescent girl population in Ghana. Third, sexual activity and adolescent pregnancy are sensitive matters, and we cannot rule out the possibility of social desirability bias on the part of respondents. Fourth, as the length of the recall period can affect data accuracy, this study acknowledges recall bias as a potential limitation. Recall bias occurs when study participants inaccurately recall past events or miss certain details when reporting on them. According to Khare and Vedel (2019), recall bias (otherwise known as memory decay) is particularly common in retrospective studies where participants are asked to recall past exposures or experiences. Lastly, the study was unable to compare data from different times, spaces, or parental roles based on their attributes due to the lapse of time, which raises concerns about triangulation. Triangulation in research, often referred to as second-level triangulation, involves using multiple data sources, methods, theories, or enumerators to examine a research question, aiming to enhance the credibility and robustness of findings (Bans-Akutey & Tiimub, 2021; Donkoh & Mensah, 2023; Heale & Forbes, 2013). In other words, triangulation can help to explore and explain complex human behavior using a variety of methods to offer a more balanced explanation of a subject matter (Carter *et al*., 2014; Noble & Heale, 2019). Nevertheless, we employed "methodological triangulation" by combining qualitative and quantitative research methods and "investigator triangulation" through the use of multiple enumerators in data collection and several researchers in data analysis to minimize researcher bias. This, therefore, strengthens the validity and reliability of our findings, increasing the overall confidence in our inferences (Bans-Akutey & Tiimub, 2021; Biney *et al.*, 2023; Donkoh & Mensah, 2023).

Despite these limitations, our findings align with previous studies of unintended adolescent pregnancy and its predictors, as well as offering leads to parents in guiding their children to navigate this critical juncture of their lives. It should be underscored that though the COVID-19 school closures may have created proximate contextual relations with unintended sexual contingencies and concomitant pregnancies, adolescent pregnancy is not exclusive to the outbreak of a pandemic. Adolescents everywhere need trustworthy social support systems under close supervision, as well as the affection of parents and other immediate relations, to prepare themselves for taking parental roles of their own. This contributes to building much safer and stronger communities for all, bereft of the emotional turmoil that comes with an adolescent child falling prey to unintended pregnancy, particularly in contemporary African societies.

5. Conclusion

The overriding objective of this study was to examine unintended pregnancy and its predictors among adolescent schoolgirls within the context of COVID-19-induced school closures in RUCs in Ejisu Municipality in Ghana. Quantitative and qualitative data were collected in this district from adolescents, in-school and out-of-school, as well as head teachers, teachers, parents, and community opinion leaders. Both the quantitative and qualitative evidence point to the loss of school (parental/guardian) caring functions, exposing adolescents to potential social vices, including increased transactional sex, early marriages, and deepened unintended teenage pregnancies. While schools are supposed to enforce discipline and ensure good moral values among students (Lu *et al.*, 2022; Owusu-Addo *et al.*, 2023), COVID-19-induced school closures disrupted these functions. This emphasizes the need for alternative measures to ensure discipline among school children in the event of disruptions, such as COVID-19-induced school lockdowns. In addition, the findings showed that lack of sex education and inadequate understanding of contraception were significant predictors of unintended pregnancy during the COVID-19 era. The findings further showed that one of the important lessons learned from the COVID-19-induced school closures was the high rate of out-of-school adolescent girls, at least for those residing in RUCs. In

addition, the results of this study indicate that girls in their early adolescence (13–15 years) had a higher risk of unintended pregnancy compared to those in their late adolescence (16–19 years). Tied to the above observation, our findings also show that a lack of parent-adolescent communication drives unintended teenage pregnancy. This suggests that parents and guardians play an important role in safeguarding their children from bad influences and unwanted adolescent pregnancy. Prior evidence supported the fact that parental involvement in adolescent sexual and reproductive health-related matters is one of the key strategies to prevent unwanted adolescent pregnancy (Okalo *et al.*, 2023). For instance, parents usually serve as protectors of their children through proper supervision and guidance. Parents also perform a protective function by providing the basic needs of their children, thus making them less likely to be influenced by bad friends with cheap gifts and promises. Because of this, there is a need to strengthen and contextualize parental roles that support effective parenting practices to reduce children's vulnerability to bad influence and misconduct. Effective parenting can also create a conducive environment for children to discuss sex-related issues with their parents freely and to seek good counsel. Within that milieu of parental guidance, there will be little or no space for children to be lured sexually or victimized.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Investigation: All authors
Methodology: All authors
Writing–original draft: All authors
Writing–review & editing: All authors

Ethics approval and consent to participate

The study's instruments were peer reviewed by the subject experts including academics and policy practitioners in both Ghana (Sunyani Technical University, Takoradi Technical University, and KNUST) and the USA (Chicago, IL; Towson, MD and Bensalem, PA). Aligned with proper research ethics, enumerators provided a brief background, highlighting participants' rights to choose whether or not to participate in the survey before the interviews commenced.

Consent for publication

All participants provided informed consent and consented to the publication of the findings obtained from this study on condition of anonymity which has been adhered to.

Availability of data

Data will be available from the corresponding author upon reasonable request.

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ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Rationality of women in fertility decisions: An intergenerational study in rural Indonesian contexts

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Abstract

This study investigates the rationality underlying women's fertility decisions in rural households, focusing on intergenerational dynamics within a specific Indonesian context. Globally, fertility patterns are shaped by complex socioeconomic, cultural, and individual factors, with women's rational considerations often overlooked or oversimplified. This research aims to explore how women in Jrengik Village, Sampang Regency, Indonesia, make decisions regarding family size, considering perspectives of consumption, production, and future security. Employing a qualitative approach through in-depth interviews with women from different generations within the same households, the study delves into their perceptions and reasoning. Preliminary findings reveal a nuanced interplay of economic considerations, such as labor availability and old-age support, with non-economic factors, including social prestige, emotional fulfillment, and cultural norms surrounding ideal family size. Notably, generational differences highlight shifts in the salience of these rationales, suggesting an evolving understanding of the "utility" of children. This study contributes to the broader discourse on fertility transitions by emphasizing the subjective rationalities of women, offering valuable insights for population policies that aim to align with community perspectives in rural areas undergoing demographic and socioeconomic transition.

Keywords: Rationality; Fertility decisions; Women's agency; Intergenerational dynamics; Rural contexts

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1. Introduction

The trajectory of global population dynamics, characterized by persistent demographic shifts, underscores the critical importance of understanding fertility decisions. While a pervasive global fertility decline has been observed across diverse regions, the underlying mechanisms and nuanced rationales that drive these changes remain a subject of intense academic scrutiny (Aitken, 2024; Bart *et al*., 2024; Ahmed *et al*., 2024). Conventional demographic models often attribute fertility transitions primarily to socioeconomic development, urbanization, and the expansion of family planning programs (Aref *et al*., 2024; Zhang *et al*., 2025). However, such macro-level explanations frequently oversimplify the complex decision-making processes occurring at the household and individual levels, particularly concerning women's active role in shaping their reproductive futures (Czaika & Weisner, 2025; Chen *et al*., 2024). A deeper inquiry into

the subjective rationality that underpins these profound life choices is essential for moving beyond deterministic views and for designing more responsive and equitable population policies globally.

Theoretical frameworks on fertility largely originate from two dominant perspectives: The economic and the sociological. The economic paradigm, notably the New Household Economics, posits fertility as a rational choice determined by the costs and benefits of children, viewing them as both consumption goods and productive assets (Becchio, 2024; Cho, 2025). In this framework, decisions on family size are seen as optimizing utility, influenced by factors such as parental income, child-rearing costs, and the economic contribution of children to household labor or old-age support (Fu *et al*., 2025; Jiang *et al*., 2024). Critically, while offering valuable insights into some aspects of fertility behavior, this perspective is often criticized for its inability to fully capture non-economic rationales, including emotional fulfillment, social prestige, gender norms, and the deeply ingrained cultural values associated with parenthood (Shobande *et al*., 2025; Ruckdeschel, 2024). Conversely, demography theories emphasize the role of social norms, cultural institutions, and power dynamics in shaping fertility preferences and behaviors (Frantsuz, 2024; Atahigwa *et al*., 2025). The First and Second Demographic Transitions, for instance, highlight shifts from traditional family structures and high fertility to individualism, delayed marriage, and below-replacement fertility (Tan *et al*., 2025; Willy & Faria, 2025). Yet, these broad sociological narratives, while illuminating macro-level trends, often fall short in explaining variations in individual rationality and decision-making within specific micro-contexts, particularly how these rationales are negotiated across different generational cohorts within families.

Empirically, numerous studies have explored fertility determinants across diverse settings. Research from various Asian countries indicates that while education and female labor force participation generally correlate with lower fertility, the pathways and specific rationales differ significantly based on local cultural and economic conditions (Kizza & Wasswa, 2024; Barbalet, 2025). In rural communities, where traditional values may persist, children are often still perceived as essential for agricultural labor, old-age security, and maintaining lineage (Thomason, 2025; Qi, 2025). However, rapid modernization and changing aspirations, even in remote areas, suggest an evolving landscape of fertility preferences (Bismoko *et al*., 2025; Lin, 2025). Despite the wealth of quantitative data on fertility trends, there remains a notable empirical void concerning in-depth, qualitative investigations into the intergenerational transfer and transformation of women's specific rationalities concerning family size within the same household lineage. Existing studies frequently aggregate data, thereby obscuring the nuanced, subjective experiences and the dynamic interplay between different generational cohorts (e.g., mother-daughter) in forming fertility intentions and decisions (Mehta *et al*., 2025; Nakamura & Akiyoshi, 2024). This limitation hinders a comprehensive understanding of how past experiences and future aspirations shape current reproductive behaviors through familial interactions.

This study critically addresses the aforementioned research gap by providing a nuanced qualitative inquiry into the rationality of women in fertility decisions, specifically focusing on the intergenerational dynamics within rural households of Jrengik, Madura-Indonesia. The central problem is the inadequate understanding of how different generations of women within the same family conceptualize and rationalize their desired number of children, considering the evolving perspectives of consumption, production, and future security. While children may historically have been seen as labor assets, contemporary rural women might balance this with aspirations for their children's education and the economic burden of larger families (Dalla *et al*., 2025; Becot & Inwood, 2024). This research offers a unique contribution by moving beyond statistical correlations to uncover the subjective meanings, evolving values, and often implicit negotiations that shape these deeply personal yet socially consequential decisions across generations (Klug *et al*., 2024).

This research utilizes the rational choice theory (RCT) and the value of children (VOC) theory as its primary theoretical lenses. While RCT explains decisions based on logical cost-benefit calculations, it is often criticized for its inability to fully capture non-economic rationales. The VOC theory addresses this limitation by emphasizing that fertility decisions are equally driven by socio-emotional, cultural, and symbolic values—such as emotional fulfillment, social prestige, gender norms, and the deeply ingrained cultural values associated with parenthood.

This study aims to refine the understanding of RCT within the context of fertility decisions. Conventionally, RCT posits that individuals make decisions based on logical calculations to maximize personal benefits and minimize costs. In fertility studies, RCT is often used to explain how couples or individuals choose their family size based on economic considerations, such as the cost of raising children versus the economic benefits (e.g., household labor or old-age support). However, this model is often criticized for being too simplistic as it fails to capture the nuances of non-economic factors. Therefore,

this research will address this limitation by demonstrating that "rationality" in fertility decisions is not confined to economic considerations alone. By analyzing qualitative data, we explore how non-economic factors, such as social values, emotions, and personal aspirations, also play an equally important role in shaping these decisions. Thus, this study contributes to a more holistic and relevant theoretical framework for RCT in complex social realities.

The objective of this research is to explore the specific rationales influencing women's fertility decisions, examining the perspectives of children as consumption goods (e.g., emotional fulfillment, social status), production assets (e.g., labor, old-age support), and components of future security (e.g., lineage, community standing). By employing an intergenerational lens, this study aims to reveal how these rationales are transmitted, challenged, or adapted across different cohorts (e.g., mothers and daughters) within the context of changing rural Indonesian society. The insights gleaned from this qualitative approach are expected to provide a rich, detailed understanding that complements existing quantitative analyses, offering a more holistic view of fertility behavior.

Theoretically, this research contributes to a refined understanding of RCT in demographic contexts by integrating a critical intergenerational perspective, demonstrating how rationality is not static but dynamically shaped by lived experiences and changing societal norms. Empirically, it provides invaluable qualitative data from a specific rural Indonesian setting, shedding light on micro-level decision-making processes that are often invisible in broader surveys. These findings are crucial for academics, policymakers, and practitioners seeking to develop more effective and context-sensitive population programs, particularly those aimed at supporting women's reproductive autonomy and fostering sustainable development in rural areas globally (Petersen, 2025). The nuanced insights derived from this study will help bridge the gap between aggregated demographic statistics and the complex realities of individual and household-level fertility choices.

2. Data and methods

This section outlines the methodological approach employed to deeply explore women's rationality in fertility decisions, specifically within the dynamic intergenerational context of rural areas. This study adopts a qualitative approach within an interpretive paradigm. The interpretive paradigm was chosen because it allows the researcher to understand social phenomena from the informants' perspectives, acknowledging that social reality is subjectively constructed and dependent on the meanings individuals ascribe to it (Lim, 2025; Aguzzoli *et al*., 2024). This approach is particularly well-suited for investigating the complex motivations, perceptions, and rationalities underlying fertility decisions that cannot be fully measured quantitatively.

This study was conducted in Jrengik Village, Sampang Regency, Madura, East Java, Indonesia. This research site was intentionally selected due to its status as a rural area currently undergoing a slow but discernible demographic transition, marked by declining, yet still relatively high, fertility rates compared to urban centers. Socioeconomically, Jrengik is predominantly an agricultural community with limited non-agricultural employment opportunities, which has historically reinforced the economic VOC as productive labor assets. However, increasing migration (primarily male) and limited arable land size are gradually challenging this traditional economic rationale. Culturally, the Madurese context is characterized by strong Islamic values and patrilineal norms, which traditionally favor larger families and place significant emphasis on gendered roles within the household. This provides a crucial backdrop for analyzing the continuity and change in the socioemotional VOC and the negotiation of women's fertility decisions across generations, particularly as younger women gain increased exposure to education and external family planning discourse. We believe this revised section adequately addresses the reviewer's request by providing a concise and relevant socioeconomic and cultural background for the study location.

2.1. Data collection

Primary data were collected through semi-structured in-depth interviews. This method was selected to provide flexibility to the researcher in eliciting rich and detailed information, while also allowing participants to articulate their views and experiences freely (Kahlke *et al*., 2024; Lee, 2025). Each interview was audio-recorded after obtaining verbal consent of the informant and then transcribed verbatim for analysis. In addition to interviews, documentation (e.g., field notes on the socioeconomic conditions of the environment and non-verbal cues) was utilized to enrich the context and enhance the internal credibility of the findings. The researcher kept these field notes throughout the data collection, documenting the participants' socioeconomic setting, non-verbal cues, and interaction context, which aided in achieving a richer, more nuanced interpretation of the interview narratives and ensuring the findings were firmly grounded in the participants' lived reality. The semi-structured interview guide was developed based on the theoretical framework and was pre-tested with two non-participating women who met the general demographic criteria in a nearby

village to ensure clarity, flow, and cultural appropriateness of the questions. Examples of core questions included: "What is the ideal number of children and why?" and "What economic or emotional considerations influence your decision on family size?"

The in-depth interviews were conducted by the principal researcher and one trained research assistant. Data collection took place over a period of 6 months, specifically from January to June 2025. To ensure participant comfort and data richness, all interviews were conducted in private, comfortable settings, primarily within the participants' homes or on their verandas, to minimize distractions and establish rapport. The average duration of each interview was between 60 and 90 min. During the recruitment phase, three potential participants declined the interview request; two cited time constraints due to their daily work schedule, and one felt uncomfortable sharing personal details. All interviews were digitally recorded with the participants' explicit consent. Immediately following the interviews, the audio files were verbatim transcribed into Indonesian language by the research assistant to maintain data integrity and facilitate timely analysis.

2.2. Participants and characteristics

The participants in this study were women residing in Jrengik, a village located in Madura, Indonesia. The selection of this location was based on its characteristics as a rural area demonstrating demographic transition, yet still maintaining traditional values related to family and children. Selection criteria of participants in this study include: (a) married women who have children, and (b) adult women who have a biological mother or adult daughter in Jrengik village, thereby enabling the exploration of intergenerational dynamics. There was a total of 15 participants in the current study, consisting of five mother-daughter pairs and five other women representing middle generations or having unique experiences in fertility decisions. To maintain privacy and research ethics, all informants were assigned pseudonyms (e.g., "Mrs. Siti," "Rina," "Mrs. Ani,"). Participants were recruited through a combination of purposive and snowball sampling to identify women who met the study's specific intergenerational criteria. Initial contact was made with community leaders in Jrengik to explain the research's purpose and obtain their permission. Following this, the first participants were identified through personal networks and referrals from trusted local gatekeepers. These initial participants then helped to identify other potential participants, particularly mother-daughter pairs, from their own networks, ensuring the sample was representative of the target demographic within the village.

The intergenerational characteristics in this study form the core of the analysis. Participants were divided into two main categories: The mother's generation (typically aged 45 years and above), who grew up and made fertility decisions in an era with strong extended family support and different socio-economic conditions, and the daughter's generation (typically aged 20–40 years), who face more modern economic realities and have more educational opportunities and access to information. The primary reason for focusing on intergenerational characteristics is to identify how socio-cultural and economic factors influence the shift or continuity of rationality in fertility decisions from one generation to the next within the same household context (Amin *et al*., 2025: Samakya, 2024). This approach allows the researcher to observe the evolution of ideas about the "utility of children"—whether as productive assets, sources of consumption, or future security—that differ across generations due to changing social and economic contexts (Baigabulov, 2024; Okafor *et al*., 2021).

The number of informants (15 women) was decided based on the principle of data saturation, which is a key criterion in qualitative research for determining sample size. Saturation was assessed during the analysis process, where the research team continuously reviewed interview transcripts. We determined that data saturation was reached when no new themes, concepts, or significant insights emerged from successive interviews, particularly concerning the core research questions on economic, socioemotional, and old-age security rationalities. The inclusion of five mother-daughter pairs was a deliberate choice to provide a robust foundation for the intergenerational analysis, while the additional five women from the category of "middle generations or with unique experiences" were included to provide a broader context and ensure a diversity of perspectives beyond the direct mother-daughter dynamic.

2.3. Phenomenological method and analytical techniques

This study adopts an interpretative phenomenological analysis (IPA) approach for data analysis (Squires, 2023). IPA aims to deeply explore individuals' lived experiences and how they make sense of those experiences. This aligns with the research objective of understanding the subjective rationality behind fertility decisions. The data analysis process involved the following steps: (i) repeatedly reading transcripts to become familiar with the data, (ii) making initial notes and marginal comments, (iii) developing emergent themes from the initial notes, (iv) searching for connections between themes and grouping them into superordinate themes, and (v) constructing a coherent

narrative of informant experiences based on the identified themes (Smith & Fieldsend, 2021).

The analysis process followed a rigorous inductive thematic coding procedure, primarily executed by the principal researcher. The steps included repeated reading to achieve immersion; initial annotation and the creation of descriptive, linguistic, and conceptual codes; and the transformation of these codes into emergent themes. These themes were then grouped and linked to form superordinate themes that were mapped to the study's theoretical lenses (RCT and VOC). To enhance credibility and rigor, the thematic framework and initial codes were independently reviewed by a trained research assistant, and any differences in interpretation were discussed until a consensus was reached, ensuring inter-coder reliability and grounding the final thematic structure firmly in the participants' raw data.

The main theoretical analytical lenses used in this research are a modified RCT (Zhi-Xuan *et al*., 2024) and the VOC theory (Xia *et al*., 2024; Murray *et al*., 2025). RCT allows for an analysis of how individuals weigh costs and benefits in decision-making, while VOC theory provides a framework for understanding the diverse values attributed to children, whether economic (labor contribution, old-age security), social (status, continuation of lineage), or psychological (happiness, personal satisfaction). By integrating these two theories, this research can identify how women's rationality in fertility is not solely based on economic calculations but also on the construction of social and emotional values that change across generations.

2.4. Validation of findings

Validation of findings was conducted through methodological triangulation, involving the use of observation and documentation in addition to in-depth interviews, to ensure data consistency and richness (Schlunegger *et al*., 2024). Validation of findings was conducted to ensure the credibility and trustworthiness of the data. Triangulation of data sources was achieved by combining in-depth interviews with extensive field documentation. Specifically, observation was used during interviews to note participants' non-verbal cues (e.g., body language, facial expressions, and tone of voice). These observations helped to validate or contextualize their verbal responses, serving as a check for internal consistency and the truthfulness of the findings. Furthermore, member checking was performed by presenting a summary of findings to selected informants to ensure that the researcher's interpretations were accurate and represented their experiences (Lloyd *et al*., 2024). Peer debriefing with fellow qualitative researchers was also conducted to gain external perspectives and enhance the objectivity of interpretations. The credibility of the study is also upheld through a thick description of the informants' context and experiences, allowing readers to assess the transferability of the findings (Bang, 2024). It is important to note that, given the qualitative, in-depth nature of this study, the findings are not intended to be statistically generalizable to all rural Indonesian contexts. Instead, the rich, detailed narratives provide insights that are transferable to settings with similar socioeconomic and cultural characteristics. The study's limitations in transferability are a deliberate consequence of its focus on deep, subjective understanding rather than broad quantitative measurement, which is a common characteristic of interpretive phenomenological research.

3. Results

This section presents the key findings of the research concerning women's rationality in fertility decisions in Jrengik, with a focused lens on intergenerational dynamics. In-depth analysis of informant narratives reveals that women's rationality in determining family size is highly diverse and complex, extending beyond mere economic calculations to encompass evolving social, emotional, and future-oriented dimensions across generations. Three overarching themes emerged from the data: (i) Shifting economic rationality: From productive assets to consumption burdens, (ii) Socio-emotional rationality: Continuity and negotiation of values, and (iii) Future aspirations and old-age security rationality. Each theme will be critically elaborated upon and supported by direct quotes from informants, including their pseudonyms and ages, to highlight the nuanced generational perspectives.

3.1. Shifting economic rationality: From productive assets to consumption burdens

Findings indicate a significant generational shift in the economic rationality concerning children. The older generation (primarily late Baby Boomers or early Generation X, approximately 55–70 years old) tended to perceive children as vital productive assets, particularly within an agrarian context, and as guarantors of future family labor. In contrast, the younger generation (predominantly Generation Y or Millennials, approximately 30–55 years old) increasingly perceives children more as consumption burdens requiring substantial investment in education and healthcare, exacerbated by limited local economic opportunities and rising modern aspirations.

Mrs. Siti, aged 68 (representing the older generation), articulated a perspective deeply rooted in past economic realities:

> *Back then, having many children was no problem at all; it was even better. The children could help in the rice fields, collect grass, or look after their younger siblings. So, they were like extra hands helping us. The more children you have, the more blessings you get – that's what our elders used to say.*
>
> Mrs. Siti

Mrs. Siti's statement clearly frames children as "labor" and "bringers of blessings," reflecting a production-based rationality and traditional beliefs about the economic advantages of having numerous children in an agrarian setting. This rationality emphasizes the instrumental VOC in sustaining household economy and enhancing the family productive capacity. Her view underscores a period when direct economic contributions from children were immediate and tangible. This finding strikingly reveals how deeply ingrained the concept of children as economic capital was for older generations, a rationality fundamentally shaped by the agrarian subsistence economy. Field observations noted that during the interview, Mrs. Siti's grandchild (around 7 years old) came into the house and was immediately instructed by Mrs. Siti to go feed the chickens without being asked, demonstrating that the concept of children as readily available and non-negotiable labor remains prevalent in their household dynamics.

In sharp contrast, Rina, aged 32 (Mrs. Siti's daughter, representing the younger generation), offered a sharply contrasting perspective:

> *Now it's different, Mom. Just having one child already gives you a headache thinking about the costs. School is expensive, private lessons, not to mention if they get sick. Maybe in the past, children could be told to help with work, but now they have to get a high education so their future is good. So, children are a huge investment, not just adding labor.*
>
> Rina, Mrs. Siti's daughter

Rina's statement exemplifies the critical shift in rationality from "productive asset" to "investment burden" or "consumption burden." She does not perceive children as adding labor but rather as long-term investments demanding significant expenditure for education and a better future. This reflects an adaptation of rationality to changing local economic structures and rising educational aspirations, where the economic output from children is no longer direct but measured by their future potential through formal schooling. Rina's rationality is clearly dominated by the escalating costs of living and education, transforming children from potential income sources into major expenditure categories. The increasing urbanization and exposure to globalized norms through media also contribute to this shift in aspirations, making education a non-negotiable part of child-rearing. What is particularly compelling here is the complete inversion of economic logic; children, once a means of current production, are now primarily perceived as costly conduits to future upward mobility, highlighting a profound shift in developmental aspirations. Observational data supported this statement, showing that Rina and her husband lived in a home with more modern standards (ceramic floors and newer electronic appliances) compared to her mother's house, indicating higher consumption aspirations that directly correlate with their perception of the cost of raising children.

However, for some women of the middle generation, economic rationality did not fully shift from the productive to the consumptive model. They often navigate both perspectives. Santi (45 years old), a mother of three children, explained her dilemma:

> *In the past, my parents didn't think too much about school fees because there weren't as many options as there are now. We went to school as we could. My children now? They have to have this and that extra lesson, and school fees are expensive. But, I still want to have more than two children, so the house isn't quiet. Sustenance is already arranged, the important thing is that we try. If someone says children are a big expense, yes, that's true. But they are also the ones who will help us later, so they are an investment too.*
>
> Santi

This quote from Santi demonstrates that for the middle generation, children are viewed as a combination of a long-term investment (support in old age) and a short-term financial burden. Their perspective reflects a gradual transition in economic rationality, different from the more absolute views of either the mother's or daughter's generation. While the mothers' generation often saw children primarily as productive assets who would contribute to the family's labor and economy, and the daughters' generation perceives them as costly investments requiring significant financial outlay, the middle generation holds a more hybrid view. This duality indicates a socioeconomic middle ground, where traditional values about family size and mutual support coexist with the modern reality of rising living costs. Their willingness to embrace both a traditional belief in divine provision ("Fortune is already arranged") and a pragmatic awareness of financial burdens highlights the complex, transitional nature of their fertility decisions. This finding underscores that the shift in economic rationality is not an

abrupt break, but a fluid, generational negotiation between past and present values.

This generational divergence is further driven by the evolving labor market in Jrengik. With decreasing agricultural land and limited non-agricultural sectors, the role of children as productive household labor has become less relevant. As agricultural land decreases and non-agricultural sectors remain limited, the role of children as productive household labor becomes less relevant. Consequently, economic rationality has transitioned from prioritizing "quantity" to "quality" of children, where investment in education is seen as the primary pathway to improving future socioeconomic status, despite the higher financial implications. This dynamic illustrates a critical adaptation where economic rationality directly mirrors the changing opportunity structures in rural areas, pushing families toward a "quality over quantity" approach, a significant departure from traditional norms.

3.2. Socioemotional rationality: Continuity and negotiation of values

Beyond economic dimensions, socio-emotional rationality plays a crucial role in fertility decisions, though with varying emphases across generations. For the older generation, having many children was often intertwined with social status, lineage continuity, and fulfilling community expectations. In contrast, the younger generation tends to prioritize personal happiness, familial bonds, and the experience of parenthood, rather than succumbing solely to social pressure or status considerations.

Ibu Ani, aged 58 (older generation), emphasized the importance of children in maintaining family reputation:

> *Having sons is important, dear. To continue the family lineage, the family name. If there's no son, it feels incomplete. And if you have many children, people won't say strange things about our family, it feels more established.*
>
> Ibn Ani

Mrs. Ani's statement vividly illustrates a strong social rationality, where children—especially sons—are seen as guarantors of lineage continuity (a symbolic future) and indicators of social status within the community. This is a form of rationality where fertility is not solely about internal family needs but also about how the family is perceived externally. The number and gender of children become a reflection of social success and compliance with communal norms. This expectation places significant social pressure on women to produce certain outcomes, even if it contradicts personal desires. This profound attachment to lineage and social validation through fertility highlights how deeply collective identity and community perception previously shaped individual reproductive choices. The fact was reinforced by non-verbal observation; when Mrs. Ani spoke about the importance of having sons and the family lineage, her husband (who was sitting nearby) nodded in agreement with his eyes closed, suggesting that this rationality is strongly supported and maintained by the family's patriarchal structure.

Devi, aged 28 (Mrs. Ani's daughter, younger generation), offered a perspective leaning more toward emotional aspects:

> *My husband and I just want two children, that's enough. The important thing is that we can take good care of them, give them full affection, and we are happy. It doesn't matter if they are boys or girls, as long as they are healthy. What the neighbors say, well, that's their business.*
>
> Devi, Mrs. Ani's daughter

Devi's statement depicts a discernible shift from social rationality, driven by community expectations, toward an emotional rationality centered on personal satisfaction and the quality of relationships within the nuclear family. Success in fertility is no longer measured by the number of children or a specific gender, but rather by the parents' capacity to provide optimal care and foster happiness. The phrase "what the neighbors say, well, that's their business" strongly indicates an active negotiation and rejection of previously binding social norms. This is evidence of an increasingly individualistic rationality, where fertility decisions are more influenced by internal desires and parenting capacity, rather than the need to maintain an image or fulfill social expectations. This stark difference underscores a fascinating evolution in the perceived "value of children," moving from fulfilling external societal demands to prioritizing internal family well-being and personal fulfillment, signifying a growing sense of individual agency. The researcher observed that Devi's demeanor was very relaxed and her tone firm when stating this sentence. This underscores a high level of agency in her decision-making, which reinforces the finding that her rationality is driven more by personal emotional fulfillment than external social pressure. Despite these shifts, the emotional aspect of happiness brought by children remains a robust common thread across both generations, albeit with differing intensity and priority. Children are universally perceived as sources of joy and strengthen family bonds, a timeless value transcending generational changes. This enduring emotional connection to children, despite vast changes in other rationales, provides a powerful insight into the deeply human core of fertility desires, acting as a consistent motivator across all cohorts.

While the older generation often sees children as a source of family pride and a continuation of the family name, and the younger generation tends to focus on personal fulfillment, women from the middle generation often integrate these two values. They view children as a fusion of collective pride and personal happiness. Mrs. Ema (38 years old), a mother of two who works in a factory, shared her perspective:

> *My children have become a part of my life. When they succeed, I feel proud. It feels like more than just having money or a position. It's a happiness that cannot be bought. In the past, my mother said that many children were a sign of an honorable family. For me, having children is a sign that I am happy, and I can be proud to show that happiness to others.*
>
> Mrs. Ema

This quote demonstrates that for the middle generation, the emotional VOC is rooted in tradition but also adapts to modern concepts of personal happiness and satisfaction. It shows a nuanced understanding of children not just as agents of familial honor, but also as sources of individual fulfillment and joy. Unlike the more definitive views of their mothers (focused on lineage and family status) or their daughters (focused on personal aspirations and self-actualization), the middle generation's narrative represents a bridge between these two worlds. They hold a dualistic perspective, valuing both the collective pride that children bring to the family and the profound personal satisfaction that comes from raising them well. This duality underscores the transitional nature of their experiences, where inherited cultural values are renegotiated to fit a more individualized and modern context.

Despite these shifts (in economic rationality), the emotional aspect of happiness brought by children remains a robust common thread across both generations, albeit with differing intensity and priority. Children are universally regarded as a source of emotional fulfillment and stability, serving as the primary family binding element. We found that the need for emotional support, companionship, and lineage continuity is not negotiated; rather, it is maintained but redefined in line with the higher cost of living and increased investment in quality. For the older generation, the emotional VOC is often tightly intertwined with social support and security. They viewed children as an extension of their existence and community, traditionally expressed through pride in a large family: In the past, having many children was a pride and assurance. Children were our greatest source of happiness, and they never truly left us. If one was sick, the others were there. The house feels alive when it is full of the laughter of children and grandchildren. Conversely, the younger generation still views children as the main source of happiness, although this value is no longer associated with having a large number of children. Their focus has shifted from the "pride of quantity" to the "quality of emotion" and personal investment. They desire children for self-fulfillment, yet acknowledge that a greater investment per child yields a more focused happiness: "Of course, we want children. Without children, life feels incomplete; no one will carry on our name. But that happiness does not come from having five. I want two, so I can (give them the best education) and ensure they are happy. That is my happiness." (Participant of the Younger Generation) This transition from distributed emotional value to focused emotional value indicates that while the core VOC value—that children bring happiness—is retained, the rationality underpinning it has been reshaped by high consumption costs.

3.3. Future aspirations and old-age security rationality

The rationality concerning old-age security is another crucial aspect of fertility decisions, which is also undergoing generational adaptation. For the older generation, having many children was the primary strategy to ensure support and care in old age, given the absence of adequate formal social security systems. In contrast, the younger generation, while still acknowledging children's role in old-age security, is beginning to develop alternative strategies or hold more realistic expectations regarding children's support, reflecting increasing mobility and individualism among the youth.

Mrs. Kartini, aged 62 (older generation), expressed concerns typical of her cohort:

> *When I'm old like this, who else will take care of me if not my children? That's why I wanted many children back then, so there would be someone to look after me, to care for me when I'm sick. If there's only one or two, they'll be busy with their own lives, who will look after us?*
>
> Mrs. Kartini

Mrs. Kartini's statement clearly demonstrates a strong "old-age security" rationality, where children are viewed as "security assets" for the future. A large number of children serves as informal social insurance in rural communities with minimal public facilities and safety nets. This rationality is highly pragmatic, based on the fundamental need for care and support in old age within a context where formal safety nets are non-existent or inaccessible. This finding profoundly illustrates how for older generations, children were not just a blessing but an indispensable,

tangible form of future security, directly compensating for the lack of formal welfare systems. This context was validated by observation: as the interview took place, Mrs. Kartini was being cared for by one of her married daughters, and her physical movements appeared limited, visually confirming her current reliance on her children as the only system for care and old-age security.

However, Indah, aged 35 (Mrs. Kartini's daughter, younger generation), presented a more pragmatic and adaptive view:

> *I understand why my mother had many children; that was just how it was. But now, children also have their own lives. I cannot entirely expect my children to take care of me later. Maybe I need to have my own savings, or hope there's some government assistance.*
>
> Indah, Mrs. Kartini's daughter

Indah's statement reflects a rationality that begins to acknowledge the limitations of children as the sole old-age security. There is an awareness that children might have their own lives and priorities, reducing their capacity to fully care for their parents. This drives a new rationality that includes alternative strategies for old-age security, such as personal savings or reliance on formal social security systems (if available). It also indicates a higher degree of realism and independence in the younger generation, alongside social changes that promote individualism and mobility. Although the VOC as a form of security still exists, it is no longer the sole or most dominant consideration. This pragmatic view was supported by the context: Indah mentioned that her husband works outside the island (migration), justifying her feelings about the need to be financially independent and to plan for old-age security without fully depending on her children, who may also migrate. This striking shift highlights a critical evolution in how future security is conceptualized, moving from a sole reliance on familial support to a diversified strategy that includes personal financial planning and aspirations for broader social safety nets.

Collectively, these findings critically illustrate how women's rationality in fertility decisions in rural Indonesia is a multi-dimensional and continuously evolving phenomenon. The intergenerational shifts reveal adaptations to changing socioeconomic conditions, where economic considerations pivot from production to consumption, social values are being reinterpreted through emotional aspects, and old-age security is redefined by incorporation of alternative strategies. This indicates that population policies cannot assume a singular rationality but must instead comprehend the diversity and dynamics of underlying values that inform individual fertility decisions.

4. Discussion

This study has provided a qualitative, intergenerational exploration of women's rationality in fertility decisions within a rural Indonesian context, revealing nuanced shifts and enduring continuities in their reproductive choices. The findings challenge simplistic interpretations of fertility decline driven solely by macroeconomic factors or broad demographic transitions. Instead, they highlight how individual rationalities are deeply embedded in dynamic socioeconomic landscapes, personal aspirations, and evolving intergenerational dialogues. This discussion critically examines the themes identified in the Results section, connecting them to established theoretical frameworks and empirical evidence, and emphasizing the unique contributions of this research.

The observed generational shift from perceiving children as "productive assets" (older generation) to "consumption burdens" or "investment objects" (younger generation) significantly refines the application of RCT and the New Household Economics (NHE) in fertility studies. While NHE posits that fertility decisions are rational calculations balancing the costs and benefits of children (Matysiak & Vignoli, D. 2024; Jarosz *et al*., 2025), our findings demonstrate that the *nature* of these costs and benefits is not static. For Mrs. Siti's generation, the economic utility of children was direct and immediate, manifested in their contribution to agricultural labor and household production, aligning with classic demographic transitions in agrarian societies (Vizuete *et al*., 2024; Tong *et al*., 2024). Children were indeed a form of human capital that directly supported family sustenance and prosperity.

However, Rina's perspective reveals a critical evolution. As rural economies diversify and educational aspirations rise, the "value" of children shifts from their immediate productive capacity to their long-term potential as educated individuals capable of securing non-agricultural livelihoods. This transition implies that the "cost" component in the fertility equation dramatically increases, encompassing not just basic sustenance but substantial investments in schooling, healthcare, and skill development (Dai *et al*., 2025). This mirrors trends observed in other developing regions where rising educational and consumption aspirations lead to lower desired family sizes (Asratie *et al*., 2024; Fauser *et al*., 2024). The qualitative narratives powerfully illustrate that "rationality" itself adapts to changing economic realities and perceived opportunities, demonstrating that women are actively recalibrating their fertility decisions based on

these shifting economic landscapes rather than passively reacting to external forces. This nuance underscores that while economic rationality persists, its specific manifestations are highly context-dependent and evolve intergenerationally, rendering a simplistic, universal cost-benefit framework insufficient. Intriguingly, this finding critically enriches the RCT and the New Household Economics by demonstrating how the economic rationality concerning children is a dynamic, not static, construct, which is highly relevant for understanding modern fertility transitions.

The study's findings on socioemotional rationality highlight a fascinating interplay between continuity and negotiation of values across generations. The older generation's emphasis on lineage continuity, social status, and communal acceptance through fertility aligns with classic sociological interpretations of the "value of children" as a source of social recognition and fulfillment of societal expectations (Riley & Chatterjee, 2022; Thi *et al*., 2021). Mrs. Ani's strong desire for sons to continue the family name reflects deeply ingrained patriarchal norms prevalent in many traditional societies, where male offspring secure social legitimacy and symbolic immortality (Tartakovsky & Mizrahi, 2025). This perspective demonstrates how fertility decisions are not merely individual choices but is profoundly shaped by collective social pressures and the desire to conform to community ideals.

In contrast, Devi's prioritization of personal happiness, spousal bonding, and the quality of parenting over external validation signifies a gradual, yet powerful, shift toward a more individualized socioemotional rationality. Her assertion, "What the neighbors say, well, that's their business," eloquently captures a growing sense of individual agency and a renegotiation of traditional social contracts. This finding resonates with the "Second Demographic Transition" theories, which emphasize increasing individualism, self-fulfillment, and autonomy in life choices, including reproduction (Musni & Schnor, 2025). While the emotional satisfaction derived from children remains a strong, continuous motivator across both generations (Wang *et al*., 2024), the sources of emotional and social fulfillment appear to be diversifying. Younger women are less bound by collective social demands and more driven by intrinsic desires for a smaller, well-managed family that can be nurtured optimally. This nuanced finding is crucial, as it suggests that policies aimed at influencing fertility should not only address economic factors but also acknowledge and support women's evolving desires for personal fulfillment and their increasing capacity to negotiate traditional social pressures, fostering greater reproductive autonomy. This is highly engaging for discussion within the lens of the Second Demographic Transition Theory, as it empirically demonstrates how post-materialistic values and individualism are gradually permeating fertility decisions at the micro-level in rural areas, even within highly communal contexts.

The dynamic around old-age security rationality represents another compelling area of intergenerational divergence. For Mrs. Kartini's generation, the decision to have many children was fundamentally a pragmatic, rational response to the absence of formal social security systems (Harris, 2025). Children were viewed as essential, tangible "security assets" for care and financial support in old age, a strategy prevalent in societies undergoing early stages of demographic transition. The fear of being uncared for in old age served as a powerful incentive for higher fertility, illustrating a clear rational calculation under conditions of vulnerability.

However, Indah's more nuanced perspective reveals a significant adaptive shift. While still acknowledging the potential role of children, her generation is actively seeking diversified strategies for old-age security, including personal savings and a nascent hope for government assistance. This indicates a growing awareness that traditional familial support systems may be strained due to children's increased mobility, individual career paths, and smaller family sizes. This transition highlights a movement away from a sole reliance on children as an "informal social safety net" toward a more complex, multi-pronged approach that reflects both changing societal structures and increased individual resourcefulness (Radey *et al*., 2024). The emerging reliance on personal savings and the aspiration for formal social security systems align with broader development trends, where states gradually assume greater responsibility for welfare provision, and individuals play more active roles in financial planning (Agudamu *et al*., 2025; Liang *et al*., 2025). This evolving rationality suggests that as societies develop, the traditional "old-age security" motive for high fertility gradually weakens, paving the way for fertility decline driven by new forms of "rational" future planning. Critically, this finding enriches our understanding of old-age security rationality within the framework of RCT, demonstrating how individuals adaptively shift their "insurance" strategies from solely relying on children to diversification, reflecting changes in socioeconomic context and access to formal security mechanisms.

The central finding of this study—the intergenerational shift from the production rationality (economic benefit) to the consumption rationality (costly investment in quality)—is not unique but is significantly nuanced by the specific Madurese rural context. This pattern

aligns broadly with the global Second Demographic Transition theory, which links declining fertility to rising individualism and investment in child quality. However, our qualitative data contrasts with purely quantitative studies from other Indonesian regions by demonstrating that this shift is not linear. Our older generation still retains high socio-emotional values, which differ from highly urbanized contexts where modernization has often fully eroded the multi-utility of children. Furthermore, while quantitative studies emphasize education and income (Kizza & Wasswa, 2024), qualitative research often highlights cultural and social capital factors. We compare and extend this by showing that the younger generation's rationale is driven less by the availability of family planning and more by an aspirational rationality, the fear of failing to provide a "quality life" due to high consumption cost a finding that resonates strongly with recent qualitative work in transitional societies (Klug *et al*., 2024). This comparative approach reinforces the novelty of our work in highlighting the dynamic negotiation of "utility" within a specific cultural lineage.

This intergenerational study critically illuminates the intricate layers of women's rationality in fertility decisions within a specific rural Indonesian context. The findings provide compelling empirical evidence that challenges reductionist views of fertility behavior. Instead, they demonstrate that women's reproductive choices are products of dynamic, adaptive rationalities shaped by profound shifts in economic realities, evolving socioemotional values, and diversifying strategies for old-age security across generations. This research underscores that "rationality" in fertility is not a static, universal concept, but a context-sensitive and historically contingent process, constantly being re-evaluated by individuals in response to changing opportunities and constraints. Understanding these deeply personal, yet socially embedded, rationalities is paramount for developing more effective, equitable, and culturally sensitive population policies that truly empower women and foster sustainable demographic futures globally. The study's unique focus on intergenerational narratives offers a vital qualitative lens, complementing existing quantitative research and enriching our theoretical understanding of complex fertility transitions.

5. Conclusion

This intergenerational qualitative study on women's rationality in fertility decisions in rural Jrengik, Madura, offers critical insights into the complex dynamics shaping family size. The core finding is that women's rationality in reproductive choices is not static or singularly driven by economic utility, but rather a fluid and adaptive construct that evolves significantly across generations, influenced by changing socio-economic landscapes and cultural aspirations.

The research reveals a compelling shift in economic rationality, moving from the older generation's perception of children as indispensable productive assets to the younger generation's view of them as substantial consumption burdens. Simultaneously, the study highlights an evolution in socioemotional rationality, where the emphasis shifts from fulfilling communal expectations toward prioritizing individual happiness and the quality of parent-child relationships. These intergenerational divergences underscore that fertility decisions are continuously re-evaluated by women, reflecting their agency in response to changing societal norms and economic realities.

Ultimately, this study contributes significantly to demographic discourse by enriching the RCT and the VOC framework, providing empirical depth through nuanced qualitative data that demonstrates how these theoretical constructs manifest and transform at the micro-level within a specific cultural context.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Formal analysis: Anita Kristina
Investigation: Boby Candra Pamungkas
Methodology: Anita Kristina
Writing–original draft: Anita Kristina
Writing–review & editing: Anita Kristina

Ethics approval and consent to participate

This study, which involved human subjects, was approved by the Research Ethics Committee of the University of Trunojoyo Madura (ethics approval number B/6758/UN46.4.1/PT.01.01/2025). The committee approved the research methodology and declared it ethically appropriate according to the seven WHO 2011 standards, namely: (1) social values; (2) scientific values; (3) equal distribution of burdens and benefits; (4) risk; (5) exploitation; (6) confidentiality and privacy; (7) consent after explanation, in compliance with the 2016 CIOMS Guidelines. This is shown by the fulfillment of

the indicators for each standard. Prior to each interview, verbal consent was obtained from every participant. The participants were informed of the study's purpose, their right to withdraw at any time, the voluntary nature of their participation, and the confidentiality of their responses. Their willingness to be interviewed and audio-recorded was confirmed and documented by the researchers.

Consent for publication

Verbal consent was obtained from each participant to use their interview data for research and publication purposes. To protect the privacy and confidentiality of the subjects, all identifying information, including their names, has been masked or concealed by assigning pseudonyms (*e.g.*, "Siti," "Santi"). The data presented in this article is anonymized to ensure that no individual can be identified.

Availability of data

The datasets generated and/or analyzed during the current study are not publicly available due to the sensitive nature of the qualitative data, which contains personal and confidential narratives of human subjects. However, the data are available from the corresponding author on reasonable request for academic purposes, contingent upon compliance with ethical standards protecting participant confidentiality.

Further disclosure

This article is based on the findings from a bachelor's thesis that has been academically examined and approved. The paper has not been previously published, uploaded to a preprint server, and presented at any conference, academic meeting, or congress.

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ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Demographic transition and opportunities for development in Bangladesh from 1971 to 2100

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Abstract

There is significant variation in estimates and assumptions about Bangladesh's demographic trajectory, highlighting the need for reassessment. This study primarily utilizes data from the 2022 Revision of the World Population Prospects to examine the demographic transition in Bangladesh and highlight a key window of opportunity. It provides a comprehensive examination of population structure, fertility, mortality, and labor force participation to contextualize the transition stages. The analysis underscores that the theory of demographic transition cannot be applied universally as a "one-size-fits-all" model. The study demonstrates that, by analyzing the common features associated with the demographic transition, including birth rates, death rates, and population trends, a country can determine its specific stage in the transition process. In the case of Bangladesh, while categorized as a lower-middle-income nation, it has reached the fourth stage of demographic transition as of 2020. This is a notable development, as many lower-middle-income countries remain in earlier stages of transition. The study emphasizes that the period from 2020 to 2037 is critical for Bangladesh to realize the maximum demographic dividend. This opportunity hinges on ensuring that the working-age population has access to quality healthcare, education, and employment opportunities. The study also underscores the importance of creating employment opportunities, with a particular emphasis on increasing female labor force participation and skill development, as well as integrating socioeconomic, cultural, and gender considerations into demographic analyses. In addition, proactive planning for an aging population post-2037 is crucial to maintaining the demographic dividend and addressing economic and social challenges. Harnessing this window wisely will determine Bangladesh's long-term socioeconomic resilience and sustainable development trajectory.

Keywords: Bangladesh; Demographic transition; Demographic window of opportunity; Demographic dividend; Population pyramid

1. Introduction

Births, deaths, and migration are fundamental drivers of population size and age–sex distribution. Long-term shifts in these components shape population growth or decline. Historical and contemporary data indicate that, in most countries, mortality declines typically precede fertility declines. Consequently, countries experience a phase of population growth followed by a phase of population shrinkage, a phenomenon known as the "demographic transition" (Notestein, 1945; Thompson, 1929). The demographic transition essentially describes the evolution of a population from a pre-modern agricultural society marked by high birth and death rates to a post-modern urban industrial society characterized by low and stable birth and death rates (Bloom & Williamson, 1998; Kirk, 1996). While the five stages of the classical demographic transition model are well-documented (Cilliers, 2018), they are summarized as follows: an initial phase of high birth and death rates; a phase of declining mortality with sustained high fertility; a phase of rapid fertility decline; a phase of slow fertility decline and sustained low mortality; and finally, a phase of low, stabilized fertility and mortality. Some countries experience a fifth stage of very low stabilized fertility and mortality.

While the classical model serves as a useful heuristic, it assumes a linear and universal pathway. In this study, we adopt a more expansive conceptual framework that incorporates demographic dividend theory and the interplay between development and demography. This approach enables us to analyze Bangladesh's trajectory as a dynamic and policy-sensitive process rather than a predetermined route. By doing so, we transcend a merely descriptive presentation of indicators and contribute a unique conceptual perspective to the existing literature. We present empirical evidence from Bangladesh's post-independence period and critically assess how the country's experience challenges conventional applications of the model.

1.1. Literature review

Demographic transition presents various demographic, social, and economic opportunities and challenges (Bloom & Williamson, 1998; Kalemli-Ozcan, 2003; Mason & Lee, 2006; M. M. Islam, 2020; Navaneetham & Dharmalingam, 2012; Spoorenberg, 2008). The opportunities are time-sensitive and depend on policies targeting health, education, and employment. Importantly, the demographic changes can also yield significant social and economic advantages, commonly referred to as the "demographic dividend" or "demographic bonus" (Chalise, 2018). However, the demographic dividend is not automatic; its realization depends on socioeconomic, cultural, and policy contexts that shape health, education, gender equality, and labor market participation (United Nations Population Fund [UNFPA], 2022). The timeframe during which a country can capitalize on this demographic dividend is known as the "demographic window of opportunity" (Chalise, 2018). During this window, a nation typically has a large proportion of its population in the working-age group, characterized by good health, quality education, and decent employment opportunities, alongside a lower ratio of young and elderly dependents. With fewer children per household, families can often invest more in each child's development, provide greater opportunities for women to participate in the formal workforce, allocate additional resources to previously unaffordable needs, and enhance savings for retirement. Furthermore, with fewer older adults in households, healthcare and living costs tend to be lower for this demographic. When these elements align, the country's economic benefits can be substantial, enabling it to fully harness its demographic dividend (UNFPA, 2016).

This singular opportunity may not necessarily guarantee positive outcomes (UNFPA, 2022). The yield of the demographic dividend largely depends on how effectively a country prepares and organizes support for its population, particularly concerning good health, quality education, and decent employment for its working-age population (UNFPA, 2016). The literature suggests that countries that fail to align these factors often experience "demographic traps," in which the potential dividend does not translate into economic gains (Bairagi & Datta, 2001). To secure the demographic dividend, investing in infrastructure and human resource development is vital before the demographic window of opportunity (Haider, 2019). Thus, the demographic dividend should be viewed as both a theoretical and a practical construct reflecting the intersection of population dynamics with social policy, governance, and economic planning rather than as an automatic by-product of demographic change.

Numerous nations have previously undergone demographic transition and experienced low birth and death rates (Bongaarts, 2008). Bangladesh has also undergone several stages of demographic transition and may have opened the demographic window of opportunity. However, recent studies show considerable variation in estimates and assumptions about Bangladesh's demographic trajectory, underscoring the need for a critical reassessment (Karim *et al.*, 2025; S. Farid & Mostari, 2022). For instance, one study indicated that Bangladesh began reaping its demographic dividend in 1980, with the window remaining open until 2020 (Navaneetham &

Dharmalingam, 2012). Conversely, another study suggested that the demographic window of opportunity emerged in 1980 and would continue for 60 years until 2040 (Matin, 2012). A third study reported that this window began in the 1990s, peaked during the 2020s, and would remain open until the 2030s (M. M. Islam, 2016). More recently, a study asserted that the potential window of opportunity in Bangladesh opened in 1984 and is projected to last until 2037 (S. Farid & Mostari, 2022). Esha & Farid (2021) emphasized the challenges of sustaining the demographic dividend, particularly in the context of urbanization, migration, and gender disparities, while Streatfield & Karar (2008) documented the evolving policy landscape. These differences highlight the importance of addressing data uncertainties, considering regional and gender differences, and situating Bangladesh's demographic transition within both policy and international contexts.

1.2. Objectives

Against this backdrop, this study reassesses both the timing of the demographic transition and the window of opportunity in Bangladesh from 1950 to 2100. It does so not only by evaluating whether the five stages of demographic transition are evident in historical data but also by applying an expanded conceptual framework that links age–structure change to policy variables, such as female labor-force participation, education and skill development, migration flows, and health policy. By situating Bangladesh's experience alongside international evidence, we identify the conditions under which the demographic dividend can be maximized or lost. This integrated approach underscores the study's unique contribution beyond existing literature. Specifically, we investigate the timing of the demographic window of opportunity to identify the optimal period for maximizing the demographic dividend. Finally, by analyzing population pyramids at both the beginning and the end of the demographic window, we examine the distribution of the economically active and inactive population by age and sex, which has significant implications for harnessing the demographic dividend in Bangladesh.

2. Data and methods

2.1. Data

This study utilized de-identified population-level data sourced from three key secondary sources: the 2022 Revision of the World Population Prospects (United Nations [UN], 2022a), the World Bank (WB) (WB, 2020a), and the International Labor Organization (ILO) (International Labor Organization, Department of Statistics [ILOSTAT], 2020). The data include single-year population estimates and medium-variant projections, along with metrics, including the crude birth rate (CBR), crude death rate (CDR), rate of natural increase (RNI), net reproduction rate (NRR), total fertility rate (TFR), infant mortality rate (IMR), and life expectancy at birth (LE_0) in Bangladesh from 1950 to 2100, all sourced from the 2022 Revision of the World Population Prospects. These specific metrics were emphasized because they directly capture generational replacement (e.g., NRR), population momentum (e.g., RNI), and key health and fertility dynamics (e.g., TFR, IMR, and LE_0). The 2022 Revision of the World Population Prospects employs the cohort–component method and future survival probabilities to project total population figures (UN, 2022a). In addition, the labor force participation rate (LFPR)—defined as the proportion of the total population aged 15–64 years who are economically active—was obtained from the WB for the period 1990–2019. Due to the unavailability of post-2019 data, we carried the 2019 age-specific rates forward until 2100. We acknowledge that these model-based estimates may not fully capture regional or informal-sector employment, seasonal migration, or gender disparities, and therefore may not precisely quantify the working-age economic potential. Furthermore, data on the LFPR by 5-year age groups for individuals aged 15–59 in 2019, used to create the population pyramid, were sourced from modeled estimates by the ILO. To enhance robustness, we triangulated across multiple sources and explicitly discussed potential margins of error and assumptions in Section S1.

2.2. Measurements

This study used various standard demographic and economic indicators based on international definitions (ILOSTAT, 2020; UN, 2022a). The economically active population (EAP) comprises individuals aged 15 to 59 who participate in the labor market and produce goods and services during a specific period. In contrast, the economically inactive population (EIP) comprises individuals in the same age range who are not engaged in such activities.

The CBR and CDR represent the number of live births and deaths per 1000 people in the mid-year population, respectively. The RNI is the difference between the CBR and the CDR. The TFR indicates that the average number of children a woman would have over her reproductive years (ages 15–49), while the NRR estimates the average number of daughters a woman would have, accounting for mortality. The IMR reflects the probability of dying before age one per 1,000 live births. LE_0 indicates the average number of years a newborn is expected to live based on current mortality conditions.

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2.3. The outcome variable for the timing of the demographic window

Using a dependency-ratio-based approach, the demographic window is defined as the period during which the proportion of the working-age population (ages 15–59) outnumbers both dependent children (ages 0–14) and older adults (ages 60 and above), yielding the lowest total dependency ratio. This period represents a significant opportunity for a country to potentially maximize its demographic dividend. In this study, we identify the demographic window as the years when the working-age population comprises approximately 64–65% of the total population and when dependency ratios reach their minimum levels.

2.4. Analytical strategies

Bangladesh achieved its independence in 1971, and our main analysis focuses on the period from 1971 to 2100. However, to capture the full demographic trajectory, pre-independence trends (1950–1970) are also included for contextual understanding, particularly for the first stage of the demographic transition. To explore the demographic transition and window of opportunity in Bangladesh, we plotted CBR, CDR, and total population from 1950 to 2100. From 1971 to 2100, we categorized the total population into three broad age groups: (i) children aged 0–14 years, (ii) working-age individuals aged 15–59 years, and (iii) older adults aged 60 years and above. This categorization reflects national retirement and old-age conventions and aligns the analysis with international demographic research. In various sectors, Bangladesh defines old age as 60 and older, with a retirement age of 59 years (M. S. Islam *et al.*, 2022). The working-age population was further segmented into the EAP and the EIP. We then plotted the total population by these broad age groups from 1971 to 2100 to assess Bangladesh's demographic window of opportunity.

In addition, population pyramids were generated at the beginning and end of the demographic window of opportunity to visualize age–sex composition and the proportion of economically active versus inactive populations. Subsequently, we plotted RNI, NRR, TFR, IMR, and LE_0. Rather than treating these indicators as purely descriptive, we interpret them through an expanded theoretical lens that integrates demographic dividend theory and development–demography interactions. This enables us to critically examine the conventional model, highlight the policy sensitivity of Bangladesh's demographic trajectory, and explore potential deviations resulting from climate, migration, or labor-force shocks. We provide a detailed discussion of assumptions and methodological constraints—including data uncertainties, margins of error, and the possibility that global projections may mask national or regional variations—to ensure transparency and enhance the robustness of our conclusions in Section S1.

3. Results

3.1. Stages of the demographic transition in Bangladesh

Figure 1 presents the CBR, CDR, and total population trends, illustrating Bangladesh's various stages of demographic transition from 1950 to 2100. The conventional characteristics of demographic transition stages and their corresponding CBR and CDR trends (Cilliers, 2018) do not match exactly with Bangladesh's CBR and CDR trends. Therefore, based on the similarities observed between conventional transition characteristics and Bangladesh's trends, five stages of demographic transition are identified from 1950 to 2100.

From 1950 to 1970, Bangladesh (formerly East Pakistan) was in the first stage of demographic transition. This stage was characterized by high CBR, high but fluctuating CDR, and a slow but steady increase in population from 39.7 to 67.5 million. The second stage of transition began in 1971. It continued until 1985, characterized by high but decreasing CBR, rapidly declining CDR, and a rapid increase in population from 68.4 to 96.0 million. The Liberation War contributed to the high CDR of 41.0 in 1971, and the CDR was 17.1 in 1972. The third stage of the demographic transition began in 1986. It continued up to 2019, characterized by decreasing CBR, a slow decline in CDR, and a rapid increase in population from 98.3 to 165.5 million (for yearly data on CBR, CDR, and total population, Table S1). The increase in population slowed down at the end of this stage.

The fourth stage of the demographic transition started in 2020. It is estimated to continue until 2067 and may not resemble the conventional characteristics of the fourth stage of demographic transition. In the fourth stage of demographic transition, Bangladesh is estimated to experience a slow declining CBR, rising CDR, and increasing population from 167.4 million in 2020 to a peak of 206.9 million in 2060–62, then to 205.9 million in 2067. The fifth stage of demographic transition is projected to start in 2068 and continue until 2100. The characteristics of the fifth stage of demographic transition in Bangladesh may not follow the conventional characteristics. In the fifth stage, Bangladesh will experience a very slow decline in CBR, a slow rise in CDR, and a decline in population from 205.5 to 176.4 million. The five stages of demographic transition, along with their intrinsic characteristics for Bangladesh, are outlined in Table 1.

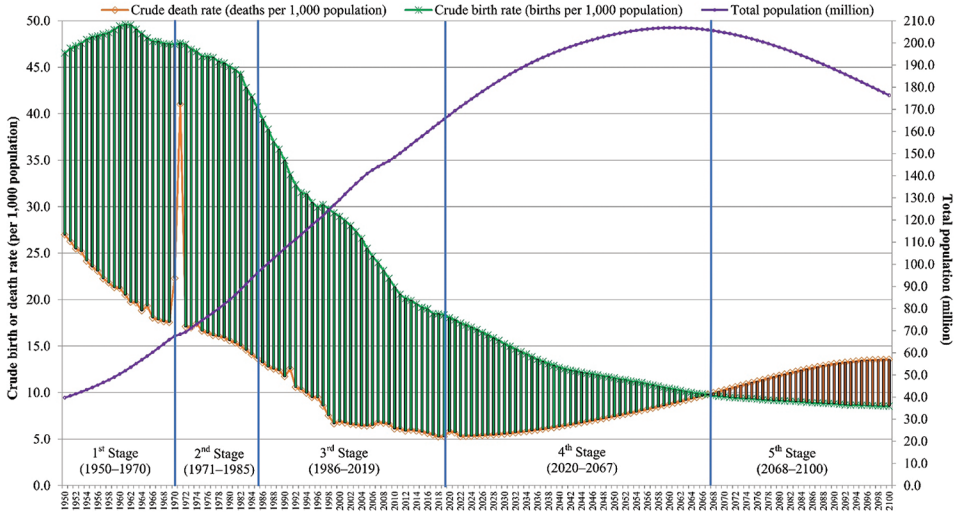

Figure 1. Stages of the demographic transition in Bangladesh from 1950 to 2100
Source: Authors' calculations based on data from the 2022 Revision of World Population Prospects (UN, 2022a).

Table 1. Conventional (and intrinsic for Bangladesh) characteristics of birth rate, death rate, and natural increase by stage of demographic transition

Stage of demographic transition	Characteristics	Birth rate	Death rate	Natural increase
First stage	Conventional	High	High	Stable or slow increase
	Intrinsic for Bangladesh	High	High but fluctuating	Slow but steady increase
Second stage	Conventional	High	Falls rapidly	Very rapid increase
	Intrinsic for Bangladesh	High but falling	Rapid declining	Rapid increase
Third stage	Conventional	Falling	Falls more slowly	Increase slows down
	Intrinsic for Bangladesh	Falling	Slow declining	Increase slows down at the end of the period
Fourth stage	Conventional	Low	Low	Falling and then stable
	Intrinsic for Bangladesh	Slow declining	Rising	Falling at the end of the period
Fifth stage	Conventional	Raising again	Low	Stable or slow increase
	Intrinsic for Bangladesh	Very slow declining	Slow rising	Falling

Source: Authors' calculations based on data from the 2022 Revision of World Population Prospects (UN, 2022a).

3.2. Fertility, mortality, and demographic window of opportunity in Bangladesh

After the 1971 Liberation War, Bangladesh experienced a high TFR of 6.8 births per woman and a high IMR of 151.3 deaths per 1,000 live births in 1972 (Figure S1 and Table S1). Since then, both the TFR and IMR have declined rapidly, reaching 2.0 and 24.0, respectively, in 2020. Demographic transition was dynamic over the period, resulting in longer LE_0 and a "demographic window of opportunity."

Due to high fertility and mortality, the age composition in Bangladesh was almost constant until 1990, with 42.9–45.5% of children aged 0–14 years, 49.4–51.8% working-age population aged 15–59 years (29.0–30.4% EAP and 20.4–21.4% EIP aged 15–59 years), and 5.1–5.5% older adults aged ≥60 years (Figure 2 and Table S2). The influence of successive fertility and mortality decline on the age composition is evident in 2012, with an increase in the older adults population aged ≥60 years by 1.5% percentage points, an increase in EAP aged 15–59 years by 5.2% percentage points, and EIP aged 15–59 years by 3.8% percentage points, and a decline in the children population. Apparently, the population is aging gradually over time. In 2020, the working-age population aged 15–59 years accounted for 64.3%, the older adults aged ≥60 years accounted for 8.8%, and children accounted for 27.0%. The percentage of the working-age population aged 15–59 years is estimated to reach its peak at 65.1% from 2024 to 2027 and to remain almost the same (64.0%)

from 2020 to 2037. This indicates that in the next 17 years, from 2020 to 2037, the country will add 26.1 million people to its total population, but there will be no change in the percentage of the working-age population and the dependents (sum of children and older adults; considering no unemployment among the working-age population) due to declining fertility and mortality. Consequently, the period from 2020 to 2037 appears to be the window of opportunity for reaping the highest demographic dividend in Bangladesh.

3.3. Population pyramid and proportion of working-age population during the demographic window of opportunity in Bangladesh

Figures 3 and 4 present the population pyramids of Bangladesh for 2020 and 2037, respectively, which illustrate

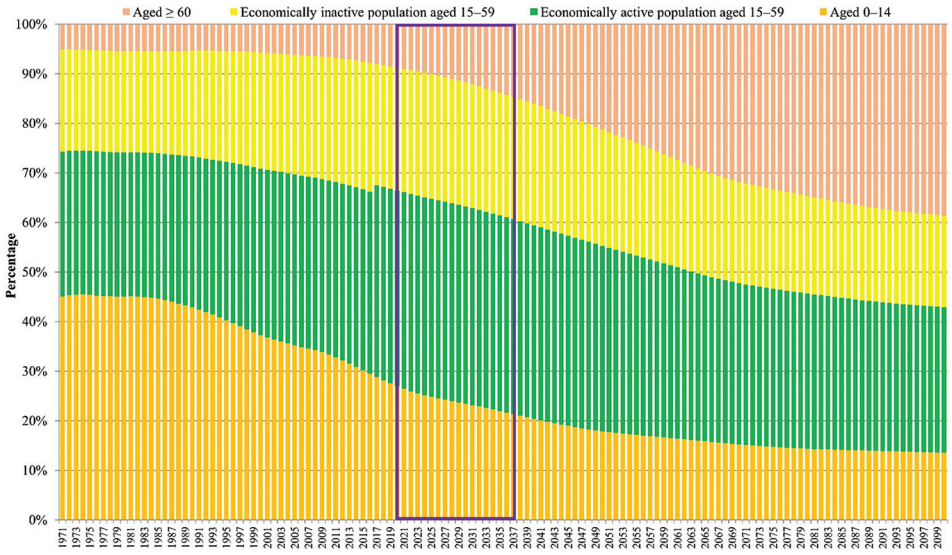

Figure 2. Percentage of total population by broad age groups (0–14, economically active population aged 15–59, economically inactive population aged 15–59, and ≥60) from 1971 to 2100, and the demographic window of opportunity from 2020 to 2037
Source: Authors' calculations based on data from the 2022 Revision of World Population Prospects (UN, 2022a), the World Bank (WB, 2020), and the International Labor Organization, Department of Statistics (ILOSTAT, 2020).

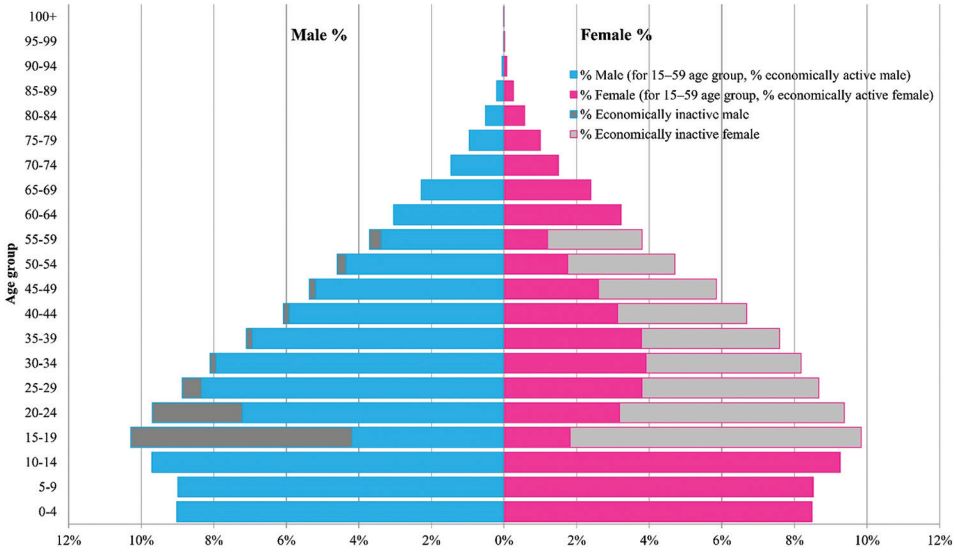

Figure 3. Population pyramid of Bangladesh in 2020
Note: The latest available sex-specific labor force participation rate for 2019 was used to generate the economically active and inactive population for 2020.
Source: Authors' calculations based on data from the 2022 Revision of World Population Prospects (UN, 2022a), the World Bank (WB, 2020), and the International Labor Organization, Department of Statistics (ILOSTAT, 2020).

the changes in population composition by age and sex at the beginning and end of the demographic window of opportunity (the corresponding values are provided in Table S3). With declining RNI and increasing LE_0 (Figure S1), the 2020 age–sex pyramid appeared to be an expansive but aging population pyramid (Figure 3). With 27% children, 64.3% working-age population, and 8.8% older adults, the highest percentage of the population (20.1%) stayed in the age group of 15–19 years. The proportion of the EIP decreased with increasing age. Among the working-age population, females have a larger share of the EIP than males. Moreover, females aged 15–59 years were disproportionately likely to be economically inactive.

With further declines in RNI and increasing LE_0 (Figure S1), the 2037 age–sex pyramid still appears to be an expansive but aged population pyramid (Figure 4). With 21.4% children, 64.0% working-age population, and 14.7% older adults, the highest percentage of the population (16.1%) would stay in the age group of 30–34 years. As the pyramids show males (100% in total) on the left side and females (100% in total) on the right side, despite using the latest available sex–specific LFPR of 2019 for 2020 to 2100, the proportions of the economically active and inactive population in 2037 appear to be only slightly different from what they were in 2020.

4. Discussion

This study employs comprehensive data, primarily sourced from the 2022 Revision of the World Population Prospects, to delineate the stages of demographic transition in Bangladesh. It also identifies a demographic window of opportunity between 2020 and 2037, offering significant potential for capitalizing on the demographic dividend. Furthermore, the study illustrates population pyramids that display EAP and EIP aged 15–59 at the beginning and end of this demographic window. By integrating empirical data and conventional demographic transition theory, this study provides a nuanced understanding of Bangladesh's population dynamics, extending prior work that focused largely on descriptive trends. In addition, this analysis places Bangladesh's demographic transition within the broader global context. For example, countries in East Asia, such as South Korea and Singapore, have successfully maximized their demographic dividends through early and large-scale investments in education, industrialization, and governance reforms. In contrast, many sub-Saharan African countries have faced challenges due to weak labor markets and institutional barriers (Mason & Kinugasa, 2008). Bangladesh represents an intermediate case—it has experienced a rapid decline in fertility (WB, 2020b); however, persistent structural constraints, such as limited job creation and gender differences in participation, may hinder the full realization of the dividend. The insights from this study are intended to assist the government and policymakers in crafting a strategic roadmap to effectively leverage the working-age population, particularly the inactive female population, to pursue Bangladesh's economic and sustainable development goals.

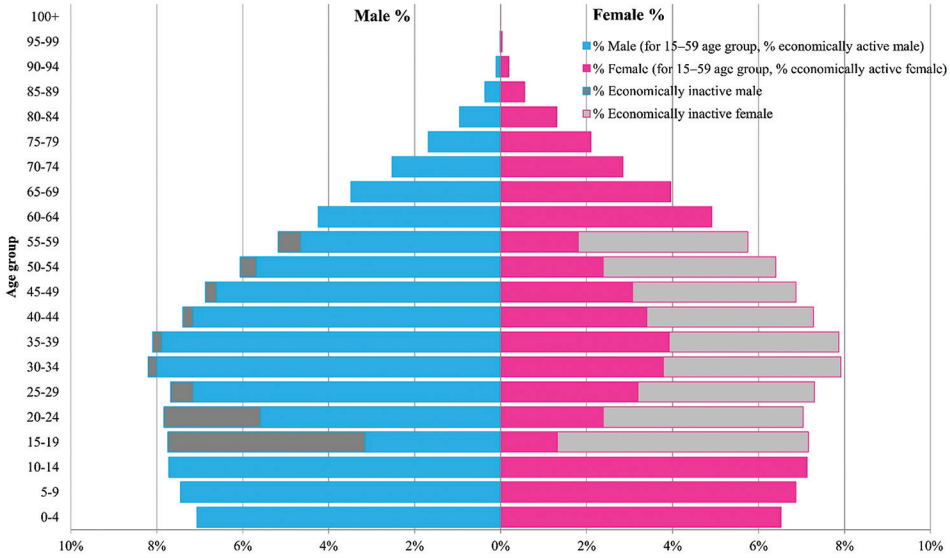

Figure 4. Projected population pyramid of Bangladesh in 2037
Note: The latest available sex-specific labor force participation rate for 2019 was used to generate the economically active and inactive population for 2037.
Source: Authors' calculations based on data from the 2022 Revision of World Population Prospects (UN, 2022a), the World Bank (WB, 2020), and the International Labor Organization, Department of Statistics (ILOSTAT, 2020).

The present study indicates that Bangladesh entered the second stage of the demographic transition in 1971 and completed it in 1985. Subsequently, it entered the third stage in 1986 and ended in 2019. Bangladesh began the fourth stage of demographic transition in 2020 and is expected to transition to the fifth stage in 2068, following its completion of the fourth stage in 2067. These timelines provide clarity in a context where prior studies have presented inconsistent stage durations (M. M. Islam, 2016; S. Farid & Mostari, 2022), highlighting the value of systematic, long-term empirical assessment. In analyzing Bangladesh's five stages of demographic transition, along with their characteristics and timelines, it is essential to consider both conventional characteristics (Table 1) and empirical data (Figure 1). However, these timelines should not be interpreted as fixed or deterministic; instead, they are contingent on socioeconomic transformation, policy effectiveness, and external shocks, such as migration, climate-related displacement, and public health crises. This recognition highlights the sensitivity of demographic projections and underscores the need for flexible, adaptive planning.

Theoretical understanding suggests that during the fourth stage of demographic transition, birth and death rates are low, resulting in stable population growth. Typically, most developed countries—characterized by stronger economies, higher levels of education, better healthcare systems, a greater proportion of working women, and a fertility rate of around two children per woman—are considered to be in this stage (Grover, 2014). The trends presented in Figure 1 do not align with the demographic transition theory. With a fertility rate of about two children per woman, Bangladesh is categorized as one of the lower-middle-income countries facing significant structural barriers to sustainable development (WB, 2024). Notably, the Bangladesh Demographic and Health Survey has consistently reported a TFR of 2.3 across four consecutive surveys conducted in 2011, 2014, 2017, and 2022 (National Institute of Population Research and Training & ICF, 2023). This highlights that while Bangladesh is progressing into the fourth stage of demographic transition, structural and socioeconomic constraints may limit the conventional demographic dividend typically observed in high-income countries. The decline in fertility rates in Bangladesh has been shaped not only by economic modernization but also by cultural transformations, women's education-driven empowerment, and the success of family planning initiatives since the 1980s (Bora *et al.*, 2022). Meanwhile, reductions in mortality rates have been facilitated by advances in immunization, maternal health programs, and rural primary healthcare initiatives. These social, cultural, and gender-related factors demonstrate that demographic transition is not merely a statistical process but one embedded in broader societal change.

The impact of successive declines in fertility on age composition is evident, leading to gradual population aging. This aging trend aligns with patterns observed in other lower-middle-income countries undergoing demographic transition (Bairagi & Datta, 2001; Streatfield & Karar, 2008). However, unlike East Asian nations that entered their aging phase after reaching high per capita incomes, Bangladesh confronts the challenge of "aging before affluence." If adequate health and pension systems are not developed in a timely manner, this situation could further exacerbate vulnerabilities within the population. As a result of the concurrent trends in CBR and CDR, Bangladesh is currently experiencing the fourth stage of demographic transition, creating a "demographic window of opportunity" from 2020 to 2037. During this period, the country's population will exhibit an age structure particularly advantageous for economic development, featuring a larger proportion of individuals in the working-age group and a smaller proportion of young and elderly dependents. Nonetheless, this opportunity should be viewed as contingent rather than guaranteed, as labor market absorption, external migration flows, and vulnerability to climate change may influence the extent to which the dividend is realized. However, existing literature showed inconsistent information on the duration of this demographic window in Bangladesh. For example, one study reported the window as "1980–2020" (Navaneetham & Dharmalingam, 2012), while others cited "1980–2040" (Matin, 2012), "1990s–2030s" (M. M. Islam, 2016), and "1984–2037" (S. Farid & Mostari, 2022). These discrepancies underline the need to standardize definitions of the working-age population and adopt consistent methodologies for estimating demographic windows. Utilizing the same criteria as the present study but drawing on data from the 2019 Revision of World Population Prospects, another study identified "2020–2040" as the demographic window of opportunity for Bangladesh (M. S. Islam *et al.*, 2022).

The period from 2020 to 2037 represents a significant demographic window of opportunity for Bangladesh to fully capitalize on its demographic dividend. However, this timeframe is not guaranteed; labor force participation variations, economic fluctuations, and external factors, such as climate events or migration, could all impact the potential outcomes. This potential can be realized if the working-age population benefits from good health, access to quality education, and decent employment opportunities. Effectively harnessing the demographic dividend requires substantial investment in the education and health sectors to cultivate high-quality human capital (Zulu, 2014). The

demographic dividend has the potential to enhance per capita income and to increase savings and investments in the Bangladeshi economy (Gómez & Hernández de Cos, 2008; Jafrin *et al.*, 2021). The manifold benefits of harvesting the demographic dividend were outlined in the Introduction section. This highlights the importance of policy coherence across education, health, and labor markets. Thus, ensuring decent employment for the entire working-age population will be crucial to maximizing the demographic dividend in Bangladesh during the 2020–2037 timeframe. In addition, future analyses could explore different methods, as described by Zou *et al.* (2024), to enhance the estimation of the demographic window.

The current LFPR stands at 61.4% of the total population as of 2019, highlighting the significant challenge of generating enough jobs to accommodate the growing working-age population in the country (Fan, 2017). While the increase in the female LFPR from 31.1% in 2010 to 38.5% in 2019 is a positive development, it remains insufficient to fully leverage the potential demographic dividend anticipated in Bangladesh between 2020 and 2037. This highlights the gendered dimension of labor market participation and underscores the need for targeted interventions to expand opportunities for women. At present, the country faces rising youth unemployment, human-capital constraints, a shortage of trained workers, low female labor-force participation, and a fluctuating savings rate. These factors may impede the realization of demographic dividends and economic growth (Jafrin *et al.*, 2021). Due to social barriers, women's participation in the job market is limited, and many provide unpaid care and services within their households. Future strategies must therefore emphasize vocational training, gender-inclusive employment policies, and greater integration of women into the formal sectors.

A significant yet often overlooked factor affecting the labor force in Bangladesh is the high proportion of economically inactive women of working age. This issue is largely due to cultural norms and religious conservatism in Muslim-majority contexts (Heath & Jayachandran, 2016; Klasen, 2019). While female labor force participation has increased, social expectations and household responsibilities continue to present substantial barriers. Future policy interventions should prioritize gender-inclusive employment strategies, childcare support, and incentives for integrating the female workforce. In the near future, factors such as gradual secularization, improved female education, and globalization—particularly the growth of the ready-made garment sector—may enhance participation rates. Furthermore, gender-inclusive hiring policies by international buyers could further promote this change. However, if socio-cultural barriers persist, the economic potential of many working-age women may remain underutilized, thereby limiting the demographic dividend.

By the end of the demographic window of opportunity in 2037, the demographic transition is estimated to yield an aged population pyramid, with approximately 14.7% (28.4 million) of the population aged 60 years or more. If effective planning for the issues and healthcare needs of older adults is not implemented by 2037, a significant portion of the demographic dividend achieved between 2020 and 2037 may have to be allocated post-2037 to address the needs of this aging population, turning the demographic dividend into a missed opportunity. By 2050, with approximately 21.3% (43.4 million) of the population comprised older adults, Bangladesh will face the challenges and demands of an aging society (UN, 2022a). This highlights the need for forward-looking policies that address retirement, healthcare systems, and long-term care. Although there have been observations of compression of morbidity and an increase in healthier older adults over time, policymakers and the government are urged to prioritize issues affecting older adults, particularly regarding disability, care needs, retirement age, and health systems (Tareque, 2022).

This study has a few limitations. Due to the unavailability of the LFPR for the 15–59 age group, we utilized the LFPR for the 15–64 age group to calculate the EAP and EIP. Given the mandatory retirement age of 59 in government services in Bangladesh, the LFPR for the 15–59 age group may be higher than that for the 15–64 age group. This may slightly underestimate the EAP, introducing potential bias in assessing labor force participation and the demographic dividend, but not the demographic window of opportunity. In addition, in the absence of LFPR data from 2020 onwards, we applied the 2019 LFPR for projections extending to 2100. Several factors, including industrial expansion, the creation of both informal and formal employment, labor market growth, and the rising female LFPR, are expected to increase the labor force volume in the coming decades (M. S. Islam *et al.*, 2022). Consequently, the proportions of EAP and EIP may differ from those shown in the 2037 population pyramid, as depicted in Figure 4. This limitation underscores that while long-term projections are useful, they should be interpreted with caution, and future research should update these analyses with updated LFPR data, revised retirement ages, and revised World Population Prospects. The age–sex distribution of the population is largely influenced by factors such as births, deaths, migration, economic conditions, warfare, political changes, social transformations, famine, and natural disasters (Tulchinsky & Varavikova, 2014). However, the traditional demographic transition model primarily focuses on birth, death, and natural increase, overlooking

other significant influences. In our demographic transition model illustrated in Figure 1, we considered total population figures rather than solely natural increase. Although all demographic indicators, including total population estimates from the 2022 Revision of World Population Prospects, accounted for migration, natural disasters, and the pandemic (e.g., COVID-19) (UN, 2022b), subsequent studies should incorporate new projections. The low- and high-variant projections from the 2022 World Population Prospects were not employed in this study. Due to the extensive data handling involved in our research, incorporating these projections fell outside the scope of our analysis. Future studies should consider using both the low- and high-variant projections, in addition to the medium-variant projections from the World Population Prospects, to better address uncertainties and enhance the accuracy of the estimates. Future analyses would also benefit from the explicit integration of population policies and health interventions in Bangladesh, including the national family planning program, community clinic initiatives, and rural health outreach efforts, all of which have shaped both fertility and mortality trends. In addition, migration—particularly labor migration to the Middle East and climate-induced internal migration—along with socioeconomic indicators, such as education, will play an increasingly critical role in shaping Bangladesh's demographic future.

5. Conclusions

Our study not only updates empirical evidence on Bangladesh's demographic transition but also advances understanding by integrating conventional demographic transition theory with country-specific data to delineate distinctive stages and timelines. It emphasizes that the theory of demographic transition cannot be universally applied as a "one-size-fits-all" model. By critically comparing conventional stage characteristics with actual CBR, CDR, and population trends, this study provides a methodological framework for identifying context-specific stages, which represents a novel contribution to demographic research in Bangladesh.

Our findings indicate that Bangladesh is currently in the fourth stage of demographic transition, with a demographic window of opportunity spanning from 2020 to 2037, providing a critical period to harness the potential demographic dividend. The study also underscores the importance of integrating socioeconomic, cultural, and gender considerations into demographic analyses. For example, highlighting the significant proportion of economically inactive women of working age and linking it directly to policy-relevant outcomes adds explanatory depth beyond descriptive statistics. Policymakers should therefore prioritize investments in quality education, healthcare, and employment generation, with a particular focus on enhancing female labor force participation and skill development to maximize the benefits of this demographic window. In addition, proactive planning for an aging population post-2037 is crucial to maintaining the demographic dividend and addressing economic and social challenges. Our study combines long-term projections with policy insights to provide a solid foundation for future research and practical interventions to promote rapid economic growth during the demographic window of opportunity.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All Authors
Formal analysis: Md. Shariful Islam, Md. Ismail Tareque
Investigation: Md. Shariful Islam, Md. Ismail Tareque
Methodology: Md. Shariful Islam, Md. Ismail Tareque
Writing–original draft: Md. Shariful Islam, Md. Ismail Tareque
Writing–review & editing: All Authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Data for this study were obtained from the 2022 Revision of World Population Prospects, the World Bank, and the International Labor Organization, which are publicly available at https://population.un.org/wpp/, https://data.worldbank.org/indicator/SL.TLF.ACTI.ZS, and https://www.ilo.org/shinyapps/bulkexplorer32/?lang=en&segment=indicator&id=EAP_2WAP_SEX_AGE_RT_A, respectively.

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RESEARCH ARTICLE

Analysis of birth rate in mainland China under the continuous adjustment of the family planning policy

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Abstract

The birth rate in mainland China declined from 12.95‰ in 2016 to 6.39‰ in 2023, posing significant challenges to social harmony and sustainable development. To evaluate the effectiveness and impact of family planning policy adjustments, this study collected birth rate and population data for mainland China (2007 – 2023) and eight provinces, including Shanghai and Beijing (provincial-level municipalities), Xinjiang, Heilongjiang, Hunan, Hebei, Hainan, and Guangdong. Using Joinpoint regression and autoregressive integrated moving average models, we analyzed birth rate trends, assessed the stimulatory effects of four family planning policy adjustments (2011 – 2021), and projected future birth rate trajectories for both mainland China and the selected provinces. The findings show that the partial two-child policies (2011, 2013) stabilized national birth rates and triggered short-term regional increases. The universal two-child policy (2016) caused a temporary surge, followed by a continued linear decline. The three-child policy (2021) failed to reverse this trend and had a negligible impact. Key drivers include a 19% decrease in the population of women of childbearing age and a 34% decline in childbearing willingness. Projections from birth rate models (2024 – 2030) demonstrate a continued national decline, with significant regional disparities in both demographic characteristics and policy responsiveness. To address these dual challenges, China must implement comprehensive reforms to its national family planning policies to support sustainable social development, alongside province-specific interventions tailored to local demographic conditions to maintain regional balance.

Keywords: Mainland China; Birth rate; Jointpoint regression; ARIMA; Family planning

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1. Introduction

The birth rate is a vital demographic indicator that reflects a nation's potential for sustainable development (Nandi *et al.*, 2019; Yakita, 2018). In mainland China, socioeconomic evolution and shifting family values have contributed to a persistent decline in birth rates (Zhang *et al.*, 2022). To address demographic imbalances, the

Chinese government has progressively relaxed its family planning policies since 2011 (Du & Dong, 2024). Initially enforcing a strict one-child policy, the reforms were introduced in phases: permitting dual-only-child couples in which both partners were only children to have a second child (2011), extending eligibility to couples where one partner was an only child (2013), universalizing the two-child policy (2015), and finally implementing the three-child policy (2021).

Despite the relaxation of family planning restrictions through these policy adjustments, which theoretically should have led to a sustained increase in birth rates, China's birth rate has not shown stable growth. On the contrary, it declined from 12.95‰ in 2016 to 6.39‰ in 2023. This counterintuitive trend indicates that the family planning policy reforms have failed to achieve their intended stimulatory effect on fertility, which also suggests that China's low fertility challenge may be more severe than the raw data implies (Chen *et al.*, 2025). Consequently, a comprehensive analysis of China's fertility issues is crucial for the nation's sustainable development.

Recent demographic studies have uncovered novel insights into global fertility trends that may shed light on China's declining birth rates. Interrupted time-series analyses across 28 European countries revealed a 14 – 22% decline in birth rates attributable to the COVID-19 pandemic (Pomar *et al.*, 2022), while spatial regression studies in Mexico demonstrated strong negative correlations between pandemic severity and fertility indicators (Azcorra *et al.*, 2023). These findings are further supported by subsequent research examining pandemic-related demographic shifts (Babu & Padma, 2024; Shiva & Mohsen, 2024).

In China's unique demographic context, researchers have developed innovative analytical approaches to address the complexities of fertility pattern analysis. Advanced time-series modeling has revealed significant autocorrelation structures within birth rate datasets (Wang & Wu, 2023), while machine learning frameworks integrating multidimensional socioeconomic variables have demonstrated enhanced predictive capabilities (Zhang, 2024). Methodological advancements have also included the application of non-linear growth modeling (Zhu & Qiao, 2018) and fuzzy time-series analysis (Ye & Zheng, 2023), yielding deeper insights into the multifactorial determinants influencing fertility behaviors.

Despite significant methodological progress, the current modeling approaches remain constrained by China's dynamic policy landscape (Liang & Li, 2024; Song *et al.*, 2025; Song & Wen, 2015; Xu *et al.*, 2022; Zhong, 2016). Empirical evidence from Liu *et al.*'s (2016) logistic regression analysis (odds ratio [OR] = 0.67 for second births) and Zhu's (2014) longitudinal cohort studies (which documented a decline in fertility intentions from 1.8 to 1.2 children) consistently demonstrates that even extensive policy liberalizations have yielded only limited improvements in fertility preferences. These persistent limitations highlight the critical need for advanced analytical frameworks that integrate behavioral economic determinants, multigenerational transmission mechanisms, and subnational heterogeneity in policy implementation. Such enhanced models would substantially improve predictive accuracy during China's unprecedented demographic transition.

In response, this study employs Joinpoint regression and autoregressive integrated moving average (ARIMA) models to analyze birth rate data from 2007 to 2023 within the context of China's family planning policy adjustments, offering new insights into the country's fertility transition and informing potential policy optimization strategies.

2. Data and methods

2.1. Data

This study utilized birth rate data (2007 – 2023) from China's National Bureau of Statistics and provincial statistical bulletins. To ensure regional representativeness, eight provinces were selected from mainland China's 31 administrative divisions, stratified by annual average birth rate:

- High birth rate provinces (20% above the mainland average): Xinjiang, Hainan
- Low birth rate provinces (20% below the mainland average): Heilongjiang, Beijing, and Shanghai
- Medium birth rate provinces (within ± 20% of the mainland average): Guangdong, Hebei, and Hunan.

Notably, Beijing, Shanghai, and Guangdong rank among China's most economically advanced areas, while the others exhibit moderate development. The birth rate data for mainland China and eight selected provinces from 2007 to 2023 are detailed in Table A1.

Beyond fertility willingness, birth rates are influenced by the size of the childbearing-age population. To assess this, age-stratified population data (2007 – 2023) were extracted from the Global Burden of Disease Study (GBD 2021) (https://ghdx.healthdata.org/). These metrics, detailed in Table A2, enable analysis of the demographic shifts underlying fertility trends.

2.2. Methods

Given the substantial influence of family planning policies on fertility patterns, birth rate trends may exhibit significant variations across different policy phases. The Joinpoint

model (Clegg *et al.*, 2009; Kim *et al.*, 2000; Rose *et al.*, 2015) offers particular advantages, as it automatically partitions the birth rate trajectory into discrete temporal segments, enabling detailed characterization of trends within each interval. The model's algorithm identifies joinpoints where significant trend alterations occur, selecting the optimal joinpoints through minimization of the mean squared error. This approach significantly strengthens the scientific validity and precision of trend analysis (Islami *et al.*, 2021; Moreno-Agostino *et al.*, 2021; Weir *et al.*, 2015). The birth rate data were analyzed using Joinpoint Regression Software (version 5.3.0.0), which incorporates evaluation criteria such as the Bayesian Information Criterion (BIC) for phase division and turning point calculation, enabling autonomous optimization computation. Consequently, the software was employed to determine the optimal phase divisions for birth rate trends and the locations of joinpoints, without presetting the number of change points. Subsequently, accounting for family planning policy adjustments, the number of joinpoints was manually specified as four (three for Heilongjiang province due to the lack of data before 2011), with the software calculating their optimal positions to evaluate the stimulatory effects of different policy interventions. Finally, a comparative analysis of both computational approaches was conducted to assess the relative strength of policy-induced effects.

For predictive modeling, an ARIMA model (Giglio *et al.*, 2022) was developed using RStudio (version 2024.04.2) with an R 4.4.1 environment. The ARIMA framework provides robust analytical capabilities for time series data, generating forecasts by leveraging historical patterns (Helfenstein, 1991; Zhang, 2003). The model incorporates three fundamental parameters: (p) autoregressive terms accounting for time-lagged effects, (q) moving average components addressing residual noise, and (d) differencing operations ensuring time series stationarity (Wang *et al.*, 2022). Widely utilized in economic and medical research, ARIMA modeling offers reliable predictive performance when stationarity requirements are satisfied (Pai & Lin, 2005; Wang *et al.*, 2005). In this study, the "auto.arima" function from R version 4.4.1 was employed to construct ARIMA models. This function automatically configures parameter search strategies and computes parameter values, recommending the optimal model based on multiple criteria, including Akaike Information Criterion (AIC)/Bayesian Information Criterion (BIC) and the Ljung–Box test. Data from all provinces were processed uniformly to determine the best-fitting model, after which each model underwent separate significance testing.

The synergistic application of Joinpoint regression for trend decomposition and ARIMA modeling for predictive analytics yields a methodologically robust framework for examining birth rate dynamics amidst evolving population policies. This dual approach enhances both the interpretability of historical trends and the reliability of future projections.

3. Results

3.1. Temporal segmentation of China's birth rate patterns using Joinpoint regression

The Joinpoint model was applied to analyze the birth rate data without predefining the number of joint points. The analytical results are presented in Figure 1. When family planning policy adjustments are not considered, the birth rate data for mainland China can be categorized into two distinct phases. The initial phase, covering 2007 to 2017, demonstrated a gradual upward trend with an annual percentage change (APC) of 0.43. Conversely, the subsequent phase, from 2017 to 2023, revealed a sharp downward trajectory, registering an APC of −11.10.

The birth rate trends in Shanghai and Beijing showed complete consistency with the national pattern observed in mainland China. Similarly, Heilongjiang and Hebei provinces largely followed the national trend, though with a slight temporal delay. In contrast, Xinjiang, Hunan, Guangdong, and Hainan exhibited notably different birth rate patterns. The divergent trends across provinces reflect varying sensitivities to policy adjustments, while confounding factors – such as economic conditions, population migration, and fertility attitudes – may amplify, diminish, or delay policy impacts.

Two principal characteristics emerged from the analysis of birth rate trends in mainland China and the eight examined provinces: (i) from 2007 to 2017, birth rates maintained relative stability with only incremental variations; and (ii) from 2017 to 2023, birth rates entered a period of accelerated decline.

Given the substantial adjustments to China's family planning policy in 2011, 2013, 2015, and 2021, four joinpoints were specified to precisely examine the policy–birth rate relationship. Due to the unavailability of birth rate data from 2007 to 2011, only three joinpoints were set for Heilongjiang. Figure 2 presents the phase division results calculated by the Joinpoint software under the given optimal number of joint points, indicating that: (i) 2007 – 2011: a gradual birth rate decline preceded the initial 2011 policy adjustment; (ii) 2011 – 2014: modest fertility recovery, potentially falling short of expectations, prompted the 2013 policy revision; (iii) 2014 – 2017: the combined effects of 2013 and 2015 policy changes drove a transient but sharp fertility increase; (iv) 2017 – 2021: limited policy impact during this period correlated with an accelerated birth rate decline; (v) 2021 – 2023: the 2021

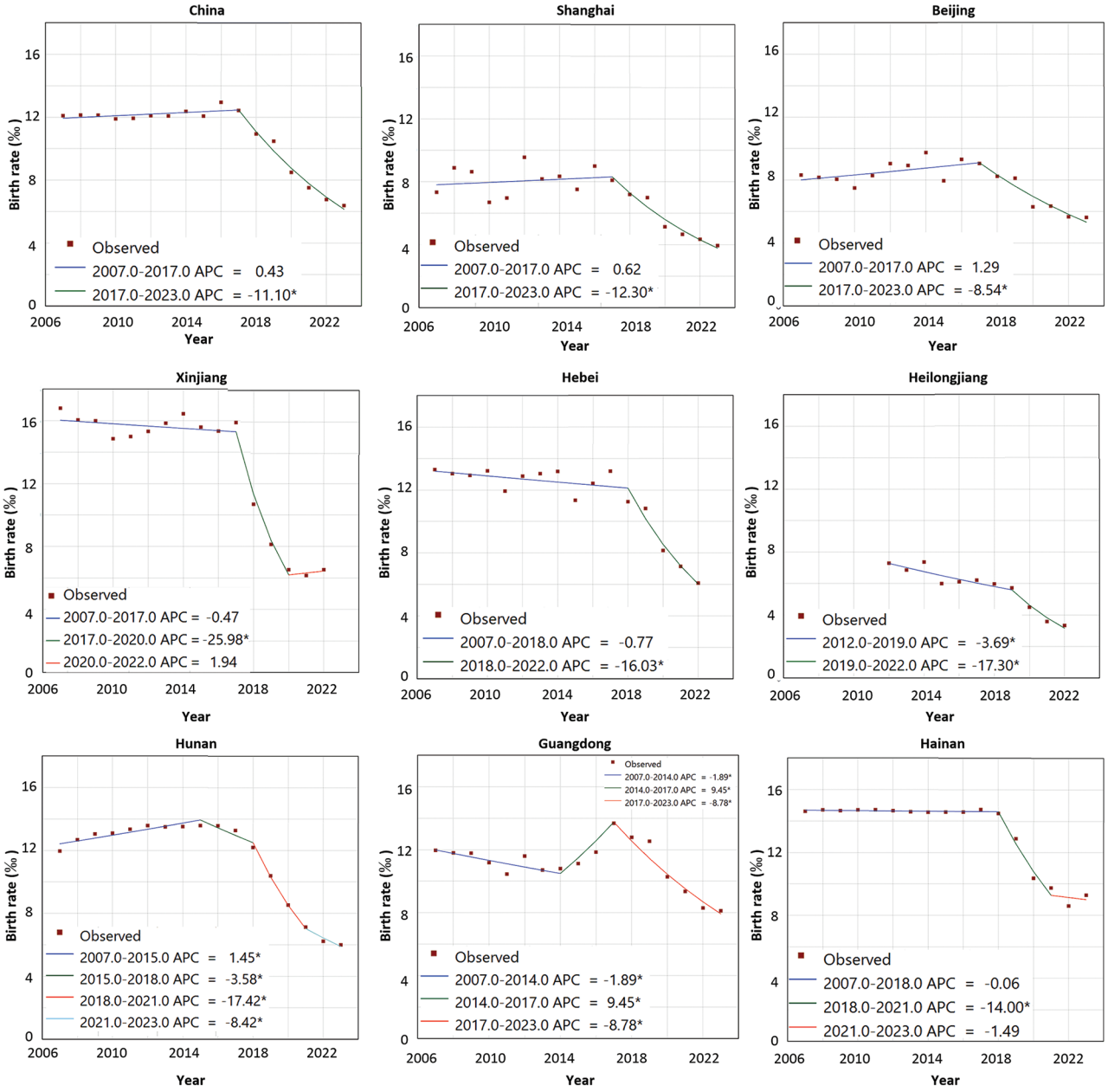

Figure 1. Joinpoint regression analysis of birth rate trends in mainland China and eight provinces
Abbreviation: APC: Annual percentage change.

policy intervention temporarily slowed, but failed to reverse the persistent downward trend. These findings underscore the nuanced dynamics between policy and fertility, where regulatory changes demonstrate time-limited effectiveness within broader demographic transitions.

Comparative analysis of Figures 1 and 2 demonstrates that every family planning policy adjustment in mainland China has induced a transient increase in birth rates. However, these policy-driven fertility fluctuations represent not a transformation of social childbearing preferences, but rather a temporal clustering of reproductive behavior among policy-affected cohorts. The 2015 universal two-child policy exemplifies this pattern, triggering concentrated second births among eligible families during 2016 – 2017, which temporarily elevated birth rates. Both Figures 1 and 2 detected the stimulatory effect of the 2015

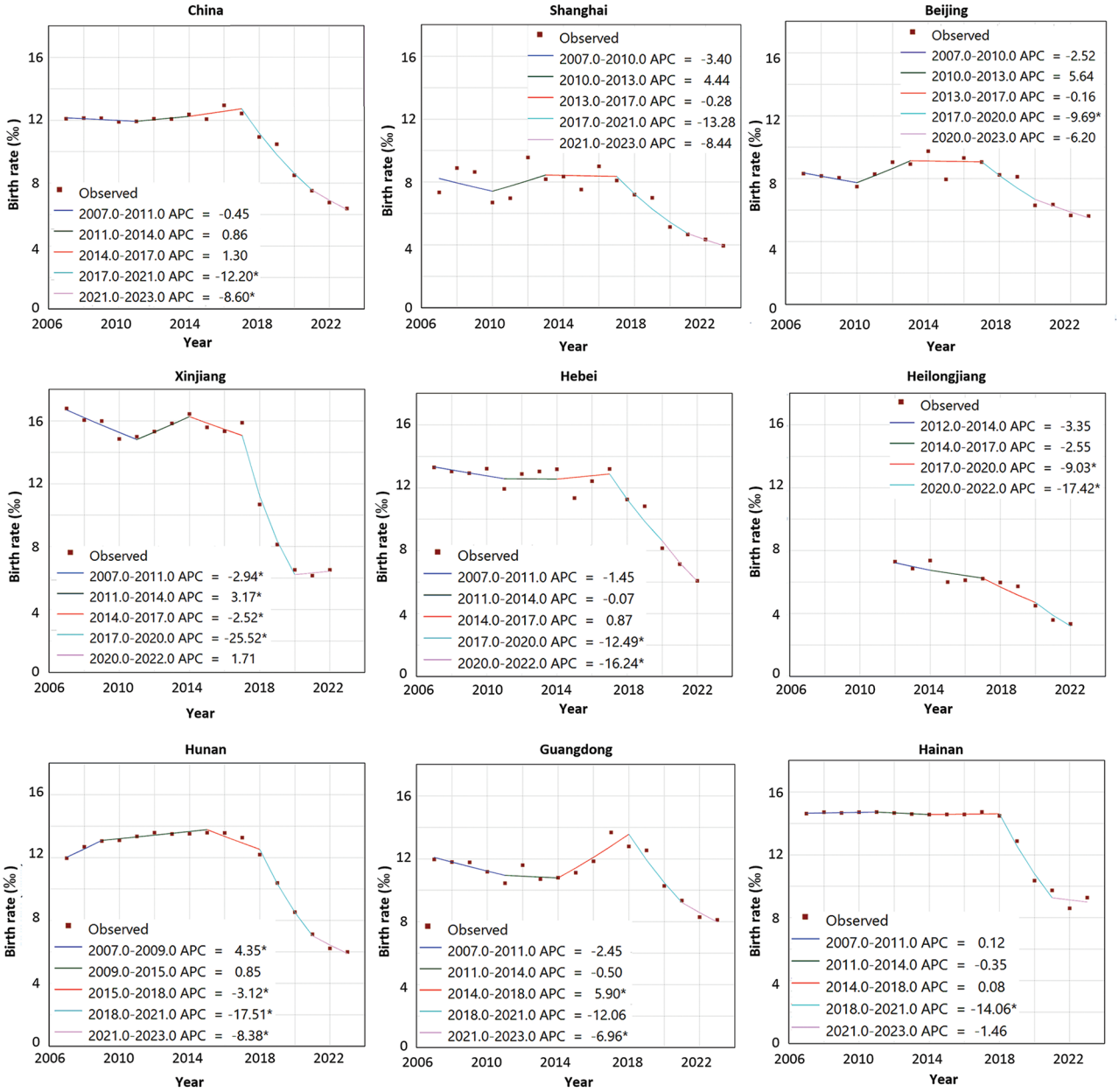

Figure 2. Policy-responsive fertility transitions: A spatiotemporal analysis of birth rates in China and eight provinces
Abbreviation: APC: Annual percentage change.

policy change, indicating that the universal two-child policy implemented had the most significant impact.

3.2. Analysis of key determinants of birth rate fluctuations

Under conditions of relative population stability, birth rate variations are primarily governed by two demographic factors: (i) the absolute size of the reproductive-age cohort and (ii) population fertility intentions. Utilizing GBD 2021 data, we quantified the reproductive-age population (2007 – 2021), with detailed stratification presented in Table A2. Given China's gender imbalance (a predominance of males over females), our analysis specifically focuses on the female reproductive cohort.

In accordance with China's Marriage Law, which stipulates a minimum female marriage age of 20 years, we operationally defined the reproductive-age population as women aged 20 – 49 years. Projections for 2022 – 2023

were derived by extrapolating from baseline populations of females aged 10 – 20 and 40 – 49 years in 2021.

Figure 3 illustrates the temporal trajectory of China's female reproductive-age population (2007 – 2023). Data for 2022 – 2023 were sourced from China's National Economic and Social Development Statistical Bulletin, while preceding years utilized GBD 2021 datasets. This demographic analysis reveals critical structural shifts in the population that fundamentally constrain birth rate dynamics.

Mainland China's total population maintained consistent growth through 2021 before entering a period of modest decline during 2022 – 2023. This demographic shift contrasts sharply with trends among women of childbearing age (20 – 49 years), whose numbers grew steadily before 2012 but subsequently underwent a marked 19% contraction. The substantial reduction in reproductive-age women, occurring alongside relative stability in the overall population size, creates fundamental demographic pressures that inevitably drive declines in the birth rate.

Based on comprehensive demographic data, including mainland China's total population, annual birth figures, and female population of reproductive age (20 – 49 years), the mean number of children per woman was computed using the following formula:

$$\mu = \frac{n_p \times r \times T}{n_w} \quad \text{(I)}$$

In Equation I, μ represents the average number of children born to a single woman, n_w is the population of women of childbearing age, n_p is the total population, r is the birth rate, and T represents the duration of female reproductive age (T=30). The result of μ is shown in Figure 4.

The average number of children per woman serves as a crucial indicator of fertility willingness. While the birth rate peaked in 2016 and 2017, this temporary increase was directly linked to China's family planning policy adjustments, particularly the 2015 universal two-child policy. This short-term rise does not reflect a fundamental change in childbearing preferences but rather represents a concentrated realization of second-child demand among policy-affected families.

From 2007 to 2023, Chinese women's childbearing willingness has shown a clear and consistent downward trajectory. In 2007, the average stood at 1.5 children per woman, but by 2023, it had declined to 0.97 – significantly below the replacement level of 2.1 needed for population stability. This sustained decrease highlights a substantial transformation in reproductive behaviors and attitudes, influenced by multiple socioeconomic, cultural, and policy factors.

The consequences of this trend are far-reaching. Continuing fertility decline may intensify demographic challenges, including population aging and workforce contraction, creating significant obstacles for economic development and social welfare systems. Policy responses should therefore incorporate comprehensive measures to alleviate child-rearing costs, enhance work–family balance, and foster family-friendly social environments. Without such interventions, the birth rate downturn is likely to continue, with profound implications for China's future demographic and economic landscape.

3.3. Autoregressive integrated moving average model-based birth rate analysis and forecasting

The stationarity and autocorrelation properties of China's birth rate data were examined through autocorrelation function (ACF) and partial autocorrelation function (PACF) plots (Figure 5). The observed trailing patterns in both ACF and PACF plots confirmed the data's suitability

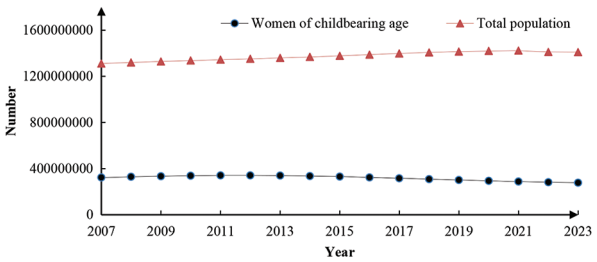

Figure 3. Trends in total population and women of childbearing age in mainland China

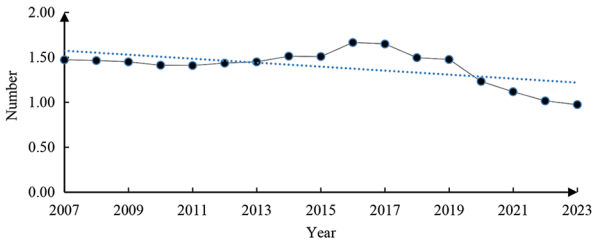

Figure 4. Average number of children born to women from 2007 to 2021

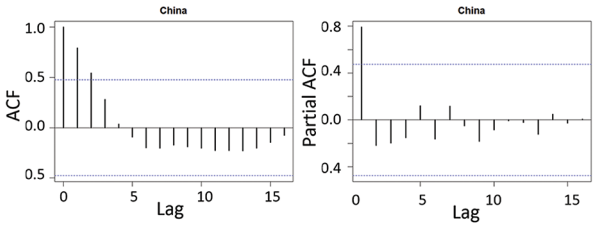

Figure 5. Autocorrelation and partial autocorrelation plots of birth rate data in mainland China
Abbreviation: ACF: Autocorrelation function.

for ARIMA modeling. Using the "auto.arima" function for optimal model selection, ARIMA(0,2,1) was identified as the most appropriate specification for China, featuring a statistically significant moving average coefficient (ma1 = −0.579, $p = 0.2743$).

Based on the selected optimal model and its parameters, we plotted the residual diagnostic results (Figure 6). The plot demonstrates three key characteristics: (i) residuals randomly fluctuate around the zero baseline, (ii) all ACF values at various lags fall within the blue dashed confidence boundaries, and (iii) residuals exhibit an approximately normal distribution. These diagnostic results confirm the model's statistical significance.

Furthermore, the model was validated using the Ljung–Box test, with AIC/BIC values calculated as shown in Table 1. For China's birth rate model, the p-value marginally exceeded 0.05, while the Q* statistic was relatively large, and both AIC and BIC values were comparatively low. These results indicate that the model possesses statistically significant explanatory power, although with potential limitations in precision.

Following confirmation of the model's statistical validity, we employed it to forecast future birth rate trends. Using the same analytical framework applied to mainland China's birth rate data, we constructed and evaluated models for eight provinces, including Shanghai and Beijing. Table 1 presents: (i) the optimal ARIMA models identified by the "auto.arima" function for each province, (ii) the corresponding Ljung–Box test results, (iii) AIC/BIC values, and (iv) selected forecasting outcomes. Residual diagnostic plots for all eight provinces are provided in Figure A1.

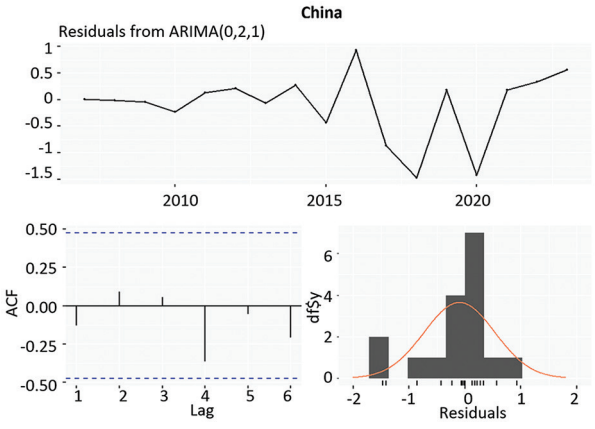

Figure 6. Residual diagnostic plots for the birth rate model in mainland China
Abbreviations: ACF: Autocorrelation function; ARIMA: Autoregressive integrated moving average.

Based on these province-specific ARIMA models, we projected birth rate trajectories through 2030, with results visualized in Figure 7.

Although the data analysis procedures and methodologies were consistent across provinces, the optimal ARIMA models for provincial birth rate data exhibited significant variation, reflecting distinct demographic characteristics.

For mainland China, the optimal birth rate model was ARIMA(0, 2, 1), indicating that the birth rate series required second-order differencing to achieve stationarity, and that short-term fluctuations were influenced by previous random disturbances. This suggests potential cumulative effects of policy interventions and a memory effect for abrupt demographic events in the national birth rate data.

For Shanghai and five other provinces, the optimal model was ARIMA(0, 1, 0), demonstrating no short-term autocorrelation and relatively stable birth rate trends. This pattern implies that birth rates in these provinces are less susceptible to short-term shocks (e.g., sudden policy changes or natural disasters).

Guangdong's optimal model, ARIMA(1, 0, 0), revealed stationary birth rates, with current rates determined by the previous year's values and random shocks. This reflects the influence of social inertia (e.g., persistent fertility attitudes and economic development). This characteristic can also indirectly explain the underlying drivers of Guangdong's population dynamics, specifically the decline in birth rates from 2007 to 2014, followed by a rapid increase during 2014 – 2016.

Hunan's ARIMA(2, 2, 0) model showed a non-stationary series requiring second-order differencing, with the current birth rates correlated with 2-year lags. This suggests delayed responses to external stimuli (e.g., policy changes).

While all models passed significance testing (though marginally in some cases), weaker significance levels may stem from external interference (e.g., policy or economic shocks). A critical limitation of ARIMA modeling warrants emphasis: its exclusive reliance on historical birth rate data and exclusion of external covariates, including policy reforms, technological advancements, and socioeconomic development. Consequently, while ARIMA provides valid short-term projections, predictive accuracy degrades progressively with longer forecast horizons.

China's birth rates are projected to continue declining, potentially falling below 5‰. Even with additional government incentives, the birth rates are unlikely to

Table 1. Statistical significance testing and key predictive metrics of autoregressive integrated moving average (ARIMA) models

Area	ARIMA model	Ljung-Box test			AIC	BIC	Year	Point forecast	Lower (95%)	Upper (95%)
		Q*	df	*p*-value						
China	(0,2,1)	3.884	3	0.274	34.77	36.19	2024	5.68	4.33	7.03
							2025	4.98	2.63	7.32
							2026	4.27	0.85	7.69
Shanghai	(0,1,0)	1.974	3	0.5778	53.51	54.28	2024	3.95	1.578	6.322
							2025	3.95	0.596	7.304
							2026	3.95	-	8.058
Beijing	(0,1,0)	4.476	3	0.2144	42.57	43.34	2024	5.63	3.945	7.315
							2025	5.63	3.247	8.013
							2026	5.63	2.712	8.548
Hunan	(2,2,0)	5.847	3	0.119	11.09	13.22	2024	6.161	5.5778	6.745
							2025	6.373	4.563	8.182
							2026	6.447	2.876	10.017
Guangdong	(1,0,0)	5.908	3	0.116	52.92	55.42	2024	8.607	6.663	10.551
							2025	9.003	6.498	11.508
							2026	9.325	6.510	12.141
Hainan	(0,1,0)	5.119	3	0.163	40.84	42.39	2024	8.946	7.397	10.495
							2025	8.612	6.422	10.803
							2026	8.279	5.596	10.961
Xinjiang	(0,1,0)	1.144	3	0.767	58.38	59.8	2023	5.846	2.838	8.854
							2024	5.162	0.908	9.416
							2025	4.478	-	9.688
							2026	3.794	-	9.810
Heilongjiang	(0,1,0)	0.971	3	0.808	21.32	21.93	2023	3.037	1.998	4.076
							2024	2.735	1.266	4.204
							2025	2.432	0.633	4.231
							2026	2.129	0.052	4.207
Hebei	(0,1,0)	0.424	3	0.928	49.69	50.39	2023	6.09	3.765	8.415
							2024	6.09	2.803	9.377
							2025	6.09	2.064	10.116
							2026	6.09	1.441	10.739

Abbreviations: AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion.

exceed 10‰, highlighting the persistent demographic challenges. Of the eight provinces examined, only Hunan and Guangdong demonstrate prospects for modest birth rate increases in the coming years, although with limited growth potential. Conversely, metropolitan areas including Shanghai and Beijing are anticipated to sustain depressed fertility levels or experience further reductions. Notably, Shanghai (below 4‰) and Heilongjiang (below 3‰) exhibit the most subdued birth rates, while Guangdong (below 10‰) and Hainan (below 9‰) register as the highest. These pronounced geographical variations underscore the heterogeneous demographic landscape across mainland China and emphasize the necessity for customized policy measures responsive to localized reproductive dynamics.

4. Discussion

This study utilized authoritative statistical data from official sources in mainland China and selected provinces, employing the Joinpoint model to assess the effects of various family planning policy adjustments on birth rates. To investigate the underlying causes of China's declining fertility, we obtained childbearing-age female population data from GBD2021 and computed the average birth rate per woman. Furthermore, we implemented the ARIMA

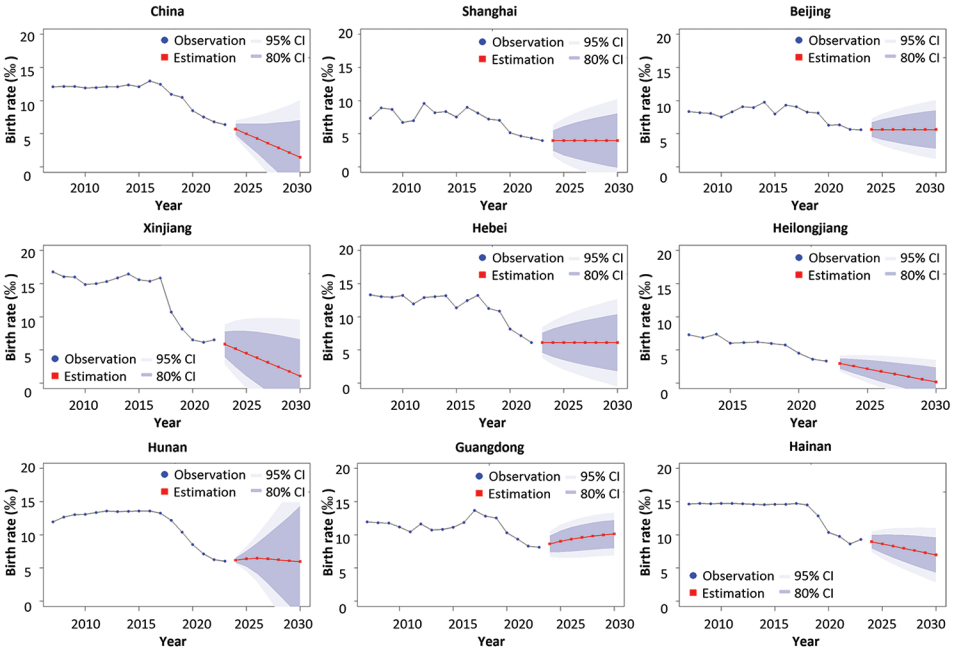

Figure 7. Trend forecast of birth rates in mainland China and eight provinces

model to forecast birth rate trends through 2030, providing insights for future family planning policy formulation.

Statistical analysis of data from 2007 to 2022 reveals a striking 44.05% decline in national birth rate (from 12.1‰ to 6.77‰), with provincial variations demonstrating clear spatial patterns – coastal provinces like Guangdong (30.60% decline) showed more moderate decreases compared to western provinces like Xinjiang (61.11% drop), while northeastern industrial zones (e.g., Heilongjiang: 54.25%) exhibited accelerated declines following local economic restructuring. Although the 2011 – 2015 policy adjustments generated temporary fluctuations – most notably a 7.1% rebound following the 2015 universal two-child policy – post-2016 trends show remarkably consistent linear declines, averaging 8.3% annually. The comprehensive three-child policy implemented in 2021 failed to reverse the persistent decline in birth rates, serving only to modestly mitigate the downward trend.

The Joinpoint analysis reveals that between 2010 and 2021, successive modifications to China's family planning policy temporarily stimulated birth rates. Each policy intervention produced a short-term fertility increase, though this primarily reflected a concentration of pent-up demand among eligible families rather than a fundamental shift in reproductive preferences (Lv *et al.*, 2025; Qi *et al.*, 2016; Zhang, 2025). Among the four major policy changes, the 2015 universal two-child policy demonstrated the most pronounced impact, while the 2021 three-child policy merely attenuated, without reversing, the ongoing fertility decline. The significant but temporary fertility rebound following the 2015 universal two-child policy indicates that a subset of Chinese families remained willing to have two children. In contrast, the markedly weaker response to the 2021 three-child policy suggests that only a minimal proportion of families have any inclination toward three-child households. From a pessimistic perspective, the birth rate data from 2011 to 2023 incorporate short-term artificial boosts induced by policy adjustments, indicating that the underlying fertility challenges are substantially more severe than the raw statistics superficially suggest. These observations lead to a critical demographic projection: barring substantial changes to socioeconomic conditions or family support systems, China's birth rate is unlikely to experience meaningful recovery, even with complete deregulation of birth limits.

Two principal interlinked factors account for China's precipitous birth rate reduction: (i) a substantial demographic contraction in the core childbearing-age population, and (ii) a profound sociocultural shift in fertility intentions across generations. From 2007 to 2023, China's reproductive-age cohort (20 – 49 years) decreased steadily at an average annual rate of 2.67 million, with the most fertile subgroup (25 – 29 years) shrinking by 38%. Concurrently, the mean number of children per woman declined from 1.47 to 0.97 (a 34% decrease), reflecting reduced fertility intentions. Moreover, China's total population grew by 7% between 2007 and 2023, further amplifying the relative decline in birth rates. Thus, China's

persistent decline in birth rates fundamentally reflects the compounded effects of (i) demographic structural shifts, (ii) evolving fertility attitudes, and (iii) policy constraints. The reduction in the childbearing-age population will persist as an irreversible reality, exerting sustained downward pressure on birth rates. To maintain sustainable social development, the Chinese government must implement targeted interventions to elevate fertility intentions among the population.

The heterogeneity of ARIMA models constructed from 2007 – 2023 birth rate data reveals significant geographical disparities in both provincial fertility levels and responsiveness to policy interventions. These variations likely stem from complex interactions among multiple factors: (i) differential implementation of family planning policies across provincial administrations, (ii) varying levels of economic development and associated opportunity costs of childrearing, (iii) persistent cultural norms regarding family size in rural versus urban areas, and (iv) dramatically different living cost pressures, particularly housing affordability – relationships that require further investigation through expanded longitudinal data collection and advanced modeling. Therefore, each province should adopt targeted measures based on its unique fertility characteristics, and the specific policy responses should be investigated and analyzed in conjunction with each province's actual conditions. It can be foreseen that Shanghai, Beijing, and other provinces modeled by ARIMA(0,1,0) are more sensitive to policy stimulus, showing quick but short-lived effects. In contrast, provinces like Hunan, modeled by ARIMA(2,2,0), and Guangdong, modeled by ARIMA (1,0,0), exhibit lower sensitivity to policy interventions, with delayed but potentially longer-lasting responses.

Based on the forecasting results of the ARIMA model, China's birth rate is expected to continue its downward trend. Beijing, Shanghai, and Hebei may maintain relatively stable birth rates, with fluctuations influenced by external stimuli; Guangdong and Hunan may experience slight increases, though the magnitude of growth will be limited. Meanwhile, Heilongjiang, Xinjiang, and Hainan are expected to see further declines in birth rates, presenting more severe challenges. Although the ARIMA model considers only the birth rate itself without accounting for other influencing factors (limiting the precision of the forecasts), the projected trends and their confidence intervals (80% CI and 95% CI) still hold practical significance. From an optimistic perspective, based on the upper bound of the 95% CI, there is a possibility that the birth rate could reverse its continuous decline before 2030. However, the likelihood of exceeding 10‰ remains extremely low. Under the most optimistic scenario for provincial birth rate projections, most provinces (such as Xinjiang) would maintain birth rates around 10‰, while a few provinces and cities (like Guangdong and Hunan) could reach 15‰. Notably, Heilongjiang, currently exhibiting the lowest birth rate, is unlikely to exceed 5‰ even under the most favorable estimates. Conversely, viewed pessimistically, China's future birth rate may decline to an exceptionally low level. These findings reflect structural demographic shifts rather than temporary fluctuations, with profound implications for China's long-term population trajectory and socioeconomic development model. China's demographic challenges will become increasingly severe, raising serious concerns about whether social stability and sustainable development can be maintained.

This study analyzed the impact of adjustments to China's family planning policy from the perspective of changes in birth rate data, which introduces some limitations. First, the ARIMA model relies on linear assumptions and cannot effectively capture nonlinear relationships in data, making it less adaptable to non-stationary or noisy datasets. As the forecast horizon lengthens, prediction accuracy may gradually decline. Second, both the Joinpoint and ARIMA models do not consider confounding factors such as economic development, population migration, and age structure. This omission weakens model significance and reduces analytical accuracy. Third, the inability to collect comprehensive occurrence rate data hinders deeper investigation into the root causes underlying the persistent fertility decline in provinces like Heilongjiang. Fourth, the birth rate data released by the Chinese government and provincial authorities may be underestimated, which could also affect the accuracy of our analysis and forecasting results. In future research, we recommend collecting more comprehensive data related to the factors influencing birth rates, enabling more robust modeling and analysis. This would support the development of effective policy recommendations aimed at stimulating birth rate increases and promoting sustainable social development.

5. Conclusion

Looking ahead, China's birth rate is expected to remain persistently below the demographic warning threshold of 15‰. This trend coincides with the nation's accelerating demographic transition toward an aging society, as evidenced by rising mortality rates, from 7.18‰ in 2021 to 7.87‰ in 2023, with further increases anticipated. The sustained fertility decline presents substantial challenges to maintaining balanced population development and

calls for comprehensive policy responses from the Chinese government. Potential measures may include further adjustments to family planning policy, improvements to the childcare support system, and the implementation of tax incentives and subsidies.

For provinces already experiencing critically low fertility rates (e.g., Heilongjiang, Shanghai, and Beijing), localized interventions tailored to provincial socioeconomic conditions must complement national policy adjustments. Such geographically specific approaches are crucial for stabilizing these vulnerable demographic landscapes. Future investigations should prioritize a systematic examination of regionally distinct fertility determinants, enabling: (i) enhanced understanding of spatial demographic variations; (ii) evidence-based policy calibration; and (iii) more effective intervention strategies.

This research direction promises to yield actionable insights for developing nuanced, location-specific solutions to China's complex demographic challenges, ultimately supporting more balanced national population development.

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Conflict of interest

The authors declare that they have no competing interests.

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Visualization: Feng Jin
Writing – original draft: Feng Jin
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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

The relevant raw data for this study were obtained from the official websites of relevant Chinese government agencies, as follows: China National Bureau of Statistics (https://www.stats.gov.cn/sj/tjgb/ndtjgb/); Beijing Municipal Bureau of Statistics (https://tjj.beijing.gov.cn/tjsj_31433/tjgb_31445/ndgb_31446/); Guangdong Statistical Information Network (http://stats.gd.gov.cn/tjgb/index.html); Hainan Provincial People's Government (https://en.hainan.gov.cn/hainan/ndsj/list3.shtml); Hebei Provincial People's Government (http://www.hebei.gov.cn/columns/3bbf017c-0e27-4cac-88c0-c5cac90ecd73/index.html); Heilongjiang Provincial People's Government (https://www.hlj.gov.cn/hlj/c108419/zfxxgk.shtml); Hunan Provincial People's Government (http://www.hunan.gov.cn/zfsj/tjgb/202403/t20240322 33262931.html); Shanghai Municipal Bureau of Statistics (https://tjj.sh.gov.cn/tjgb/index.html); and Statistical Bureau of Xinjiang Uygur Autonomous Region (http://tjj.xinjiang.gov.cn/tjj/tjgn/ist.shtml).

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Appendix

Table A1. Birth rate data (per 1,000 population) for mainland China and eight provinces

Year	Province								China
	Shanghai	Beijing	Xinjiang	Heilongjiang	Hebei	Hunan	Guangdong	Hainan	
2007	7.34	8.32	16.79	-	13.3	11.96	11.96	14.62	12.10
2008	8.89	8.17	16.05	-	13.04	12.68	11.8	14.71	12.14
2009	8.64	8.06	15.99	-	12.93	13.05	11.78	14.66	12.13
2010	6.70	7.5	14.85	-	13.22	13.10	11.18	14.71	11.90
2011	6.97	8.29	14.99	-	11.93	13.35	10.45	14.72	11.93
2012	9.56	9.05	15.32	7.3	12.88	13.58	11.60	14.66	12.10
2013	8.18	8.93	15.84	6.86	13.04	13.5	10.71	14.59	12.08
2014	8.35	9.75	16.44	7.37	13.18	13.52	10.8	14.56	12.37
2015	7.52	7.96	15.59	6.00	11.35	13.58	11.12	14.57	12.07
2016	9.00	9.32	15.34	6.12	12.42	13.57	11.85	14.57	12.95
2017	8.10	9.06	15.88	6.22	13.2	13.27	13.68	14.73	12.43
2018	7.20	8.24	10.69	5.98	11.26	12.19	12.79	14.48	10.94
2019	7.00	8.12	8.14	5.73	10.83	10.39	12.54	12.87	10.48
2020	5.14	6.30	6.53	4.50	8.16	8.53	10.28	10.36	8.50
2021	4.67	6.35	6.16	3.59	7.15	7.13	9.35	9.74	7.52
2022	4.35	5.67	6.53	3.34	6.09	6.23	8.30	8.60	6.77
2023	3.95	5.63	-	-	-	6.00	8.12	9.28	6.39

Note: "-" indicates that provincial birth rate data were not published. In the Joinpoint analysis, missing data were excluded. For ARIMA model construction: the models for Hebei and Xinjiang were built using data from 2007 to 2022 to predict the 2023 birth rate, while the model for Heilongjiang was based on data from 2012 to 2022 and also used to predict the 2023 birth rate.

Table A2. Population data for childbearing-age women in mainland China from 2007 to 2021

Year	Age range						Total
	20 – 24	25 – 29	30 – 34	35 – 39	40 – 44	45 – 49	
2007	57,673,318	46,110,944	53,832,358	60,808,029	65,253,210	39,501,056	323178915
2008	61,050,385	46,585,673	51,385,517	60,191,565	66,259,247	42,899,430	328371818
2009	63,241,219	48,043,709	49,363,450	59,352,937	66,226,203	47,438,854	333666372
2010	63,771,398	50,574,596	47,945,374	57,981,720	65,544,025	52,190,620	338007734
2011	62,361,114	54,104,685	46,997,382	55,909,221	65,578,053	56,450,084	341400539
2012	59,483,123	57,832,811	46,535,324	53,361,930	64,870,456	59,564,671	341648316
2013	55,657,362	60,891,359	46,811,977	50,751,746	64,679,220	61,025,458	339817122
2014	51,381,564	62,595,237	48,046,843	48,557,504	63,764,089	61,342,113	335687349
2015	47,236,816	62,495,359	50,315,428	46,959,344	62,683,718	60,986,963	330677627
2016	43,803,173	60,392,886	53,526,482	45,835,539	59,953,763	60,282,503	323794346
2017	41,046,417	56,913,274	56,890,882	45,207,075	56,726,036	59,530,157	316313840
2018	38,796,584	52,673,649	59,582,579	45,324,608	53,449,896	58,815,048	308642363
2019	36,938,727	48,211,700	60,971,351	46,402,935	50,829,410	57,872,003	301226125
2020	35,444,893	44,097,412	60,657,011	48,519,083	48,711,138	56,406,032	293835568
2021	34,306,654	40,866,334	58,469,485	51,597,150	47,977,697	54,260,079	287477400
2022	57,673,318	46,110,944	53,832,358	60,808,029	65,253,210	39,501,056	323178915
2023	61,050,385	46,585,673	51,385,517	60,191,565	66,259,247	42,899,430	328371818

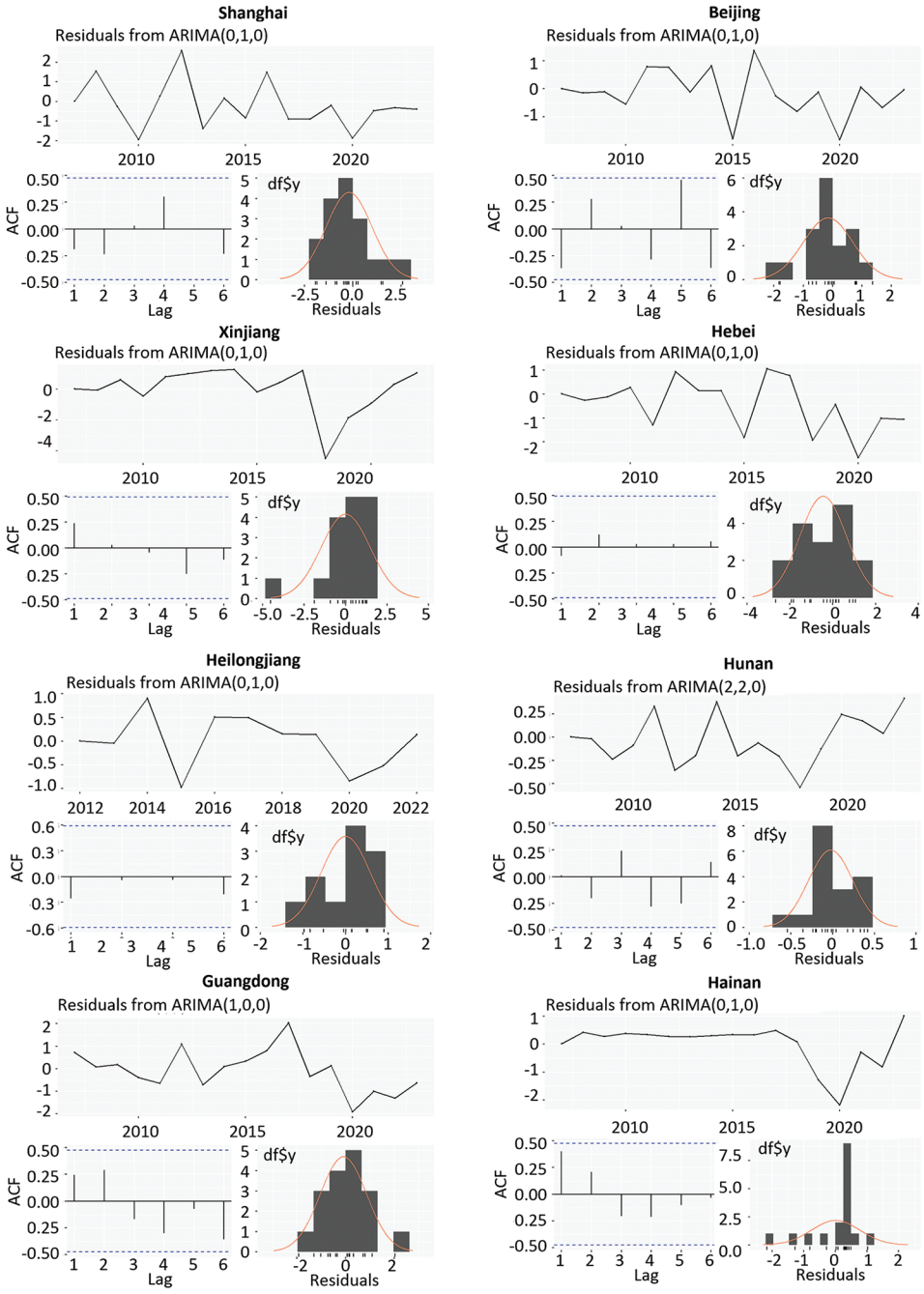

Figure A1. Residual diagnostics for birth rate models in eight Chinese provinces
Abbreviation: ARIMA: Autoregressive integrated moving average.

ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Influence of household wealth status on transactional sex and condom use among Nigerian youth: A cross-sectional analysis of the 2018 Demographic and Health Survey

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Abstract

Globally, despite the increasing social and economic interventions to achieve better health behavior outcomes for the younger generation, the rising rate of engagement in risky sexual behaviors (RSBs) among young people is alarming, particularly in developing countries. This could be attributed to households' wealth conditions that contribute to poor access to sexual and reproductive health services. This study investigates the influence of household wealth status on RSBs (transactional sex and non-condom use) among unmarried youth aged 15–24 years in Nigeria. Survey data from the 2018 Nigeria Demographic and Health Survey were used to better understand RSBs among a weighted sample of 12,664 unmarried adolescents and young adults in Nigeria. Descriptive statistics were presented using frequency tables, while analytical methods included Pearson's Chi-square test and multivariate logistic analysis. The study found that individuals aged 20–24 were significantly more likely to engage in RSBs, particularly among those from households in the poorest wealth quintile (odds ratio [OR]: 1.69, 95% confidence interval [CI]: 1.04–2.76), living in communities with average poverty levels (OR: 1.34, 95% CI: 0.69–2.59), with higher education (OR: 3.22, 95% CI: 1.20–8.66), with community media access (OR: 2.04, 95% CI: 1.27–3.26), and residing in high-poverty communities (OR: 1.54, 95% CI: 0.94–2.54). To mitigate the negative effects of RSBs and their consequences, youth support initiatives should be prioritized by governments and non-governmental organizations through adaptation and mitigation strategies, particularly for those residing in low-wealth households, to discourage them from engaging in RSBs.

Keywords: Household wealth status; Risky sexual behavior; Transactional sex; Unprotected sex; Young people; Nigeria

1. Introduction

About 20% of sub-Saharan Africa's (SSA) population falls within the 15–24 age range, a critical demographic that primarily relies on others for support and plays a vital role in every society (Menon *et al*., 2016). This age group is considered important for workforce development and marks a critical transition to independence. However, they are also vulnerable to risky sexual behaviors (RSBs), such as early sexual debut, multiple sexual partners, unprotected sexual intercourse, and unprotected mouth-to-genital contact, due to emotional instability and the influence of peer pressure (Ajayi & Okeke, 2019). These behaviors pose significant public health risks, particularly in the transmission of sexually transmitted infections (STIs), including the human immunodeficiency virus (HIV), and exposure to unwanted pregnancy (Melesse *et al*., 2020; Menon *et al*., 2016). The Centers for Disease Control (2022) emphasized that young people are disproportionately affected, with 21% of all new HIV diagnoses occurring among those aged 13–24. This age group also has the highest rates of STIs compared to any other age group (Dadzie *et al*., 2022). This situation has contributed to a dramatic increase in sexually transmitted diseases among the young population, primarily caused by an increase in the burden of household socioeconomic conditions, limited availability of reproductive healthcare, including condoms, and exposure to transactional sex to meet daily needs (Ajayi & Okeke, 2019).

Evidence shows that in Nigeria, young people (15–24 years) constitute 15.6% of its total population, despite a low HIV incidence of 1.4% (Commission, 2019); however, 34.1% of all new infections in the last 2 years were among those aged 15–24 (National Agency for the Control of AIDS, 2019). In all regions of Nigeria, young people account for the largest proportion of these statistics (United Nations Department of Economic and Social Affairs, 2022). Given the high level of infectious disease, Oladunmoye *et al*. (2022) have shown that unwanted pregnancy, unsafe abortion, mental health problems, and depression among the youth are influenced by household socioeconomic status. Despite the progress toward improving youths' health outcomes in Nigeria, such as providing access to condom use, HIV testing, and awareness about healthy sexual behaviors (Bobo *et al*., 2023), substantial disparities in access to sexual and reproductive health services persist due to perceived household wealth status (Ajayi & Okeke, 2019). In addition, various initiatives aimed at promoting condom use at the regional level in Nigeria have been recorded. One of such approaches is the Culturally Sensitive Approaches led by Alhaji Sani Umar in northern Nigeria, where condom use is low. The initiative aimed at engaging the traditional and religious leaders to promote reproductive health and condom use, helping change attitudes in communities where contraception was previously regarded as taboo (Dirisu *et al*., 2022).

There are undoubtedly various reasons for the low use of sexual and reproductive health services, particularly among younger individuals in Nigeria compared to older ones. One such reason is the lack of money to buy condoms, primarily due to the financial conditions of numerous Nigerian households (Dirisu *et al*., 2022). Researchers from different fields of study have studied individual, household, and neighborhood factors, including socioeconomic causes of RSBs among young people. Such research includes the influence of family structure, community poverty, financial conditions of households, gender, ethnicity, region, mass media, place of residence, and educational attainment (Curtis *et al*., 2020; Melesse *et al*., 2020; Odii *et al*., 2020; Odimegwu *et al*., 2019; Odimegwu & Ugwu, 2022; Odimegwu & Somefun, 2017; Shittu *et al*., 2022). Other studies included personal factors such as age, gender, and employment status (Putra *et al*., 2021; Somefun, 2019). Sano *et al*. (2018) found that most youths are unable to practice safer sex practices due to the wealth status of many households in Nigeria (Popoola, 2020). Moreover, existing studies on the effect of household wealth status and family structure among young people have had mixed findings (Curtis *et al*., 2020; Odii *et al*., 2020; Odimegwu *et al*., 2019). Increasing condom awareness, accessibility, and usage, along with support from families and reduced peer pressure, can lead to the overall well-being of young people.

On a larger scale, a study by Odimegwu & Adedini (2022) revealed that young people from poor households were at lower risk of RSBs, although this finding differed from those of other research. However, the research suggests that STI prevention, including HIV/acquired immunodeficiency syndrome (AIDS) policies in Nigeria, must consider the impact of poor household wealth status on the spread of infectious diseases among the youth population (Odimegwu & Adedini, 2022). Furthermore, studies indicate that risky sexual activity at an early age can have severe implications on a young person's physical and mental health, which increases the risk of contracting STIs, including HIV/AIDS, unsafe abortions, depression, anxiety, and other reproductive health issues (Somefun, 2019). Research also shows that early sexual debut can increase the risk of delinquent behavior, including substance abuse and criminal activity (Ajayi & Okeke, 2019). Conversely, young people who delay early sexual activity and multiple sexual engagements tend to have better reproductive health services, access to education, and contraceptive methods,

enabling them to make informed choices regarding their sexual behavior despite the economic conditions of their family (Popoola, 2020). Therefore, understanding the interplay between household economic constraints and access to reproductive health services is important for shaping policies that promote positive sexual behavior, such as access and use of contraceptive methods, to help young people achieve their reproductive desires.

Many previous studies on associated factors between household wealth status and its influence on transactional sex and condom use (Mensah, 2020; Popoola, 2020) have not adequately taken into consideration the sexual health of young people residing in poor households in Nigeria. Despite these studies, there is a need to understand the household wealth influence on transactional sex and unprotected sex (non-condom use) among young people in Nigeria. This study becomes relevant as it is geared to fill this gap. Therefore, this study aims to examine the influence of household wealth status on transactional sex and condom use among young people in Nigeria using the most recent demographic and health survey (DHS) data, providing a holistic understanding of RSB. Understanding these factors is essential for shaping effective reproductive health policies, improving access to contraceptive use, and family planning. This research also aims to ascertain if household wealth status has a significant relationship with youth dynamics of transactional sex and condom use patterns in Nigeria. Hence, the hypothesis to guide our analysis is that young people from poor household wealth status are more likely to engage in transactional sex compared to those from higher household wealth status.

1.1. Theoretical framework

The study is anchored on the social ecological model (SEM) and the family stress theory, which together provide a multilevel understanding of how household wealth status influences RSBs among young people. The two theories provide a comprehensive perspective of the interplay between household socioeconomic status and sexual behavior. The SEM posits that individual behavior is shaped by multiple interacting levels of influence, including individual, interpersonal, household/family, community, and societal factors (Bronfenbrenner, 1994; Ugwu, 2022). Within this framework, household status—captured through indicators such as socioeconomic status (income, education, occupation), family structure (single-parent vs. dual-parent households), and household living arrangements—functions as an important contextual determinant of young people's sexual behaviors. In addition, limited financial resources can restrict access to education, reproductive health services, and protective measures such as condoms and other contraceptive methods, increasing vulnerability to risky sexual practices. The framework also suggests that young people from households with absent or less-involved parents may experience less monitoring, leading to experimentation with sex at an earlier age or engaging in multiple partnerships (Ugwu, 2022). Hence, families that encourage open discussions about sexuality tend to reduce risky behaviors, whereas silence, taboo, or conflictual environments heighten risks of sexual engagements (Shu, 2024).

On the other hand, the family stress framework emphasizes the role of economic and societal pressures in shaping the sexual behavior of individuals (Hill, 1949). The theory posits that economic and social pressures within households influence family functioning and, consequently, youth behavior (Shu, 2024). Young people with low household socioeconomic status are often exposed to family stressors such as instability, conflict, or parental absence due to labor migration (Ugwu, 2022). These conditions can undermine effective parental guidance and increase young people's susceptibility to peer pressure, substance use, or transactional sex, which are common pathways to RSBs.

Based on the SEM and family stress theoretical perspectives, this study provides a more holistic analysis of household influence on the dynamics of RSBs among young people in Nigeria. SEM explains the economic and societal determinants of sexual decisions, while the family stress framework highlights household/family stress or conflicts leading to emotional distress, which are coped with through engagement in risky sexual activities. These two theoretical perspectives offer critical insights for policymakers and reproductive health practitioners, emphasizing the importance of multifaceted interventions that address the household economic deprivation, parental absence/weak supervision, and peer dominance as factors influencing the sexual behaviors of Nigerian youths.

2. Data and methods

2.1. Data source and sample size

This study used secondary data from the 2018 Nigeria Demographic Health Survey (NDHS) conducted across all 36 states of the country and the Federal Capital Territory, Abuja. A cross-sectional quantitative design method of data collection was adopted for the survey, implying that data from the sampled population were taken at a single point in time (Commission, 2019). The NDHS is a nationally representative survey that gathers vital health and demographic data on women of reproductive age (15–49 years) and men aged 15–59 years. The 2018 NDHS used a nationally representative, randomly selected sample of 42,000 households. A two-stage stratified cluster

sampling design was used to select the survey respondents, and they were located at the primary sampling units referred to as enumeration areas (EAs). Other reports have provided comprehensive details on the sampling plan and data collection techniques (Melesse *et al.*, 2020; Odimegwu *et al.*, 2019; Putra *et al.*, 2021). The target population for the study was adolescents and young adults aged 15–24 years. A total of 12,664 (females: 3,778 and males: 8,886) samples were extracted from the subsets of data contained in the 2018 NDHS, as shown in Figure 1.

2.2. Measurements

2.2.1. Outcome variables

The outcome variables in this study were transactional sex and non-condom use (unprotected sex) among adolescents and young adults aged 15–24. Transactional sex was measured from the DHS question: "Have you had sex or been sexually involved with anyone because he gave you or told you he would give you gifts, cash, or anything else in the past 12 months?" Responses were subsequently categorized as "Yes" or "No" to indicate whether the individual had engaged in transactional sex (exchanging sex for money, gifts, or other forms of compensation). Previous studies have shown that one factor that continues to contribute to the rising rate of STIs is transactional sex (sex trade), especially among the youth (Adu *et al.*, 2022; Ugwu *et al.*, 2022). This behavior is linked to serious health risks and is believed to be brought on by an unequal power dynamic in romantic relationships, especially when the individual is not economically viable. Non-condom use, that is, unprotected sex without a condom in their last sexual intercourse, was evaluated through the question, "Did you use a condom during your last sex with your most recent partner?" The unprotected sex variable was coded "1" if youths reported not using condoms, and otherwise, "0." The 12-month reference period helped capture the most recent behaviors and minimize recall errors. The interest in non-condom use was because it constitutes the key pathway through which young people can contract STIs and HIV infections, both of which continue to spread sporadically (Odimegwu & Ugwu, 2022).

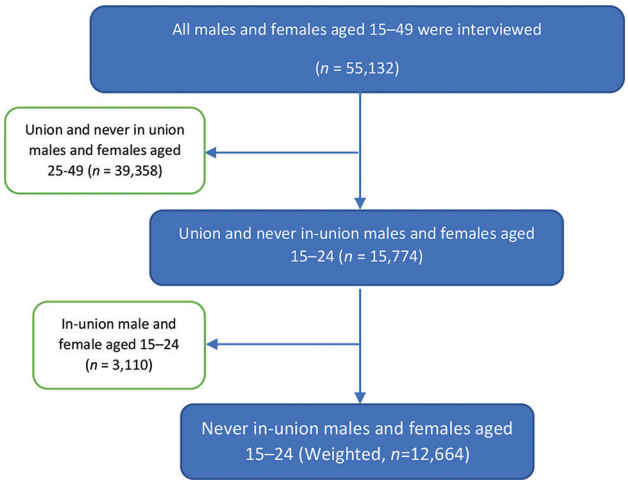

Figure 1. Procedure for sample selection

2.2.2. Explanatory variables

The key primary explanatory variable for this study was perceived household wealth status. Previous studies have suggested four important dimensions of individual empowerment to access sexual and reproductive health services, particularly in developing countries, such as the household wealth level (Oladunmoye *et al.*, 2022; Popoola, 2020). We considered the household dimensions of empowerment in this study and identified several economic variables, including the respondent's occupation, earnings from work, wealth status, and the seasonality of the occupation. In this study, we considered the household wealth quintile, which the DHS used to measure household wealth status. The DHS questions about household wealth status were not restricted to any category of individuals. Therefore, the analysis incorporated youths aged 15–24. For classification, adolescents and young adults were categorized as living in a "wealthy household" if they resided in households within the richest wealth quintile. Conversely, respondents were classified as living in a "poor household" if they belonged to the lowest wealth quintile. Thus, perceived household wealth status was measured as the percentage of adolescents and young adults from households in the wealthiest or poorest wealth quintile (Decker *et al.*, 2021). Apart from the key explanatory variable, the following co-variables were included in the analysis: age of adolescents and young adults, educational attainment, place of residence, community media access, community poverty level, sex of the head of household, and community education level. In addition, certain variables were regrouped from their original categories in the datasets to make interpretations simpler and more meaningful. For instance, age was grouped as 15–19/20–24 years, while educational attainment was categorized as lower than primary/secondary or higher education. The selection of key explanatory variables and covariates was based on previous research showing their significant links to RSBs and other health outcomes (Enane *et al.*, 2018; Odimegwu & Ugwu, 2022).

2.3. Statistical analysis

This study's statistical analysis utilized STATA version 17, employing a 5% significance level. Descriptive analysis presented frequencies and percentages of adolescents' and young adults' background characteristics. Cross-tabulations between RSBs and both individual-level and community-level characteristics, using Chi-square tests,

were employed to examine associations between outcomes and individual-level variables. Multivariable binary logistic regression modeled the effects of key explanatory variables and individual-level characteristics on transactional sex and condom use in NDHS data, reporting adjusted odds ratios (OR) with 95% confidence intervals (CI). Covariates with p-values ≤ 0.2 in bivariate analysis were included in the multivariable model.

2.4. Ethical clearance

This study's data are publicly available on the DHS Programme website (https://www.dhsprogram.com) and were used with permission from the Integrated Public Use Microdata Series and DHS. The data are anonymous, with no identifiable respondent information. The DHS survey and biomarker protocols for each country were approved by local ethics review boards, ensuring compliance with relevant guidelines and regulations. Participants over 18 provided informed consent, while those under 18 required parental or guardian consent and assent from the minors themselves.

3. Results

3.1. Characteristics of the study population

Table 1 provides the distribution of the study samples analyzed. A total of 8,886 respondents were males, with 73.8% aged 15–19 and 26.2% aged 20–24. Among them, 19.6% had primary or lower education, the majority (71%) had attained secondary education, and only 9.4% had higher education. For the perceived household wealth status, most male respondents were from poor households (50.5%). Slightly over 30% of the male respondents were from communities with varying levels of educational attainment (low, average, and high). In addition, male respondents from male-headed households (74.9%) outnumbered those from female-headed households (25%).

For the female respondents, Table 1 shows that out of 3,778 female respondents, 65.2% aged 15–19, while 34.8% aged 20–24. Most of them (64.6%) had secondary education, while 27.5% had primary or lower education, and less than 10% had attained a higher education. For perceived household wealth status, most female respondents were from poor households (61.9%), while < 40% were from wealthy households. Moreover, female respondents from male-headed households (84.7%) outnumbered those from female-headed households.

3.2. Bivariate analysis of sociodemographic characteristics, community-level factors, and RSBs

Table 2 shows the bivariate analysis of the association between having unprotected sex and the sociodemographic characteristics of the respondents. The results revealed that all the explanatory variables were significantly associated with having unprotected sex, except for the sex of the head of the household. A total of 46% of young adults aged between 20 and 24 engaged more in unprotected sex compared to 37% of adolescents (15–19 years). Adolescents/young adults who have attained higher education (53%) had higher tendencies to engage in unprotected sex than those with secondary (42.23%) and primary/lower education (28.21%). In the case of perceived household wealth status, adolescents/young adults from poor households (35.51%) engaged more in protected sex than those from wealthy households (48.54%). In addition, adolescents/young adults from rural areas (40.37%) engaged slightly less in unprotected sex than their counterparts residing in urban areas (45.05%). Adolescents/young adults with access to community media had a very high tendency to engage more in unprotected sex than those without. High

Table 1. Characteristics of the study population

Characteristics	Males, *N*=8,886 (%)	Females, *N*=3,778 (%)
Age		
15–19	73.79	65.22
20–24	26.21	34.78
Educational attainment		
Primary and lower	19.63	27.47
Secondary	71.01	64.58
Higher	9.36	8.94
Household wealth status		
Wealthy households	49.45	38.14
Poor households	50.55	61.86
Place of residence		
Urban	49.72	40.55
Rural	50.28	59.55
Community media access		
No	71.87	72.37
Yes	28.13	27.98
Community poverty level		
Low	36.21	27.16
Average	34.99	31.21
High	28.80	41.64
Community education level		
Low	33.58	43.99
Average	32.94	28.53
High	33.48	27.47
Sex of head of household		
Male	74.95	84.73
Female	25.05	15.27

community poverty (31.24%) was associated with lower engagement in unprotected sex than the communities with average (42.56%) and low (49.25%) levels of poverty. Adolescents/young adults from communities with average levels of education (46.29%) had slightly more unprotected sex than those from communities with high (41.29%) and low levels of education (40.3%). The results further revealed that, among other variables, only educational attainment was significantly associated with transactional sex. That is, adolescents/young adults with primary education and less education (23.78%) engage more in transactional sex than those with secondary education (15.92%) and higher education (11.69%).

Table 2. Bivariate analysis of risky sexual behaviors, sociodemographic characteristics, and community-level factors

Characteristics	Risky sexual behavior	
	Transactional sex (%)	Unprotected sex (%)
Age		
15–19	16.59*	37.14***
20–24	15.64*	46.53***
Educational attainment		
Primary/lower education	23.78***	28.21***
Secondary	15.92***	42.23***
Higher	11.69***	53.33***
Household wealth status		
Wealthy households	15.84	48.54***
Poor households	16.26	35.51***
Place of residence		
Urban	16.38	45.05**
Rural	15.72	40.37**
Community media access		
No	15.54	38.31***
Yes	16.87	50.11***
Community poverty level		
Low	15.28	49.25***
Average	16.79	42.56 ***
High	16.23	31.24***
Sex of head of household		
Male	15.89	42.55
Female	16.32	42.56
Community education level		
Low	13.62*	40.31**
Average	16.44*	46.29**
High	17.37*	41.29**

Note: Statistical significance determined at * $P<0.05$, ** $P<0.01$, and *** $P<0.001$.

3.3. Multivariable analysis of RSBs

Table 3 presents the binary logistic regression of the independent and outcome variables. The purpose of this study was to investigate the effect of each independent variable on the outcome variable. However, the results in Table 3 show that none of the independent variables were significantly associated with unprotected sex, although variations in the ORs indicated both increased and decreased likelihoods. Male respondents, aged 20–24, had an increased odds of engaging in unprotected sex (OR = 1.57) compared with the male youths aged 15–19. In addition, adolescent males with higher education had an increased odds of engaging in unprotected sex compared to their peers with secondary and primary/lower

Table 3. Multivariable analysis of risky sexual behavior

Characteristics	Unprotected sex odds ratio		Transactional sex odds ratio	
	Male	Female	Male	Female
Age				
15–19	Ref.	Ref.	Ref.	Ref.
20–24	1.57*	1.69*	0.98*	1.70*
Education				
Primary/lower	Ref.	Ref.	Ref.	Ref.
Secondary	2.63*	2.43*	1.38*	2.43*
Higher	3.91*	3.22*	2.18*	3.22*
Place of residence				
Urban	Ref.	Ref.	Ref.	Ref.
Rural	1.08*	0.94*	0.88	0.94
Community media exposure				
No	Ref.	Ref.	Ref.	Ref.
Yes	1.32*	2.04*	1.21	2.04
Head of the household				
Male	Ref.	Ref.	Ref.	Ref.
Female	1.14	0.80	1.29	0.80
Community poverty level				
Low	Ref.	Ref.	Ref.	Ref.
Average	0.86	1.34	1.54	0.57
High	0.58	0.69	1.54	0.69
Community education level				
Low	Ref.	Ref.	Ref.	Ref.
Average	0.80*	1.34*	0.95*	1.30*
High	0.75*	0.76	0.90*	0.76

Note: Statistical significance determined at *$p<0.05$.

education (OR = 3.22). Male adolescents/young adults from female-headed homes had an increased odds of engaging in unprotected sex (OR = 1.14) compared to those in male-headed households. Meanwhile, adolescent boys in average and high-poverty communities had a lower odds of engaging in unprotected sex compared to their counterparts in average (OR = 0.86) and low (OR = 0.58) poverty communities. For the female respondents, females aged 20–24 had an increased odds of engaging in unprotected sex (OR = 1.69) compared with the female youths aged 15–19. Furthermore, adolescent females with higher education had an increased odds of engaging in unprotected sex compared to their peers with secondary and primary or less education (OR = 3.91). Adolescent girls from female-headed homes had a lower odds of engaging in unprotected sex (OR = 0.8) compared with those in male-headed households. Adolescent girls in communities with average poverty had a higher odds of engaging in unprotected sex compared to their peers in low- and high-poverty communities (OR = 1.34). Adolescent girls in communities with average education had an increased odds of engaging in unprotected sex compared to their peers from communities with low and high levels of education (OR = 1.34).

In addition, Table 3 further shows that none of the independent variables were significantly associated with transactional sex, although variations in the ORs indicated both increased and decreased likelihoods. Male respondents, aged 20–24, had an increased odds of engaging in transactional sex (OR = 0.98) compared with the male youths aged 15 to 19. In addition, adolescent males with higher education had an increased odds of engaging in transactional sex compared to their peers with secondary and primary/lower education (OR = 2.18). Conversely, adolescent boys in rural areas had a lower odds of engaging in transactional sex compared to their counterparts in urban areas (OR = 0.88). Media exposure was found to increase the odds of male respondents engaging in transactional sex (OR = 1.21). Adolescent boys from female-headed homes had an increased odds (OR = 1.29) of engaging in transactional sex compared to those in male-headed homes. Meanwhile, adolescent boys in average and high-poverty communities had a higher odds of engaging in transactional sex compared to their counterparts in average (OR = 1.54) and low-poverty communities (OR = 1.54). For the female respondents, females aged 20–24 had an increased odds of engaging in transactional sex (OR = 1.70) compared to the female youths aged 15 to 19. In addition, adolescent/young adult females in higher education had an increased odds of engaging in transactional sex compared to their peers in secondary and primary/lower education (OR = 3.22). Conversely, adolescent girls in rural areas had a lower odds of engaging in transactional sex compared to their counterparts in urban areas (OR = 0.94), while media exposure was found to increase the odds of female respondents engaging in transactional sex (OR = 2.04). Adolescent girls from female-headed homes had a lower odds (OR = 0.8) of engaging in transactional sex compared to girls in male-headed homes. In addition, adolescent girls in communities with average poverty had a lower odds of engaging in transactional sex compared to their peers in low- and high-poverty communities (OR = 0.57). Moreover, adolescent girls in communities with average education had an increased odds of engaging in unprotected sex compared with their peers in communities with low and high levels of education (OR = 1.30).

4. Discussion

The objective of this study was to examine the influence of household wealth status on transactional sex and condom use among young people in Nigeria. Specifically, the aim was to investigate the determinants of RSBs (transactional sex and condom use [unprotected sex]) among adolescents and young adults in Nigeria with a special focus on the role of household wealth status. In line with previous studies in SSA, the results established that young people living in the poorest households and those residing in urban areas engage in unprotected sex and transactional sex (Ajayi & Okeke, 2019; Dana *et al*., 2019; Odimegwu & Ugwu, 2022; Odimegwu & Somefun, 2017). These findings show that RSBs have been consistently high among young people due to household constraints. This finding is consistent with a prior study conducted by Decker *et al.* (2021), which demonstrates that youths from poor households are generally exposed to RSBs, which increases the possibility of contracting STIs, including HIV/AIDS (Decker *et al*., 2021). However, this result is in disagreement with the findings of Odii *et al.* (2020) and Ssewanyana *et al.* (2020), whose studies identified a lack of comprehensive information on sex education and contraceptive knowledge among young people as a cause of RSBs. Hence, the findings reiterate the need for government and policymakers to commit to creating awareness about abstinence as a significant intervention program that supports young people to have adequate knowledge about the use of reproductive health services, particularly in Nigeria.

Across genders, the results revealed that about two-thirds (65.8%) of the study population over 20 years old had engaged in RSB. In addition, the bivariate results showed that all the independent variables, including living in a high-poverty neighborhood and high educational attainment, were significantly associated with unprotected sex across gender. The results showed that living in a

high-poverty neighborhood in Nigeria was seen as a risk factor for young people to engage in RSB. This finding is not surprising because prior studies have shown that young people living in high-level poverty communities are more exposed to the negative effects of sexual behavior (Somefun, 2019). This exposure is mainly caused by a lack of access to social media platforms, such as mobile phones and the internet, which are needed to obtain information about the impacts of RSB, despite the living conditions of their households. These results have some policy implications in line with Sustainable Development Goal 3, aimed at attaining universal access to affordable, reliable, sustainable healthcare, as well as reducing the epidemic of AIDS, tuberculosis, malaria, and other non-communicable diseases among adolescents and young adults in Nigeria. Interventions aimed at improving the health outcomes of young people, including a reduction in the rate of HIV/AIDS, and other infectious diseases such as tuberculosis and malaria, should consider the role of households' wealth status where adolescents and young adults reside.

Furthermore, the findings from the multivariate regression analyses revealed that the likelihood of engaging in RSB among young people was significantly higher for female adolescents and young adults aged 20–24 than for their counterparts aged 15–20, by a factor of 1.7. These findings corroborate those of previous studies, which found that an increase in age among youths is negatively associated with youth health and well-being (Odimegwu & Ugwu, 2022; Somefun, 2019; Stiglic & Viner, 2019). Furthermore, it reiterates the importance of other studies showing that older youth without economic viability and from poor households are more vulnerable to RSBs (Anyanwu *et al*., 2020; Dirisu *et al*., 2022; Tende, 2020). The findings could be explained by the possibility that low-income households contribute to a lack of access to housing, food, and healthcare, as well as to school dropouts, unemployment due to a lack of education, and inadequate oversight and monitoring of youth activities. This validates previous studies, which found that most youth deaths are linked to exposure to infectious diseases such as STIs, including HIV/AIDS, and this is closely associated with household socioeconomic factors, including a lack of access to social safety nets provided by the government to access sexual reproductive health services (Folayan *et al*., 2022; Nzoputam *et al*., 2022).

After adjusting for all the selected sociodemographic factors, age, place of residence, higher education, community poverty level, and community media access were found to be significantly associated with the risk of transactional sex. For instance, having primary/lower or secondary education attainment significantly reduced the odds of engaging in transactional sex, as validated by previous studies (Ajayi & Okeke, 2019; Anyanwu *et al*., 2020; Tende, 2020). In addition, living in urban areas has previously been shown to cause a greater risk of transactional sex among youths (Ajayi & Okeke, 2019). Plausibly, engaging in transactional sex could be determined by the perceived level of household wealth where adolescents and young adults reside. Hence, the community level of education contributes to youths' engagement in transactional sex, possibly through the lack of proper dissemination of information concerning the harmful effects of engaging in RSBs. These findings suggest that community-based initiatives can play a vital role in empowering youth with accurate information and skills to make informed decisions about their sexual and reproductive health, both in school and out-of-school settings. In addition, there is a need to strengthen parent–child communication on sexual and reproductive health issues to promote healthy sexual behaviors. Thus, support structures such as social promotion centers and youth centers are needed to sustain information on sexual and reproductive health for young people. The findings further highlight the need to engage communities, religious leaders, and parents in promoting and organizing awareness campaigns and conference debates on sexual and reproductive health problems to educate young people in Nigeria.

Furthermore, findings on the influence of age, educational attainment, female household head, and average neighborhood poverty level on the risk of unprotected sex were as expected. Female-headed households in Nigeria, particularly those from poor backgrounds, may increase young women's vulnerability to high-risk sexual behavior, thereby raising their risk of HIV infection and negatively impacting their long-term health outcomes. This has policy implications, as there is a need for more pragmatic strategies to eradicate infectious diseases among adolescents and young adults in both rural and metropolitan areas. In addition, achieving universal access to affordable, reliable, and sustainable healthcare, along with improved household wealth, is essential to enhancing adolescent and young adult health outcomes in Nigeria. Previous studies have indicated that the place of residence (urban or metropolitan areas) determines the likelihood of unprotected sex among young people in Nigeria (Ajayi & Okeke, 2019; Folayan *et al*., 2022; Odimegwu & Ugwu, 2022; Odimegwu & Somefun, 2017). There were variations in the risk of unprotected sex across community education levels in Nigeria, with youths from moderately educated communities showing higher exposure to unprotected sex, likely due to insufficient knowledge of contraceptive use and inadequate sex education. The rates of unprotected sex in less educated

communities (Ajayi & Okeke, 2019; Odimegwu & Ugwu, 2022) were higher among youths residing in communities without access to education (Envuladu *et al*., 2021; Ugwu *et al*., 2022). This is an indication that youths from poor households are more likely to engage in unprotected sex, which may contribute to the higher risk observed among youths from less and moderately educated communities compared with those from highly educated communities in Nigeria.

This study leverages the SEM and the family stress theory to provide a nuanced understanding of the complex interplay between household socioeconomic status and RSBs among young people in Nigeria. By integrating these frameworks, we gain a deeper insight into the multifaceted determinants of RSBs, including individual, social, environmental, and household factors. The SEM highlights the intricate relationships between individual, social, and environmental drivers, while the family stress theory sheds light on how household socioeconomic stressors, such as poverty and financial instability, can shape young people's behaviors. This integrated approach offers critical implications for policymakers and health practitioners, emphasizing the need for comprehensive interventions that address the socioeconomic, individual, household, and environmental factors influencing RSBs.

By considering individual, household, and community factors, these theories provide a holistic understanding of the decisions surrounding RSBs. This study's findings can inform existing sexual and reproductive health interventions aimed at reducing RSBs among young people in Nigeria. However, developing targeted interventions requires a more comprehensive approach. A multilevel analysis that accounts for individual, household, and community-level factors is essential to unravel the complex factors contributing to RSBs among young people in Nigeria. This approach can inform evidence-based interventions and policy decisions, ultimately enhancing the effectiveness of sexual and reproductive health programs.

4.1. Policy implications of the findings

This study has some policy implications for young people in SSA, particularly in Nigeria. The results show that older youth and those living in poor resource households are more likely to engage in RSBs such as transactional sex and unprotected sex, underscoring the importance of promoting positive sexual behavior. The Nigerian government has implemented several health policy initiatives to address RSBs among young people. These initiatives aim to improve access, inclusivity, and equity in service delivery nationwide, focusing on adolescent-friendly services and comprehensive sexual and reproductive health education, particularly for young people with financial constraints. Therefore, efforts should be made to increase access to health insurance, which will reduce household financial barriers to healthcare services across Nigeria. Collaborating with the state and local government councils will further help to provide free and affordable sexual and reproductive services in a safe, confidential environment, in partnership with organizations like The Youth Development and Empowerment Initiative. This is because such interventions have the potential to educate young people on sexual and reproductive health, HIV, and STI prevention. Furthermore, a government-initiated program will help young people achieve sexual and reproductive health autonomy, helping them to make informed choices about their sexual behaviors.

4.2. Strengths and limitations

In this study, cause-and-effect relationships could not be established because of the application of cross-sectional DHS data, and the only independent variable was temporal factors connected to adolescent and young adult sexual behaviors. In addition, there was a chance of reporting bias on the primary explanatory variable (perceived household wealth status) used in the study, as it was self-reported data. Another limitation is that, although the data were the most recent available to researchers, they were from the 2018 NDHS, which is 7 years old. This data may not provide the current problems among the Nigerian youths. Despite these drawbacks, the results of this study are crucial for shaping current strategies and initiatives aimed at reducing youth involvement in RSBs. This can be achieved by providing them with all the financial support needed to enhance their health outcomes, thereby improving the wealth status of the households where they reside. In addition, it is imperative to ensure that the youth in Nigeria have access to cheap, dependable, and sustainable health care services. It is suggested that further research involve qualitative studies in different parts of the country to further investigate the health risks associated with RSBs for youths in Nigeria.

5. Conclusions

This study established that young people from poorer households are likely to engage in transactional and unprotected sex in Nigeria. The results can inform policies and interventions aimed at reducing RSBs and promoting reproductive health among vulnerable populations. In addition, educational attainment, place of residence, community media access, community poverty level, female as the household head, and community education level were significantly associated with the risk of transactional

sex and non-condom use. Thus, there is a need to sensitize and support young people, particularly those from poor households in Nigeria. To lessen the negative effects of RSBs and their consequences, government and non-governmental organizations should implement adaptation and mitigation strategies to empower youth from poor households and discourage them from engaging in transactional sex and non-condom use.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

Ethics approval was not required for this study because the data are secondary and available in the public domain. To conduct our study, we registered and requested the dataset from the DHS online archive, receiving approval to access and download the data files. According to the DHS report, all respondents' data were anonymized during the data collection.

Consent for publication

Not applicable.

Availability of data

The data utilized in this study can be accessed publicly through the IPUMS DHS or DHS Program websites: https://www.idhsdata.org/idhs/, https://dhsprogram.com/.

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RESEARCH ARTICLE

Empowerment, sexual autonomy, and contraceptive choices: Recent evidence from Bangladeshi women

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Abstract

In low- and middle-income countries, women's empowerment is a vital driver for overall development. Using data from the 2022 Bangladesh Demographic and Health Survey, this study investigates how women's household decision-making power and autonomy over sexual rights influence contraceptive method choice among married women in Bangladesh. Findings show that 59% of women used modern contraceptives, while 10% relied on traditional methods. Multilevel multinomial logistic regression (MLMLR) analysis reveals that women with higher household decision-making autonomy and those who supported the right to refuse sex with their husbands were significantly (p<0.001) more likely to prefer either modern or traditional contraception compared to the reference category, "non-users." Moreover, older women, those from wealthier households, women desiring more children, and those who had experienced child mortality were significantly less likely to choose traditional or modern contraception compared to non-users. Conversely, the likelihood of preferring modern or traditional methods was significantly higher among highly educated couples, those earning cash income, non-Muslim women, those who received visits from family planning workers (FPWs), and those with access to mass media. Community-level factors also influenced contraceptive method choices: Urban women and those from communities with higher levels of female education were more likely to use contraceptives than their non-user counterparts. The MLMLR analysis also found significant variations in contraceptive method choice across clusters and regions. The findings underscore the critical role of women's empowerment, particularly in household decision-making and sexual autonomy, in shaping contraceptive behavior. Strengthening women's agency at both individual and community levels through policies and programs, expanding FPW doorstep services, and empowering low-educated, rural women in household decisions may boost effective contraceptive use and advance Bangladesh's family planning efforts.

Keywords: Bangladesh; Women's empowerment; Women's household decision-making autonomy; Contraceptive method choice; Multilevel multinomial logistic regression

1. Introduction

Women's empowerment is now recognized as a vital ingredient in shaping global development initiatives, especially in low- and middle-income countries (LMICs). Women's empowerment encompasses various dimensions, such as decision-making autonomy, financial independence, access to education, and reproductive and sexual rights. These factors significantly impact a woman's autonomy in making informed decisions regarding her reproductive health and rights, including contraceptive method use and method choice (Lahole *et al*., 2024; Nkoka *et al*., 2021). Family planning (FP) plays a vital role in helping women manage childbirth, prevent unintended pregnancies, create a suitable gap between successive childbirths, and enhance maternal and child health. While many countries, including Bangladesh, have made significant progress in increasing contraceptive use, disparities persist, emphasizing the need to explore the effect of women's empowerment on their reproductive behavior, particularly contraceptive use and method choice (Lahole *et al*., 2024; Nkoka *et al*., 2021).

Bangladesh has witnessed a remarkable shift in contraceptive use over recent decades. The prevalence of contraceptive methods has increased from just 8.0% in the mid-1970s to approximately 64.0% by 2022 (National Institute of Population Research and Training [NIPORT] *et al*., 2024), with 54.7% using modern contraceptive methods and 9.3% relying on traditional methods. This achievement in expanding modern contraception is largely credited to proactive FP programs and increased awareness (Kamal & Islam, 2012). Despite these advancements, the continued prevalence of 19% unintended pregnancies and a 10% unmet need for FP among currently married Bangladeshi women, equally split between the desire to space and limit births, has critical implications for women's empowerment and their ability to make informed contraceptive choices. Although the persistent demand for FP points to widespread awareness and willingness to use contraceptives, the relatively small decline in unmet need, from 12% in 2017–2018 to 10% in 2022 (NIPORT *et al*., 2024), highlights ongoing challenges. The high levels of unintended pregnancies and unmet demand for contraception suggest that improvements in access and decision-making autonomy remain limited. This ongoing gap likely reflects deeper structural barriers, such as restrictive gender norms, limited reproductive agency, and gaps in service delivery, which continue to hinder many women from turning their reproductive intentions into actual contraceptive use. Moreover, the fact that unmet need is evenly distributed between spacing and limiting births may indicate a mismatch between women's fertility preferences and the availability, accessibility, or acceptability of contraceptives and their method choice.

Household power structures significantly influence women's contraceptive method use and choice (Dhak *et al*., 2020; Sarwer *et al*., 2024). In many families, traditional gender norms place decision-making authority solely in the hands of men, restricting women's control over their reproductive and sexual health and rights. However, research indicates that women with greater autonomy in household decision-making are more likely to choose modern contraception (Dhak *et al*., 2020; Khatun *et al*., 2023; Kumari *et al*., 2024; Lahole *et al*., 2024; Sarwer *et al*., 2024). Based on data from the Bangladesh Demographic and Health Surveys (BDHS), previous studies suggest that women with higher decision-making power are more inclined to adopt effective FP methods, underscoring the role of women's empowerment in reproductive behavior (Rahman *et al*., 2014; Sarwer *et al*., 2024).

Education is a well-recognized key determinant of contraceptive use and method choice among women in LMICs, including Bangladesh. Highly educated women are generally more informed about contraceptive options and feel more confident in making reproductive decisions (Lahole *et al*., 2024; Rahman *et al*., 2014; Sarwer *et al*., 2024). Educated women are also more likely to seek medical healthcare services, engage in frequent discussions about FP with their husbands and neighbors, and adopt more effective, that is, modern contraceptive methods to achieve their desired family size (Dhak *et al*., 2020; Kamal & Islam, 2012; Khatun *et al*., 2023; Kumari *et al*., 2024; Lahole *et al*., 2024; Sarwer *et al*., 2024). Therefore, investing in female education is a strategic approach to enhancing reproductive autonomy and advancing gender equality in Bangladesh, as well as in other developing countries.

Despite overall progress in contraceptive use, significant disparities still exist between places of residence. Urban women generally have better access to healthcare facilities, greater exposure to mass media, and higher levels of education, all of which contribute to increased contraceptive use. In contrast, women residing in rural areas face substantial challenges, including limited access to medical facilities, lower literacy rates, and restrictive cultural norms that hinder their ability to make independent reproductive choices (Dhak *et al*., 2020; Kamal & Islam, 2012; Lahole *et al*., 2024; Sarwer *et al*., 2024). Bridging these gaps requires targeted policies and programs based on the findings from studies using the most recent data and appropriate statistical analysis that focus on underprivileged women, ensuring equal access to contraceptive services across different socioeconomic strata.

Women's bargaining power within households plays an important role in shaping contraceptive method use and choice in Bangladesh (Kamal & Islam, 2012; Rahman *et al*., 2014; Sarwer *et al*., 2024) and other LMICs. Factors such as decision-making autonomy, education, mass media exposure, and regional disparities significantly influence women's ability to make informed reproductive and sexual health decisions (Kamal & Islam, 2012; Rahman *et al*., 2014; Sarwer *et al*., 2024). Strengthening women's empowerment can lead to increased use of more effective contraceptive methods, improved maternal health outcomes, and overall progress toward national and global development objectives.

However, the effects of women's household decision-making autonomy—and particularly the impact of their sexual rights—on contraceptive method choice have not been thoroughly explored in Bangladesh. Specifically, the link between women's sexual rights—captured through their attitudes toward the acceptability of wife-beating when a wife refuses sex—remains largely overlooked in the existing body of research. We argue that such an attitude serves as a direct indicator of a woman's sexual autonomy and overall empowerment, making it a critical variable for understanding how power dynamics influence reproductive choices. This study aims to rigorously examine how women's household bargaining power, specifically decision-making autonomy and sexual rights, shapes contraceptive method choices among women in Bangladesh. A key area of interest lies in exploring the link between attitudes toward gender-based violence, specifically, the perception that a husband is justified in hitting his wife for refusing sex, and its relation to contraceptive decision-making.

The study aims to contribute by highlighting how power relations and women's sexual rights influence contraceptive method choices in Bangladesh, offering new insights for improving reproductive health policies and gender-equitable FP programs. The structure of the study is organized in a standard scientific manner. It begins with an abstract, followed by the introduction, then details the data and methods (including data sources, variables, and statistical analysis), presents the results, proceeds with a discussion (interpretation of findings and comparison with prior studies), outlines the strengths and limitations, and concludes with policy implications, followed by references.

1.1. Theories and the conceptual framework

1.1.1. Theories

Women's decision-making on contraceptive method use and choice is a multilevel process that is influenced by individual cognition, relationships with other people, community settings, and health-system conditions. Psychological theories of decision-making—the most prominent being the Theory of Planned Behavior (TPB)—suggest that the decision to use contraceptives can be determined by individual attitudes, social expectations, and the perceived capability of an individual to act upon these expectations. TPB has been extensively used in reproductive health behavior research, particularly in studies on contraceptive use and persistence (Ajzen, 1991).

In addition to TPB, Bulatao (1989) and other similar theories argue that contraceptive method choice as a consequence of: (i) Contraceptive objectives (desired family size, spacing), (ii) competence and knowledge (skills and information to use methods), (iii) evaluation (attitudes toward safety, side effects, acceptability), and (iv) access (availability, cost, and service quality). These dimensions help explain why, among users, specific approaches such as traditional and modern methods (pills, injectables, sterilization, condoms, intrauterine device [IUD]) are more or less popular. This framework has been applied and generalized in empirical studies across many LMICs, including Bangladesh, to demonstrate how both demand-side (knowledge, preferences, parity) and supply-side (method availability, provider bias) variables influence method mix (Bulatao, 1989).

In conservative societies, such as Bangladesh, the attitudes of men and the decision-making patterns of couples often affect women's contraceptive practices, which is a contribution of gender and power theories. Research consistently indicates that communication between spouses and the locus of decision-making (woman, husband, joint) are strong predictors of contraceptive adoption and method choice. The use of contraception is also linked with women's empowerment (autonomy in decision-making, social independence, attitudes toward gender-based violence), although this correlation may depend on the specific domain of empowerment and the type of method used. Therefore, gendered power relations should be considered alongside psychological and access-related factors to comprehensively address contraceptive patterns (Ajzen, 1991; Kundu *et al*., 2022).

Finally, the social ecological model (SEM) offers a convenient organizing taxonomy: (i) Individual (age, education, parity, fertility desires, knowledge, attitudes), (ii) interpersonal (husband/partner influence, family, social norms), (iii) community (urban/rural setting, local service mix, cultural norms), and (iv) system/policy (FP program outreach, commodity supply, service quality). SEM emphasizes cross-level interactions (e.g., how access modulates the impact of attitudes), which is critical for both explaining causes and informing policy-making (Kundu *et al*., 2022).

1.1.2. Conceptual framework

The conceptual framework of this study combines TPB, Bulatao's method-choice dimensions, women's empowerment constructs, and the SEM:

(i) Individual: Age, education, parity, fertility preference, knowledge regarding contraceptive methods, and attitudes (perceived benefits/harms) influence intention to use contraception and preference for a specific method (Ajzen, 1991).

(ii) Interpersonal variables: Partner/husband attitudes, communication between spouses, and household decision-making, and family influence directly affect both the use and choice of method (male or female), and mediate the impact of individual intention (Ajzen, 1991; Kundu *et al*., 2022).

(iii) Community and service environment: Geographic location, place of residence (urban or rural), method availability within the community, and prevailing community behavioral patterns influence access and the feasibility of preferred methods. These factors also impact perceived behavioral control (TPB) and method evaluation (Ajzen, 1991; Bulatao, 1989). For example, programmatic factors such as the strength of FP programs, supply chains for contraceptive commodities, and the quality of outreach and counseling services can influence method choice through changes in access, cost, and quality. System-level factors can enhance or dampen the effects of the other domains (NIPORT *et al*., 2024).

2. Data and methods

2.1. Data source and sample

This study used data from the most recent 2022 BDHS. The survey was conducted by NIPORT, a government organization in Bangladesh. After excluding one rural cluster from the Chittagong division, data collection was undertaken in 674 clusters. A total of 30,358 women were enumerated across 30,300 households in the selected clusters. Of these, 30,078 ever-married women from both rural and urban areas were deemed eligible for interview, representing 99% of those listed. Out of these, 20,217 married women were qualified to provide full information, and ultimately 18,245 were successfully interviewed. The data collection followed a two-stage cluster sampling design. In the first stage, 675 primary sampling units were chosen using probability proportional to size, comprising 237 urban and 438 rural locations. The survey collected extensive information on topics such as fertility, contraceptive method mix, contraceptive use, maternal and child healthcare, nutritional status of mothers and children, and various socio-demographic factors. The 2022 BDHS employed the Integrated Multi-Purpose Sampling Master Sample to collect data from respondents in the selected enumeration areas, covering the entire country. A comprehensive description of the survey is documented in other sources (NIPORT *et al*., 2024). After removing cases with missing information, a final sample of 17,783 married women aged 15–49 was included in the analysis. It is important to note that in Bangladesh, sexual relations and childbearing outside of marriage are culturally stigmatized, socially unacceptable, and legally prohibited. For this reason, our study was restricted to married women only. A summary of the sampling procedure is presented in Figure 1.

2.2. Description of variables

2.2.1. Outcome variable

The outcome of interest of this study was the choice of contraceptive method. The survey documented a wide range of FP methods, including oral pills, IUDs, injections, diaphragms, male condoms, female sterilization, male sterilization, implants, and emergency contraception. These methods are collectively classified as modern methods. In contrast, methods such as periodic abstinence, withdrawal, and lactational amenorrhea are categorized as traditional methods. Consequently, contraceptive method choice was classified into three categories: Non-use, traditional methods, and modern methods. The breakdown of contraceptive method mix and use rate is illustrated in Figure 2.

2.2.2. Explanatory variables

This study mainly focuses on examining the effect of women's empowerment in household decision-making and their sexual rights on the choice of contraceptive methods: Traditional method, modern method, and non-use (reference category). To fulfill the objectives of the study and based on data availability, three indicators of women's empowerment were considered: FP decision-making, household decision-making autonomy, and sexual rights of women—specifically, a woman's right to refuse sex with her husband. The third indicator is the main focus of this study, as it directly reflects women's reproductive and sexual rights and overall empowerment. The dataset included five response options for FP decision-making: Respondent alone, husband/partner alone, joint decision by both spouses, someone else, and other. The last two categories were merged and labeled as "others."

The survey collected data on five indicators related to the "justification of wife-beating." This study specifically focused on the indicator assessing whether "beating is justified if a wife refuses to have sex with her husband." This

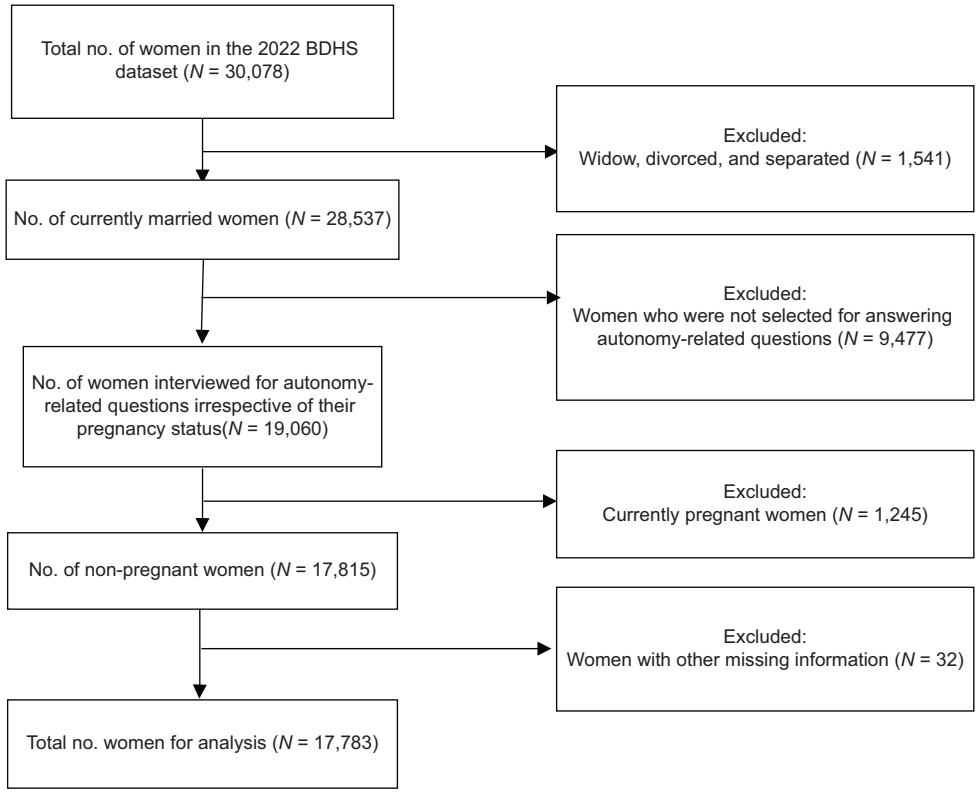

Figure 1. Flowchart of the sample selection process from the 2022 BDHS
Abbreviation: BDHS: Bangladesh demographic and health survey.

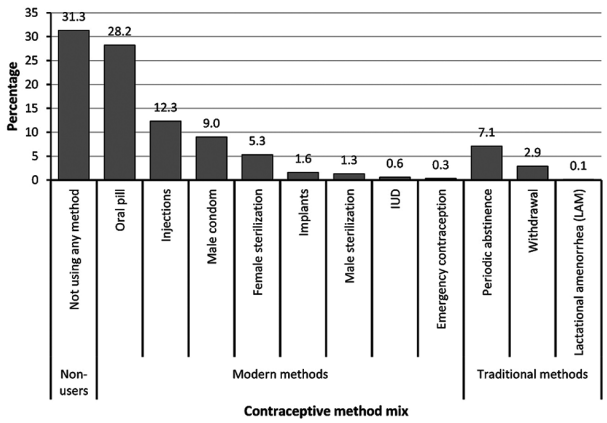

Figure 2. Breakdown of contraceptive method mix used by women in Bangladesh
Source: 2022 Bangladesh Demographic and Health Survey data.
Abbreviation: IUD: Intrauterine device.

variable was selected because it is directly linked to women's sexual autonomy, making it a critical factor in examining its association with contraceptive use and method choice. Furthermore, responses to the other four indicators showed nearly 98% agreement, indicating no substantial variation or influence on contraceptive behavior. Based on this, the other indicators of "*justification of wife-beating*" were excluded from the analysis.

Women's household decision-making autonomy was assessed using five indicators: (i) Control over the respondent's earnings, (ii) decisions regarding the respondent's healthcare, (iii) authority over major household purchases, (iv) decision-making regarding visits to family or relatives, and (v) control over the use of the husband's earnings. Each indicator offered five to six response options: Respondent alone, husband/partner alone, joint decision by both spouses, respondent with another person, someone else, and other. To quantify autonomy, a weight of 2 was assigned for independent decision-making by the respondent, 1 for joint decisions, and 0 for all other cases. The reliability of these assigned weights was evaluated using Cronbach's alpha, which yielded a score of 0.703, demonstrating strong reliability and consistency. The estimated median score was 4.0, with composite scores categorized into two groups: Values above 4.0 were classified as "high" autonomy for women, while those at or below 4.0 were labeled as "low" autonomy.

Aligned with earlier studies conducted in Bangladesh and other LMICs, and a comprehensive literature review (Arends-Kuenning, 2001; Hossain *et al.*, 2018; Khatun *et*

al., 2023; Kumari *et al*., 2024; Kundu *et al*., 2022; Sarwer *et al*., 2024), the other explanatory variables encompass socio-demographic variables such as women's age group, number of living and deceased children, births in the past five years, education levels of both women and their husbands, women's participation in paid jobs irrespective of formal and informal sectors, household wealth index, religious affiliation, desire for more children, visits from government FP workers (FPWs) to the respondents, and access to mass media.

The 2022 BDHS dataset lacks direct economic indicators such as individual income or consumption expenditure. To overcome this limitation, Demographic and Health Surveys (DHS) generally evaluate economic status using the household wealth index, a composite measure widely used in demographic and health research. This index was developed by the BDHS based on various socioeconomic factors, including household facilities, household environment, and ownership of consumer goods. The details of the computation procedure for the household wealth index are provided in the 2022 BDHS report (NIPORT *et al*., 2024). In addition, four community-level variables were included in the analysis: Residence, administrative regions, socioeconomic status, and women's education. Consistent with previous studies (Lahole *et al*., 2024), data regarding place of residence and administrative regions were directly sourced from the BDHS dataset, while other community-level factors were derived from aggregated cluster-level data. The BDHS directly provided the composite wealth index score for each household in the raw dataset, taking into account the respondents' place of residence. To measure community-level wealth status, we followed a methodology comparable to that used for household-level wealth measures or indices (Dias & de Oliveira, 2015). Based on these cluster-specific scores, we computed a national median score. Socioeconomic status was then classified as high if the composite score was equal to or above the national median, and as low if it was below the national median.

Similarly, the educational status of women in every neighborhood (cluster) was estimated using data on individual educational attainment of women living in the respective clusters. The 2022 BDHS data provided educational attainment in completed years in continuous form. Based on this data, we calculated a median educational score for each cluster. Clusters with a median score greater than the national median were classified as having a high level of education, whereas clusters with a median score equal to or less than the national median were labeled as having a low level of women's education.

Table 1 presents the comprehensive operational definitions and measurements of the individual, demographic, socioeconomic, and community-level factors included in this study for analysis. Before conducting multivariable analysis, the variance inflation factor (VIF) was used to assess multicollinearity. Due to the existence of multicollinearity, we excluded the variable, namely, "children ever born to per woman," from the analysis (the estimated VIF was 5.67). After this, the highest VIF value was recorded as 2.21, indicating that multicollinearity was not a concern in the analysis of this study.

2.3. Statistical analysis

This study employed simple cross-tabulation, bivariate, and multivariate statistical techniques. The association between the independent variables and types of contraceptive method choice—non-use, traditional method, and modern method—was assessed using χ^2 tests. Given the hierarchical structure of the data—where women were nested within households, and households were nested within clusters—the influence of both individual-level (including demographic, household, and socioeconomic factors) and community-level variables on the three categories of contraceptive method choice (non-use [reference category], traditional method, and modern method) was assessed using multilevel multinomial logistic regression (MLMLR) analysis.

An initial assessment of the MLMLR indicated that household-level factors accounted for a negligible proportion of the total variance. In a separate analysis (not shown in the table), we observed that a significant majority of households (71%) included only one eligible woman. As a result, applying a three-level multinomial logistic regression would primarily capture variation at the individual or household level rather than at the cluster level. To address this limitation, we opted for a two-level MLMLR approach. The application of MLMLR was considered more appropriate, as women from households with similar characteristics may have varying choices of contraceptive methods depending on the characteristics of their surrounding community.

It is notable that, despite its advantages, MLMLR has several limitations. It relies on the assumption of the independence of irrelevant alternatives (IIA), which may not hold when closely related outcome choices are involved. Additionally, the model can be computationally demanding and complex, especially when it includes numerous outcome categories or levels of random effects, which may lead to convergence and interpretability issues. There is also the challenge of correctly specifying the model to prevent biased estimates, as well as the issue of limited or incomplete cluster-level data, which may hinder the analysis of contextual effects.

Table 1. Operational definitions of individual and socio-demographic factors and percentage/mean (±SD) distribution of the respondents (*n*=17,783)

Covariates	Definition	Measurement scale and coding	*n*	Percentage/mean (±SD)
Individual and socio-demographic factors				
Present age	Present age of the women at the time of the survey (in completed years)	Ordinal	-	32.2±8.80
	1=15–24	4,099	23.1	
	2=25–34	6,260	35.2	
	3=35–49	7,424	41.7	
Children ever born	Mean no. of children ever born per woman	Ordinal and continuous	17,783	2.23±1.38
Living children	Number of living children per woman at the time of the survey	Ordinal and continuous	17,783	2.09±1.25
Children died	Number of deceased children at the time of the survey	Ordinal and continuous	17,783	0.14±1.25
Births in the past five years	Total number of births in the past five years	Ordinal and continuous	17,783	0.46±0.61
Women's education	A woman's level of education	Ordinal	-	-
	0=No education	2,373	13.3	
	1=Primary	4,681	26.3	
	2=Secondary	8,140	45.8	
	3=Higher	2,589	14.6	
Husband's education	Husband's level of education	Ordinal	-	-
	0=No education	3,851	21.7	
	1=Primary	4,989	28.1	
	2=Secondary	5,669	31.9	
	3=Higher	3,274	18.4	
Engaged in earning cash	Whether the women were engaged in cash earning at the time of the survey	Binary	-	-
	0=No	11,918	67.0	
	1=Yes	5,865	33.0	
Wealth index	Household wealth index	Ordinal	-	-
	1=Poorest	3,123	17.6	
	2=Poorer	3,508	19.7	
	3=Middle	3,534	19.9	
	4=Richer	3,691	20.8	
	5=Richest	3,927	22.1	
Religion	Religious affiliation	Nominal	-	-
	1=Islam	15,912	89.5	
	2=Others	1,871	10.5	
Desire for more children	Whether the women expressed a desire for more children	Binary	-	-
	0=No	12,050	67.8	
	1=Yes	5,733	32.2	
Visited by FPHW	Whether the respondent was visited by a family planning worker	Binary	-	-
	0=No	14,538	81.8	
	1=Yes	3,245	18.2	
Access to media	Whether the respondent had access to newspapers, radio, or TV	Binary	-	-
	0=No	7,298	41.0	
	1=Yes	10,485	59.0	

(Cont'd...)

Table 1. ***(Continued)***

Covariates	Definition	Measurement scale and coding	*n*	Percentage/mean (±SD)
Women's autonomy-related factors				
Family planning decision-maker	Family planning decision-maker	Nominal	-	-
	1=Respondent alone	2,037	11.5	
	2=Husband alone	1,572	8.8	
	3=Husband–wife jointly	13,951	78.5	
	4=Others	223	1.3	
Household decision-making autonomy	Power bargaining of the respondents in the household decision-making	Ordinal	-	-
	1=Low	12,078	67.9	
	2=High	5,705	32.1	
Right to refuse sex	Whether the respondents have the right to refuse sex with their husbands	Binary	-	-
	0=No	17,238	96.9	
	1=Yes	545	3.1	
Community-level variables				
Place of residence	The place of residence where the respondent was living at the time of the survey	Nominal	-	-
	1=Urban	6,234	35.1	
	2=Rural	11,549	64.9	
Administrative regions	The place of the administrative region where the respondent was living at the time of the survey	Nominal	-	-
	1=Barishal	1,913	10.8	
	2=Chattogram	2,610	14.7	
	3=Dhaka	2,698	15.2	
	4=Khulna	2,324	13.1	
	5=Mymensingh	1,915	10.8	
	6=Rajshahi	2,319	13.0	
	7=Rangpur	2,169	12.2	
	8=Sylhet	1,835	10.3	
Community-level women's education	Community-level women's education derived from women's individual raw dataset	Nominal	-	-
	1=Low	10,865	60.1	
	2=High	6,918	39.9	
Community-level wealth	Community-level wealth derived from women's individual raw dataset	Nominal	-	-
	1=Low	11,061	62.2	
	2=High	6,722	37.8	
Total number of women	Total number of sampled women	*N*	17,783	100.0

Source: Bangladesh Demographic and Health Survey 2022.
Abbreviations: SD: Standard deviation; TV: Television.

Notwithstanding its limitations, MLMLR is an adequate and more suitable statistical technique for examining trichotomous outcomes of interest, such as contraceptive method choice (i.e., non-use [reference category], traditional, and modern methods). It accounts for the hierarchical nature of the data while allowing for the simultaneous comparison of several categorical outcomes. This makes MLMLR particularly relevant and effective in reproductive health research, where both individual-level and cluster-level determinants influence contraceptive behavior.

2.3.1. Model-building process

In this study, the model-fitting procedure involves four stages: (i) The initial stage involved constructing a null model (without explanatory variables) to examine the baseline variation across clusters. (ii) The second stage

included only individual-, socio-demographic-, and autonomy-related factors (Model I). (iii) In the third stage, we included only community-level variables (Model II). (iv) In the final stage (Model III), all relevant individual, demographic, household socioeconomic, and women's autonomy-related factors, as well as community-level explanatory variables that may influence the choice of contraceptive methods, were included to develop a contextual model.

2.3.2. Random-effects analysis (Measures of variance)

Random variation in the choice of traditional or modern FP methods, compared to non-use, across clusters was determined using the intra-class correlation coefficient (ICC), proportional change in variance (PCV), and median odds ratio (MOR). In this context, the ICC reflects the proportion of overall variation in the use of traditional and modern methods that is attributable to differences between clusters. The PCV, which represents the percentage of variance explained in a multilevel model, was used to assess the extent to which variation in FP method choice could be attributed to individual- or community-level factors. The MOR was estimated to quantify the heterogeneity in the odds of contraceptive method preference among women across clusters.

The results of the MLMLR analyses are presented using relative risk ratios (RRRs). To present the main results of the four MLMLR models clearly, the 95% confidence intervals (CIs) were not included in the table but are described in the findings. The level of significance was set at $p<0.10$. Estimates were made nationally representative by applying the individual weighting factor. Graphical presentations were created using MS Excel, and data were analyzed using the Statistical Package for the Social Science v25 (IBM, United States of America [USA]) and Stata 15 (StataCorp, USA).

2.4. Ethical consideration

This study used the nationally representative 2022 BDHS data set, which is publicly available free of charge from the DHS Program website (https://dhsprogram.com/data/dataset_admin/). The DHS program provides standardized recode files in multiple formats for public use. All DHS surveys undergo ethical review by the Institutional Review Board of the International Classification of Functioning, Disability and Health, United States. In addition, the BDHS protocol received ethical approval from the Bangladesh Medical Research Council, under the Ministry of Health and Family Welfare, Bangladesh. As the DHS datasets are de-identified and publicly available for research purposes, this study did not require additional ethical approval.

3. Results

3.1. Characteristics of the sample women

Table 1 presents the percentage distribution of the respondents by their background characteristics. The average (mean ± standard deviation) age of the women was 32.2 ± 8.8 years. The mean number of children ever born and currently living children per woman was 2.23 ± 1.38 and 2.09 ± 1.25, respectively. Among the women, 14.4% had attained higher education, while the corresponding percentage for their husbands was 18.4%. One-third of the women were engaged in cash-earning activities, and 37.3% belonged to economically disadvantaged households.

The respondents were predominantly Muslim, and about one-third expressed a desire to have more children. Less than one-fifth of the respondents had been visited by government FPWs. More than three-quarters participated in joint decision-making regarding FP, whereas only 11.5% made these decisions independently. Of the respondents, two-fifths had no access to any media, such as newspapers, radio, or television. Less than one-third had a high level of autonomy in household decision-making, and only 3.1% believed that they had the right to refuse sexual relations with their husband. Over one-third (35.1%) of the women resided in urban areas, and 15.2% were from the Dhaka division. Nearly two-fifths lived in communities where women had higher education, and 37.8% were from communities with high wealth levels.

3.2. Breakdown of the contraceptive method mix

Figure 2 presents a detailed breakdown of the contraceptive method mix and corresponding usage rates. As illustrated in the figure, the oral pill emerged as the most commonly used modern contraceptive method among women in Bangladesh, followed by male condoms, female sterilization, implants, male sterilization, IUDs, and emergency contraception, in that order. Among traditional methods, periodic abstinence was the most preferred, followed by withdrawal and the lactational amenorrhea method, respectively. The prevalence rates for each method are also indicated in the figure.

3.3. Differentials in contraceptive method choice

Table 2 presents the variations in contraceptive method choice among women based on their individual, socio-demographic, and community-level factors. The findings indicate that one in 10 women used traditional contraceptive methods, while nearly two-thirds (58.6%) were currently using modern contraceptive methods. In contrast, 31.1% of the women were non-users of any contraceptive method. Overall, 68.7% of the women were contraceptive users.

Table 2. Distribution of women aged 15–49 years by contraceptive use status and method choice by individual, socio-demographic, and community-level factors (*n*=17,783)

Covariates	Percentage of women			χ^2-test *p*-value
	Non-users	Using traditional methods	Using modern methods	
Individual, demographic, and socioeconomic factors				
Present age				
15–24	33.3	6.7	59.9	<0.001
25–34	27.4	7.5	65.1	
35–49	33.4	14.2	52.4	
Women's education				
No education	36.7	11.5	51.7	<0.001
Primary	28.2	10.1	61.6	
Secondary	31.0	9.2	59.8	
Higher	32.8	11.5	55.7	
Husband's education				
No education	31.7	10.9	57.4	<0.001
Primary	28.8	8.8	62.4	
Secondary	33.3	9.5	57.2	
Higher	31.2	12.2	56.7	
Earn cash				
No	33.8	9.5	56.7	<0.001
Yes	26.2	11.3	62.4	
Wealth index				
Poorest	26.9	8.4	64.7	<0.001
Poorer	30.6	9.4	60.0	
Middle	30.6	10.1	59.3	
Richer	31.9	10.2	57.9	
Richest	35.4	12.0	52.6	
Religion				
Islam	32.1	9.7	58.2	<0.001
Others	24.1	13.5	62.5	
Desire for more children				
No	25.5	11.5	63.1	<0.001
Yes	43.5	7.2	49.3	
Visited by family planning workers				
No	33.7	10.6	55.6	<0.001
Yes	20.3	7.6	72.0	
Family planning decision maker				
Respondent alone	32.4	7.4	60.3	<0.001
Husband alone	31.9	10.6	57.5	
Husband-wife jointly	30.4	10.6	59.0	
Others	73.5	0.4	26.0	
Access to media				
No	34.6	9.7	55.8	<0.001
Yes	29.0	10.4	60.6	
Women's autonomy-related factors				
Family planning decision-maker				
Respondent alone	32.4	7.4	60.3	<0.001
Husband alone	31.9	10.6	57.5	
Husband-wife jointly	30.4	10.6	59.0	
Others	73.5	0.4	26.0	
Women's household decision-making autonomy				
Low	35.8	9.7	53.5	<0.001
High	30.3	11.0	58.7	
Wife has the right to refuse sex with their husbands				
No	38.0	9.0	53.0	<0.001
Yes	31.1	10.1	58.7	
Community-level factors				
Place of residence				
Urban	28.7	11.6	59.7	<0.001
Rural	32.7	9.3	58.0	
Administrative regions				
Barishal	30.6	11.9	57.4	<0.001
Chattogram	36.3	9.9	53.8	
Dhaka	33.2	10.2	56.6	
Khulna	29.0	11.1	59.9	
Mymensingh	28.9	7.8	63.2	
Rajshahi	26.2	10.0	63.7	
Rangpur	25.4	10.4	64.2	
Sylhet	40.8	9.2	50.1	
Women's community-level education				
Low	34.3	11.5	54.2	<0.001
High	26.1	9.8	64.1	
Community-level wealth				
Low	31.1	9.3	59.6	<0.001
High	32.3	12.3	55.4	
Total	31.3	10.1	58.6	-

Source: Bangladesh Demographic and Health Survey 2022.

All variables included in the analysis showed a statistically significant association (p<0.001) with contraceptive method choice. The use rate of modern contraceptive methods was significantly higher among

women aged 25–34 years, whereas the highest prevalence of traditional method use was observed among older women aged 35–49 years. The prevalence of modern contraceptive use was also significantly higher among women with primary education, those whose husbands had primary education, women engaged in earning cash at the time of the survey, and those from the poorest households.

Additionally, non-Muslim women, those who expressed no desire for further childbearing, women who had been visited by FPWs, and those who independently made decisions regarding contraceptive use had higher rates of modern contraceptive use. Access to mass media, a high level of autonomy in household decision-making, and the belief that a wife has the right to refuse sexual intercourse with her husband were also positively associated with modern contraceptive practices. Furthermore, the adoption of modern contraceptive methods was more widespread among urban residents, women from communities with higher levels of female education, and those from communities with lower wealth levels.

Furthermore, women with no schooling and those with advanced education were more likely to rely on traditional contraceptive methods. Use of traditional methods was also more common among women whose partners were highly educated, those engaged in earning cash, the wealthiest women, non-Muslim women, and those who did not express a desire for additional children. Additionally, women who had not been visited by FPWs and those with access to mass media showed a higher tendency to use traditional methods. The use of traditional contraceptive methods was also more prevalent among women with greater autonomy in household decision-making, urban residents, women from the Barishal division, those from communities with low levels of female education, and those residing in more affluent communities.

3.4. Model fit of multilevel analysis

The random effects and model fitting estimates from the MLMLR analyses are displayed in Table 3. The model's goodness-of-fit was evaluated using the Akaike information criterion (AIC), Bayesian information criterion (BIC), and log-likelihood estimates. Lower values of AIC and BIC, along with higher values of log-likelihood, indicate a better-fitting model. A detailed examination of the estimates (not shown in the table) suggests that Model III provides the best fit for this study, as it incorporates individual, demographic, socioeconomic, and community-level factors. Notably, the estimated BIC values for model I and model III are almost identical, suggesting that the addition of community-level variables contributes little improvement. However, Model III offers a marginally better fit to the data than Model I, even after accounting for the number of estimated parameters.

3.4.1. Empowerment-related factors associated with use of specific contraceptive methods

The MLMLR analysis results presented in Table 3 reveal that the prevalence of modern FP methods was notably higher in the women with greater household decision-making power (RRR: 1.23; 95% CI: 1.06–1.42; $p<0.001$) compared to those with low autonomy, relative to non-users. While women with higher autonomy also showed a higher tendency to choose traditional methods compared to their less autonomous counterparts (relative to non-users), this association was found to be comparatively weaker (RRR: 1.17; 95% CI: 1.00–1.35; $p<0.10$). Joint decision-making between spouses regarding FP was significantly and positively associated with a preference for modern FP methods (RRR: 1.15, 95% CI: 1.01–1.28). In contrast, when the husband alone made decisions regarding FP, the likelihood of using traditional methods increased significantly (RRR: 1.68, 95% CI: 1.30–2.18; $p<0.001$), relative to non-users. Furthermore, women who believed that a wife has the right to refuse sex with her husband were more likely to prefer either traditional (RRR: 1.20, 95% CI: 1.06–1.34) or modern contraceptive methods (RRR: 1.33, 95% CI: 1.10–1.57), compared to those who did not hold this belief, relative to non-users.

3.5. Individual, demographic, and socioeconomic factors associated with contraceptive method choice

Table 3 shows that women aged 35–49 were significantly less likely to adopt any contraceptive method than those aged 15–24 years, relative to non-users. Additionally, a higher number of living children was positively associated with the use of either traditional or modern methods. Women who had experienced child mortality tended to use modern contraceptives less, compared to non-users; however, this factor was not significantly associated with the use of traditional methods. Recent childbirth was positively related to the use of either traditional or modern contraceptive methods relative to non-use.

Women's level of education showed a significant and positive linear association with contraceptive method choice. Women with higher education were 1.79 times more likely to choose traditional methods and 1.68 times more likely to prefer modern FP methods than those with no formal education, relative to non-users. Similarly, women whose husbands had attained higher levels of education were also more likely to use either traditional or modern contraceptive methods than those whose husbands had no formal education, relative to non-users.

Table 3. Results of multilevel multinomial logistic regression analysis of choosing traditional or modern contraceptive methods over non-use among women in Bangladesh

Covariates	Null model		Model I		Model II		Model III	
	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use
Individual, demographic, and socioeconomic-level factors								
Fixed-effects intercept	−1.09	0.67	−2.23	0.33	−0.67	0.79	−1.77	0.55
Present age (in years)								
15–24 (ref)	-	-	-	-	-	-	-	-
25–34	-	-	0.73***	0.67***	-	-	0.72***	0.67***
35–49	-	-	0.80*	0.35***	-	-	0.79*	0.34***
Living children	-	-	-	1.31***	-	-	1.33***	1.34***
Children died	-	-	-	0.87***	-	-	0.95	0.88***
Births given in the past five years	-	-	-	1.48***	-	-	1.12*	1.49***
Women's level of education								
No education (ref)	-	-	-	-	-	-	-	-
Primary	-	-	1.48***	1.55***	-	-	1.46***	1.56***
Secondary	-	-	1.55***	1.62***	-	-	1.53***	1.63***
Higher	-	-	1.84***	1.69***	-	-	1.79***	1.68***
Husband's level of education								
No education (ref)	-	-	-	-	-	-	-	-
Primary	-	-	0.99	1.12*	-	-	0.98	1.13**
Secondary	-	-	1.02	1.02	-	-	1.01	1.03
Higher	-	-	1.38***	1.26***	-	-	1.33***	1.22**
Engaged in earning cash								
No (ref)	-	-			-	-		
Yes	-	-	1.54***	1.53***	-	-	1.53***	1.49***
Household wealth index								
Poorest (ref:)	-	-	-	-	-	-	-	-
Poorer	-	-	0.95	0.78***	-	-	0.92	0.77***
Middle	-	-	0.97	0.74***	-	-	0.93	0.72***
Richer	-	-	0.88	0.67***	-	-	0.83#	0.65***
Richest	-	-	0.80*	0.53***	-	-	0.72**	0.50***
Religious affiliation								
Islam (ref)	-	-	-	-	-	-	-	-
Others	-	-	1.85***	1.50***	-	-	1.90***	1.56***
Desire for more children								
No (ref)	-	-	-	-	-	-	-	-
Yes	-	-	0.42***	0.33***	-	-	0.44***	0.34***
Visited by family planning workers								
No (ref)	-	-	-	-	-	-	-	-
Yes	-	-	1.15*	1.99***	-	-	1.14#	1.94***

(Cont'd...)

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Table 3. ***(Continued)***

Covariates	Null model		Model I		Model II		Model III	
	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use	Traditional versus non-use	Modern versus non-use
Access to mass media								
No (ref)	-	-	-	-	-	-	-	-
Yes	-	-	1.24***	1.43***	-	-	1.21***	1.34***
Women's autonomy-related factors								
Family planning decision-maker								
Respondent alone (ref)	-	-	-	-	-	-	-	-
Husband alone	-	-	1.69***	1.07	-	-	1.68***	1.08
Husband-wife jointly	-	-	1.65***	1.09#	-	-	1.66***	1.15***
Others	-	-	0.03***	0.23***	-	-	0.04***	0.24***
Household decision-making autonomy								
Low (ref)	-	-	-	-	-	-	-	-
High	-	-	1.18#	1.29***	-	-	1.17#	1.23***
Women have the right to refuse sex with their husbands								
No (ref)	-	-	-	-	-	-	-	-
Yes	-	-	1.22***	1.31***	-	-	1.20***	1.33***
Community-level factors								
Place of residence								
Urban (ref)	-	-	-	-	-	-	-	-
Rural	-	-	-	-	0.69***	0.82***	0.67***	0.68***
Administrative regions								
Barishal (ref)	-	-	-	-	-	-	-	-
Chattogram	-	-	-	-	0.69***	0.79**	0.65***	0.75**
Dhaka	-	-	-	-	0.75**	0.88	0.82#	1.04
Khulna	-	-	-	-	0.98	1.10	0.99	1.19
Mymensingh	-	-	-	-	0.73**	1.19*	0.70**	1.12*
Rajhshahi	-	-	-	-	0.99	1.30**	1.03	1.43**
Rangpur	-	-	-	-	1.09	1.38***	1.04	1.38***
Sylhet	-	-	-	-	0.57***	0.65***	0.55***	0.64***
Community-level women's education								
Low (ref)	-	-	-	-	-	-	-	-
High	-	-	-	-	0.87#	1.23***	0.91	1.21***
Community-level wealth								
Low (ref)	-	-	-	-	-	-	-	-
High	-	-	-	-	1.12#	0.88	1.09	0.89

Note: #$p<0.10$; *$p<0.05$; **$p<0.01$; ***$p<0.001$.
Abbreviation: ref: Reference.

Women's cash earnings also emerged as a significant influencing factor in contraceptive method use and choice. Women engaged in income-generating activities, particularly those earning cash, were 1.53 times more likely to use traditional methods and 1.49 times more likely to use modern methods than those not involved in paid

jobs, relative to non-users. Interestingly, the household wealth index demonstrated a negative association with the adoption of modern contraceptive methods, indicating that an increase in wealth was linked to a decreased likelihood of choosing modern methods among women.

Religious affiliation played a notable role; Muslim women were significantly less likely to use both modern and traditional contraceptive methods compared to non-Muslim women. Additionally, women who expressed a desire to have more children were considerably less likely to use any contraceptive methods—traditional or modern—compared to those who did not, relative to non-users. There were positive relationships between FPWs' visits and the adoption of modern contraceptive methods, although the influence on the choice of traditional methods was somewhat weaker. Moreover, access to mass media was positively associated with the use and choice of traditional or modern FP methods.

3.6. Community-level factors and random effects associated with contraceptive method choice

This study incorporated four community-level factors. Among these, community-level wealth did not have any significant impact on the choice of FP methods after adjusting for other explanatory variables. Women residing in rural areas were less likely to use either traditional or modern FP methods compared to their urban counterparts, relative to non-users. Specifically, the odds of choosing traditional and modern methods were 33.0% and 32.0% lower, respectively, among rural women than their urban counterparts, relative to non-users.

The findings also highlight regional disparities in contraceptive method choices across different administrative regions. Women from the Rajshahi division had a significantly higher likelihood of choosing modern contraceptive methods compared to those from the Barishal division, while the lowest likelihood was observed among women from the Sylhet division, relative to non-users. In addition, compared to women in Rajshahi, those in Dhaka, Mymensingh, and Sylhet divisions were significantly less likely to use traditional methods, relative to non-users.

Furthermore, women living in communities with a high level of female education were significantly more likely to choose modern contraceptive methods than those from communities with a lower level of female education. However, this factor did not have a significant impact on the choice of traditional methods, relative to non-users.

Based on the random-effects analysis, the estimated ICC value from the null model (Table 4) indicates that 12.5% of the variability in contraceptive method choice among married women can be attributed to differences across clusters, reflecting heterogeneous individual and socioeconomic structures at the community level. Analysis of the PCV in the final model revealed that 34.4% of the variation in contraceptive method choice across communities was explained by the inclusion of individual, demographic, socioeconomic, and community-level factors. Furthermore, the MOR in the null model was estimated at 1.56, indicating heterogeneity in contraceptive method choice between clusters. This suggests that, all else being equal, the odds of using a contraceptive method were 1.56 times higher in clusters with a greater prevalence of contraceptive use compared to those with lower usage.

Table 4. Results of random effects from multilevel multinomial logistic regression analyses

Measures of random-effects	Null model	Model I	Model II	Model III
Cluster-level variance (standard error)	0.47 (0.02)	0.38 (0.02)	0.33 (0.02)	0.31 (0.02)
ICC (%)	12.50	10.40	9.10	8.60
PCV (%)	Ref.	19.10	29.80	34.40
MOR	1.56	1.43	1.37	1.34

Abbreviations: ICC: Intra-class correlation coefficient; MOR: Median odds ratio; PCV: Proportional change in variance; Ref: Reference.

4. Discussion

This study examined the extent to which household decision-making power and sexual rights influence contraceptive method choices among Bangladeshi women, using the nationally representative 2022 BDHS data. The analysis included 17,783 married women. The results indicate that overall, 68.7% of these women were using contraception, with 10.1% relying on traditional methods and 58.6% using modern contraceptive methods. These findings show minimal variation from national estimates as reported in the 2022 BDHS report (NIPORT *et al*., 2024), likely due to the sampling procedure used in this study. The slight differences can be attributed to the exclusion of women with missing information related to women's empowerment, currently pregnant women, and those with other missing information.

Our findings support Bulatao's theory (Bulatao, 1989) and the SEM, which suggest that women with greater household decision-making autonomy are more inclined to utilize modern or traditional contraceptive methods rather than forgo contraception entirely. This empowerment enables access to vital reproductive health information and supports informed FP decisions. Research indicates that such women are more likely to proactively consult healthcare providers and collaborate with their partners

in selecting suitable contraceptive options, thereby increasing uptake (Abita & Girma, 2022). Additionally, higher autonomy helps overcome socio-cultural barriers and dispel common misconceptions about contraception, allowing for a more informed assessment of benefits and better management of potential side effects (R. Ghosh *et al.*, 2021; Mutumba, 2022; Rahman *et al.*, 2014). Ultimately, the ability to make independent decisions contributes to improved reproductive health outcomes, as these women are more likely to adopt either modern or traditional methods compared to non-users.

Women empowered to refuse sexual intercourse with their husbands show a higher likelihood of choosing either modern or traditional FP methods compared to their less empowered counterparts. This ability reflects a higher degree of personal autonomy and empowerment within the marital relationship, which is strongly associated with improved reproductive health outcomes. More empowered women generally have better access to FP resources and information, and they are more confident in negotiating sexual and reproductive choices with their partners. This autonomy enables them to make informed decisions about contraception, including adopting modern or traditional methods to manage fertility and protect their reproductive and sexual health and rights. In contrast, women with lower levels of decision-making autonomy may experience difficulties in accessing and using contraceptives, resulting in higher rates of non-use. Recent studies emphasize that promoting women's control and agency over their sexual and reproductive choices is key to increasing contraceptive uptake and enhancing overall reproductive well-being (Abita & Girma, 2022; Ghosh *et al.*, 2021; Mutumba, 2022).

Most of our findings corroborate prior research conducted in Bangladesh (Khatun *et al.*, 2023; Kundu *et al.*, 2022; Sharif *et al.*, 2023) and other countries (Ghosh & Siddiqui, 2017; Kumari *et al.*, 2024; Lahole *et al.*, 2024; Teshale, 2022). The results indicate that women aged 35–49 were more likely to use traditional FP methods and less likely to prefer modern contraception compared to those aged 15–24. These findings are largely in line with studies from Bangladesh (Khatun *et al.*, 2023; Kundu *et al.*, 2022; Rana *et al.*, 2024; Sharif *et al.*, 2023), Ghana (Lahole *et al.*, 2024), Ethiopia (Hailegebreal *et al.*, 2023), Senegal (Zegeye *et al.*, 2021), Malawi (Forty *et al.*, 2021), India (Ghosh & Siddiqui, 2017), and Pakistan (Kumari *et al.*, 2024).

However, these findings contradict some earlier research (Tessema *et al.*, 2021; Yifru *et al.*, 2020), which found that older women were more likely to choose modern contraceptives than their younger counterparts. This discrepancy may be explained by the tendency of older women to prefer traditional contraceptive methods, such as periodic abstinence, over modern alternatives. This preference is often shaped by long-standing practices, cultural traditions, and limited exposure to contemporary contraceptive options (Hossain *et al.*, 2018). Moreover, religious doctrines and cultural customs play a significant role in shaping contraceptive choices. In some communities, skepticism or hesitation toward modern contraceptive methods may lead older women to rely more on traditional practices (Hossain *et al.*, 2018). Other demographic factors examined in this study, including the number of living children, child mortality, and childbirths in the past five years, yielded findings consistent with earlier studies (Rana *et al.*, 2024; Sharif *et al.*, 2023). Women with more children or those who have recently given birth are more likely to opt for either modern or traditional methods of contraception to prevent further or closely spaced pregnancies, or to create a substantial interval between successive births. Conversely, women who have experienced child loss tend to be more hesitant to use contraception, often seeking to conceive again as a way to compensate for their loss. The emotional and psychological impact of losing a child can create a strong desire for another pregnancy, leading many women to avoid the use of any FP methods. This tendency is particularly evident in societies where having a certain number of children is highly valued. In addition, cultural and societal expectations place pressure on women to bear children to uphold family lineage, and the death of a child can further reinforce the urgency to conceive again, often influenced by family or community expectations.

Our study found a positive association between women's level of education and their likelihood of using either modern or traditional contraceptive methods compared to their non-user counterparts. Research from Bangladesh (Alam *et al.*, 2024; Hoq, 2020; Kundu *et al.*, 2022; Rana *et al.*, 2024; Sharif *et al.*, 2023), and other developing countries (Ali & Abrejo, 2017; MacQuarrie & Aziz, 2024; Naz *et al.*, 2024; Tumwizere *et al.*, 2024) has shown that women who have completed at least a secondary level of education are more likely to adopt modern contraception than those with no formal education. This trend may be explained by the fact that women with higher education levels have greater access to information about the benefits of contraception, particularly modern methods, through various media platforms. Moreover, they are more inclined toward preventive healthcare practices, including seeking FP services. Higher-educated women are likely to possess greater health literacy, enabling them to navigate the healthcare system efficiently, access appropriate services, and understand the guidance they receive regarding FP options.

Our findings, consistent with a study from Senegal (Zegeye *et al.*, 2021), suggest that women whose husbands

are more educated are more likely to prefer either modern or traditional contraceptive methods than to remain non-users. In addition, women whose husbands had some primary education were more likely to choose modern contraceptives, but not traditional ones. In contrast, a husband's secondary education did not have a significant effect on the choice of FP methods. Educated husbands tend to be better informed about reproductive health and FP, making them more likely to support contraceptive use. However, in some societies, husbands hold considerable influence over women's reproductive decisions. While some educated men advocate for FP, others may maintain conservative views that discourage contraception, resulting in variations in its use and choice among women.

The engagement of women in income-generation activities was found to be a critical element in the choice of FP methods. Findings show that the women who were involved in income-generating activities, compared to those who were not, were more likely to choose either modern or traditional methods. These findings are consistent with many previous studies conducted in Bangladesh (Huda *et al.*, 2017; Islam *et al.*, 2017; Islam *et al.*, 2016; Khatun *et al.*, 2023) and other LMICs (Alemu *et al.*, 2022). However, some other studies have found no meaningful relationship between women's working status and contraceptive use (Kundu *et al.*, 2022).

It is plausible that cash-earning women have greater financial autonomy, enabling them to make informed decisions about FP, including the use of modern contraceptive methods. Their economic independence empowers them to control the timing and number of children, which supports career advancement and work–life balance. Additionally, women with paid employment typically have increased opportunities to utilize health and FP services, allowing them to gather information and make informed choices. Exposure to modern ideas through media, workplaces, and social networks further increases their awareness of the benefits of contraceptive use, making them more likely to adopt any FP method suitable for them.

An important finding of this study is that household wealth is negatively associated with the choice of contraceptive methods. The use of any FP method decreases with an increase in the wealth index. Our findings do not align with some previous studies conducted in Bangladesh. For instance, using 2017–2018 BDHS data, Kundu *et al.* (2022) found no meaningful association between household wealth and the choice of any FP method. In contrast, a study from Senegal found a significant positive association between wealth and FP method use (Zegeye *et al.*, 2021).

The association between household wealth and contraceptive use varies across populations and social contexts. Higher education levels, cultural beliefs, and personal preferences often shape women's reproductive choices, favoring methods that align with their lifestyle or future fertility plans. Additionally, greater awareness of potential side effects may lead them to avoid certain options. Moreover, wealthier families may prefer larger family sizes due to socioeconomic or cultural factors, further reducing contraceptive use. Overall, this negative correlation stems from differences in access, beliefs, education, health concerns, and fertility preferences across socioeconomic groups.

In this study, we found that Muslim women and those who expressed a desire for additional children showed a significantly lower likelihood of using any form of contraception, whether modern or traditional, compared to non-users. These findings are also supported by the SEM theory and by other studies conducted in Bangladesh (Islam & Habib, 2024) and Afghanistan (Alomair *et al.*, 2020). In numerous Muslim communities, children are considered divine blessings, and the use of contraception may be viewed as obstructing God's will. In addition, some women consider birth control sinful, believing it hinders the acceptance of such divine gifts. Moreover, cultural traditions in certain Muslim societies emphasize the importance of large families. In Muslim countries such as Afghanistan, where child mortality rates are high or in areas impacted by conflict, having more children is often seen as essential for preserving family lineage and ensuring stability (Alomair *et al.*, 2020; Kamal & Islam, 2012).

Our findings indicate that visits from FPWs significantly enhance the likelihood of reproductive-aged women adopting both modern and traditional contraceptive methods. These results align with numerous previous studies conducted in Bangladesh (Hossain & Phillips, 1996; Kamal & Islam, 2012). In Bangladesh, visits by FPWs have been instrumental in enhancing contraceptive use among women. One study demonstrated that household outreach services significantly improved the continuity of contraceptive use, with the impact intensifying over time (Hossain & Phillips, 1996). Similarly, low contraceptive prevalence rates were found to be associated with infrequent contact with FPWs, especially in hard-to-reach areas (Kamal & Islam, 2012). Another study indicated that FPWs' visits reduce contraception-related expenses and potentially increase demand, with recent visits significantly influencing women's contraceptive behavior. These findings underscore the critical role of regular, targeted home visits in promoting both modern and traditional contraceptive methods among users rather than non-users (Arends-

Kuenning, 2001; Kamal & Islam, 2012). These findings also reflect the core principles of TPB.

Access to mass media is a powerful factor that encourages women to adopt FP methods (Abita & Girma, 2022; Ghosh *et al.*, 2021; Mutumba, 2022). Media platforms, such as radio, television, print media, and online outlets play a critical role in informing individuals about reproductive health by offering detailed explanations of various contraceptive options, including their benefits, usage, side effects, and effectiveness. This dissemination of accurate information helps dispel myths and reduce misconceptions about contraception. Moreover, mass media frequently present expert opinions, personal testimonials, and public service announcements that normalize FP-related discussions. These portrayals not only enhance awareness but also foster a positive perception of contraceptive practices, encouraging informed decision-making. Consequently, individuals are more inclined to choose either modern or traditional FP methods rather than forgo contraception, ultimately improving overall reproductive health outcomes. This finding also aligns with the SEM theory.

Joint decision-making between spouses plays a crucial role in shaping women's preferences for modern or traditional contraceptive methods. When couples engage in FP discussions, they tend to align their reproductive goals and make well-informed choices. This collaboration allows both partners to address concerns, share reliable information, and assess the benefits and potential side effects of various contraceptive options. Studies have shown that couples who decide jointly report greater satisfaction with their contraceptive choices and demonstrate more consistent use (Abita & Girma, 2022). Furthermore, effective communication between spouses helps dispel misconceptions and alleviate fears related to contraception, ultimately leading to increased use of either modern or traditional methods (Ghosh *et al.*, 2021; Kamal & Islam, 2012; Mutumba, 2022). This finding also echoes the theory of Bulatao and TPB. This cooperative approach not only empowers women by actively involving them in decision-making but also reinforces the couple's commitment to managing their reproductive health, resulting in improved overall FP outcomes.

Consistent with the SEM theory and numerous previous studies, our findings indicate that women from rural communities, compared to their urban counterparts, are less likely to prefer modern or traditional contraceptive methods relative to non-users (Ghosh & Siddiqui, 2017; Kundu *et al.*, 2022; Lahole *et al.*, 2024; Sharif *et al.*, 2023; Teshale, 2022). Rural women in Bangladesh are less likely to use any contraceptive methods than urban women due to socioeconomic, cultural, and accessibility barriers. Moreover, limited healthcare access reduces exposure to FP services, as rural areas have fewer healthcare centers and infrequent visits from FPWs. Lower education levels among rural women compared to their urban counterparts also contribute to misinformation and fear of side effects, which discourage contraceptive use and limit method choice. Cultural and religious norms among rural populations often favor larger families and restrict discussions on reproductive health, further limiting the adoption of the FP method. Additionally, financial constraints make contraception a lower priority for rural households focused on daily survival.

The heterogeneous picture of contraceptive use and method choice across regions is well documented in previous studies from Bangladesh (Ghosh & Siddiqui, 2017; Kundu *et al.*, 2022; Sharif *et al.*, 2023) and aligns with the outcomes of our study. These findings suggest that the use of FP methods in Bangladesh varies significantly by region due to differences in healthcare accessibility, education, and cultural norms. Healthcare infrastructures, which play a key role, are not uniform across the administrative regions of the country. More urbanized and developed regions have better access to FP services, while rural and remote areas, such as the Chittagong Hill Tracts, face shortages of healthcare facilities and government FPWs, limiting contraceptive availability.

In addition, educational disparities across communities influence contraceptive use. Regions with higher literacy rates tend to have greater awareness of FP, leading to a stronger preference for modern contraceptive methods. In contrast, lower literacy rates in certain regions contribute to misconceptions and a reliance on traditional methods or non-use. Cultural and religious beliefs further shape contraceptive preferences; conservative regions may discourage the utilization of modern contraceptive methods, favoring traditional practices. Addressing these disparities requires region-specific strategies, expanded FPW outreach, and improved healthcare access to ensure equitable reproductive and sexual health services.

A key strength of this study is its use of the latest comprehensive and nationally representative survey data, providing sufficient statistical power to accurately assess the effects of explanatory variables. The application of sampling weights in the analysis further enhanced the reliability of the estimates and standard errors. Additionally, by examining contraceptive method choice at the individual, socioeconomic, and community levels, the study employed robust statistical techniques that effectively captured hierarchical or cluster-level influences on the outcomes. However, a notable limitation lies in

the reliance on cross-sectional data, which prevents the establishment of causal relationships between the outcome of interest and the explanatory variables. Moreover, since DHS data are self-reported, it is susceptible to recall bias. Another important limitation of this study is the use of the mixed-effects multinomial logit regression model, which is based on the IIA assumption. This assumption implies that the odds of choosing between any two contraceptive methods remain unaffected by the presence or absence of other alternatives. In reality, however, some methods may be more or less substitutable, potentially violating this assumption. In this analysis, the IIA assumption was not explicitly tested, and therefore, caution is warranted when interpreting the estimates. Future studies could explore extensions to models that relax this assumption, such as the nested logit or multinomial probit model. Despite this limitation, the MLMLR model offers a practical balance between analytical rigor and interpretability when working with large, complex survey datasets, such as the BDHS. Alternative models that relax the IIA assumption are often computationally intensive and less accessible in multilevel frameworks. Thus, the use of MLMLR remains a justified and effective choice for this analysis.

5. Conclusion

The results of this study indicate a very strong connection between women's empowerment, specifically their roles in household decision-making and their sexual agency, and their likelihood of using modern or traditional methods of contraception. Women who are able to make key decisions in their households and who have the agency to refuse sex with their husbands are significantly more likely to use contraceptives compared to women who lack such autonomy. These findings indicate that improving contraceptive access in Bangladesh should not rely solely on traditional service delivery mechanisms, but must also address the underlying power structures that contribute to reduced contraceptive use.

Drawing on a thorough literature review and established research, this study also considers other important explanatory factors that influence Bangladeshi women's contraceptive method choices. These factors include women's age group, number of living and deceased children, births within the past five years, women's and their husbands' educational attainment, women's employment status, household wealth index, religious affiliation, desire for more children, visits from government FPWs, and access to mass media.

Furthermore, women who are more financially independent are more likely to choose either traditional or modern contraceptive methods. Interestingly, contraceptive use appears lower among women living in more affluent households. There are also marked regional variations in contraceptive use and preferences. To reduce regional disparities, policy implications highlight the need to expand government FPWs, improve healthcare access, and promote education and awareness. Improving contraceptive uptake, especially in rural and underserved areas, requires empowering women in household decision-making and sexual rights, removing cultural and religious barriers, and encouraging spousal involvement in FP decisions. Additionally, expanding media access can help dispel myths and increase awareness, thereby improving FP outcomes. To ensure equitable access to contraception across Bangladesh, tailored approaches that account for regional and socioeconomic disparities are essential. Future research and policy efforts should focus on dismantling socio-cultural barriers and implementing programs that strengthen women's agency, ensuring that every woman has both the resources and the right to make informed decisions about her reproductive health.

Policies must explicitly recognize and uphold women's autonomy, including their sexual rights and their right to consent within marriage. Legal frameworks should be aligned with international human rights commitments, ensuring that women's ability to refuse sex is both protected and respected. Simultaneously, educational initiatives targeting both youths and adults should include comprehensive, culturally sensitive content on sexual rights, bodily autonomy, and consent. Establishing safe, community-based platforms for confidential support can also provide women with the resources and encouragement needed to assert control over their reproductive choices.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

This study used the nationally representative 2022 Bangladesh Demographic and Health Surveys (BDHS) dataset, which is publicly available from the Demographic and Health Surveys (DHS) Program website (https://dhsprogram.com/data/dataset_admin/) at no cost. The DHS program provides standardized recode files in multiple formats for public use. All DHS surveys undergo ethical review by the Institutional Review Board of the International Classification of Functioning, Disability and Health, United States. In addition, the BDHS protocol received ethical approval from the Bangladesh Medical Research Council, under the Ministry of Health and Family Welfare, Bangladesh. As the DHS data sets are de-identified and publicly available for research purposes, this study did not require additional ethical approval.

Consent for publication

As the DHS data sets are de-identified and publicly available for research purposes, consent for publication is not required.

Availability of data

The data used in this study are publicly available from the DHS Program data website: https://dhsprogram.com/data/dataset_admin/.

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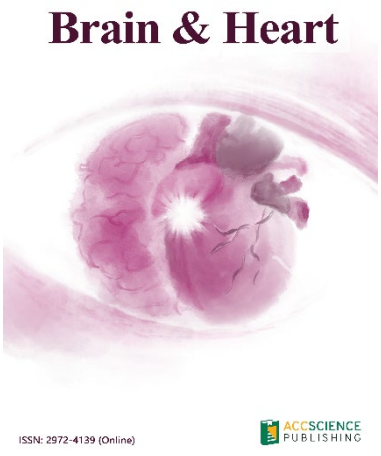

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