

ORIGINAL RESEARCH ARTICLE

Global, regional, and national burden of neck and low back pain from 1990 to 2021: Findings from the Global Burden of Disease Study 2021

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Abstract

Neck pain (NP) and low back pain (LBP) are the leading causes of years lived with disability (YLDs) worldwide. We aim to estimate the latest burden, trends, inequalities, and risk factors of NP and LBP. We retrieved data from the Global Burden of Disease Study 2021 on the incidence, prevalence, and YLDs of NP and LBP from 1990 to 2021 in 21 regions and 204 countries and territories. Temporal trends were assessed using estimated annual percentage changes and joinpoint regression analysis. We quantified health inequalities and demonstrated the potential to reduce the burden. Finally, we assessed the disease burden of LBP attributable to modifiable risk factors. The global burden of NP and LBP has increased by more than 70% and 60%, respectively, from 1990 to 2021. The primary drivers of this rise are population growth and aging. While the age-standardized rates (ASRs) of NP have remained stable, those for LBP have decreased. Regionally, North Africa and the Middle East bear the highest burden of NP, while Central Europe has the highest burden of LBP. A significant positive correlation exists between ASRs of LBP and the sociodemographic index (SDI), with the highest burdens of NP and LBP observed in regions with middle and high-middle SDI. Occupational ergonomic factors remain the leading cause of YLDs. The global burden of NP and LBP is increasing, especially in high-risk regions and among vulnerable populations. We urgently need public health interventions targeting modifiable risk factors to reduce the increasing disability associated with spinal pain.

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1. Introduction

Neck pain (NP) and low back pain (LBP) are severe global health challenges that contribute significantly to the global burden of non-communicable diseases (Guan *et al.*, 2023; Knezevic *et al.*, 2021). According to the latest data from the Global Burden of Disease (GBD) Study 2021, approximately 701 million people worldwide suffer from LBP, and 253 million people suffer from NP (GBD 2021 Diseases and Injuries Collaborators, 2024). LBP has been consistently ranked as the top cause of years lived with disability (YLDs) globally, and NP has ranked among the top five causes of YLDs over the past three

decades (GBD 2021 Diseases and Injuries Collaborators, 2024; GBD 2021 Neck Pain Collaborators, 2024). These musculoskeletal disorders not only impair individuals' quality of life but also impose high socioeconomic costs through reduced productivity and increased healthcare burden (Kleinman *et al.*, 2014; Solumsmoen *et al.*, 2022).

Previous studies have emphasized that there are significant geographic differences in the impact of NP and LBP, with higher burdens often found in high-income countries (Shim *et al.*, 2024). However, amid rapid socioeconomic change and demographic transition, the dynamics of these situations remain unclear, especially in low- and middle-income countries. The exploration of cross-country inequalities and identification of modifiable factors can inform global health strategies aimed at reducing the burden of spinal pain and improving population health (Cao *et al.*, 2024; GBD 2021 Risk Factors Collaborators, 2024). In addition, the global patterns and long-term trends of NP and LBP across different age groups, sexes, and sociodemographic index (SDI) have not been systematically analyzed. Given the current situation, updating and predicting epidemiological data on NP and LBP will help allocate limited health resources globally.

Neck pain and LBP are the major types of spinal pain (Kent *et al.*, 2015). Despite their different anatomical locations, NP and LBP share similar pathophysiologic mechanisms and clinical features and often face similar challenges in diagnosis, treatment, and prevention (Jones *et al.*, 2023; Pontes-Silva *et al.*, 2022). Such commonalities justify their joint consideration in epidemiological studies and contribute to a comprehensive understanding of the burden of spinal pain.

This study aims to investigate the incidence, prevalence, and YLDs of NP and LBP at the global, regional, and national levels from 1990 to 2021. To better understand the influence of age, sex, geographic location, and SDI, we conducted subgroup analyses to systematically assess burden and trends. We also predicted the global burden from 2022 to 2036 and assessed risk factors of patients with LBP.

2. Methods

2.1. Data source and study population

The retrospective study collected disease burden-related data using a method similar to that used in previous publications (Cao *et al.*, 2024; Guan *et al.*, 2023). The data from the GBD Study 2021 are available online (<http://ghdx.healthdata.org/gbd-results-tool>). A more detailed description is provided in Sections S1–S6. The study population included patients of all ages and sexes with

NP and LBP. In the GBD study, the reference case for NP was defined as pain lasting at least a day from the occipital bone to the area of the first thoracic vertebra (whether or not referred to extremities) (GBD 2021 Neck Pain Collaborators, 2024). LBP was defined as pain lasting a day or more between the 12th rib and the gluteal fold (GBD 2021 Low Back Pain Collaborators, 2023).

From the GBD Study 2021, we extracted the number, rates, and age-standardized rates (ASRs) of incidence, prevalence, and YLDs for NP and LBP, as well as the YLDs attributable to each risk factor, globally, in 21 regions, and in all 204 countries and territories. All the data have 95% uncertainty intervals (UI).

2.2. Statistical analysis

2.2.1. Descriptive analysis

We compared the absolute numbers and ASRs of incidence (ASIR), prevalence (ASPR), and YLDs (ASYR), along with their 95% UI, for NP and LBP from 1990 to 2021. Subgroup analyses were stratified by SDI quintiles, sex, and 17 age groups (ranging from <5 years to 80+ years, in 5-year increments).

2.2.2. Trend analysis

We calculated the estimated annual percentage changes (EAPCs) in ASRs. To further parse the phase trends over the period, we used the joinpoint regression model to identify and quantify mutation points in the data, segmenting the data into different trend segments.

2.2.3. Decomposition analysis

Based on the decomposition analysis described by Xie *et al.* (2018), it is possible to visualize the contributions of three factors (aging, demographics, and epidemiology) to changes in incidence, prevalence, and YLDs from 1990 to 2021. Epidemiological changes refer to actual variations in rates driven by shifts in disease risk, etiology, or disability weights, after filtering out the effects of population growth and aging.

2.2.4. Cross-country inequality and frontier analysis

The SDI ranges from 0 to 1. In this study, 1 represents the highest level of education, the highest per capita income, and the lowest fertility rate. We developed a smoothed spline model to estimate the correlation function between ASYR and SDI for NP and LBP in 2021 across 204 countries and territories, and we calculated the expected value. We used the slope index of inequality (SII; absolute inequality index) and relative concentration index (RCI; relative inequality index) to measure cross-country inequality (GBD 2019 MSK in Adolescents Collaborators,

2024). We further applied frontier analysis to produce a nonlinear boundary indicating the minimum achievable burden based on the state of development and to identify the countries and territories with the best control of the disease burden.

2.2.5. Predictive analysis

We constructed and fitted Bayesian age-period-cohort (BAPC) models to predict ASRs for NP and LBP over the next 15 years (2022–2036) using the BAPC and INLA packages in R. Compared to other prediction methods, BAPC exhibits better coverage and accuracy, as demonstrated in previous studies (Knoll *et al.*, 2020; Wu *et al.*, 2024).

All statistical analyses were conducted using Joinpoint (version 5.2.0; National Cancer Institute, National Institutes of Health, United States of America) and R (version 4.3.1). Statistical significance was set at $p < 0.05$. The detailed methodology is described in Sections S1–S6.

3. Results

3.1. Global burden and trends of neck pain

In 2021, the global incidence, prevalence, and YLDs for NP were 43,286,061, 206,029,629, and 20,415,497, respectively, reflecting increases of 73.8%, 79.8%, and 78.4% since 1990. The global ASRs of NP showed a slightly decreasing trend from 1990 to 2021 (Table 1 and Figure 1A–C). Further joinpoint analysis (Table S1 and Figure S1A–C) showed the same trend in both male and female groups. The stage-wise trends of ASRs for NP showed a significant pattern ($p < 0.05$), marked by an initial increase, a decrease, and a subsequent rise.

Subgroup analyses were performed by sex and age group (Figure 1A–C and Figure S2). The trends of NP were similar in men and women, with the incidence, prevalence, and YLDs increasing each year from 1990 to 2021. Women had a higher incidence, prevalence, and YLDs across all age groups than men. In terms of crude numbers, the age groups with the highest incidence of NP in both men and women were 40–44 years, and the age groups with the highest prevalence and YLDs were 45–49 years. In terms of rate (per 100,000 population), the age group with the highest incidence rate in women was 40–44 years (1,144.81) and in men was 75–79 years (878.32). The age group with the highest prevalence rate among women was 55–59 years (6,188.08), and among men was 75–79 years (4,355.48). The highest YLD rates for both sexes occurred in the 55–59 age group (407.51 for men, 606.02 for women).

Regionally, North Africa and the Middle East had the highest ASIR (719.67), ASPR (3,753.21), and ASYR

(368.74) for NP among the 21 regions (Table S2). Among 204 countries and territories (Table S3 and Figure 2A–C), the Islamic Republic of Iran had the highest ASIR (931.97), ASPR (4,409.28), and ASYR (433.49) for NP.

3.2. Global burden and trends of low back pain

In 2021, the global incidence, prevalence, and YLDs for LBP were 266,873,321, 628,838,475, and 70,156,962, respectively, marking increases of 61.7%, 62.6%, and 61.7% since 1990 (Table 1). The global ASIR, ASPR, and ASYR for LBP decreased from 1990 to 2021 (Table 1 and Figure 1D–F). Joinpoint analysis confirmed this downward trend across both sexes (Table S3 and Figure S2D–F), with a significant stage-wise trend ($p < 0.05$) showing an initial increase, followed by a decrease, and then another increase.

Subgroup analyses were shown in Figure 1D–F and Figure S3. Trends in the burden of LBP were similar in men and women, with the incidence, prevalence, and YLDs increasing each year from 1990 to 2021. Women consistently showed higher incidence, prevalence, and YLDs than men across all age groups. The highest incidence, prevalence, and YLDs in both sexes occurred in the 50–54 age group, closely followed by the 55–59 age group. The highest incidence rate (6,860.59), prevalence rate (27,030.72), and YLD rate (2,814.80) in women were in the age group of 75–79 years. Since the “80+ years” age group contains multiple five-year segments, after correction, the age group with the highest incidence rate (10,533.82), prevalence rate (16,760.19), and YLD rate (1,757.46) for LBP in men was also 75–79 years.

Regionally, Central Europe had the highest ASIR (5,181.24), ASPR (3,753.20), and ASYR (1,439.39) for LBP among the 21 regions (Table S4). Among 204 countries and territories (Figure 2D–F and Table S3), Hungary had the highest ASIR (5,408.81), ASPR (14,024.64), and ASYR (1,573.52) for LBP.

3.3. Decomposition analysis

Figure S4 and Table S5 illustrate the contributions of aging, population growth, and epidemiological changes to the increasing global burden of NP and LBP. Both aging and population growth consistently contributed positively to the incidence, prevalence, and YLDs of NP and LBP, with population growth being the largest contributor. Notably, the positive influence of epidemiological changes was observed only in the prevalence and YLDs of NP in females and the overall population.

3.4. Cross-country inequality and frontier analysis

Among the quintile SDI groups, the middle SDI had the highest burden of NP and LBP, and the high-middle SDI

Table 1. The incidence, prevalence, and YLDs of neck pain and low back pain in 2021 and their estimated annual percentage changes from 1990 to 2021

Rank	Incidence			Prevalence			YLDs		
	Number of cases	ASIR	EAPC, 1990–2021	Number of cases	ASIR	EAPC, 1990–2021	Number of cases	ASIR	EAPC, 1990–2021
Neck pain									
Global	43,286,061 (33,941,594, 52,883,959)	519.28 (407.85, 633.38)	−0.01 (−0.26, 0.25)	206,029,629 (161,756,683, 252,863,254)	2,443.02 (1,923.04, 3,002.33)	−0.05 (−0.37, 0.27)	20,415,497 (13,638,705, 28,856,643)	242.30 (162.60, 342.76)	−0.04 (−0.12, 0.03)
Low SDI	4,298,818 (3,390,096, 5,287,328)	494.71 (387.89, 607.47)	−0.02 (−0.34, 0.31)	18,712,872 (14,345,250, 23,252,672)	2,321.64 (1,815.89, 2,866.18)	−0.03 (−0.45, 0.40)	1,866,847 (1,233,277, 2,699,923)	228.84 (151.86, 325.01)	0.01 (−0.09, 0.11)
Low-middle SDI	9,353,471 (8,139,905, 10,546,428)	463.48 (363.79, 565.81)	−0.06 (−0.38, 0.25)	37,787,972 (29,307,348, 46,793,959)	2,130.82 (1,676.00, 2,620.14)	−0.07 (−0.46, 0.32)	3,750,146 (2,476,083, 5,396,702)	210.09 (139.27, 298.06)	−0.05 (−0.21, 0.11)
Middle SDI	14,977,034 (11,768,991, 18,524,086)	555.25 (437.18, 679.26)	0 (−0.26, 0.26)	69,369,412 (54,309,923, 85,573,357)	2,531.39 (1,987.91, 3,107.99)	0.02 (−0.30, 0.34)	6,886,927 (4,532,447, 9,780,164)	251.30 (168.07, 356.55)	0.03 (−0.03, 0.09)
High-middle SDI	8,961,321 (7,024,439, 11,153,757)	560.27 (440.25, 683.62)	0.04 (−0.19, 0.27)	44,285,587 (35,254,428, 54,610,078)	2,641.01 (2,071.81, 3,239.16)	−0.01 (−0.30, 0.29)	4,383,938 (2,896,189, 6,144,813)	263.13 (176.50, 373.80)	0 (−0.05, 0.05)
High SDI	6,593,066 (5,197,608, 8,088,413)	505.17 (400.77, 615.55)	−0.02 (−0.21, 0.16)	35,699,510 (28,576,565, 43,400,095)	2,563.57 (2,015.55, 3,136.62)	−0.10 (−0.35, 0.15)	3,510,370 (2,374,175, 4,868,137)	255.14 (170.37, 359.98)	−0.11 (−0.19, −0.03)
Low back pain									
Global	266,873,321 (235,369,489, 299,406,380)	3,176.63 (2,811.82, 3,562.29)	−0.29 (−0.32, −0.26)	628,838,475 (551,834,407, 700,881,341)	7,463.13 (6,575.68, 8,321.80)	−0.32 (−0.35, −0.28)	70,156,962 (50,194,205, 94,104,688)	832.18 (595.85, 1,115.24)	−0.32 (−0.35, −0.28)
Low SDI	24,608,330 (21,598,995, 27,916,670)	3,134.89 (2,760.73, 3,519.33)	−0.19 (−0.21, −0.17)	55,999,862 (49,426,590, 63,405,672)	7,364.87 (6,427.17, 8,255.87)	−0.21 (−0.23, −0.19)	6,254,664 (4,446,006, 8,373,290)	815.25 (582.63, 1,097.15)	−0.18 (−0.2, −0.16)
Low-middle SDI	54,298,819 (47,620,836, 61,354,906)	3,113.93 (2,740.21, 3,499.77)	−0.18 (−0.22, −0.13)	126,191,233 (110,548,447, 142,904,183)	7,317.71 (6,386.63, 8,227.13)	−0.18 (−0.23, −0.14)	14,064,118 (10,073,508, 18,918,257)	810.23 (580.5, 1,088.22)	−0.17 (−0.22, −0.12)
Middle SDI	74,568,788 (65,108,174, 84,107,629)	2,770.57 (2,435.96, 3,119.83)	−0.19 (−0.24, −0.15)	173,417,025 (150,668,277, 195,125,730)	6,421.04 (5,616.75, 7,199.09)	−0.20 (−0.25, −0.15)	19,437,989 (13,849,605, 26,187,075)	717.45 (512.59, 962.53)	−0.20 (−0.25, −0.15)
High-middle SDI	54,050,238 (47,424,129, 60,795,832)	3,250.38 (2,870.70, 3,648.88)	−0.38 (−0.42, −0.33)	128,827,069 (113,031,393, 144,240,276)	7,631.54 (6,693.46, 8,509.81)	−0.43 (−0.47, −0.38)	14,394,112 (10,223,002, 19,435,230)	854.81 (611.67, 1,147.00)	−0.41 (−0.46, −0.37)
High SDI	59,095,839 (52,994,576, 65,248,529)	4,118.80 (3,695.02, 4,589.31)	−0.17 (−0.19, −0.14)	143,792,047 (129,652,681, 157,076,124)	9,783.64 (8,876.62, 10,734.23)	−0.19 (−0.21, −0.16)	15,937,890 (11,551,525, 21,216,646)	1,094.34 (792.26, 1,459.42)	−0.20 (−0.23, −0.17)

Abbreviations: ASIR: Age-standardized incidence rate (per 100,000 population); EAPC: Estimated annual percentage change; SDI: Sociodemographic index; YLDs: Years lived with disability.

had the highest ASRs (Table 1). The ASYR for NP and LBP exhibited a nonlinear relationship with SDI (Figure S5). At low to middle SDI levels, ASYR was negatively correlated with SDI, but this shifted to a positive correlation at higher SDI levels. Spearman's correlation coefficient analysis showed that there was no monotonic correlation between

the YLDs of NP and SDI ($\rho = 0.119$, $p = 0.111$), while the YLDs of LBP were positively correlated with SDI ($\rho = 0.417$, $p < 0.001$).

The SII and RCI of NP and LBP in 1990 and 2021 are shown in Figure S6. Positive slope values indicate

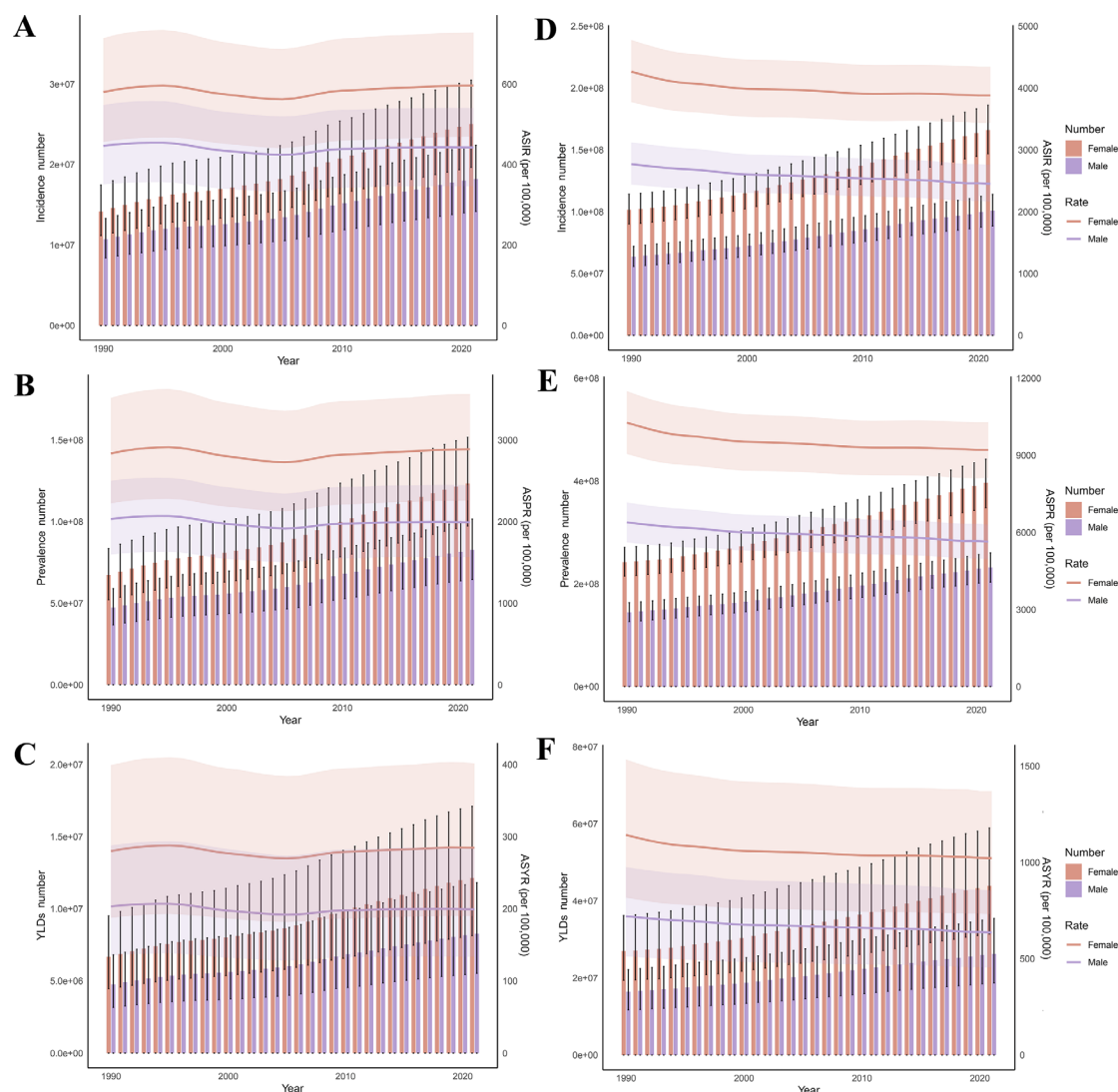


Figure 1. The numbers and age-standardized rates (per 100, 000) of incidence, prevalence, and YLDs of neck pain and low back pain at the global level from 1990 to 2021. (A) ASIR, (B) ASPR, and (C) ASYR of neck pain. (D) ASIR, (E) ASPR, and (F) ASYR of low back pain. Note: Error bars and shaded regions indicate 95% uncertainty intervals.

Abbreviations: ASIR: Age-standardized incidence rate; ASPR: Age-standardized prevalence rate; ASYR: Age-standardized rate of YLDs; YLDs: Years lived with disability.

inequalities that are unfavorable to lower socioeconomic status groups. The SII of NP rose from 119.9450 to 172.6466, and the SII of LBP rose from 681.8238 to 892.8565 from 1990 to 2021, suggesting that inequality in the burden of YLDs between high-income and low-income countries widened during this period. In comparison, the RCIs of NP and LBP were 0.06 and 0.12, respectively, in 1990, and 0.05 and 0.09 in 2021, suggesting a greater concentration of health resources or health conditions in the high-income group.

Frontier analysis identified the 10 countries with the

greatest potential to reduce the burden of NP and LBP, with effective differences ranging from 260.60 to 318.24 for NP and 561.13 to 944.00 for LBP (Figure 3 and Table S6). The countries with the greatest potential for reducing NP burden include Iran, Austria, Türkiye, Denmark, the United Kingdom, Greece, Saudi Arabia, Kuwait, Italy, and Sweden. For LBP, these countries include Hungary, Czechia, Albania, Romania, Serbia, Poland, Montenegro, Slovakia, Bulgaria, and Ukraine. Additionally, Figure 3B and 3D highlight the 15 countries with the smallest effective differences in low-SDI regions and the 30 countries with the largest effective differences in high-SDI regions.

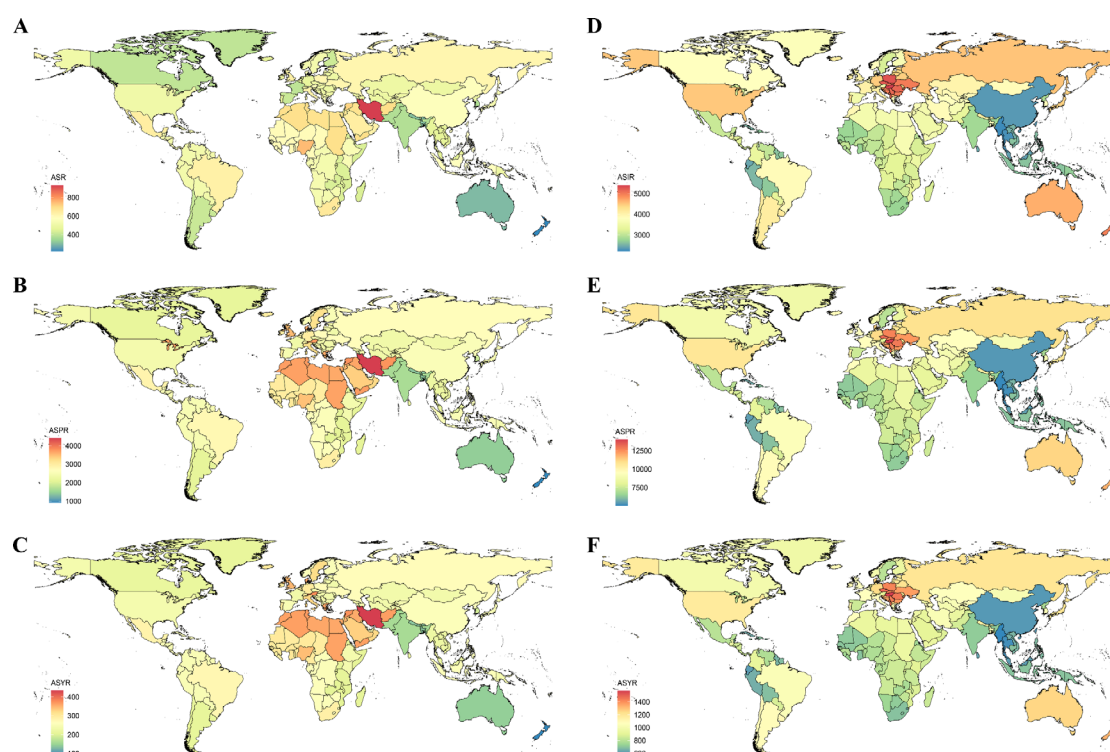


Figure 2. The national age-standardized rates of incidence, prevalence, and YLDs of neck pain and low back pain in 2021. The national (A) ASIR, (B) ASPR, and (C) ASYR of neck pain in 2021. The national (D) ASIR, (E) ASPR, and (F) ASYR of low back pain in 2021.

Abbreviations: ASIR: Age-standardized incidence rate; ASPR: Age-standardized prevalence rate; ASYR: Age-standardized rate of YLDs; YLDs: Years lived with disability.

3.5. Predictive analysis

The predicted ASRs of NP and LBP by 2036 are shown in Figure 4 and Table S7. Globally, the ASIR, ASPR, and ASYR of NP were predicted to remain stable, with predicted values of 517.51, 2,442.03, and 238.93, respectively, by 2036. The ASIR, ASPR, and ASYR of LBP globally were predicted to gradually decrease to 3,102.49, 7,264.42, and 797.18, respectively, by 2036.

3.6. Risk factors of low back pain

We determined the contributions of three risk factors to the ASYR of LBP from 1990 to 2021 globally, by SDI quintiles, and across 21 regions. Occupational ergonomic factors (OEF) have been the main ASYR cause of LBP over the past 32 years. Smoking and high body-mass index (BMI) had similar risk contributions. In particular, only high BMI was associated with a yearly increase in ASYR. Another point to note is that the sex difference is widening year by year, with each risk factor contributing increasingly to LBP in the female group (Table 2 and Figure S7).

Among the five SDI categories, the ASYR attributable to OEF and smoking showed decreasing trends, while the ASYR attributable to high BMI showed an increasing

trend. The higher the SDI, the lower the risk contribution of OEF, whereas smoking and high BMI show higher risk contributions (Figure 5A–C). In low to high-middle SDI groups, the risks of OEF, smoking, and high BMI were ranked from high to low; in high SDI, the risks of smoking, OEF, and high BMI were ranked from high to low risk in ASYR (Table 2).

Figure 5D–F and Table S8 show the contribution of the 3 risk factors for the ASYR of LBP in 21 regions from 1990 to 2021. In 2021, the ASYR attributable to OEF was highest in Eastern Sub-Saharan Africa and lowest in the Caribbean; the ASYR attributable to smoking was highest in Central Europe and lowest in Western Sub-Saharan Africa; and the ASYR attributable to high BMI was highest in high-income North America and lowest in Southeast Asia. From 1990 to 2021, the risk of OEF tended to decrease in most regions, with the largest decrease (–36%) in East Asia; however, it tended to increase in Oceania, Andean Latin America, the Caribbean, Southern Latin America, and Central Latin America, with the largest increase (40%) in Oceania. Smoking risk declined in all regions except Eastern Europe (up 6%), with the largest decline in Tropical Latin America (–43%). The ASYR attributable to high BMI increased

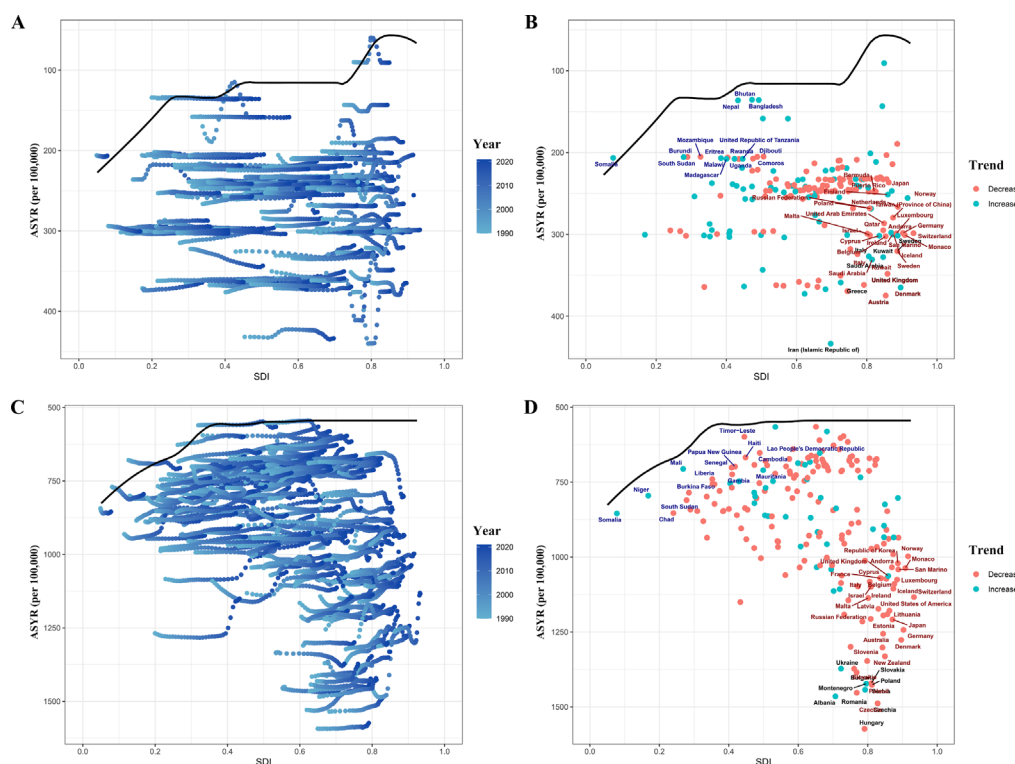


Figure 3. Frontier analysis based on SDI and age-standardized YLD rates of neck pain and low back pain from 1990 to 2021. The (A) frontier and (B) representative countries for ASYR of neck pain. The (C) frontier and (D) representative countries for ASYR of low back pain. Notes: Frontiers are delineated in a solid black line; countries and territories are indicated by dots. The distance between a country's observed ASYR and its frontier, defined as the effective margin, represents the unrealized health gains that exist based on the country's current level of development. The top 10 countries and territories with the largest effective differences are marked in black; red dots indicate increases in ASYRs between 1990 and 2021; blue dots indicate decreases. Abbreviations: ASYR: Age-standardized rate of YLDs; SDI: Sociodemographic index; YLDs: Years lived with disability.

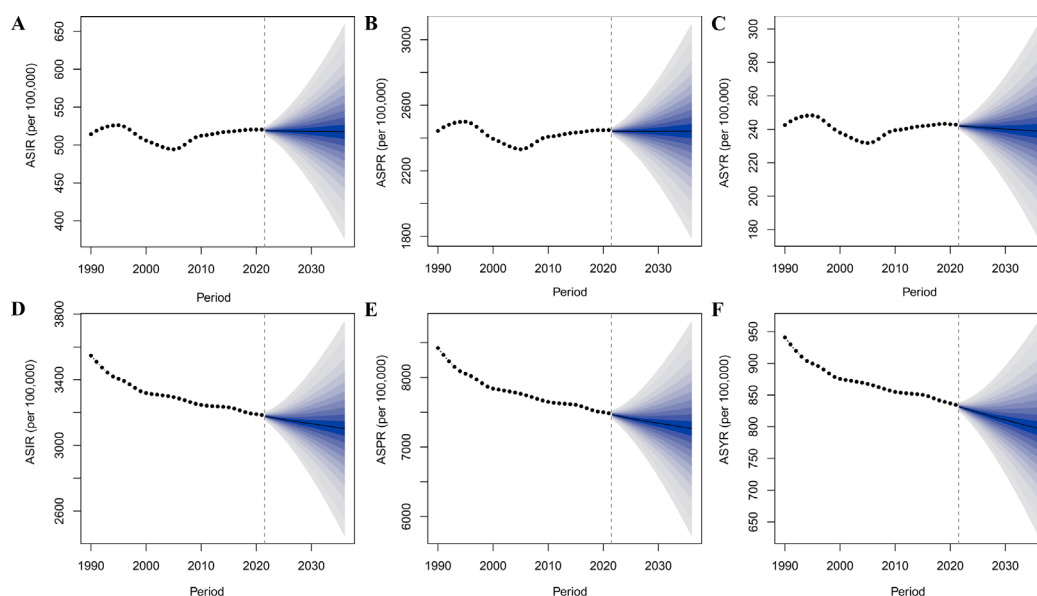


Figure 4. Predictions of age-standardized rates of incidence, prevalence, and YLDs of neck pain and low back pain from 2022 to 2036. Predictions of (A) ASIR, (B) ASPR, and (C) ASYR of neck pain. Predictions of (D) ASIR, (E) ASPR, and (F) ASYR of low back pain. Abbreviations: ASIR: Age-standardized incidence rate; ASPR: Age-standardized prevalence rate; ASYR: Age-standardized rate of YLDs; YLDs: Years lived with disability.

Table 2. The 1990 and 2021 ASYRs attributable to different risk factors for low back pain, globally and in SDI quintiles

Location	All risk factors		High body-mass index		Occupational ergonomic factors		Smoking	
	ASYR, 1990	ASYR, 2021	ASYR, 1990	ASYR, 2021	ASYR, 1990	ASYR, 2021	ASYR, 1990	ASYR, 2021
Global	383.74 (267.97, 523.59)	326.71 (221.51, 458.89)	70.22 (7.14, 146.48)	97.66 (9.78, 204.00)	226.82 (158.99, 304.34)	183.82 (129.49, 247.24)	153.22 (91.37, 226.59)	102.04 (60.03, 152.10)
Low SDI	387.45 (281.50, 518.81)	332.41 (233.43, 447.75)	27.81 (3.09, 55.76)	50.30 (5.07, 103.18)	331.67 (238.02, 442.90)	269.53 (191.97, 364.56)	75.09 (44.42, 112.87)	54.56 (31.26, 83.63)
Low-middle SDI	330.98 (232.71, 443.68)	310.46 (214.70, 429.40)	35.21 (3.78, 72.71)	71.69 (7.24, 148.95)	246.08 (173.55, 328.38)	214.86 (152.60, 288.79)	98.85 (58.37, 146.14)	71.99 (41.27, 107.70)
Middle SDI	333.08 (234.46, 452.76)	273.76 (186.49, 383.11)	41.92 (4.49, 87.55)	79.10 (7.86, 168.24)	233.70 (163.86, 313.51)	165.91 (115.24, 223.39)	114.81 (69.15, 170.11)	76.02 (44.67, 112.12)
High-middle SDI	413.04 (286.29, 567.78)	347.64 (230.26, 492.06)	91.90 (9.24, 192.00)	115.59 (11.61, 238.00)	224.43 (157.63, 303.00)	166.57 (114.59, 226.75)	175.37 (105.27, 257.09)	135.23 (80.14, 200.19)
High SDI	464.16 (314.56, 646.55)	419.57 (267.87, 607.07)	118.84 (11.60, 248.80)	161.80 (16.00, 332.59)	186.74 (129.62, 252.22)	165.69 (118.62, 222.72)	247.25 (147.56, 367.62)	173.83 (101.74, 261.13)

Abbreviations: ASYR: Age-standardized rate of YLDs (per 100,000 population); SDI: sociodemographic index; YLDs: years lived with disability.

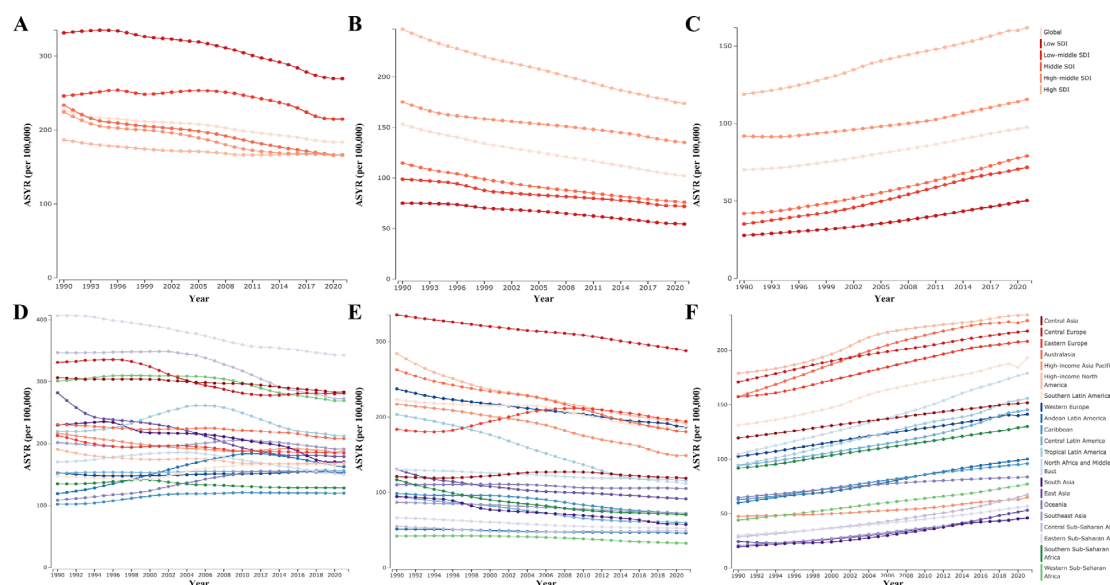


Figure 5. Trends in the contribution of risk factors for low back pain to ASYR in 5 SDI categories and 21 regions from 1990 to 2021. Contribution of (A) occupational ergonomic factors, (B) smoking, and (C) high body-mass index in quintiles of SDI. Contribution of (D) occupational ergonomic factors, (E) smoking, and (F) high body-mass index in 204 countries and territories.

Abbreviations: ASYR: Age-standardized rate of YLDs; SDI: sociodemographic index; YLDs: Years lived with disability.

annually across all regions, with the largest increase in Central Sub-Saharan Africa (134%).

4. Discussion

This study provides updated data and key insights into the incidence, prevalence, and YLDs of NP and LBP, revealing critical trends across different sex, age, and SDI groups. Although the official GBD 2021 report has already provided a comprehensive baseline for 2020 on this topic (GBD 2021 Low Back Pain Collaborators, 2023; GBD 2021 Neck Pain Collaborators, 2024), we have expanded our analysis to include data up to 2021. More importantly, by employing complementary statistical frameworks (such as joinpoint regression, decomposition, and frontier analysis), we have conducted a more in-depth analysis, enabling a more detailed examination of the factors driving change, temporal inflection points, and cross-national health inequalities. Several key findings emerged from this study. First, population expansion, due to growth and aging, has significantly contributed to the rising burden of NP and LBP. Women consistently experience a higher burden than men, with NP affecting middle-aged individuals and LBP most prevalent in the elderly. Second, socioeconomic factors, as captured by the SDI, play an important role in the disease burden. Third, there are significant regional and national differences. Health resources are more concentrated in the more developed economies. Unfortunately, our advanced analysis shows that more high-income countries exhibit greater effective disparities, and the gap in healthcare resource allocation continues to widen. Lastly, in high-income populations, lifestyle factors such as sedentary behavior, smoking, and obesity are prevalent. In contrast, in low- and middle-income regions, OEF related to manual labor contributes similarly to the high burden.

Over the past three decades, the global burden of NP and LBP has risen by more than 70% and 60%, respectively. Despite a softening of the underlying epidemiological trends (declining ASRs), these shifts are far from offsetting the impacts of population growth and aging. The global population grew by approximately 49% from 1990 to 2021 (population source: <https://population.un.org/>), directly correlating with the rise in NP and LBP cases. As the population grows, the absolute number of people suffering from these conditions also rises. Regions with high birth rates and rapidly growing populations, such as sub-Saharan Africa, South Asia, and Latin America, are seeing more people enter vulnerable age groups, significantly increasing the absolute number of cases (Cieza *et al.*, 2021; Gouda *et al.*, 2019). With rising global life expectancy, the burden of musculoskeletal conditions, including NP and LBP, has inevitably increased (Briggs *et*

al., 2016). Degenerative changes in the spine, including disc degeneration, osteoarthritis, and muscle loss, increase susceptibility to NP and LBP, especially in people aged 75–79 (Wong *et al.*, 2017). This age group has grown significantly over the past three decades, driven by advances in healthcare and improved living conditions (Chen *et al.*, 2023). The influence of global population aging is particularly pronounced in regions such as East Asia and Europe, where life expectancy has increased rapidly (Calvo *et al.*, 2023; Jayawardhana *et al.*, 2023). A study by Longobucco *et al.* (2019) suggests that proactive management and targeted rehabilitation programs can significantly improve the quality of life for this age group, highlighting key areas for the development of healthcare policy and practice. However, attributing the increasing global burden of these conditions solely to population growth and aging oversimplifies the issue. Many underlying factors are influenced by shifting social, environmental, and economic contexts.

Sex differences are another critical aspect, with women disproportionately affected by NP and LBP. Biological factors, such as hormonal differences and sexed social roles, may contribute to this disparity. Hormonal factors, such as estrogen, can influence pain sensitivity and inflammatory responses, heightening women's perception of pain (Paredes *et al.*, 2019). Multitasking demands, combining professional and household activities, further increase women's risk of musculoskeletal pain (Arvidsson *et al.*, 2020). Recent studies have highlighted the need for sex-equity strategies in public health planning and workplace ergonomics (Gkiouleka *et al.*, 2018; Silva *et al.*, 2022). The findings emphasize the need for targeted interventions and healthcare strategies for these vulnerable groups.

Another important finding is the geographic variation. This study identifies North Africa, the Middle East, and Central Europe as regions with the highest ASRs of NP and LBP. These geographic differences are driven by several factors, including urbanization, occupational risk exposure, access to healthcare resources, and lifestyle patterns (Buchbinder *et al.*, 2018). In North Africa and the Middle East, the burden of NP is the highest globally. Economic transitions and industrialization in these regions have led to increased sedentary behavior and exposure to occupational hazards, such as heavy lifting and repetitive strain, common in blue-collar and service industry jobs (Coggon *et al.*, 2013; Herr *et al.*, 2015). In Central Europe, the high prevalence and incidence of LBP may be more attributable to population aging, sedentary lifestyles, and high obesity rates. Similarly, the shift toward service-based economies has led to increased sedentary work, further exacerbating the burden of musculoskeletal

conditions (Sterud *et al.*, 2016). In contrast, in sub-Saharan Africa and South Asia, the burden of NP and LBP may appear lower despite rapid population growth. This may be due to underreporting and insufficient healthcare infrastructure, as these regions face significant barriers to access and treatment, implying that the true burden may be underestimated (Ameh *et al.*, 2017). Moreover, as these regions develop economically, they are at risk of experiencing burdens similar to those of more developed regions if early preventive measures are not taken.

Sociodemographic index plays a critical role in understanding the global burden of NP and LBP, emerging as a key determinant of health disparities (GBD 2021 Risk Factors Collaborators, 2024; Guan *et al.*, 2023; Shim *et al.*, 2024). In middle-SDI regions, such as Southeast Asia, Latin America, and Eastern Europe, urbanization and industrialization have transformed work environments and lifestyles (Das & Paul, 2021). People in these regions face increasing risks, including sedentary behavior, poor workplace posture, and rising obesity rates (NCD Risk Factor Collaboration, 2024; Guan *et al.*, 2023). These countries are in a transitional phase where economic improvements outpace healthcare infrastructure, limiting access to musculoskeletal care (Kruk *et al.*, 2018). Despite more resources in high-SDI regions, they do not always outperform low-SDI countries in managing NP and LBP. High-SDI regions, such as North America, Western Europe, and East Asia, benefit from advanced healthcare systems, aiding early diagnosis and intervention. However, these regions still face a high burden due to sedentary lifestyles, obesity, and aging populations. Economic development alone does not alleviate the musculoskeletal burden unless occupational and lifestyle risks are addressed (Punnett & Wegman, 2004). Some lower-SDI countries perform better on YLDs. While underreporting may exist, these countries can offer insights into successful strategies, underscoring that “development is not destiny.”

Modifiable risk factors are key to fully understanding the increasing burden of NP and LBP and addressing future challenges. Although the GBD study did not provide risk factor data for NP, given the similarity between NP and LBP, we can derive similar insights (Jones *et al.*, 2023; Kent *et al.*, 2015; Pontes-Silva *et al.*, 2022). OEFs continue to play a major role in the rising burden of LBP. Repetitive movements, manual labor, or poorly designed ergonomic workspaces are key contributors (Arvidsson *et al.*, 2020; Punnett & Wegman, 2004). In low- and middle-income countries, manual labor jobs still expose workers to musculoskeletal injuries. With advancing urbanization, the global workforce is increasingly shifting toward jobs requiring prolonged sitting, such as office work, where

poorly designed workspaces contribute to poor posture and increased spinal pressure (Straker & Mathiassen, 2009). For example, in high-income countries, workers in technology-driven industries often experience neck fatigue (often referred to as “tech neck”) due to prolonged computer screen use (Grasser *et al.*, 2023).

Smoking is an important but often overlooked risk factor for NP and LBP. It impairs blood flow to spinal tissues, accelerating disc degeneration and causing chronic pain (Oda *et al.*, 2004). Smoking also triggers systemic inflammation, worsening musculoskeletal pain and hindering injury recovery (Arnson *et al.*, 2010). Despite global efforts, continued smoking in numerous regions exacerbates musculoskeletal conditions. Smoking is preventable, and public health campaigns and cessation programs can significantly reduce NP and LBP where smoking is prevalent.

A particularly notable factor is high BMI. We found that the burden of LBP attributable to high BMI is rising globally. High BMI is a recognized risk factor for LBP and is also associated with increased NP severity (Manderlier *et al.*, 2022). The mechanical load of excess weight, particularly in the abdomen, shifts the body’s center of gravity, altering posture and increasing the likelihood of chronic spine pain (Samartzis *et al.*, 2011). Additionally, obesity is often accompanied by a lack of physical activity and poor dietary habits, factors that can lead to sarcopenia. The progressive loss of muscle mass and function deprives the spine of effective muscular support, thereby further increasing the risk of musculoskeletal pain (Lee *et al.*, 2023). From a pathophysiological perspective, the impact of obesity extends beyond mechanical compression. Obesity is a chronic disease characterized by excessive body fat accumulation that induces metabolic stress. The resulting elevation in circulating fatty acids can evoke widespread inflammatory responses and promote the secretion of pro-inflammatory cytokines (Gao *et al.*, 2025). This increased production of systemic inflammatory factors accelerates the degradation of the extracellular matrix, contributing directly to intervertebral disc degeneration. In both high- and middle-SDI countries, the sharp rise in obesity rates, combined with sedentary behavior, creates a perfect storm for the development of NP and LBP. This is particularly problematic because obesity is also associated with other health issues, such as cardiovascular disease and diabetes, which can further complicate the management of musculoskeletal disorders (Iso *et al.*, 2021).

This study has several limitations. First, the estimates of the burden of NP and LBP are largely based on data from low- and middle-income countries, where underreporting and incomplete medical records are common. This may

lead to an underestimation of the true burden in these regions. Second, the data used in the GBD study come from different countries with varying diagnostic practices, potentially leading to inconsistencies and misclassification. Although advanced modeling techniques help mitigate these issues, the study's findings still rely heavily on model-based estimates, particularly for regions with limited data. Given the uncertainty associated with primary data, caution is warranted when interpreting the trends in the burden of NP and LBP identified in this study. Third, the time lag in GBD data means that the estimates are based on historical trends and may not fully reflect recent changes in healthcare or lifestyle factors.

5. Conclusion

In conclusion, the global burden of NP and LBP is considerable and has increased significantly over the past three decades. Incidence, prevalence, and YLDs varied significantly by sex, age, socioeconomic status, and geography. LBP, in particular, accounted for the greatest disability, disproportionately affecting aging populations and females. Despite health resources being concentrated in high-income countries, the burden is more pronounced in middle- to high-SDI regions. Modifiable risk factors, such as OEF, high BMI, and smoking, contributed significantly to the YLDs of LBP. Addressing this growing burden requires a multifaceted approach that includes public health campaigns to reduce modifiable risk factors, improve workplace ergonomics, and enhance healthcare access in under-resourced regions.

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Conflict of interest

The authors declare they have no competing interests.

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable

Availability of data

Data used for the analyses are publicly available from the Institute of Health Metrics and Evaluation (<http://www.healthdata.org/>; <http://ghdx.healthdata.org/gbd-results-tool>). The codes generated during the study are available from the corresponding author upon reasonable request.

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