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Global burden of low back pain from 1990 to 2021: a comprehensive analysis of risk factors and trends using the Global Burden of Disease Study 2021

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Abstract

Background This study comprehensively assesses low back pain-related risk factors and the global burden from a multi-dimensional perspective, aiming to provide scientific evidence for disease prevention.

Methods Data from the Global Burden of Disease (GBD) database spanning from 1990 to 2021 were incorporated into this study. We conducted an analysis of baseline data, as well as gender and age subgroup data. Additionally, we introduced the Age-Period-Cohort (APC) and decomposition analysis models to clarify the independent effects of factors such as age, period, cohort, population growth, population aging and changes in epidemiological trends on the disease burden. The Estimated Annual Percentage Change (EAPC) was used to measure the temporal trends of health indicators. To enhance practical applicability, we constructed a model that integrates frontier analysis with health inequality assessment. Furthermore, the Autoregressive Integrated Moving Average (ARIMA) model was employed to forecast trends in LBP over the next 15 years.

Results In 2021, the global age-standardized prevalence of low back pain decreased by 11.06% compared to that in 1990. However, the number of affected individuals increased from 386.7 million to 628.8 million. Concurrently, the age-standardized Disability-Adjusted Life Years (DALYs) rate declined by 11.22% relative to 1990, while total DALYs rose from 43,386,225 to 70,156,962. The results derived from multiple models indicate that higher socio-demographic index levels, advancing age, female sex and occupational ergonomics-related factors may contribute to disparities in the burden of low back pain. Furthermore, this unequal health gap appears to be widening over time.

Conclusions Disease burden of low back pain exhibit varying manifestations across different regions and temporal dimensions. Higher levels of the Socio-Demographic Index(SDI), increasing age, female gender and adverse occupational ergonomic factors may be important risk elements for the burden of low back pain. Meanwhile, certain changes in epidemiological trends may alleviate this burden to some extent. In the absence of effective intervention measures, the gaps in health inequality engendered by the aforementioned diverse factors are likely to expand continuously. In light of this, it is crucial to actively develop systematic, comprehensive and targeted health prevention strategies.

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Keywords Low back pain, Burden of disease, Age-standardized prevalence rate, Age-standardized disability-adjusted life years rate, Risk factors

Background

Low back pain (LBP) is a syndrome characterized by discomfort in the lower back, lumbosacral region and buttocks. LBP ranks among the leading causes of Disability-Adjusted Life Years (DALYs) globally and significantly impacts various demographic groups [1]. Specifically, under the influence of academic pressure, adolescents often adopt poor sitting postures and engage in excessive use of electronic devices. As a combined result, the age at which low back pain first appears among adolescents has been gradually decreasing [2]. This issue particularly affects middle-aged individuals, especially those engaged in heavy labor who have endured prolonged high spinal loads as well as sedentary office workers. These populations often experience instability in their lumbar muscles, which can lead to alterations in spinal physiological curvature and subsequently result in pain [3]. Furthermore, with degenerative changes occurring within the musculoskeletal system, the burden of low back pain also accumulates among older adults [4]. Additionally, the total cost associated with low back pain in the United States has surpassed 100 billion US dollars annually, representing a public health concern that warrants urgent attention [5–7].

The Global Burden of Disease (GBD) database is a crucial resource in the realm of global public health, developed and maintained by the World Health Organization, Harvard University, the World Bank, and the Global Burden of Disease Study Group [8]. Recent studies have examined various indicators related to the incidence of LBP and DALYs. However, no systematic investigation has been conducted on indicators associated with LBP prevalence [9]. Furthermore, considering the advantages of the Autoregressive Integrated Moving Average (ARIMA) model in capturing nonlinear trends and volatility changes compared to the Bayesian Age-Period-Cohort Model (BAPC) model, this paper incorporates the ARIMA model alongside age-period-cohort (APC) analysis, decomposition analysis, health inequality assessment and other methodologies [10–12]. This approach aims to uncover potential dynamic and complex variations across different temporal and spatial dimensions. By employing a more detailed epidemiological evaluation method for LBP, we aspire to provide valuable insights that will support informed health decisions and contribute to reducing the disease burden associated with LBP.

Methods

Data source

The GBD study offers a comprehensive array of multi-dimensional and multi-level epidemiological data concerning 371 diseases and injuries, as well as 88 risk factors across 204 countries and regions. This study integrates an extensive burden of disease index that encompasses incidence, mortality, prevalence, years of life lost (YLLs), years lived with disability (YLDs) and DALYs [13]. Relying on the aforementioned characteristics, the GBD database offers essential information support for research in the realm of global public health [8]. In this analysis, the data pertaining to low back pain-related diseases and DALYs from 1990 to 2021 were included for the purpose of conducting a burden of disease alert assessment.

Case definition

Low back pain, defined as localized discomfort in the lumbar region, refers to pain experienced in the posterior area of the body extending from the lower margin of the twelfth rib to the inferior gluteal fold. This condition is characterized by its duration of at least one day and may occur with or without accompanying pain in one or both lower limbs [14]. The prevalence rate denotes the proportion of both new and existing cases of a disease within a specified population at a given time while DALYs is the overall presentation of years of life lost (YLDs) and years lived with disability (YLLs) [15].

Procedures

Statistical methods such as multivariable regression models and multiple imputation have been applied to the GBD database to address the issues of confounding factors and missing data. The study design and methodology are thoroughly detailed in the existing GBD literature [16]. In light of multiple considerations aimed at enhancing the accuracy and standardization of data, this paper continues to utilize a unified data standard and classification method derived from the GBD database. This approach facilitates the standardization of data from diverse sources, thereby increasing comparability among datasets. It is important to emphasize that we conducted an extensive cleaning of the original data, meticulously screening for and eliminating recording errors, missing key information, as well as repetitive and redundant reports. These efforts aim to minimize potential biases in the data while enhancing its intrinsic value for further analysis.

Statistical analysis

Before model fitting, baseline data as well as gender and age subgroup data were analyzed. The APC and decomposition analysis models were used to evaluate other factors on LBP burden. Additionally, the Estimated Annual Percentage Change (EAPC) was utilized to evaluate the temporal trends in disease burden. To enhance practical applicability, we developed a model incorporating frontier analysis and health inequality analysis. Specifically, frontier analysis is utilized to evaluate the association between the disease burden of LBP and the Socio-Demographic Index (SDI). This, in turn, facilitates the analysis of whether the low back pain burden in regions and countries with different SDI levels is increasing or decreasing relative to the expected values. As a result, relevant forecasters can optimize resource allocation in accordance with the SDI-related disease burden patterns. Health inequality assessment, on the other hand, focuses on the disparities in the LBP disease burden among countries with different SDI levels, particularly between high-SDI and low-SDI countries. It clearly presents policymakers with the unequal distribution of the disease burden, providing crucial support for formulating targeted public health policies. Finally, we utilized the Autoregressive Integrated Moving Average (ARIMA) model to predict the burden trend of LBP over the next 15 years. Stata 16.0 and R 4.4.2, along with its integrated development environment RStudio, were employed to ensure efficiency, accuracy and reproducibility in our analyses.

Results

Current situation analysis

Global burden of low back pain

Based on the results from the GBD database, data analysis indicates that in 2021, the global age-standardized LBP prevalence was 7463.13 per 100,000 (95% UI: 6575.68–8321.80). This represents an 11.06% decrease (95% UI: 10.59% to 11.58%) compared to the prevalence in 1990, which was recorded at 8391.58 per 100,000 (95% UI: 7381.14 to 9367.39). However, during the same period, the total number of individuals suffering from low back pain increased significantly from approximately 386.7 (95% UI: 341.6 to 434.2) million to about 628.8 (95% UI: 551.8 to 700.9) million.

Regional burden of low back pain

In 2021, in terms of age-standardized prevalence of low back pain, Central Europe (12831.04, 95% UI: 11293.99 to 14267.18), Australasia (11327.03, 95% UI: 9980.82 to 12746.38), Eastern Europe (11189.88, 95% UI: 9858.28 to 12447.24), High-income North America (10475.84, 95% UI: 9747.66 to 11177.32) and High-income Asia Pacific (10041.05, 95% UI: 8876.21 to 11287.71) were at the highest levels, while East Asia (5418.74, 95% UI: 4746.47 to 6045.66), Andean Latin America (5769.81, 95% UI: 5050.62 to 6502.89) and Southeast Asia (5859.18, 95% UI: 5118.41 to 6584.80) were at the the lowest level. In addition, the regions showing an increase in these indicators between 1990 and 2021 are Tropical Latin America (3.27%, 95% UI: 1.79% to 4.70%), Central Latin America (1.25%, 95% UI: −0.11% to 2.50%) and Andean Latin America (0.37%, 95% UI: −2.20% to 3.27%). Age-standardized point prevalence tended to decrease in all but these three regions, with decreases in East Asia (−18.54%, 95% UI: −20.09% to −17.22%) and South Asia (−10.55%, 95% UI:−11.88% to −9.45%) had the most significant decreases. The data on the burden related to the prevalence of LBP as mentioned above are detailed in Table 1. Correspondingly, the data on the aspects related to DALYs are also presented in Table 1.

Country-level burden of low back pain

In 2021, Hungary (14,024.64, 95%UI, 12,361.13 to 15,712.34) and Czech Republic (13,298.59, 95%UI, 11,720.80 to 14,874.21) in Eastern Europe had the highest age-standardized prevalence of low back pain. In comparison, the Maldives (5020.83, 95% UI, 4401.32 to 5671.95), Myanmar (5056.85, 95% UI, 4441.86 to 5710.22) and Thailand (5169.73, 95% UI, 4487.19 to 5814.51) were the lowest. In addition, there were significant differences in the trends in standardized prevalence between 1990 and 2021 among countries. The largest increases were observed in Sweden (20.77%, 95% UI, 11.45% to 29.32%), Taiwan (17.91%, 95% UI, 11.86% to 23.73%), and Pakistan (10.48%, 95% UI, 7.60% to 13.56%). In contrast, China (−19.49%, 95%UI, −21.04% to −18.21%), India (−13.69%, 95%UI, −14.99% to −12.43%) and Denmark (−12.70%, 95%UI, −21.11% to −5.68%). When the study focused on the number of people with low back pain, China, India and the United States of America had the highest number of epidemic cases of low back pain. The lowest was found in the Northern Mariana Islands, Saint Kitts and Nevis, American Samoa, Marshall Islands, Cook Islands, Palau, Tuvalu, Nauru, Niue and Tokelau. The data on the burden related to the prevalence of LBP as mentioned above are detailed in Fig. 1 and Table S1. Correspondingly, the data on the aspects related to DALYs are also presented in Fig. 1 and Table S1.

Gender and age subgroup analysis

Our results indicate that, overall, the prevalence rate and the number of cases of the LBP among the female population are higher than those among the male population. Furthermore, the prevalence exhibited a general upward trend with advancing age, peaking in the 80–84 age group

Table 1 Prevalent cases and disability adjusted life years (DALYs) for low back pain in 2021, and percentage change in age standardised rates (ASRs) per 100,000, by Global Burden of Disease region, from 1990 to 2021

	Prevalence (95% UI)			DALYs (95% UI)		
	No, in millions (95% UI)	ASRs per 100,000 (95% UI)	Percentage change in ASRs from 1990 to 2021	No, in thousands (95% UI)	ASRs per 100,000 (95% UI)	Percentage change in ASRs from 1990 to 2021
Global	628.8 (551.8,700.9)	7463.1 (6575.7,8321.8)	−11.1 (−11.6,−10.6)	70,157 (50,194.2,94,104.7)	832.2 (595.9,1115.2)	−11.2 (−11.8,−10.7)
High-income Asia Pacific	27.1 (23.8,30)	10,041 (8876.2,11,287.7)	−9.4 (−10.4,−8.4)	3027.7 (2147.7,4085.7)	1140.1 (814.6,1534.1)	−9.2 (−10.4,−8.1)
High-income North America	49.5 (46,52.6)	10,475.8 (9747.7,11,177.3)	−6.8 (−11.5,−1.1)	5425.1 (3944.5,7058.8)	1159.5 (843.8,1514)	−8 (−12.7,−2.4)
Western Europe	58.1 (51.2,64.6)	9533 (8439.7,10,690.6)	−3.3 (−4.9,−1.7)	6445 (4566.7,8666)	1069 (766.4,1441.3)	−3.3 (−5,−1.6)
Australasia	4.4 (3.8,4.9)	11,327 (9980.8,12,746.4)	−8 (−11.4,−4.9)	488.4 (349,661.2)	1268.2 (904.8,1709)	−7.9 (−11.2,−4.3)
Andean Latin America	3.7 (3.3,4.2)	5769.8 (5050.6,6502.9)	0.4 (−2.2,3.3)	419.8 (298.5,559.6)	646.9 (458.2,863.7)	0.1 (−2.9,3.1)
Tropical Latin America	23.5 (20.5,26.4)	9303.7 (8187.7,10,456)	3.3 (1.8,4.7)	2598.8 (1862.6,3499.2)	1029.6 (741.5,1382.1)	3.1 (1.5,4.7)
Central Latin America	19.7 (17.3,22.2)	7487.1 (6597.8,8413.6)	1.3 (−0.1,2.5)	2204.6 (1574.6,2963.7)	837.4 (597.9,1127)	1.2 (−0.2,2.7)
Southern Latin America	7.5 (6.7,8.5)	9741.1 (8600.8,10,945.7)	−0.3 (−3,2.6)	843.3 (596.1,1134.5)	1090.8 (772.1,1464.4)	−0.6 (−3.6,2.6)
Caribbean	3.1 (2.7,3.5)	6007 (5348.7,6726.1)	−1.4 (−3.3,0.7)	344.5 (247.9,462.4)	670.9 (483.4,901.2)	−1.9 (−4.1,0.3)
Central Europe	20.6 (18.2,22.9)	12,831 (11,294,14,267.2)	−2.8 (−3.9,−1.6)	2290.5 (1634.3,3088.3)	1439.4 (1027.2,1934.4)	−2.5 (−3.7,−1.2)
Eastern Europe	31.8 (28.1,35.4)	11,189.9 (9858.3,12,447.2)	−4 (−5.1,−2.9)	3508.1 (2503.6,4720)	1241.4 (889.7,1666.4)	−4 (−5.3,−2.9)
Central Asia	8.4 (7.4,9.5)	9188.5 (8032.3,10,254.5)	−1.2 (−2.9,0.5)	952.8 (682,1286.1)	1029.9 (732.9,1385.7)	−1.3 (−3.1,0.5)
North Africa and Middle East	50.6 (44.8,57.2)	8713.5 (7713,9767.2)	−2.5 (−3.8,−1.2)	5661.7 (4031,7583.4)	967.4 (696.7,1297)	−3 (−4.6,−1.4)
South Asia	119.4 (104.1,135.1)	6919.7 (6023.4,7778.7)	−10.5 (−11.9,−9.5)	13,247.6 (9487.5,17,842.6)	762.3 (544.5,1022.8)	−10.3 (−11.7,−9.1)
Southeast Asia	42.1 (36.5,47.5)	5859.2 (5118.4,6584.8)	−1.3 (−2.6,0.1)	4757.9 (3371.9,6410.5)	658 (468,885.6)	−1.1 (−2.6,0.4)
East Asia	105.1 (91.9,118.4)	5418.7 (4746.5,6045.7)	−18.5 (−20.1,−17.2)	11,867.6 (8333.7,16,052.1)	611.8 (433.8,820.5)	−18.5 (−20,−17.1)
Oceania	0.7 (0.6,0.8)	6322.2 (5498.3,7093.7)	−0.9 (−3.7,1.6)	76.2 (54.4,102.6)	705.1 (504.1,943.5)	−1 (−4,1.8)
Western Sub-Saharan Africa	21.5 (19,24.4)	6911.7 (6039,7750.4)	−2.6 (−3.4,−1.9)	2419.5 (1713,3244.3)	770.6 (549.4,1039)	−2 (−2.9,−1.2)
Eastern Sub-Saharan Africa	20.7 (18.3,23.4)	7607.2 (6640.3,8512.4)	−3.6 (−4.5,−2.6)	2317.8 (1643.3,3112.6)	844.4 (602.7,1135.5)	−3.2 (−4.3,−2.1)
Central Sub-Saharan Africa	6.8 (6,7.7)	7619.3 (6670.3,8565.2)	−3.2 (−5.8,−0.6)	755 (536.1,1006.8)	842.7 (603.1,1136.4)	−2.5 (−5.3,0.6)
Southern Sub-Saharan Africa	4.6 (4,5.2)	6510.4 (5661.4,7303)	−4.8 (−6.4,−3.5)	505 (362,678.4)	712.9 (510.7,955)	−6 (−7.7,−4.4)

95% UI 95% uncertainty intervals

(Fig. 2). When examining the impact of age on case numbers, a similar upward trend was observed. However, the peak occurred within the 50–54 age group. Correspondingly, data regarding DALYs are presented in Figure S2.

Age-period-cohort model

The APC model results revealed that age, period and cohort significantly affected LBP prevalence (Fig. 3). Specifically, when focusing on the effect of age, the

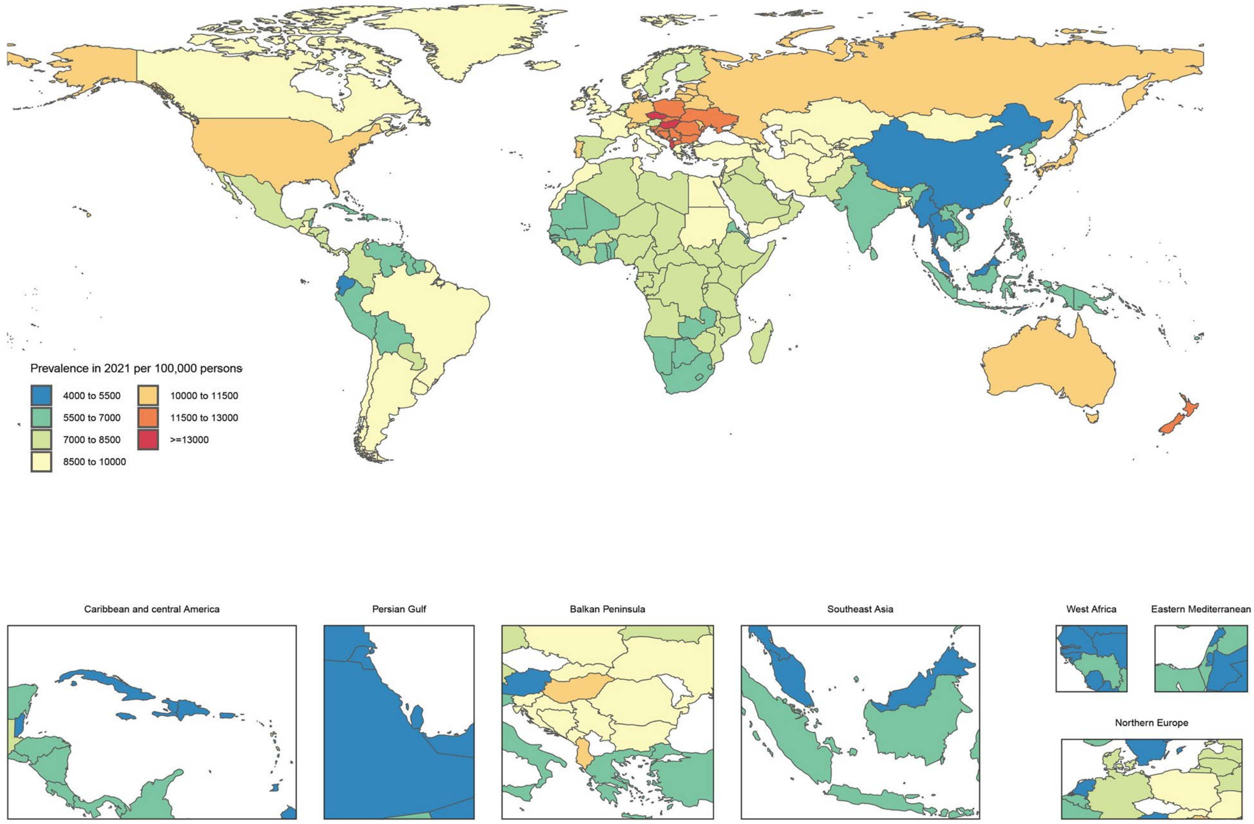

Fig. 1 Age-standardised prevalence of low back pain per 100,000 population in 2021, by country

prevalence rate of LBP shows a trend of increasing with age, reaching a peak at a relatively high age, and then tending to decline. As for the period effect, we found that the prevalence rate showed an increasingly strong upward trend as time went by. Finally, the results of the cohort effect indicate that the prevalence in different birth cohorts shows a gradually declining trend.

Estimated annual percentage change model

In this study, the annual percentage change of disease burden-related indicators over time was quantified using the EAPC model, which was designed to accurately describe trends and effectively compare group differences. Specifically, Taiwan (Province of China) (EAPC = 0.64, 95% CI: 0.55 to 0.73) and Sweden (EAPC = 0.60, 95% CI: 0.46 to 0.75) had the fastest rates of increase in disease-related indicators. In contrast, Mainland China (EAPC = −0.50, 95% CI: −0.60 to −0.39), India (EAPC=−0.50, 95% CI: −0.62 to −0.38) and Denmark (EAPC=−0.71, 95% CI: −0.84 to −0.58) showed the fastest decline (Table S3).

Risk analysis

Crude risk analysis

The GBD data has identified eight key risk factors for LBP across three levels. Given the overlap among these risk factors, this study concentrated on three primary contributors: smoking, occupational ergonomic factors and high body mass index. Notably, occupational ergonomic factors have emerged as the most significant risk factor for the global burden of low back pain in 2021. Similar trends were observed in separate analyses conducted for men and women (Figure S3, Figure S4 and Figure S5).

Decomposition analysis

Our results demonstrate that population growth was the predominant contributor to the increase in low back pain burden, followed by population aging (Fig. 4) [17]. Among countries with varying SDI levels, those classified as medium-high SDI were most significantly impacted by population aging, whereas low SDI countries experienced the least effect. In addition, increased changes in epidemiological trends may contribute to a decrease in the prevalence of low back pain.

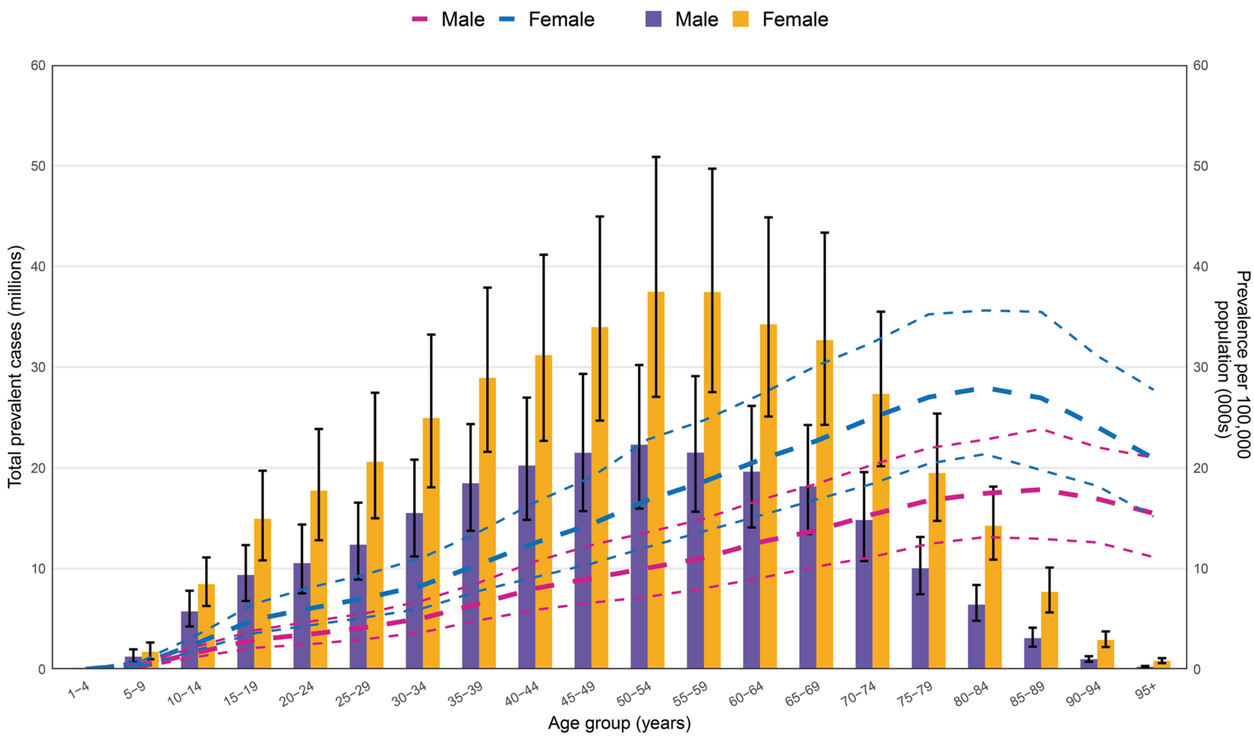

Fig. 2 Number of prevalent cases and prevalence of low back pain per 100,000 population, by age and sex in 2021 globally. Lines indicate prevalence with 95% uncertainty intervals for men and women

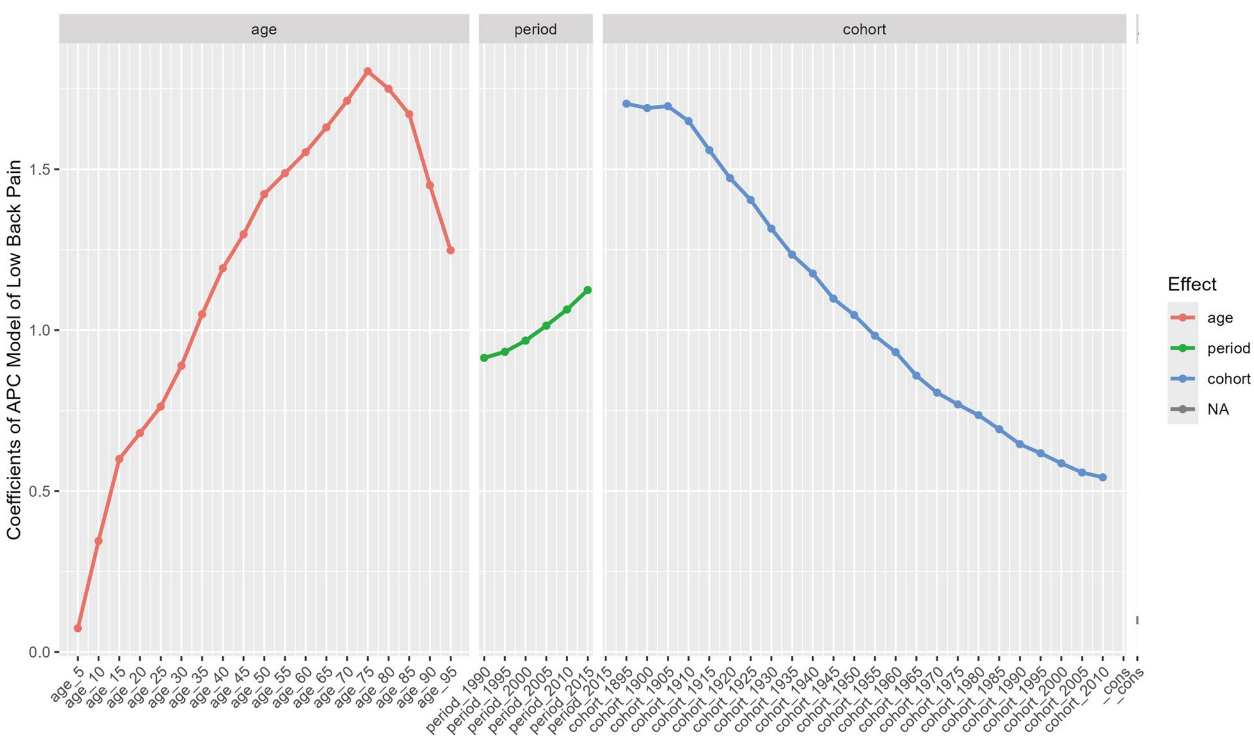

Fig. 3 Age period cohort trends of low back pain from 1990 to 2021

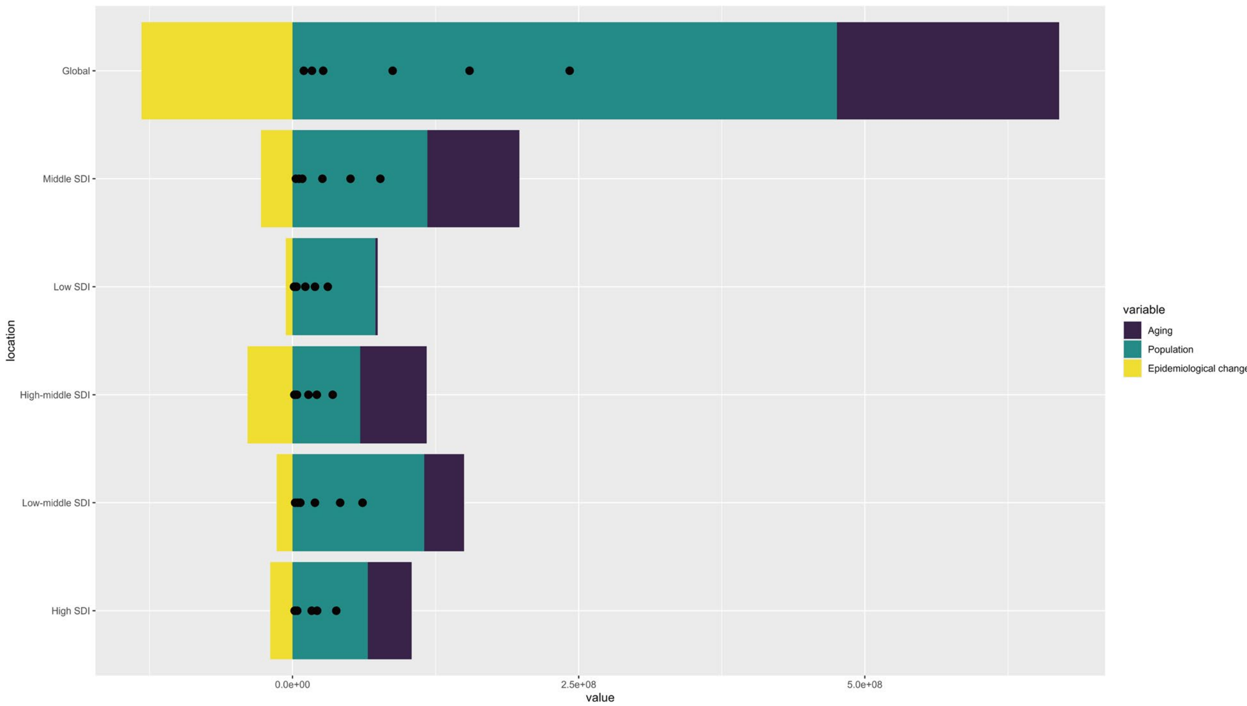

Fig. 4 Results of decomposition analysis model for low back pain from 1990 to 2021. A positive value for each component indicates a corresponding positive contribution in DALYs, and a negative value indicates a corresponding negative contribution in DALYs

Frontier analysis

There was a generally positive correlation between the age-standardized prevalence of LBP and the SDI over the past 30 years [R=0.59 (95% CI: 0.55 to 0.64), $p < 0.001$] (Fig. 5). In this context, regions such as Central Europe, Australasia, Eastern Europe, Tropical Latin America and Central Sub-Saharan Africa exhibited a higher prevalence of low back pain than anticipated based on data analysis from 1990 to 2021. Conversely, Western Europe, Western Sub-Saharan Africa, Southern Sub-Saharan Africa, Oceania, Caribbean, Southeast Asia, East Asia and Andean Latin America reported lower rates than expected. Furthermore, country-level data mining results indicated that with advancements in social economy development, the overall burden of low back pain has shown an upward trend and this trend became more pronounced when the SDI value reached 0.6 (Fig. 6). Notably, countries such as Hungary, Albania, Romania, Serbia and Nepal experienced significantly higher disease burdens than predicted. On the contrary, the disease burden in countries such as Nepal, the Maldives, Puerto Rico and Bermuda were significantly lower than anticipated. Correspondingly detailed Disability-Adjusted Life Years (DALYs) data are presented in Figure S6 and Figure S7.

Health inequality analysis

The health inequalities model was employed to examine the disparities in disease burden among countries with varying SDI. The findings indicate a significant upward trend in these inequalities (Fig. 7). Specifically, the disparity between high and low SDI countries regarding the incidence of low back pain cases has progressively widened, increasing from 6,024 cases per 100,000 individuals in 1990 to 8,077 cases per 100,000 individuals in 2021. Corresponding data on DALYs are presented in Figure S8.

Prediction analysis

Bayesian age-period-cohort model

The prediction results indicate that, within the time frame from 2022 to 2050, all standardized rate indicators exhibit a downward trend. However, all standardized quantity index demonstrate an increasingly subdued upward trajectory over time. When stratified by gender, both the male and female groups showed a similar trend to the overall trend (Figure S9, Figure S10).

Autoregressive integrated moving average model

Based on the BAPC model, we introduced the ARIMA model, which is more suitable for short-term predictions,

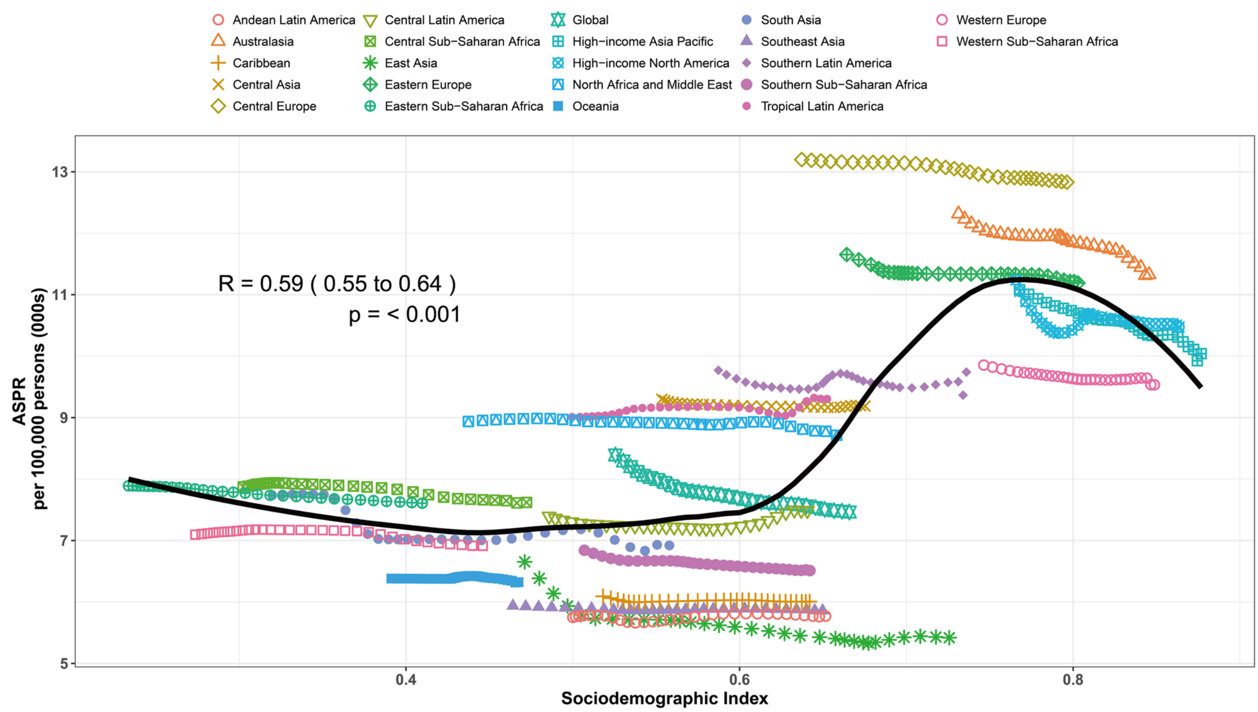

Fig. 5 Age-standardised prevalence of low back pain for Global and the 21 Global Burden of Disease regions by sociodemographic index, 1990–2021. Thirty-two points are plotted for each region and show the observed age-standardised prevalence from 1990 to 2021 for that region. Expected values, based on sociodemographic index and disease rates in all locations, are shown as a solid line. Regions above the solid line represent a higher than expected burden and regions below the line show a lower than expected burden

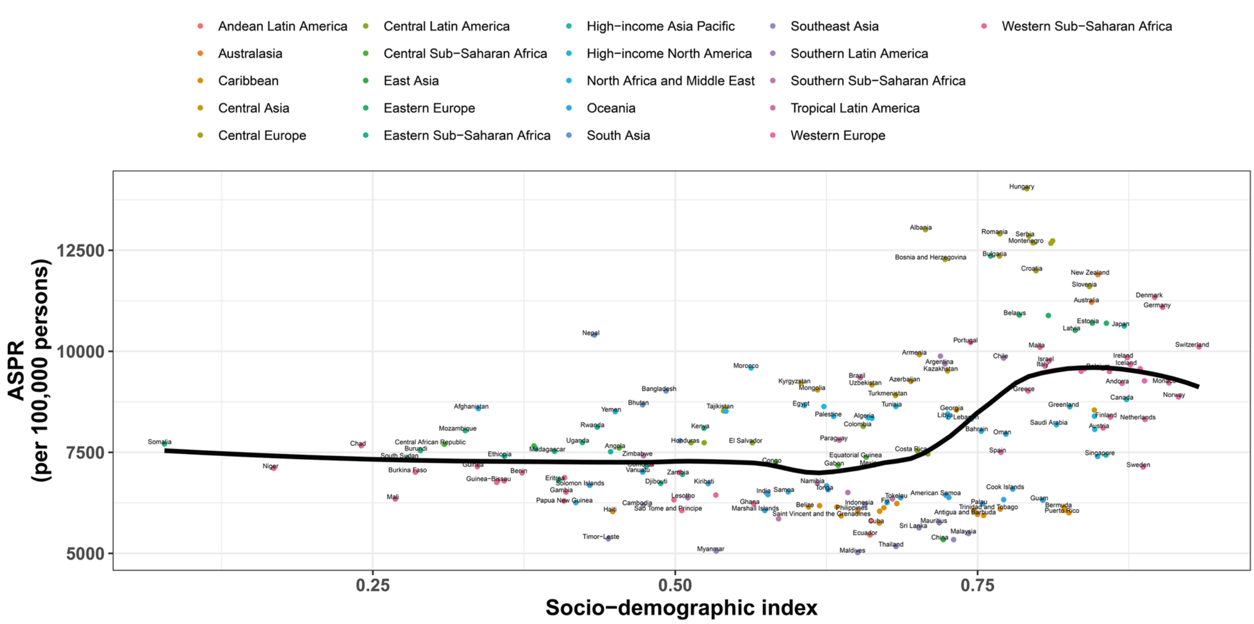

Fig. 6 Age-standardised prevalence of low back pain for 204 countries by sociodemographic index, 1990–2021. Expected values, based on sociodemographic index and disease rates in all countries, are shown as a solid line. Regions above the solid line represent a higher than expected burden and regions below the line show a lower than expected burden

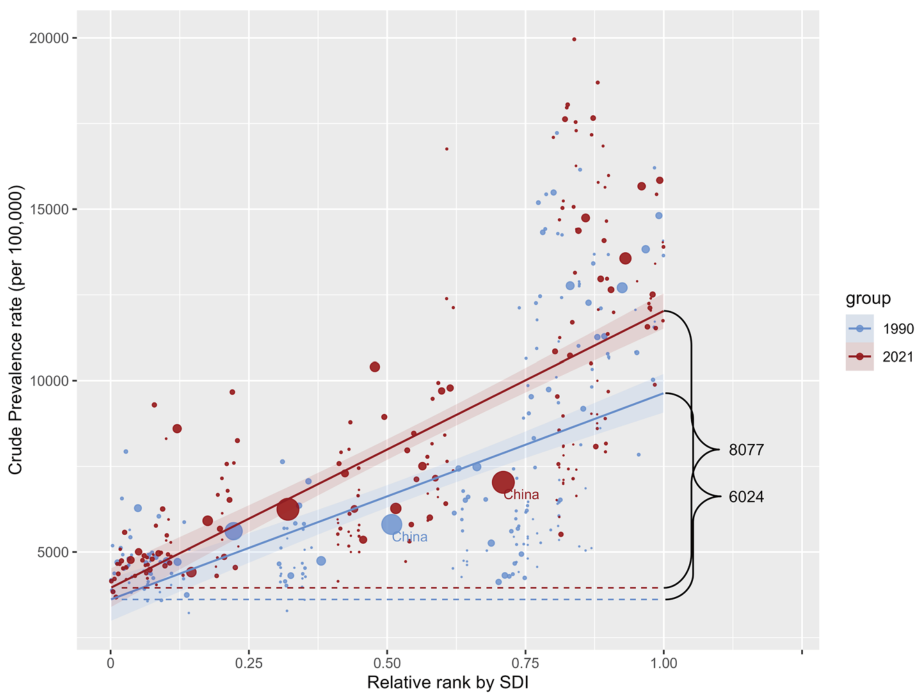

Fig. 7 Health inequality analysis model results for low back pain from 1990 to 2021

to develop a forecasting system for the prevalence and DALYs rate over a 15-year period. This approach aims to achieve a more accurate assessment of recent future trends. Generally, the results obtained from both the ARIMA and BAPC models were consistent regarding age-standardized incidence rates. Specifically, there was an overall downward trend in age-standardized incidence. However, it is noteworthy that when focusing on the female demographic group, divergent results emerged. In particular, the prevalence of low back pain among women exhibited an upward trend projected over the next 15 years (Figs. 8, 9 and 10).

Discussion

This study conducts a comprehensive analysis of the burden of low back pain globally, across 21 regions and in 204 countries from 1990 to 2021. In terms of indicator assessment, this paper encompasses the DALYs metrics utilized in previous research while also incorporating prevalence-related indicators into consideration [9]. Additionally, a series of models with varying dimensions were introduced to enhance the understanding of disease burden information. The findings revealed that while the standardized rate measures attributed to low back pain have been decreasing globally, the absolute numerical measures of disease burden continue to rise. This suggests that there remains a critical need for sustained attention and vigilance in addressing and managing the burden associated with low back pain.

Gender

Consistent with the findings of the GBD2019 report, our study indicates that women experience a higher burden of low back pain compared to men [18]. This disparity may stem from physiological and psychosocial differences. From a physiological perspective, women generally possess a wider pelvis than men, which necessitates compensation in lumbar lordosis. Furthermore, the strength of pelvic floor muscles responsible for maintaining spinal stability is typically weaker in women than in men, thereby increasing their susceptibility to low back pain [19]. Additionally, women's menstrual cycles significantly influence low back pain. During perimenopause and menopause, there can be a short-term decrease in lumbar spine bone mineral density by 2–3% due to reduced estrogen production [20, 21]. During pregnancy, weight gain around the abdomen and an anterior shift in center of gravity lead to continuous contraction of lumbar muscles as compensation, exacerbating strain. Notably, relaxin secretion during pregnancy contributes to the relaxation of lumbar ligaments and joints, further compromising spinal stability and elevating the risk of low back pain among women [22, 23]. When examining psychosocial aspects, research has demonstrated that women often face group-specific psychological stressors

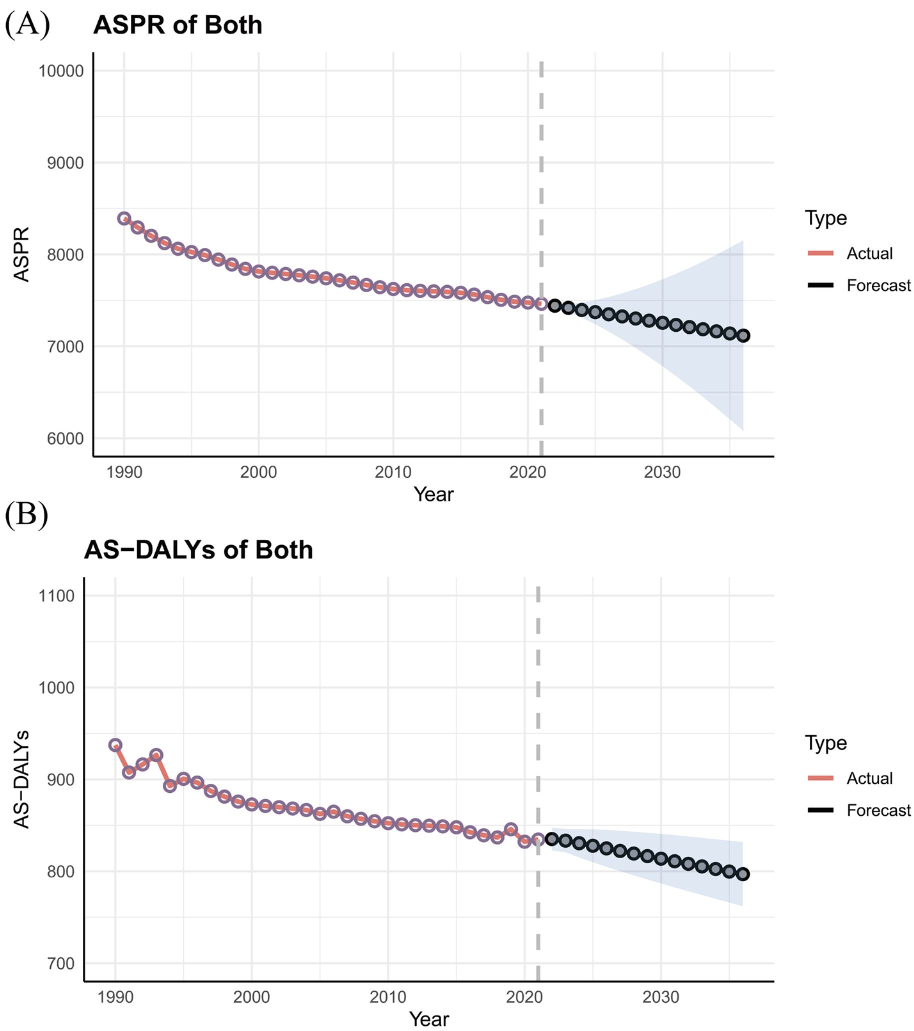

Fig. 8 Forecast of prevalence with LBP from 2022–2036 through ARIMA. The blue line indicates the predicted value, the blue area indicates the 95%CI of the predicted value

within social contexts and such stress can intensify muscle tension [24]. Moreover, evidence suggests that women may exhibit heightened sensitivity to pain relative to men [25]. Consequently, strategies aimed at preventing low back pain in women should address physiological structures while emphasizing spine and pelvic health care. This includes promoting correct posture adjustments, utilizing supportive tools for waist support, engaging in spinal function exercises and enhancing core muscle training to strengthen abdominal musculature effectively thereby reducing the risk of developing low back pain.

Age, period and cohort

In addition, age is a significant factor influencing the burden of low back pain. The results of the age subgroups and the age dimension of the APC model jointly indicate that the prevalence of low back pain exhibits an increasing trend with advancing age, peaking in older age groups before subsequently declining. Specifically, as individuals age, the human spine undergoes a series of degenerative changes during which the cumulative effects of these conditions contribute to the rising prevalence of low back pain [26–28]. However, in older populations, further limitations on physical activity lead to a marked reduction in waist usage and consequently lower probabilities of posture-related injuries [1, 29]. Moreover, as individuals reach advanced ages, those who survive tend to possess relatively good health knowledge reserves [30, 31]. In addition, individuals suffering from severe lower back pain and other conditions that adversely affect their quality of life and physical health may experience premature mortality due to the impact of these diseases. This phenomenon can lead to a natural health selection process

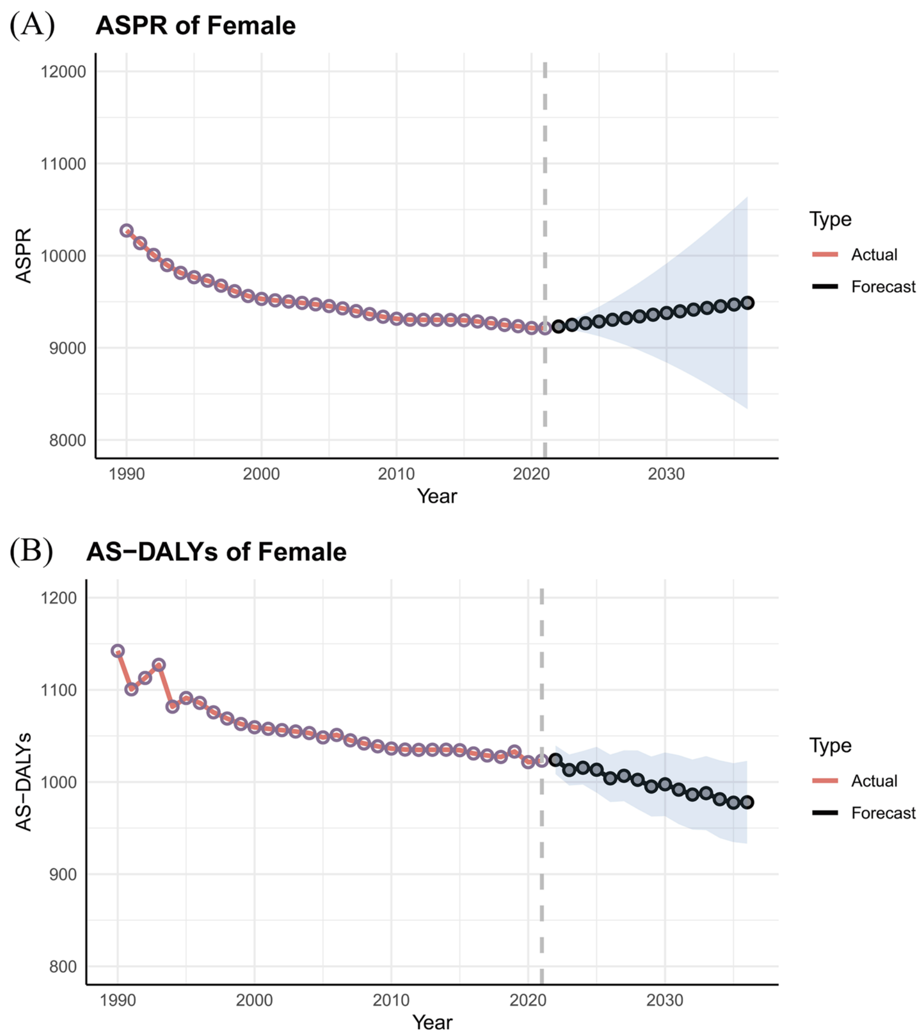

Fig. 9 Forecast of prevalence with LBP among females from 2022–2036 through ARIMA. The blue line indicates the predicted value, the blue area indicates the 95%CI of the predicted value

within the elderly population, ultimately resulting in a declining trend in the standardized prevalence rate of lower back pain. This observation aligns with findings from the APC model when examining age effects. In addition, when focusing on the other dimensions of the APC model, we observe that the prevalence of low back pain has shown an increasingly strong upward trajectory over time. This increase can primarily be attributed to various risk factors discussed below. Finally, analysis of the cohort dimension reveals that compared to earlier birth cohorts, later birth cohorts exhibit a downward trend in low back pain prevalence. This may be attributed to the combined effects of multiple factors, such as the improvement of living environment, the enhancement of healthcare level and the increase in health literacy.

Population growth, aging and changes in epidemic trends

The results of the decomposition analysis indicated that population growth is a predominant factor contributing to the burden of low back pain, followed closely by population aging. This suggests that as the population increases and its structure ages, the disease burden associated with low back pain is likely to rise. Changes in epidemic trends, such as the emergence of new diseases or advancements in vaccine development and distribution, can lead to a decrease in the prevalence of low back pain. When new diseases arise and capture public health attention, they often redirect medical resources, prevention strategies and public focus towards them. Consequently, this heightened awareness may encourage individuals to prioritize their own health maintenance [32]. As a result, certain risk factors for low back pain, such as poor sitting

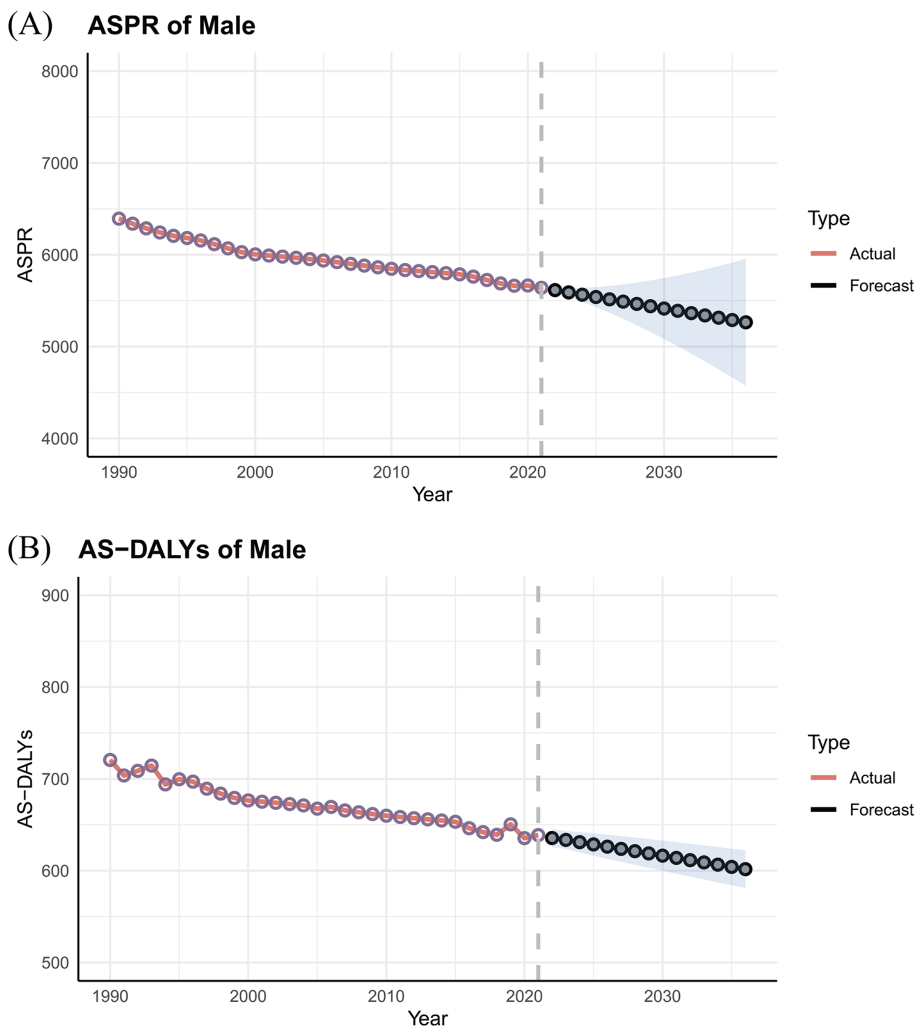

Fig. 10 Forecast of prevalence with LBP in men from 2022–2036 through ARIMA. The blue line indicates the predicted value, the blue area indicates the 95%CI of the predicted value

posture and insufficient physical activity, may be mitigated through an increase in health consciousness among the populace. Furthermore, advancements in vaccine development also contribute to reducing the prevalence of low back pain and some vaccines target diseases that are associated with this condition. By preventing these diseases through vaccination efforts, there is an indirect reduction in the risk of developing low back pain [33]. In conclusion, to prevent low back pain among older adults, it is essential to focus on adjusting lifestyle habits including maintaining proper posture and regulating activity levels regarding frequency and intensity. Additionally, targeted exercises for waist strength should be emphasized. Specifically,These include stretching routines, leg raises and traditional fitness activities. The judicious application of rehabilitation methods such as hot compresses, massage therapy and physical therapy will further aid in effectively lowering the risk of low back pain while enhancing overall lumbar health.

Crude risk factors

Low back pain is recognized as a multifactorial disease, with numerous predisposing factors contributing to its onset and progression. Our findings indicate that occupational ergonomic factors play a pivotal role in the burden of low back pain. Specifically, the prevalence of this condition can be largely attributed to the evolving structure of the global workforce, particularly due to the sustained growth and popularity of high-risk industries such as service and construction. A socio-ecological correlation study conducted across 24 workplaces revealed that individuals spend over 60% of their working day in sedentary positions. Notably, employees within construction companies engage in sedentary behavior for approximately

44% of their working hours, whereas those employed by financial service providers and research institutions exhibit even higher rates, spending between 76 to 80% of their work time in sedentary activities [34, 35]. These patterns of sedentary behavior, coupled with unreasonable work-life habits, such as poor posture, constitute significant risk factors for the development of low back pain [1]. Consequently, enterprises should implement proactive measures aimed at enhancing working conditions. This includes strengthening occupational health training programs, encouraging employees to take regular breaks, promoting proper posture adjustments and reducing overall sedentary behavior.

Levels of the SDI and health inequality factors

The results of the frontier analysis indicated a generally positive correlation between the disease burden indicators of low back pain and the SDI. Furthermore, health inequality analysis revealed that this positive inequality pattern exhibited a significant worsening trend. This finding was corroborated by decomposition analysis, which demonstrated that the burden of low back pain was most pronounced in countries with medium–high SDI, while those with low SDI experienced a comparatively lower burden. The cause of this phenomenon in high-income countries may be attributed to their relatively advanced levels of population aging. Additionally, as these nations undergo economic transformation alongside globalization and technological advancements, the service sector has emerged as the dominant component of their economies. This shift has led to specific work patterns that may predispose individuals to develop low back pain [36, 37]. In contrast, many low and medium SDI countries continue to rely on traditional agriculture and labor-intensive manufacturing practices. These environments often involve diverse work postures and frequent physical activities, which can mitigate the risk of developing low back pain to some extent [38].

Prediction of the trend of LBP burden

Finally, two prediction models with distinct strengths were employed to interpret and project the future trends in the burden of LBP. The structure of these prediction models indicates that women are likely to continue experiencing a higher burden of LBP compared to men in the future. Notably, the ARIMA model revealed an increasing trend in the prevalence of low back pain among women. This finding underscores the necessity for heightened attention towards women's health in LBP prevention efforts and highlights the urgent need for more targeted low back pain prevention strategies specifically designed for women.

Limitations

Inevitably, our research has certain limitations. In terms of data sources and quality, the GBD database exhibits inherent selection bias due to inconsistent data collection standards, underreporting and overreporting across regions, and updates that lag behind actual conditions, which affects the accuracy and timeliness of analyses and predictions. Furthermore, the data integration biases resulting from the diversity of data sources may also lead to misinterpretations of our results. Additionally, although this database encompasses epidemiological studies and health statistics from multiple countries and regions worldwide, there is a lack of data or accessibility issues in some middle and low income countries. Consequently, results rely on modeling data from DisMod-MR 2.1. Regarding disease risk factors, this study only analyzes the primary risk factors provided by the database. Therefore, while this paper builds upon other methods for enhancement, further high-quality research with larger scales is still needed to refine and supplement the current conclusions.

Conclusions

This study deeply analyzes the risk factors and trends of the global burden of low back pain. Global population growth, aging, higher levels of the SDI, female gender and poor occupational ergonomics may be important risk factors for the burden of LBP, while certain changes in the prevalence trends can alleviate this burden to some extent. Without effective interventions, the gap in health inequality will widen. Therefore, it is urgent to formulate and implement targeted and effective health prevention measures.

Abbreviations

LBP	Low Back Pain
GBD	Global Burden of Disease
APC	Age-Period-Cohort
EAPC	Estimated Annual Percentage Change
ARIMA	Autoregressive Integrated Moving Average
DALYs	Disability-Adjusted Life Years
BAPC	Bayesian Age-Period-Cohort
YLLs	Years of Life Lost
YLDs	Years Lived with Disability
UI	Uncertainty Intervals
SDI	Socio-Demographic Index

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
NY: Conceptualization, Methodology, Data curation, Visualization, Validation, Writing - Original Draft and Writing - Review & Editing. JKD: Formal analysis, Investigation, Data curation, Writing - Original Draft and Writing - Review & Editing. WHW: Software, Writing - Original Draft and Writing - Review & Editing. HYF: Writing - Original Draft, Writing - Review & Editing, Supervision and Funding acquisition.

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Data availability
The datasets generated and analysed during the current study are available in the Global Burden of Disease repository, [https://vizhub.healthdata.org/gbd-results].

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
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Competing interests
The authors declare no competing interests.

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