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ORIGINAL RESEARCH

The Impact of Population Aging on Ergonomic-Related Low Back Pain Across Regions with Different Development Levels

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Background and Objective: Population aging is a major driver of the ergonomic low back pain(LBP) burden, but its impact may vary across regions with different development levels. This study aimed to quantify and compare these differences.
Methods: Using data from the Global Burden of Disease Study 2021 (GBD 2021), we conducted a decomposition analysis to assess the independent contributions and attributable fractions of population aging and epidemiological rate changes to the disability-adjusted life years(DALYs) of ergonomic LBP from 1990 to 2021. Differences were compared across Socio-demographic Index(SDI) regions and by sex.
Results: From 1990 to 2021, population aging contributed to an increase of 958,564.25 DALYs globally (attributable fraction: 24.74%). The highest attributable fraction was observed in high-middle SDI regions (127.9%). Globally, reductions in DALY rates fully offset the effects of aging ($R < -1$), with the largest relative impact seen in low-SDI regions ($R = 14.64$). The contribution of aging was higher in men (29.36%) than in women (21.70%) across all regions.
Conclusion: The impact of aging on the burden of ergonomic LBP is not uniform and follows a non-linear pattern across SDI levels. Public health efforts can mitigate this burden. Targeted strategies focusing on high-middle SDI regions and male workers are needed to support healthy aging and reduce disparities in global occupational health protection.
Keywords: population aging, low back pain, LBP, ergonomic risk factors, disability-adjusted life years, DALYs, socio-demographic index, SDI

Introduction

The global population is undergoing an irreversible shift toward aging, contributing to a growing burden of disease. The global elderly population is projected to double from 800 million in 2024 to 1.6 billion by 2050, and its share of the world's total population is expected to rise from 10.2% to 16.4%.[1–3] While this trend reflects progress in development, it also drives changes in the disease spectrum. Aging is associated with physiological and cognitive decline, leading to a higher burden of non-communicable diseases and disability, which poses challenges for health systems.[1,2,4] The pace and pattern of aging vary across historical and social contexts,[1] suggesting that a single approach to health policy may be insufficient. Therefore, examining the relationship between aging and disease burden at the regional level is essential to move the concept of "healthy aging" into practical implementation.

The relationship between population aging and social development remains debated. Some studies suggest a negative association, as described by Modigliani and Cao,[5] while others argue that aging may support long-term development by encouraging human capital accumulation and savings.[6,7] This divergence highlights the need to assess the effects of aging within specific development contexts.LBP is a common and burdensome musculoskeletal condition that often begins in adolescence and accumulates over the life course.[8,9] It is now one of the leading causes of disability worldwide. In 2020, more than 600 million people were affected by low back pain, and this number is projected to exceed 800 million by 2050.[10] Beyond

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pain and disability, it contributes to work limitations, social inequality, and economic losses.[11] Among various contributing factors, ergonomic exposure at work is regarded as an important precipitating factor for LBP.[12] In Europe, over 50% of cases are attributed to occupational ergonomic factors. As the average age of the global workforce increases, the burden of work-related low back pain is expected to rise.Although previous studies have examined regional disparities in the burden of ergonomic-related LBP,[12,13] limited evidence exists on the net effects of key drivers such as aging, population growth, and epidemiological changes. Accurately estimating the independent contribution of these factors is essential for developing targeted, region-specific strategies to promote healthy aging and address future challenges.

We used the GBD 2021 database to quantify the independent net effect of population aging on the burden of ergonomic-related LBP. The study aimed to: (1) assess the impact of aging on disease burden; (2) compare the relative contributions of aging and changes in epidemiological rates; and (3) examine gender differences in the effect of aging. The findings are expected to provide evidence for developing region-specific interventions and support the global effort toward healthy aging.

Definitions

Different Development Levels

In this study, “different development levels” refer to categories based on the Socio-demographic Index (SDI), a composite indicator of development used in the GBD study. Analyses were stratified by SDI groups (eg, low, low-middle, middle, high-middle, high, or SDI quintiles), which allow comparisons across settings with different socio-demographic profiles.

DALYs

Disability-adjusted life years (DALYs) quantify total health loss and are defined as the sum of years of life lost (YLLs) due to premature mortality and years lived with disability (YLDs) due to non-fatal health outcomes (DALY = YLL + YLD).

Ergonomic Back Pain

In the GBD context, “ergonomic back pain” is defined as the proportion of the population exposed to work-related conditions that contribute to LBP. Exposure estimates are based on population distribution across nine occupational categories.

SDI Regions

“SDI regions” refer to GBD SDI groupings (SDI quintiles or SDI categories) used for stratified reporting. They are not geographic regions per se; rather, they group locations by similar SDI levels to facilitate comparisons.

Regional Level

“Regional level” denotes the analysis unit of location used in GBD reporting (eg, global, SDI group, or other GBD location groupings, depending on the analysis). In this manuscript, results are reported at the global level and stratified by SDI group.

Attributable Fraction

The attributable fraction (also termed the population attributable fraction in risk assessment) is the proportion of a health outcome that would be prevented if exposure to a specific risk factor were reduced to a counterfactual minimum (theoretical minimum risk exposure level, TMREL) while other factors remained unchanged. In GBD, the attributable burden is estimated using the comparative risk assessment framework, and the attributable fraction links exposure distributions and relative risks to the fraction of outcome burden attributable to the risk factor.

Methods

Data Source

All data were obtained from the GBD 2021, coordinated by the Institute for Health Metrics and Evaluation (IHME). GBD 2021 provides estimates of the health burden from 1990 to 2021 for 371 diseases and injuries across 204 countries and territories. We extracted data on LBP attributed to ergonomic risk factors. Burden indicators included the number and rate of DALYs. Analyses were conducted globally and across the five SDI regions, covering the total population and individuals aged 55 years and older, with results stratified by sex. (The locations included in the five SDI quintiles are detailed in the Supplementary Material).

SDI

SDI is a composite indicator used to assess the level of development of a country or region. It is positively correlated with income per capita and mean years of schooling, and negatively correlated with the total fertility rate among females younger than 25 years. Specifically, income per capita reflects the economic status of residents in a given area; mean years of schooling is commonly measured using education-level indicators (eg, average years of education); and fertility rate reflects women's reproductive level in that region.

Range and Stratification

SDI typically ranges from 0 to 1, where 0 represents the lowest theoretical level of health-related development and 1 represents the highest level of development. Based on SDI values, the GBD study categorizes countries or regions worldwide into five levels: low SDI (0.081–0.449), low-middle SDI (0.445–0.607), middle SDI (0.612–0.689), high-middle SDI (0.690–0.805), and high SDI (0.812–0.929).

Definition of LBP Attributed to Ergonomic Risk Factors

In GBD 2021, occupational ergonomic factors are defined as a risk exposure, rather than as the disease itself. This exposure refers to the proportion of the population exposed to work-related ergonomic conditions that may contribute to LBP, and is estimated based on population distributions across nine occupational categories. Within the comparative risk assessment framework, this exposure is used to estimate the burden of LBP attributable to occupational ergonomic risk factors. The theoretical minimum risk exposure level (TMREL) is defined as employment in clerical and related occupations (Source: https://www.healthdata.org/research-analysis/diseases-injuries-risks/factsheets-hierarchy?field_field_topic_sub_type_value%5Brisk%5D=risk).

Quantifying the Contribution of Population Aging

Decomposition analysis[14–16] was used to separate the independent contributions of population aging, population growth, and changes in epidemiological rates (DALY rates) to the burden of LBP attributed to occupational ergonomic factors. Decomposition analysis is a method used to understand patterns and changes in data; its core idea is to separate an observed overall change into several key driving factors. It can help clarify how different factors influence the total change. In this study, all analyses were performed using R software (version 4.2.3).

Statistical Analysis

Decomposition Analysis

Decomposition analysis was used to break down changes in DALYs due to occupational ergonomic factors into three drivers:

(1) Population aging (A): changes in the age distribution of the population, reflecting a shift toward older age groups.
(2) Population growth (P): changes in total population size.
(3) Changes in epidemiological rates (M): changes in age-specific DALY rates.

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The basic formulas follow previous studies and are defined as:

- A = Ma + Iam + Ipa + Ipam, where Ma is the main effect of age-specific rates, Iam is the interaction between aging and age-specific rates, Ipa is the interaction between aging and population growth, and Ipam is the three-way interaction.
- P = Mp + Ipm + Ipa + Ipam, where Mp is the main effect of population growth, Ipm is the interaction between population growth and age-specific rates, Ipa is the interaction between population growth and aging, and Ipam is the three-way interaction.
- M = Mm + Ipm + Iam + Ipam, where Mm is the main effect of changes in age-specific rates, Ipm is the interaction between age-specific rates and population growth, Iam is the interaction between age-specific rates and aging, and Ipam is the three-way interaction.

The results report both absolute and relative contributions of each factor to the total change in DALYs. Absolute contribution refers to the number of DALYs attributed to each factor. Relative contribution is calculated as the proportion of attributable DALYs divided by the total DALYs in 1990, multiplied by 100%. In cases where the attributable DALYs exceed the 1990 baseline, this proportion may exceed 100%.

Quantifying Impact: Ratio (R)

To compare the relative contributions of changes in epidemiological rates and population aging, we calculated a R, defined as:R = (DALYs attributable to changes in epidemiological rates)/(DALYs attributable to population aging).

This ratio reflects the degree to which changes in epidemiological rates offset or amplify the effects of population aging, with interpretations as follows:

R <-1: A decrease in epidemiological rates fully offset and exceeded the effect of population aging.

R =−1: The two effects cancelled each other out entirely.

-1 < R < 0: The decrease in rates partially offset the impact of aging, but not completely.

0 < R < 1: Aging was the dominant driver, with a greater effect than the increase in rates.

R > 1: The increase in epidemiological rates had a greater effect than population aging.[3]

Results

Global Trends in the Aging Population, 1990–2021

From 1990 to 2021, the global population aged 55 years and older increased from 671.4 million to 1.486 billion. Its share of the total population rose from 12.57% to 18.83%. In 2021, the proportion of people aged 55 and older varied across the five SDI quintiles: 29.77% in high SDI regions, 26.59% in upper-middle SDI, 19.19% in middle SDI, 12.55% in lower-middle SDI, and 7.34% in low SDI regions (Table 1).

Table 1 Elderly Population by Region in 2021

Age	Location					
	Global	**High SDI**	**High-Middle SDI**	**Middle SDI**	**Low SDI**	**Low-Middle SDI**
55+ years	1,485,986,171.02	345,013,047.81	346,677,258.95	469,858,503.88	82,057,984.58	241,083,012.86
55-59 years	395,728,003.99	72,736,676.80	89,937,336.67	137,945,554.70	25,331,094.89	69,461,877.82
60-64 years	320,047,853.31	68,170,164.80	72,933,910.20	101,782,614.63	19,716,730.14	57,165,697.35
65-69 years	275,842,158.52	60,625,318.33	66,404,353.29	89,136,503.81	15,076,273.03	44,360,197.43
70-74 years	205,839,220.39	53,360,512.68	48,848,558.22	61,628,112.07	10,370,443.68	31,446,911.05
75-79 years	131,884,404.58	36,213,141.57	29,868,010.46	39,181,385.90	6,420,830.80	20,079,019.93
80-84 years	87,583,056.92	26,972,305.21	21,832,235.02	23,820,671.89	3,373,105.11	11,500,543.66
85-89 years	45,721,791.05	16,498,057.55	11,377,209.60	11,467,915.27	1,334,963.88	4,997,049.19
90-94 years	17,889,373.59	7,666,620.33	4,371,778.53	3,855,375.57	358,463.17	1,618,230.64
95+ years	5,450,308.67	2,770,250.53	1,103,866.96	1,040,370.05	76,079.87	453,485.79
All ages	7,891,353,300.74	1,094,047,735.61	1,304,031,282.73	2,448,543,920.68	1,117,382,590.51	1,921,112,323.91

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Table 2 Impact of Population Aging and Epidemiological Factors on Disease Burden, 1990–2021

Location_Name	Both					
	Global	Low-Middle SDI	Low SDI	High-Middle SDI	High SDI	Middle SDI
Overall_Difference	3,874,014.90	1,505,813.72	925,432.59	191,918.12	281,057.87	967,915.79
Aging	958,564.25	190,093.00	−20,954.08	245,459.21	14,144.37	599,190.01
Population	5,425,938.36	1,698,273.83	1,253,075.85	612,171.35	437,435.50	1,630,338.36
Epidemiological_Change	−2,510,487.72	−382,553.10	−306,689.18	−665,712.44	−170,521.99	−1,261,612.59
Aging_Percentage	24.74	12.62	−2.26	127.90	5.03	61.91
Population_Percentage	140.06	112.78	135.40	318.98	155.64	168.44
Epidemiological_Change_Percentage	−64.80	−25.41	−33.14	−346.87	−60.67	−130.34
R	−2.62	−2.01	14.64	−2.71	−12.06	−2.11

Impact of Population Aging on Ergonomic-Related LBP DALYs Across the Five SDI Regions

In 2021, ergonomic risk-related LBP accounted for a total of 15,569,218.82 DALYs globally. This represents an increase of 4,717,129.12 DALYs compared to 1990. Between 1990 and 2021, population aging contributed to an increase of 958,564.25 DALYs globally, accounting for 24.74% of the overall rise (Table 2).

Across the five SDI quintiles, the DALYs attributable to population aging were 14,144.37 in high SDI, 245,459.21 in upper-middle SDI, 599,190.01 in middle SDI, 190,093.00 in lower-middle SDI, and –20,954.08 in low SDI regions. The corresponding attribution proportions were 5.03%, 127.9%, 61.91%, 12.62%, and –2.26%, respectively. Aging contributed positively to the DALY increase in four of the five regions, with the highest proportion observed in the upper-middle SDI group (Table 2 and Figure 1).

It is noteworthy that population growth was the main driver of the total DALY increase in all five SDI regions.

Comparison of DALY Rate Changes and Population Aging Contributions Across Five SDI Regions

From 1990 to 2021, the decline in the DALY rate for ergonomic-related LBP resulted in a global reduction of 3,796,179.99 DALYs. By SDI quintile, the decrease in DALYs attributable to rate changes was 170,521.99 in high

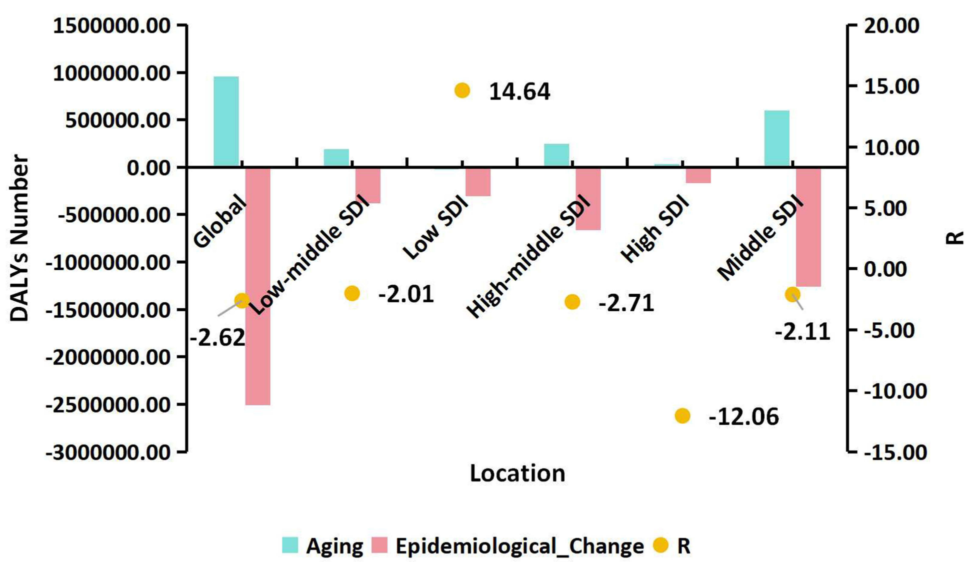

Figure 1 Impact of Population Aging and Epidemiological Factors on Disease Burden, 1990–2021. Light blue represents the effect of population aging, pink represents the effect of epidemiological factors, and yellow represents the R value, where R = (DALYs attributable to changes in epidemiological rates)/(DALYs attributable to population aging).
Abbreviation: DALYs, disability-adjusted life years.

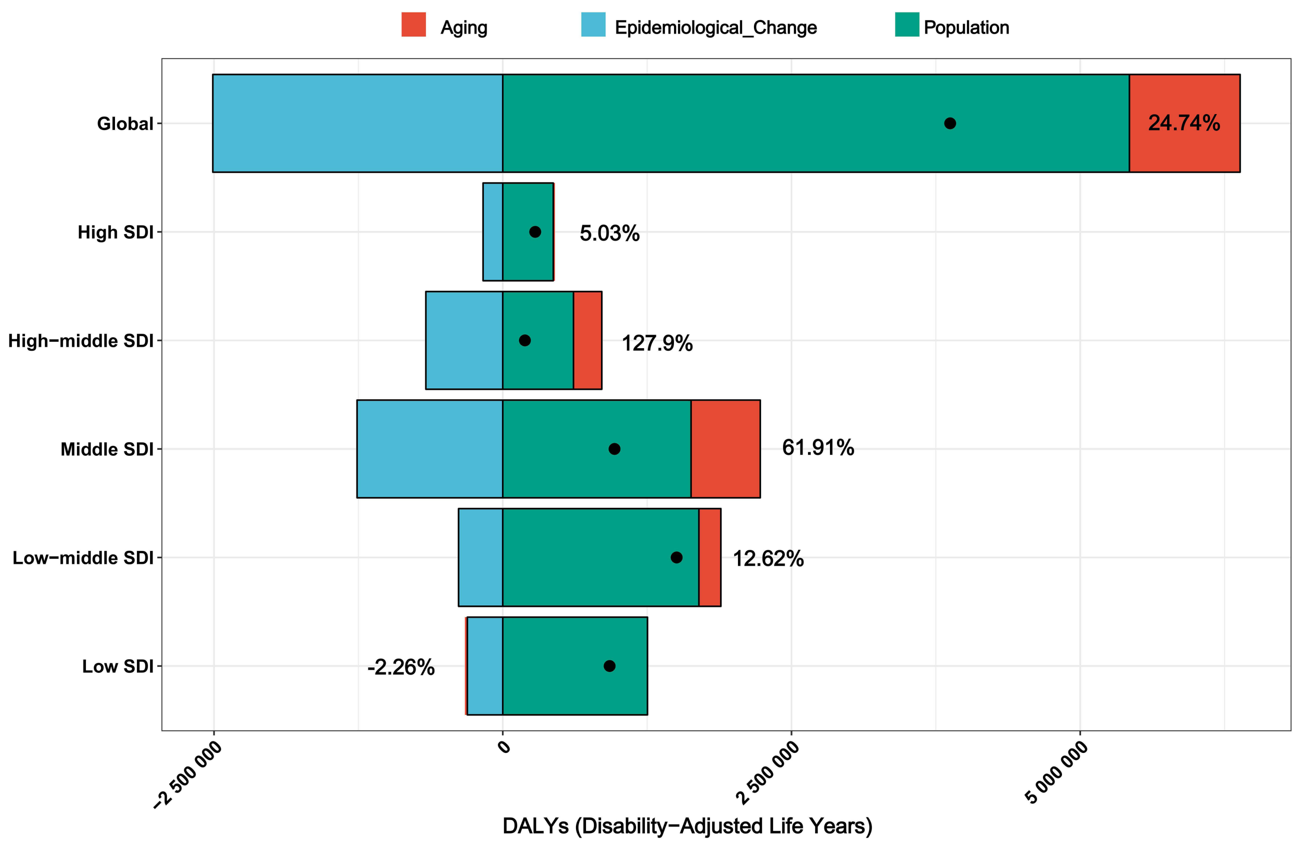

Figure 2 Decomposition analysis of DALYs for ergonomic LBP globally and across SDI regions, 1990–2021. Red represents the effect of population aging, green represents the effect of population growth, and blue represents the effect of epidemiological factors.
Abbreviations: DALYs, disability-adjusted life years; SDI, Socio-demographic Index.

SDI, 665,712.44 in upper-middle SDI, 1,261,612.59 in middle SDI, 382,553.10 in lower-middle SDI, and 306,689.18 in low SDI regions.

After quantifying contributions, we found that the reduction in DALY rates fully offset the impact of population aging in the global, high, middle, and lower-middle SDI regions (R < –1). In the low SDI group, the impact of rate change was substantially greater than that of aging, with R = 14.64 (Table 2 and Figure 2).

Gender Differences in the Impact of Population Aging on DALYs Attributable to Ergonomic LBP Across Five SDI Regions

In 2021, ergonomic-related LBP accounted for 7,256,394.87 DALYs in males and 8,312,823.95 in females worldwide. Compared to 1990, this represents an increase of 1,957,739.31 DALYs in males and 2,759,389.81 in females.

Over the past three decades, population aging contributed to 29.36% of the DALY increase in males, which was notably higher than the 21.7% observed in females. This pattern was consistent across all SDI regions except the middle SDI group, with the largest gender gap recorded in the high-middle SDI region, reaching 71.15% (Table 3 and Figure 3).

Discussion

This study is the first to quantify the impact of population aging on the burden of LBP attributable to occupational ergonomic factors from 1990 to 2021. It also assessed variations across regions with different SDI levels and between genders. The findings show that aging is a major driver of the increase in DALYs caused by ergonomic-related LBP. This effect was more pronounced in higher SDI settings, where the attributable proportion reached 127.9%, suggesting a combined pressure from aging and occupational exposure.Further analysis showed that changes in DALY rates offset the impact of aging at the global level. In low SDI regions, these changes were the main contributor to burden reduction,

Table 3 Gender Differences in the Impact of Population Aging on Disease Burden, 1990–2021

Location_Name	Male						Female					
	Global	Low-Middle SDI	Low SDI	High-Middle SDI	High SDI	Middle SDI	Global	Low-Middle SDI	Low SDI	High-Middle SDI	High SDI	Middle SDI
Overall_Difference	1,606,153.5	574,876.56	391,646.76	74,757.42	138,530.81	425,398.16	2,267,861.4	930,937.16	533,785.83	117,160.7	142,527.06	542,517.62
Aging	471,540.95	80,771.95	−16,357.39	128,534.38	15,567.76	260,757.68	492,221.34	108,424.56	−4035.66	118,091.09	565.88	340,201.43
Population	2,597,484.17	796,784.69	565,075.14	305,417.85	259,749.21	727,991.64	2,829,587.7	902,428.2	688,884.6	306,221.87	181,700.86	906,512.35
Epidemiological_Change	−1,462,871.62	−302,680.08	−157,070.99	−359,194.82	−136,786.16	−563,351.16	−1,053,947.65	−79,915.6	−151,063.11	−307,152.25	−39,739.67	−704,196.15
Aging_Percentage	29.36	14.05	−4.18	171.94	11.24	61.3	21.7	11.65	−0.76	100.79	0.4	62.71
Population_Percentage	161.72	138.6	144.28	408.55	187.5	171.13	124.77	96.94	129.06	261.37	127.49	167.09
Epidemiological_Change_Percentage	−91.08	−52.65	−40.11	−480.48	−98.74	−132.43	−46.47	−8.58	−28.3	−262.16	−27.88	−129.8

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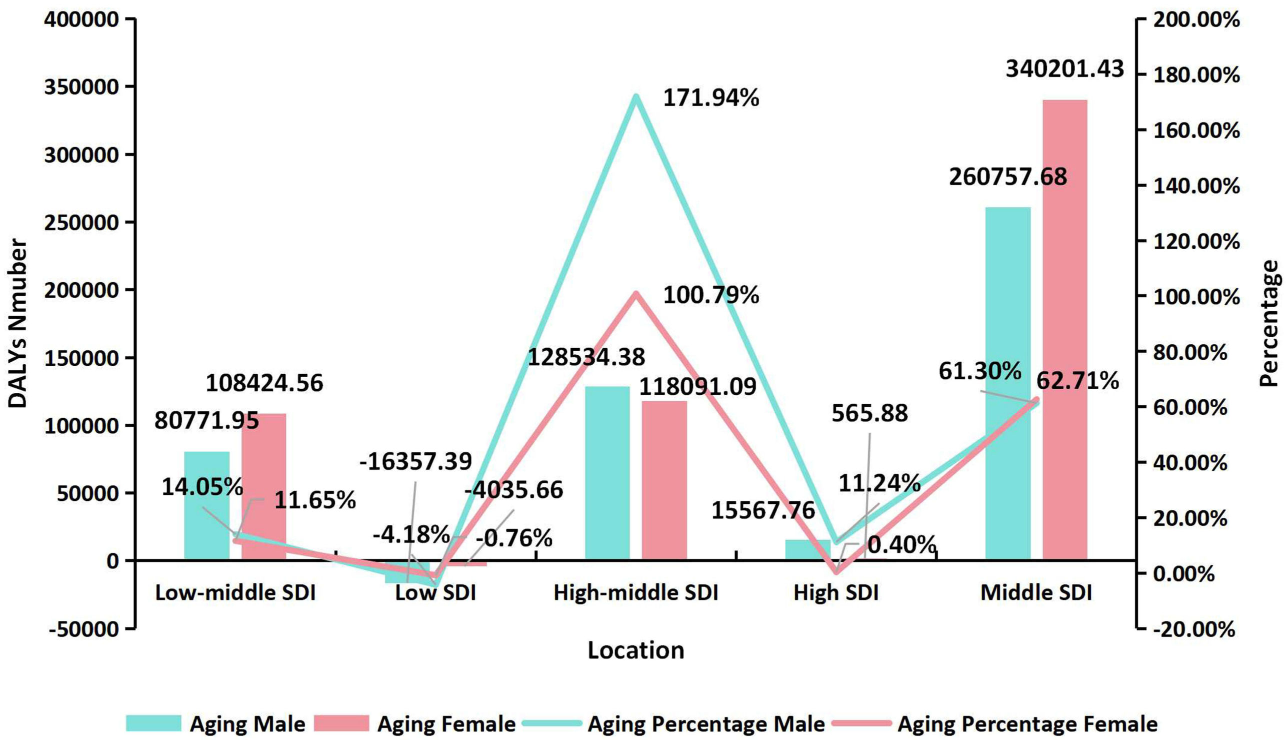

Figure 3 Gender Differences in the Impact of Population Aging on Disease Burden, 1990–2021. Light blue represents males, and pink represents females.

highlighting the potential value of public health interventions. In addition, aging contributed more to the disease burden in males than in females, a pattern consistent across regions. This may reflect the influence of gender segregation in work-related exposures.By identifying aging-related risks, this study highlights high-middle SDI regions and male workers as priority targets for future intervention. The findings offer data-driven support for developing tailored, inclusive strategies to promote healthy aging across different levels of development.

Although population aging is most advanced in high SDI regions, this study found that the health loss attributed to aging-related ergonomic LBP was most severe in upper-middle SDI regions, with an attributable proportion of 127.9%—24 times that of high SDI regions and 10 times that of lower-middle SDI regions. This pattern is closely linked to rapid economic growth and underdeveloped occupational health protection systems in these regions.[17,18] In recent years, upper-middle SDI countries have experienced fast expansion in sectors such as logistics and information technology, which have attracted large numbers of young workers.[17] However, these industries often involve prolonged sitting, standing, and repetitive tasks, which increase the risk of LBP and other related conditions.[17] At the same time, traditional high-risk sectors such as manufacturing and construction remain prevalent, further contributing to the occupational health burden. Additionally, rising life expectancy and declining fertility rates[18] have led to more older workers staying in the workforce longer, resulting in continued exposure to cumulative ergonomic strain. Occupational protection systems in upper-middle SDI regions remain incomplete. The development and use of ergonomic support tools are limited, and healthcare systems often fall short in addressing the occupational health challenges posed by rapid economic transition.[18] In contrast, although high SDI regions face more advanced aging, their well-established medical infrastructure and occupational safety measures help mitigate the rise in ergonomic-related disease burden.[19,20] This contrast highlights the vulnerability of upper-middle SDI regions in managing the combined pressures of aging and occupational risk.These findings underscore the importance of developing region-specific public health policies. Upper-middle SDI regions need to implement early intervention strategies, strengthen occupational health protection, improve ergonomic safety, and expand access to related medical services and assistive technologies to reduce the growing burden of LBP associated with aging.[21]

Encouragingly, the global decline in DALY rates has offset the increase in the burden of ergonomic LBP caused by population aging. However, the extent of this positive effect differs across regions. In high SDI regions, the reduction fully counteracted—and even exceeded—the negative impact of aging. In contrast, in low SDI regions, the effect of rate decline was much greater than that of aging. This reflects a disparity in the capacity of public health systems to respond to aging across different settings.In high SDI regions, strong economic foundations support the development of primary healthcare systems, the enforcement of occupational health regulations (such as mandatory ergonomic assessments), and the application of advanced medical technologies.[20,22] These factors enhance prevention and management capabilities, allowing for proactive risk control and reduction in the per capita burden of ergonomic LBP.[20,22] These results suggest that the health challenges associated with aging are not unavoidable and can be addressed through effective public health interventions.However, the high R value (14.64) in low SDI regions does not indicate a well-functioning public health system. Instead, it reflects complex patterns of disease burden shaped by local context. Many countries in this group face limited economic resources and underdeveloped systems for occupational health protection and disease prevention.[23–25] The baseline DALY rates are high, so even small improvements—such as international health assistance or ergonomic education—can result in noticeable relative gains. Additionally, these regions have a lower proportion of older adults,[26] and aging is progressing more slowly. Population growth remains a major contributor to increasing disease burden, amplifying the apparent effect of changes in DALY rates.These findings suggest that the observed “advantage” in low SDI regions may be fragile, and the absolute disease burden may remain substantial. The results also reinforce that ergonomic LBP is a preventable condition with considerable potential for burden reduction. High and middle SDI regions should continue to maintain and refine their successful approaches. For low SDI countries, stronger international support is needed to convert current relative improvements into sustained reductions in absolute burden, and to avoid a situation where health indicators improve without a real decline in disease impact.

Previous studies on the burden of musculoskeletal disorders, including LBP, have generally found a higher burden among women, often attributing this to biological traits or gender-related social roles.[12,24,27,28] However, this study offers a different perspective: men appear to be more affected by the relative impact of population aging on the burden of ergonomic LBP. This gender difference may be shaped by both demographic shifts and occupational gender segregation. As life expectancy gaps between men and women have narrowed, more men are reaching older ages, increasing their cumulative exposure to risk factors for musculoskeletal conditions, including LBP.[28] In contrast, women may experience a “burden ceiling effect,” where longer life expectancy does not translate proportionally into higher disease burden.[29] Occupational patterns also play a role. Men are more likely to work in physically demanding sectors such as construction, manufacturing, and agriculture—jobs commonly associated with ergonomic risks like heavy lifting, prolonged standing, and the use of vibrating tools.[28,30] Additionally, gendered behaviors further widen exposure differences. Men tend to have higher rates of smoking and alcohol consumption, both linked to musculoskeletal disorders.[26,28] Cultural norms around masculinity may discourage men from reporting pain or using protective equipment such as back supports, and contribute to delayed recognition of occupational injury. In contrast, women are more likely to seek early medical attention, which may prevent minor injuries from progressing to chronic conditions.[28] Importantly, despite regional differences in industrialization, labor protection laws, and healthcare infrastructure, this gender disparity remains consistent across all SDI levels, pointing to its structural roots. As long as gender segregation in labor and social roles persists, the disproportionate impact of aging on men’s burden of ergonomic LBP is unlikely to be resolved.Therefore, integrating gender considerations into occupational health policy is essential. Efforts should focus on expanding access to ergonomic support tools in male-dominated industries and institutionalizing early screening and risk education. Developing gender-responsive strategies for occupational disease prevention will be critical in addressing the health challenges posed by aging and in promoting fair and sustainable healthy aging worldwide.

Addressing the challenges of population aging requires a fundamental shift from viewing aging as a social burden to recognizing it as a development opportunity. This transformation rests on three key strategies. First, advances in life sciences, medicine, and artificial intelligence can support technologies related to cell storage, repair, and regeneration, helping to build long-term health reserves and explore the potential of the aging population as a productive workforce. Second, promoting age-friendly cities and societies is essential. This involves improving the physical environment, adapting infrastructure to meet the needs of older adults, and fostering inclusive social norms to reduce barriers to

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participation. Third, a coordinated health service system led by governments and supported by various social actors should be established. This system should encourage and support older adults in re-employment, volunteering, and knowledge sharing, enabling them to realize their value. Together, these approaches can help older individuals become both beneficiaries and contributors to social development, and support the creation of an equitable, healthy, and dynamic aging society.[31]

Although this study offers important insights into the relationship between population aging and the burden of LBP related to occupational ergonomic factors, several limitations should be noted. First, the analysis was based on data from the GBD study, which, despite its global coverage and standardized methodology, may have regional data quality differences that could affect the accuracy of burden estimates in some areas. Second, the decomposition method used in this study quantified the relative contribution of aging to disease burden. However, this approach is an attribution analysis and does not imply causal inference. Aging itself results from both increased life expectancy and decreased fertility rates, but this study did not separately assess their individual contributions to disease burden.[18] Third, although stratification by SDI allows for regional comparisons, SDI is a broad indicator that cannot fully capture differences in occupational structure, healthcare access, or labor protection across countries within the same SDI group. Therefore, national-level heterogeneity could not be fully addressed. Fourth, key individual-level risk factors such as occupational category, smoking, and obesity were not included in the analysis. These factors may interact with aging in influencing the development of LBP. Future public health strategies should take these potential risks into account. In conclusion, further research is needed to improve data quality and conduct more detailed analyses of contributing factors to better understand the mechanisms linking population aging and work-related LBP, and to support more targeted and effective health interventions.

Conclusion

This study quantified the net effect of population aging on the burden of LBP attributable to occupational ergonomic factors from 1990 to 2021 across different SDI levels. The findings revealed a nonlinear relationship between aging and disease burden, with distinct SDI-specific effects. While the decline in DALY rates fully offset the impact of aging at the global level, a substantial relative effect remained in low-SDI regions ($R = 14.64$), highlighting a capacity gap in public health responses. The contribution of aging also showed consistent gender differences across regions, suggesting a potential impact of gender segregation. These results suggest that achieving healthy aging requires a shift from passive burden mitigation to proactive opportunity development. Health strategies should be tailored to different stages of socio-economic development, integrating population policies with occupational health. In high-to-middle SDI regions, priority could be given to sector- and job-specific “ergonomic risk scans” (eg, in high-exposure industries such as logistics), together with strengthened workplace surveillance and early-warning systems, and a focus on early-warning education and training for male workers to improve the targeting and feasibility of interventions. Strengthening current health systems and promoting bilateral cooperation with low-SDI countries may help close the gap in occupational health capacity. Future research should further explore the influence of specific risk factors to support more precise intervention strategies.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors used ChatGPT-4.0 to assist with language polishing. All content generated with the help of this tool was subsequently reviewed and revised by the authors as necessary. The authors take full responsibility for the final content of the publication.

Abbreviations

DALYs, disability-adjusted life years; LBP, Low back pain; GBD, Global Burden of Disease; IHME, the Institute for Health Metrics and Evaluation; SDI, Socio-demographic Index; TMREL, theoretical minimum risk exposure level.

Data Sharing Statement

The relevant data from the literature is stored in the attachments. For further inquiries, please feel free to contact the author (Xueneng Yang:3237559787@qq.com).

Ethics Approval and Consent to Participate

According to Items 1 and 2 of Article 32 of the Measures for the Ethical Review of Life Science and Medical Research Involving Human Subjects (China, February 18, 2023), this study constitutes a secondary analysis based on the GBD database and is therefore exempt from ethics review/IRB approval.

Consent for Publication

All authors reviewed the final manuscript and provided their approval for submission.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. United Nations Population Division. World population prospects 2024. 2026 [Available from: https://population.un.org/wpp/. Accessed March 04, 2026.
2. World Health Organization. Ageing and health 2026 Available from: https://www.who.int/news-room/factsheets/detail/ageing-and-health. Accessed March 04, 2026.
3. Guan S-Y, Zheng J-X, Feng X-Y, et al. The impact of population ageing on musculoskeletal disorders in 204 countries and territories, 1990-2021: global burden and healthcare costs. *Ann Rheumatic Dis*. 2025;84(12):2128–2138. doi:10.1016/j.ard.2025.08.002
4. Kuzu Ş, Canli M, Valamur İ, et al. Effects of aerobic exercise in addition to core stabilization exercises on functional capacity, physical performance and fall risk in geriatric individuals with chronic non-specific low back pain. *BMC Sport Sci Med Rehabilit*. 2025;17(1):218. doi:10.1186/s13102-025-01271-7
5. Modigliani F, Cao SL. The Chinese saving puzzle and the life-cycle hypothesis. *J Econ Lit*. 2004;42(1):145–170. doi:10.1257/002205104773558074
6. Li J, Chen X, Han X, et al. Spatiotemporal matching between medical resources and population ageing in China from 2008 to 2017. *BMC public Health*. 2020;20(1):845. doi:10.1186/s12889-020-08976-z
7. Lopreite M, Mauro M. The effects of population ageing on health care expenditure: a Bayesian VAR analysis using data from Italy. *Health Policy*. 2017;121(6):663–674. doi:10.1016/j.healthpol.2017.03.015
8. Wu A, March L, Zheng X, et al. Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. *Ann Translat Med*. 2020;8(6):299. doi:10.21037/atm.2020.02.175
9. Yang X, Li R, Shu J, et al. Current status, trends, and forecast analysis of LBP disease burden attributable to occupational ergonomic factors in China. *J Pain Res*. 2025;18:5493–5506. doi:10.2147/JPR.S536096
10. Ferreira ML, de Luca K, Haile LM. Global, regional, and national burden of low back pain, 1990-2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. *Lancet Rheumatol*. 2023;5(6):e316–e29. doi:10.1016/S2665-9913(23)00098-X
11. Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. *Lancet*. 2018;391(10137):2356–2367. doi:10.1016/S0140-6736(18)30480-X

12. Yang N, Di J, Wang W, et al. 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. *BMC public Health*. 2025;25(1):1886. doi:10.1186/s12889-025-23178-1
13. Wu M, Wu P, Lu H, et al. Global burden of occupational ergonomic factor-induced low back pain, 1990~2021: data analysis and projections of the global burden of disease. *Front Public Health*. 2025;13:1573828. doi:10.3389/fpubh.2025.1573828
14. Reitsma MB, Fullman N, Ng M. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990-2015: a systematic analysis from the Global Burden of Disease Study 2015. *Lancet*. 2017;389(10082):1885–1906. doi:10.1016/S0140-6736(17)30819-X
15. Huang H, Hu C, Zhang R, et al. Global burden of pulmonary arterial hypertension and associated heart failure: global burden of disease 2021 analysis. *JACC Heart Fail*. 2025;13(10):102385. doi:10.1016/j.jchf.2024.12.005
16. Liu W, Xu Q, Wang X, et al. Global trends and cross-country inequalities in spinal cord injury attributable to falls: a systematic analysis of the Global Burden of Disease Study 2021. *Spine J*. 2025;25(10):2280–2290. doi:10.1016/j.spinee.2025.04.008
17. Zhang YK, Wang JX, Ge YZ, et al. Low back pain among the working-age population: from the global burden of disease study 2021. *BMC Musculoskeletal Disord*. 2025;26(1):441. doi:10.1186/s12891-025-08704-x
18. Kämpfen F, Wijemunige N, Evangelista B Jr. Aging, non-communicable diseases, and old-age disability in low- and middle-income countries: a challenge for global health. *Int J Public Health*. 2018;63(9):1011–1012. doi:10.1007/s00038-018-1137-z
19. Lozano R, Fullman N, Mumford JE, et al. Measuring universal health coverage based on an index of effective coverage of health services in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396(10258):1250–1284. doi:10.1016/S0140-6736(20)30750-9
20. Li K, Wu J, Zhang R, et al. Global, regional, and national burdens of pertussis among adults: a systematic analysis of age-specific trends using Global Burden of Diseases 2021 data. *Infect Diseases Poverty*. 2025;14(1):85. doi:10.1186/s40249-025-01355-z
21. Zong X, Hu H, Li H, et al. Global, regional, and national burden of DALYs attributable to occupational risks, 1990–2021: trends and projections to 2030. *Soc sci med*. 2026;389:118810. doi:10.1016/j.socscimed.2025.118810
22. Birk HO, Vrangbæk K, Rudkjøbing A, et al. Denmark. *Health System Review Health Systems in Transition*. 2024;26(1):1–186.
23. Tan J, Zhu Z, Wang X, et al. Global burden and trends of musculoskeletal disorders in postmenopausal elderly women: a 1990–2021 analysis with projections to 2045. *Arthritis Res Therapy*. 2025;27(1):127. doi:10.1186/s13075-025-03587-8
24. Xu J, Li J, Huang H, et al. High-BMI-related low back pain in China: a GBD-based observational study on sex–age trends and projections (1990–2021). *Eur J Med Res*. 2025;30(1):496. doi:10.1186/s40001-025-02765-3
25. Xu S, Shang J, Yang S, et al. Global, regional, and national burden of cardiovascular diseases among postmenopausal women, 1990–2040: a systematic analysis for the global burden of disease study 2021. *J Adv Res*. 2025. doi:10.1016/j.jare.2025.09.039
26. Guan S-Y, Zheng J-X, Sam NB, et al. Global burden and risk factors of musculoskeletal disorders among adolescents and young adults in 204 countries and territories, 1990–2019. *Autoimmunity Rev*. 2023;22(8):103361. doi:10.1016/j.autrev.2023.103361
27. Liang B, Wei Y, Pei H, et al. Burden of musculoskeletal disorders - global and BRICS+ nations, 1990-2021. *China CDC Weekly*. 2025;7(15):514–522. doi:10.46234/ccdcw2025.081
28. Yang X, Li R, Liu J, et al. Unequal disease burdens: exploring the intersection of gender, health and disease dynamics in China. *BMC public Health*. 2025;25(1):2182. doi:10.1186/s12889-025-23354-3
29. Li Y, Yin N, Li C, et al. Global burden of cardiovascular disease in women, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Medicine*. 2025;104(27):e43215. doi:10.1097/MD.0000000000043215
30. Wu A-M, Cross M, Elliott JM. Global, regional, and national burden of neck pain, 1990-2020, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. *Lancet Rheumatol*. 2024;6(3):e142–e55. doi:10.1016/S2665-9913(23)00321-1
31. Zheng X, Luo Y, Su B, et al. Developmental gerontology and active population aging in China. *China CDC Weekly*. 2023;5(8):184–187. doi:10.46234/ccdcw2023.033