ORIGINAL ARTICLE

Burden of low back pain attributable to modifiable risk factors in Gulf Cooperation Council countries, 1990-2023: a Global Burden of Disease analysis

Hussam A. Alzahrani[1]*, Elaf S. Althobaiti[2], Renad A. Altuwaiher[3], Manal I. Alrefaee[4], Abdulelah M. Alsakti[5], Faisal S. Alhafi[6], Duaa A. Qulasrar[7], Maram A. Almarhabi[8], Naif A. Alzahrani[9]

ABSTRACT

Background: To assess low back pain (LBP) attributable to high body mass index (BMI), occupational ergonomic factors, and smoking in Gulf Cooperation Council (GCC) countries from 1990 to 2023, with exploratory forecasting to 2050.

Methodology: GBD Study 2023 sex- and age-specific data were analyzed for six GCC countries during 1990-2023. Absolute disability-adjusted life years (DALYs) were summed from unrounded estimates, and male and female age-standardized DALY rates were summarized using an equally sex-weighted mean to compare rates without favoring the larger sex population. Trends were assessed using estimated annual percentage change, with exploratory ARIMA and ETS forecasting.

Results: DALYs attributable to selected LBP risk factors increased by 447.4%, from 46,635 in 1990 to 255,288 in 2023. High BMI showed the largest increase, from 16,157 to 111,138 DALYs (+587.7%), followed by occupational ergonomic factors, from 18,824 to 89,123 (+373.5%), and smoking, from 11,655 to 55,028 (+372.2%). Age-standardized rates for high BMI and occupational ergonomic factors increased in all GCC countries, while smoking-attributable rates declined in most countries except Saudi Arabia. Females had a higher BMI-related burden, whereas males had a higher smoking-related burden.

Conclusion: LBP burden attributable to high BMI and occupational ergonomic risk factors increased across the GCC, whereas smoking-related trends differed by country. These findings support obesity prevention, occupational risk reduction, tobacco control, and improved LBP management.

Keywords: Low back pain, Gulf Cooperation Council, disability-adjusted life years, body mass index, occupational health, obesity.

Introduction

Low back pain (LBP) is among the most common musculoskeletal conditions and a leading cause of disability worldwide [1]. It is defined as pain localized to the region between the lower margin of the twelfth rib and the inferior gluteal folds, with or without lower-limb pain. Clinically, LBP may present as an acute condition that resolves spontaneously or as chronic pain influenced by biological, psychological, and social factors.

Globally, LBP remains a major public health concern. It is consistently ranked among the leading causes of years lived with disability (YLDs) and contributes substantially to disability-adjusted life years (DALYs) [2]. Although age-standardized prevalence estimates have declined in some settings, the absolute number of people affected by LBP has increased because of population growth and aging [3]. The burden is particularly relevant among

Correspondence to: Hussam A. Alzahrani
*College of Medicine, Taif University, Taif, Saudi Arabia.
Email: Ahsam0358@gmail.com
Full list of author information is available at the end of the article.
Received: 28 August 2026 | **Accepted:** 16 October 2026

OPEN ACCESS
This is an open access article distributed in accordance with the Creative Commons Attribution (CC BY 4.0) license: https://creativecommons.org/licenses/by/4.0/) which permits any use, Share — copy and redistribute the material in any medium or format, Adapt — remix, transform, and build upon the material for any purpose, as long as the authors and the original source are properly cited. © The Author(s) 2026.
AMEM

older adults and women and is associated with modifiable risk factors, including high body mass index (BMI), occupational ergonomic factors, and smoking.

In Gulf Cooperation Council (GCC) countries, LBP is an increasingly important public health concern due to rapid urbanization, sedentary lifestyles, high obesity rates, and changing occupational patterns. Manual work, labor migration, and physically demanding jobs may increase exposure to occupational ergonomic hazards, contributing to the regional burden of LBP [4]. However, regional evidence on the LBP burden attributable to modifiable risk factors remains limited relative to global estimates.

This study aimed to assess the burden of LBP attributable to high BMI, occupational ergonomic factors, and smoking in GCC countries from 1990 to 2023, examine temporal, demographic, and risk-factor patterns across the region, and explore possible future trajectories using ARIMA and ETS forecasting models.

Methods

Data source

Data were obtained from the Global Burden of Disease (GBD) Study 2023 through a GBD Results Tool export (https://vizhub.healthdata.org/gbd-results/). Data were selected for LBP, DALYs, high BMI, occupational ergonomic factors, and smoking in Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates over 1990-2023. The workbook contains male and female estimates for five-year age groups, together with age-standardized rates, and includes measures expressed as numbers or rates with reported uncertainty bounds. The original data-extraction date is not recorded in the supplied workbook.

Case definition

LBP was defined according to the GBD case definition as pain localized to the lumbar region, between the lower margin of the twelfth rib and the inferior gluteal fold, lasting at least one day, with or without lower-limb pain. DALYs represent the sum of years of life lost and years lived with disability, providing a summary measure of health loss attributable to a disease or risk factor.

Data processing

Data were processed using R version 4.5.3. For each location, year, and risk factor, unrounded male and female age-specific DALY counts were summed to derive combined-sex absolute DALYs and rounded only for presentation. Age-standardized rates were retained separately for males and females. For summary country comparisons, an equally sex-weighted age-standardized rate index was constructed as (male age-standardized rate + female age-standardized rate)/2. This prespecified descriptive average gives males and females equal influence regardless of their population sizes, supporting sex-balanced comparisons across countries with different population sex structures. It is labeled "sex-mean" throughout and is distinct from a directly estimated GBD both-sex rate. Uncertainty limits were not averaged across sexes, because this would not yield a valid confidence or uncertainty interval for the index. Source values were screened for missingness, duplication, and implausible lower uncertainty bounds.

Statistical analysis

Burden was summarized for 1990 and 2023 by country and risk factor using total attributable DALYs, the equally sex-weighted age-standardized rate index (sex-mean), and relative percentage changes. Sex-specific age-standardized rates were also evaluated independently, including their temporal trends. For descriptive cross-country age-specific summaries, GCC averages were calculated as unweighted arithmetic means across the six countries; these summaries characterize a typical country rather than the pooled GCC population. Neither country means nor the sex-mean index is described as a population-weighted regional rate.

Temporal trends in age-standardized DALY rates were quantified using the estimated annual percentage change (EAPC). The EAPC was calculated by fitting a log-linear regression model: $\ln(\text{rate}) = \alpha + \beta \times \text{year}$. The EAPC was then derived as $100 \times (\exp(\beta) - 1)$, with 95% confidence intervals calculated from the standard error of β. Trends were classified as increasing when both the EAPC estimate and its lower 95% confidence interval were above zero, decreasing when both the estimate and upper 95% confidence interval were below zero, and stable otherwise. Analyses were performed separately for males, females, and the sex-averaged series.

Age-period-cohort (APC) analysis

An age-period-cohort (APC) model was applied to occupational ergonomic factor-attributable DALY rates to characterize patterns associated with age, calendar period, and birth cohort. Rate ratios relative to the overall grand mean were estimated for each dimension. The age effect describes variation in DALY rates across age groups, the period effect describes variation across calendar periods, and the cohort effect describes variation across birth cohorts. Smoothed trend curves were overlaid within each dimension to facilitate visual interpretation. Given the inherent identification constraints of APC models and the ecological nature of GBD estimates, the resulting age, period, and cohort patterns were interpreted descriptively rather than as independent causal effects.

Exploratory forecasting analysis

Exploratory forecasts of age-standardized DALY rates were generated to describe possible future trajectories through 2050. Annual age-standardized DALY rate series from 1990 to 2023 were modeled separately by country, sex, and risk factor. Autoregressive integrated moving average (ARIMA) models were fitted using the auto.arima() function in the R forecast package. Exponential smoothing state space (ETS) models were also fitted using the ets function as a complementary approach. Forecasts were reported as point estimates with prediction intervals for selected years. Because GBD estimates are modeled

population-level data, these forecasts were considered exploratory and interpreted cautiously.

Results

Overall LBP-attributable burden in GCC countries, 1990-2023

Between 1990 and 2023, the total number of DALYs attributable to the three selected LBP risk factors increased from 46,635 to 255,288 across GCC countries, corresponding to a 447.4% increase (Table 1). High BMI accounted for the largest absolute increase, rising from 16,157 to 111,138 DALYs (+587.7%). Occupational ergonomic factors increased from 18,824 to 89,123 DALYs (+373.5%), while smoking-attributable DALYs increased from 11,655 to 55,028 (+372.2%). Saudi Arabia accounted for the largest absolute number of DALYs across all three risk factors, largely reflecting its population size. However, several smaller GCC countries showed large relative percentage increases because of lower baseline DALY counts in 1990. Therefore, percentage changes were interpreted together with absolute changes to avoid overemphasizing relative increases from small starting values. The totals reflect sums of unrounded exported values; summing individually rounded country counts produces 89,122 occupational ergonomic DALYs in 2023 and 11,654 smoking-attributable DALYs in 1990, each one less than its corresponding correctly rounded underlying total.

Geographic distribution of burden in 2023

High body-mass index

In 2023, the age-standardized DALY rate attributable to high BMI was highest in Kuwait (239.30 per 100,000; 95% UI: 43.04-448.42), followed by Qatar (234.67; 95% UI: 40.94-439.37), Saudi Arabia (208.56; 95% UI: 35.63-391.91), the UAE (184.14; 95% UI: 31.94-354.23), Bahrain (181.76; 95% UI: 31.03-349.08), and Oman (176.86 per 100,000; 95% UI: 29.65-345.78). Compared with 1990, age-standardized high BMI DALY rates increased in all six GCC countries, with the largest relative increase observed in Oman (+88.6%), followed by Saudi Arabia (+76.9%), the UAE (+69.4%), Qatar (+66.8%), Bahrain (+61.1%), and Kuwait (+57.4%) (Table 1; Figure 1).

In 2023, the sex-averaged age-standardized high BMI-attributable DALY rate was highest in Kuwait (239.30 per 100,000), followed by Qatar (234.67), Saudi Arabia (208.56), the United Arab Emirates (184.14), Bahrain (181.76), and Oman (176.86). These sex-averaged rates increased in all six countries between 1990 and 2023, with the largest relative increase in Oman (+88.6%) and the smallest in Kuwait (+57.4%) (Table 1; Figure 1). No joint-sex uncertainty interval was calculated from the sex-specific source bounds.

Occupational ergonomic factors

In 2023, the equally sex-weighted age-standardized DALY index attributable to occupational ergonomic

Table 1. *Attributable DALY burden in GCC countries, 1990 and 2023.*

Country	Risk factor	DALY rate 1990	DALY rate 2023	Rate % change	Total DALYs 1990	Total DALYs 2023	DALYs % change
Bahrain	High BMI	112.87	181.76	61.0	397	2,842	615.4
Bahrain	Occ. ergonomic factors	98.65	123.20	24.9	537	2,553	375.7
Bahrain	Smoking	107.06	88.67	-17.2	424	1,912	351.0
Kuwait	High BMI	152.07	239.30	57.4	1,779	11,560	549.9
Kuwait	Occ. ergonomic factors	113.25	137.15	21.1	1,972	8,322	322.0
Kuwait	Smoking	114.41	94.27	-17.6	1,683	6,409	280.9
Oman	High BMI	93.76	176.86	88.6	1,041	7,774	646.8
Oman	Occ. ergonomic factors	74.11	106.44	43.6	1,399	7,128	409.6
Oman	Smoking	88.52	58.47	-33.9	1,348	3,764	179.3
Qatar	High BMI	140.66	234.67	66.8	461	7,315	1,488.0
Qatar	Occ. ergonomic factors	129.46	160.16	23.7	654	6,613	911.0
Qatar	Smoking	77.55	71.71	-7.5	416	3,775	806.3
Saudi Arabia	High BMI	117.91	208.56	76.9	10,990	60,095	446.8
Saudi Arabia	Occ. ergonomic factors	89.75	98.70	10.0	11,979	42,812	257.4
Saudi Arabia	Smoking	52.98	67.98	28.3	6,275	29,465	369.5
United Arab Emirates	High BMI	108.72	184.14	69.4	1,489	21,552	1,347.9
United Arab Emirates	Occ. ergonomic factors	107.16	136.09	27.0	2,283	21,694	850.3
United Arab Emirates	Smoking	70.84	45.61	-35.6	1,508	9,703	543.3

Note: DALY counts are calculated by summing underlying unrounded male and female, age-specific values and then rounding final totals; sums of individually rounded country counts can differ by one DALY. Rate = arithmetic mean of male and female age-standardized DALY rates per 100,000 (sex-averaged descriptive rate, not an official GBD both-sex estimate). Rate percentage change compares 1990 and 2023 sex-averaged rates.

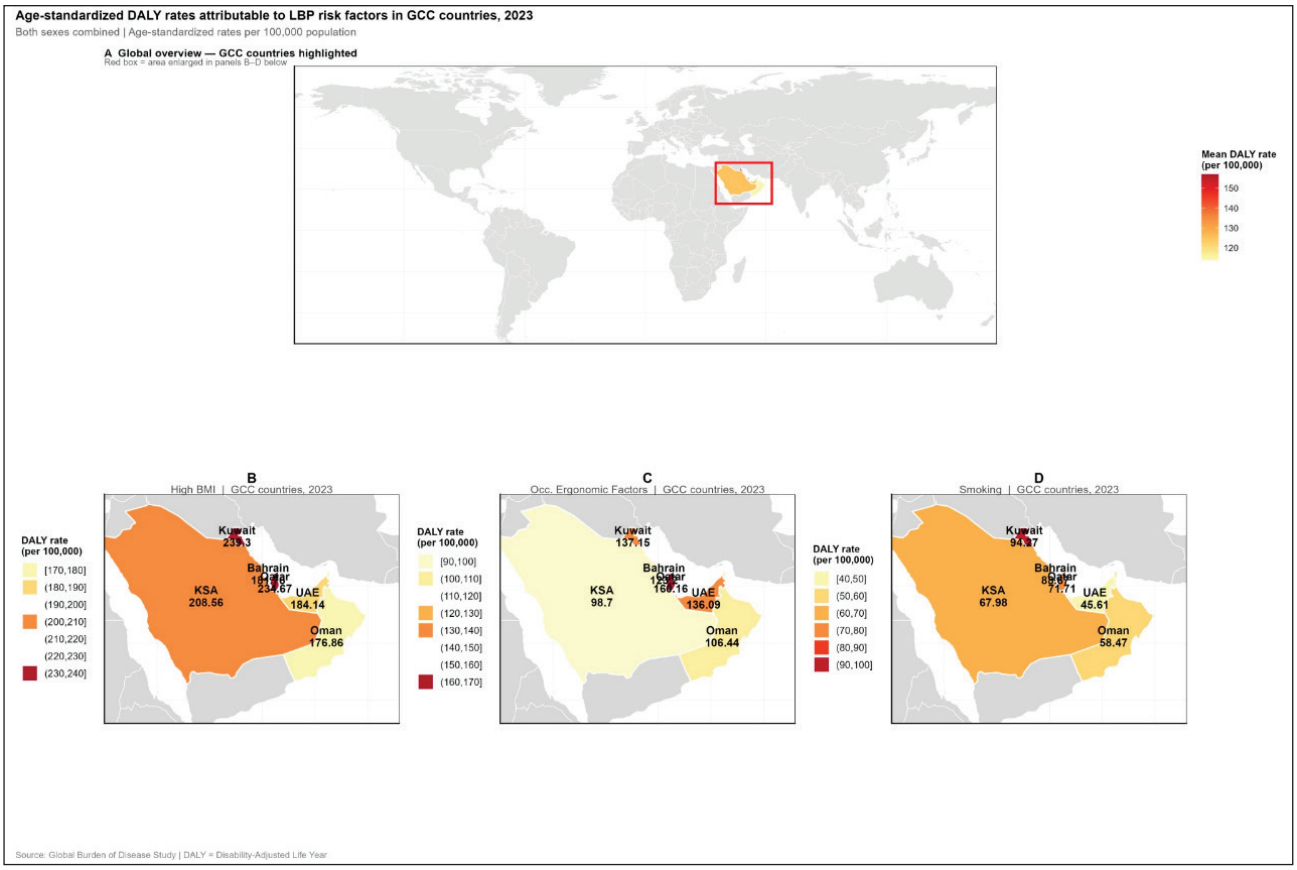


Figure 1. *Age-standardized DALY rates attributable to LBP risk factors in GCC countries, 2023. Panel A: World map highlighting GCC countries (mean DALY rate across all three risk factors). Panels B-D: Choropleth maps of the GCC region, one per risk factor. Both sexes combined; rates per 100,000 population.*

factors was highest in Qatar (160.16 per 100,000), followed by Kuwait (137.15), the United Arab Emirates (136.09), Bahrain (123.20), Oman (106.44), and Saudi Arabia (98.70). These rates increased in all six countries relative to 1990 (Table 1; Figure 1). Some lower uncertainty bounds for occupational ergonomic estimates were negative in the supplied export. As uncertainty bounds for the sex-mean index cannot be obtained by averaging male and female bounds, no joint-sex 95% uncertainty intervals are reported; the invalid negative values are not reproduced as valid DALY-rate bounds.

Smoking

In 2023, sex-averaged age-standardized smoking-attributable DALY rates were highest in Kuwait (94.27 per 100,000), followed by Bahrain (88.67), Qatar (71.71), Saudi Arabia (67.98), Oman (58.47), and the United Arab Emirates (45.61). Between 1990 and 2023, the rates declined in five GCC countries and increased only in Saudi Arabia, from 52.98 to 67.98 per 100,000 (+28.3%) (Table 1; Figure 1). Uncertainty intervals averaged across sexes were omitted because they do not represent jointly estimated bounds.

Temporal trends, 1990-2023

Age-standardized DALY rates showed distinct temporal patterns by risk factor (Figure 2). High BMI-attributable age-standardized DALY rates increased consistently across all GCC countries during the study period. Occupational ergonomic factor-attributable rates also increased across the region, although the magnitude varied by country. In contrast, smoking-attributable rates declined in most GCC countries, except in Saudi Arabia, where the rate increased over time.

Sex-specific patterns were also evident. Females had higher BMI-attributable age-standardized DALY rates than males in 2023, whereas males had substantially higher smoking-attributable age-standardized DALY rates. In 2023, the mean GCC high BMI-attributable rate was 261.2 per 100,000 among females compared with 148.3 per 100,000 among males. Conversely, the mean smoking-attributable rate was 117.4 per 100,000 among males compared with 24.9 per 100,000 among females.

Estimated Annual Percentage Change

Estimated annual percentage changes (EAPCs) in the sex-averaged age-standardized rate series are presented by country and risk factor in Table 2. Sex-specific EAPCs and 95% regression confidence intervals are presented separately in Supplementary Table S3 (Figure 3). Confidence intervals for EAPCs quantify uncertainty in the fitted temporal regression, not the uncertainty of the GBD attributable DALY estimates.

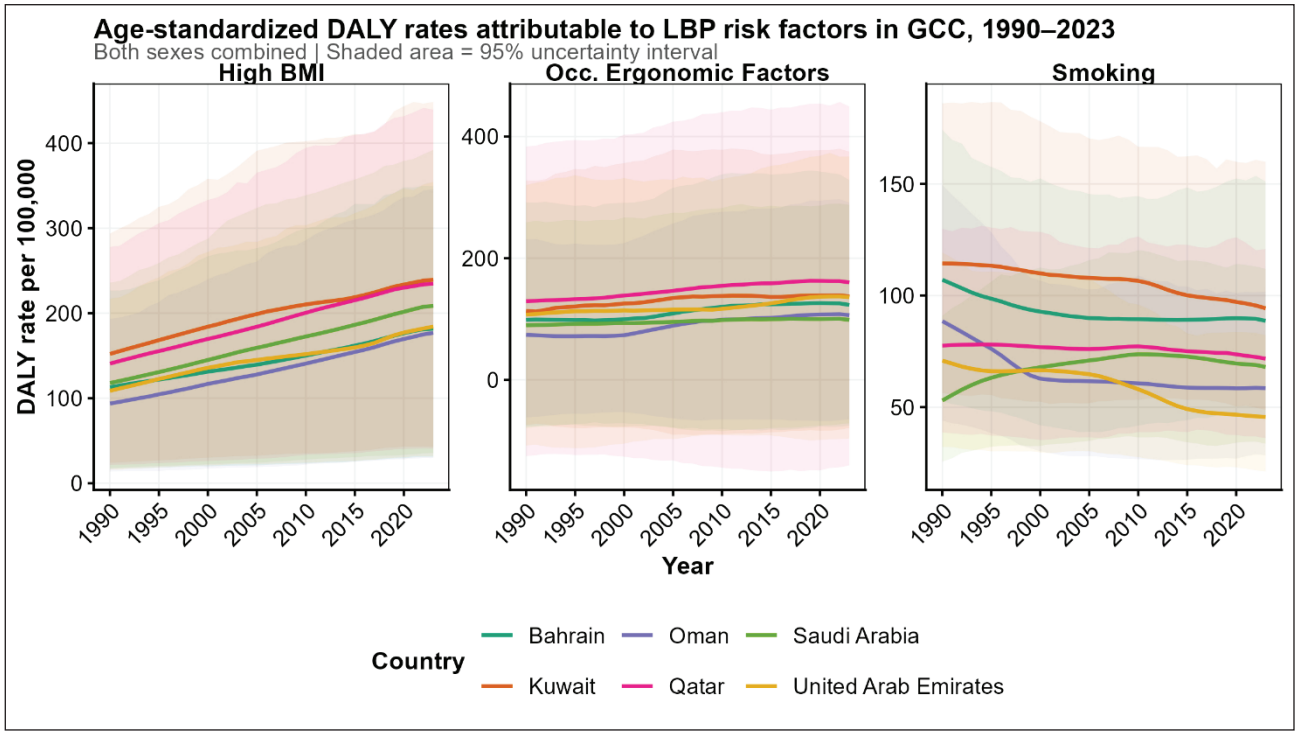


Figure 2. *Temporal trends of age-standardized DALY rates by GCC country, 1990-2023. One line per country; shaded area = 95% uncertainty interval. Panels by risk factor.*

Table 2. *Estimated annual percentage change (EAPC) in sex-averaged age-standardized DALY rates, 1990-2023.*

Country	Risk factor	Sex	EAPC	95% CI	Trend
Bahrain	High BMI	Sex-mean	1.460	(1.44 to 1.48)	Increasing
Bahrain	Occ. ergonomic factors	Sex-mean	1.002	(0.89 to 1.11)	Increasing
Bahrain	Smoking	Sex-mean	-0.451	(-0.55 to -0.35)	Decreasing
Kuwait	High BMI	Sex-mean	1.335	(1.27 to 1.40)	Increasing
Kuwait	Occ. ergonomic factors	Sex-mean	0.629	(0.53 to 0.72)	Increasing
Kuwait	Smoking	Sex-mean	-0.582	(-0.62 to -0.54)	Decreasing
Oman	High BMI	Sex-mean	1.952	(1.92 to 1.98)	Increasing
Oman	Occ. ergonomic factors	Sex-mean	1.570	(1.41 to 1.73)	Increasing
Oman	Smoking	Sex-mean	-1.082	(-1.30 to -0.86)	Decreasing
Qatar	High BMI	Sex-mean	1.600	(1.56 to 1.64)	Increasing
Qatar	Occ. ergonomic factors	Sex-mean	0.811	(0.76 to 0.87)	Increasing
Qatar	Smoking	Sex-mean	-0.199	(-0.23 to -0.16)	Decreasing
Saudi Arabia	High BMI	Sex-mean	1.755	(1.71 to 1.80)	Increasing
Saudi Arabia	Occ. ergonomic factors	Sex-mean	0.373	(0.34 to 0.41)	Increasing
Saudi Arabia	Smoking	Sex-mean	0.608	(0.41 to 0.81)	Increasing
United Arab Emirates	High BMI	Sex-mean	1.458	(1.38 to 1.53)	Increasing
United Arab Emirates	Occ. ergonomic factors	Sex-mean	0.714	(0.62 to 0.81)	Increasing
United Arab Emirates	Smoking	Sex-mean	-1.447	(-1.61 to -1.28)	Decreasing

Note: The "Sex-mean" series is the yearly arithmetic mean of male and female age-standardized DALY rates and is not the GBD both-sex rate. EAPC = 100 × (exp(β) − 1), where β is the slope from log(rate) regressed on calendar year. CI = regression-based confidence interval, not the GBD uncertainty interval. Full male and female trends are shown in Supplementary Table S3.

High BMI

High BMI-attributable DALY rates increased significantly in all six GCC countries for the sex-averaged series. Oman recorded the highest EAPC (1.952%; 95% CI: 1.924-1.979), followed by Saudi Arabia (1.755%; 95% CI: 1.711-1.799), Qatar (1.600%; 95% CI: 1.557-1.644), Bahrain (1.460%; 95% CI: 1.441-1.478), the UAE (1.458%; 95% CI: 1.384-1.532), and Kuwait (1.335%; 95% CI: 1.267-1.404). Sex-stratified analyses revealed that males showed higher EAPCs than females in most GCC countries, most notably in Oman (males: 2.406%, 95% CI: 2.329-2.483 *vs.* females: 1.733%, 95% CI:

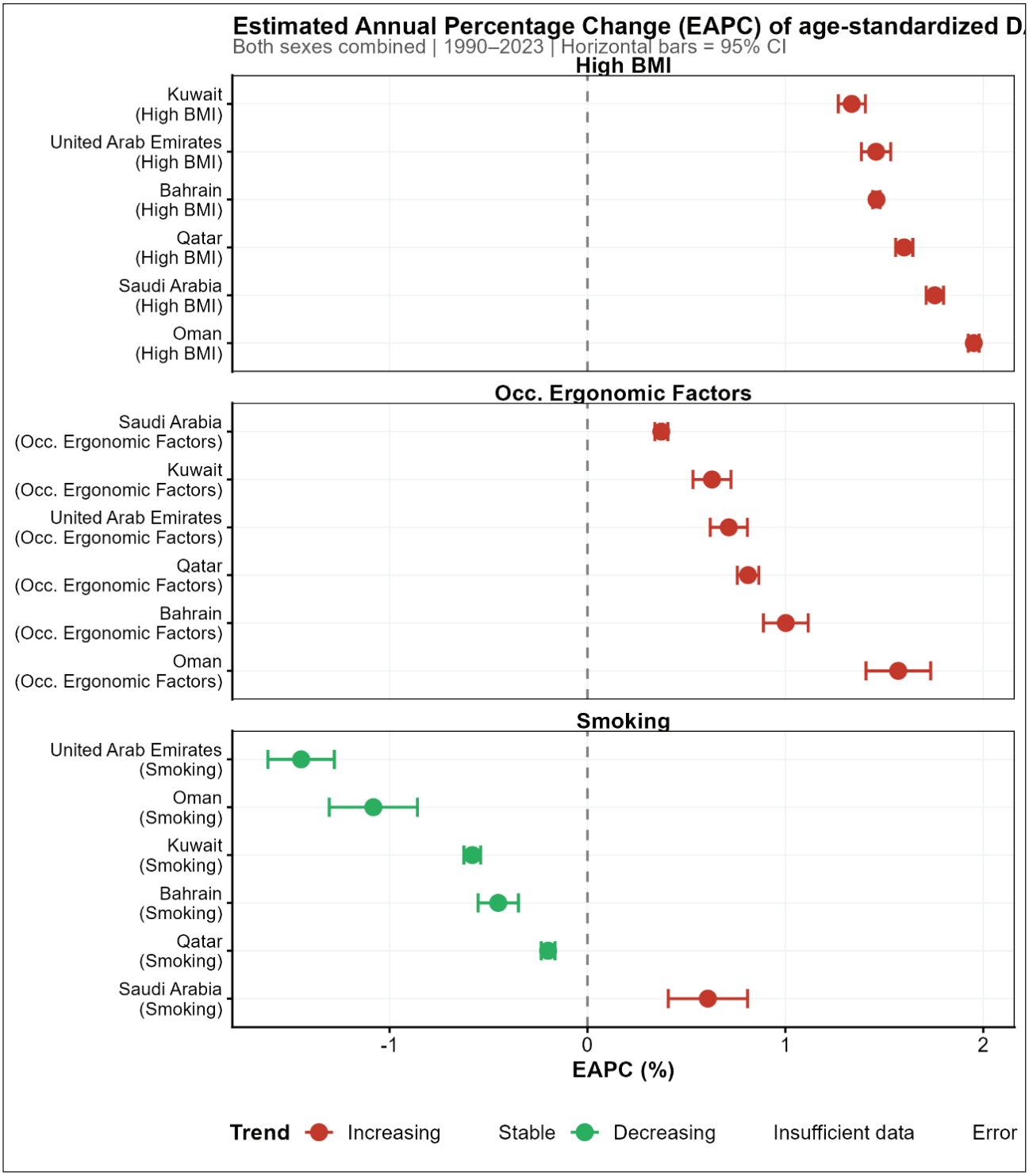


Figure 3. *Estimated annual percentage change (EAPC) of age-standardized DALY rates, 1990-2023. Forest plot with 95% confidence intervals, stratified by risk factor and sex.*

1.723-1.744) and Saudi Arabia (males: 2.069%, 95% CI: 2.003-2.136 *vs.* females: 1.587%, 95% CI: 1.554-1.621).

Occupational ergonomic factors

All GCC countries demonstrated significantly increasing EAPC trends for occupational ergonomic factor-attributable DALY rates among the sex-averaged series. Oman showed the highest EAPC (1.570%; 95% CI: 1.407-1.734), followed by Bahrain (1.002%; 95% CI: 0.889-1.115), Qatar (0.811%; 95% CI: 0.757-0.866), the UAE (0.714%; 95% CI: 0.620-0.808), Kuwait (0.629%; 95% CI: 0.533-0.725), and Saudi Arabia (0.373%; 95% CI: 0.340-0.406). A consistent sex-specific pattern was observed: female EAPC values exceeded male values in all six countries, most strikingly in Oman (females: 3.828%, 95% CI: 3.511-4.147 *vs.* males: 0.689%, 95% CI: 0.571-0.807) and Bahrain (females: 2.399%, 95% CI: 2.183-2.615 *vs.* males: 0.274%, 95% CI: 0.210-0.339).

Smoking

Smoking-attributable DALY rates showed a predominantly declining trend across the GCC region. The UAE recorded the largest annual decrease (EAPC: −1.447%; 95% CI: −1.615 to −1.279), followed by Oman (−1.082%; 95% CI: −1.305 to −0.859), Kuwait (−0.582%; 95% CI: −0.625 to −0.540), Bahrain (−0.451%; 95% CI: −0.553 to −0.349), and Qatar (−0.199%; 95% CI: −0.234 to −0.164). Saudi Arabia was the only GCC country with an increasing smoking-attributable trend for the sex-averaged series (EAPC: +0.608%; 95% CI: 0.408-0.809). Smoking-attributable rates declined more steeply among females than among males in most GCC countries.

Age and sex patterns of LBP burden in 2023

Figure 4 presents age-specific DALY rates in 2023, averaged across GCC countries and stratified by sex. High BMI-attributable DALY rates increased progressively with age, peaking at 70-74 years (mean GCC rate: 599.9 per 100,000) before declining slightly in the oldest age groups. Occupational ergonomic factor-attributable rates showed a working-age peak at 40-44 years (262.4 per 100,000). Smoking-attributable rates peaked at 70-74 years (185.5 per 100,000), consistent with the long latency between sustained smoking exposure and musculoskeletal burden.

Marked sex differences were evident across all three risk factors. For high BMI, females had substantially higher age-standardized DALY rates across the GCC than males (mean: 261.2 *vs.* 148.3 per 100,000). For smoking, males had markedly higher age-standardized DALY rates than females (mean: 117.4 *vs.* 24.9 per 100,000). Occupational ergonomic factor-attributable rates were broadly comparable between the sexes (males: 148.3 per 100,000; females: 106.3 per 100,000), although consistently higher EAPCs among females suggested a narrowing of this gap over time (Supplementary Table S3).

Age-period-cohort analysis

The APC model for occupational ergonomic factor-attributable DALY rates across the GCC region suggested variation by age, period, and birth cohort (Figure S2). The age effect increased from younger to middle working-age groups, peaking at approximately 40-54 years. The

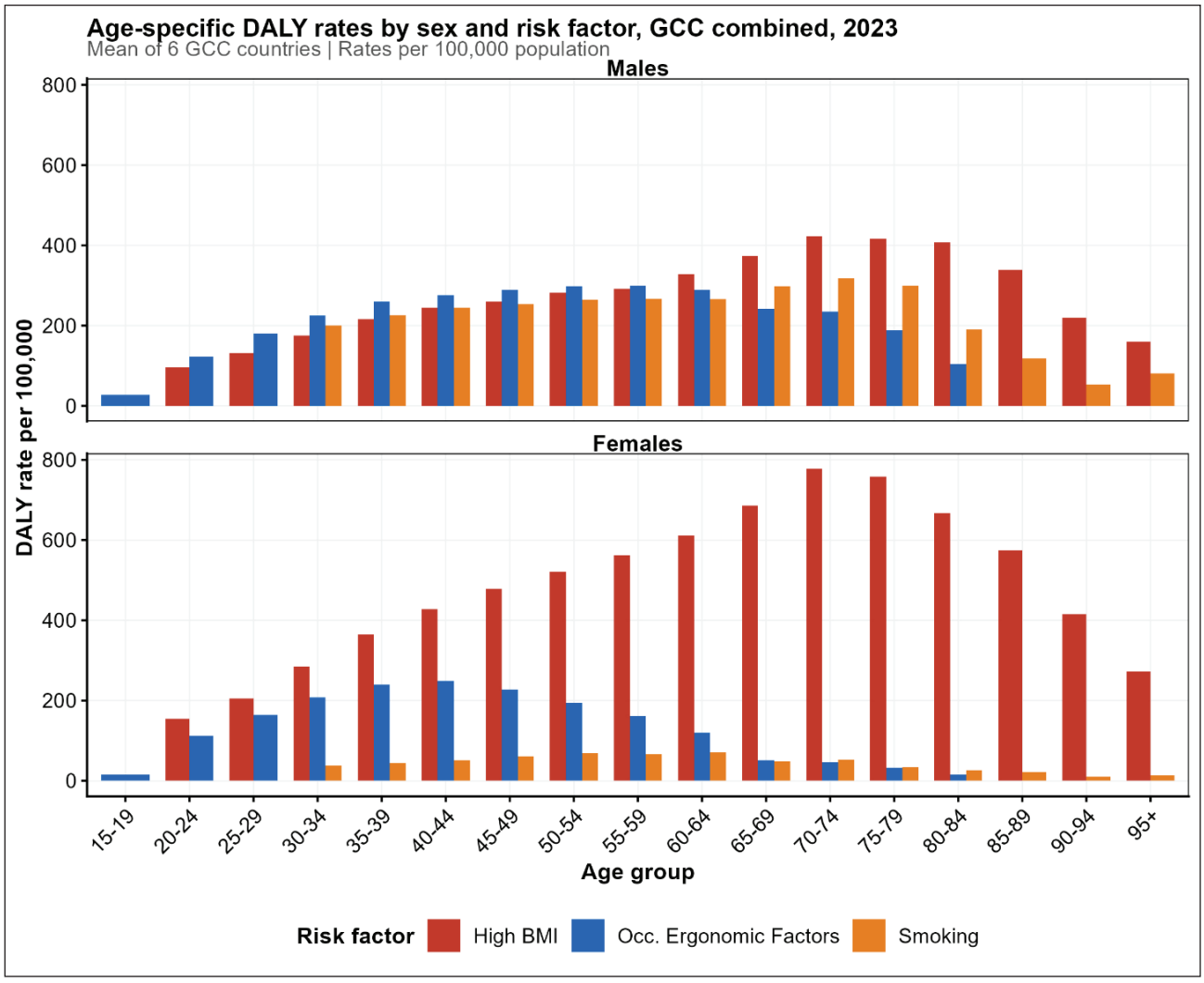


Figure 4. *Age-specific DALY rates by sex and risk factor, GCC combined, 2023. Values represent the mean across 6 GCC countries. Rates per 100,000 population.*

period effect showed an upward pattern over calendar time. The cohort effect appeared lower among more recent birth cohorts. However, these findings should be interpreted cautiously, as APC analysis of GBD-modeled ecological data cannot confirm individual-level exposure histories or causal relationships.

Exploratory forecasting of age-standardized DALY rates to 2050

ARIMA forecasts

ARIMA forecasts suggested a high BMI-attributable age-standardized DALY rates may continue to increase across GCC countries through 2050 (Figures S3-S5; Supplementary Table S1). For occupational ergonomic factors, ARIMA forecasts suggested broadly stable or modestly declining age-standardized DALY rates through 2050. Prediction intervals were wider for occupational ergonomic factors than for other risk factors. For smoking, forecasts suggested a continued decline in most GCC countries, while Saudi Arabia appeared more likely to maintain comparatively higher smoking-attributable rates.

ETS forecasts

ETS forecasts were generally consistent with ARIMA models in the direction of the projected trends (Figure S6; Supplementary Table S2). High BMI-attributable DALY rates showed a possible continued increase in most GCC countries, whereas smoking-attributable DALY rates generally showed stable or declining patterns. Overall, the exploratory forecasting analysis suggested that high BMI may remain an important contributor to future LBP burden in the GCC. These results should be interpreted as possible trajectories rather than definitive predictions, particularly where prediction intervals were wide.

Discussion

This analysis demonstrated a substantial increase in LBP burden attributable to modifiable risk factors across GCC countries between 1990 and 2023. Within the Global Burden of Disease (GBD) attribution framework, high BMI and occupational ergonomic factors were prominent contributors, while smoking-attributable burden declined in most GCC countries but showed a contrasting pattern in Saudi Arabia. Sex-specific differences were also evident, with a greater high BMI-attributable burden among females and a greater smoking-attributable burden among males.

Previous studies in GCC countries support the substantial burden of LBP, particularly in occupational settings. In Saudi Arabia, reported prevalence estimates range from 64% to 89%, with a high burden among healthcare professionals associated with workload and manual handling [5,6]. Similar patterns have been reported in Kuwait, where LBP prevalence varies by occupation and is particularly relevant among hospital workers exposed to physical strain [7,8]. Evidence from Qatar, although largely derived from healthcare and occupational populations, also indicates a considerable LBP burden [9,10]. These findings are broadly consistent with the importance of occupational ergonomic factors observed in the present analysis, although the wide uncertainty intervals for this risk factor warrant cautious interpretation.

The increase in smoking-attributable LBP burden in Saudi Arabia differed from the pattern observed in most other GCC countries. This may reflect differences in historical smoking trends, population aging, delayed effects of previous tobacco exposure, or changes in smoking behavior across population subgroups. However, because this study used modeled population-level estimates, these explanations should be regarded as hypotheses rather than causal conclusions and require confirmation using national surveillance and longitudinal data.

Age- and sex-specific patterns further demonstrated heterogeneity in attributable LBP burden. High BMI-attributable burden was greater among females, whereas smoking-attributable burden was greater among males, and occupational ergonomic burden was concentrated in working-age groups. The APC analysis also suggested variation in occupational ergonomic burden across age, period, and birth cohort. However, given the identification constraints of APC models and the ecological nature of GBD estimates, these patterns should be interpreted descriptively rather than as independent causal effects.

Exploratory forecasts suggest that current risk-factor patterns may remain relevant through 2050, particularly for high BMI. These projections represent plausible trajectories rather than definitive predictions and should be interpreted cautiously, especially where prediction intervals are wide and because future changes in population characteristics, policies, and risk-factor exposure are not fully captured by historical trends.

This study has several limitations. First, GBD estimates depend on available data and statistical modeling assumptions and are therefore subject to uncertainty and potential measurement error. Second, uncertainty intervals for occupational ergonomic factor-attributable burden were wide, limiting the precision of some comparisons. Third, the ecological design does not permit individual-level causal inference. Fourth, large percentage changes may partly reflect relatively small baseline DALY counts; therefore, absolute and relative changes should be considered together. Finally, potentially relevant factors, including physical activity, healthcare utilization, specific occupational settings, and psychosocial factors, were not directly evaluated, and long-term forecasts remain inherently uncertain.

Despite these limitations, the findings support a multifactorial approach to reducing LBP burden across the GCC. Obesity prevention, workplace ergonomic interventions, and continued tobacco-control efforts may address important modifiable contributors identified within the GBD framework. Strengthening prevention alongside appropriate clinical management may help mitigate the growing regional burden of LBP.

Conclusion

LBP is a substantial and growing public health problem in GCC countries, with high BMI and occupational ergonomic exposures identified as major contributors

within the GBD attribution framework. Although the smoking-attributable burden declined in most GCC countries, Saudi Arabia showed an increasing smoking-attributable burden. Exploratory forecasts suggest that high BMI-attributable burden may remain an important challenge in the coming decades, although these projections should be interpreted cautiously. The observed sex- and age-specific differences highlight the need for targeted prevention strategies, including obesity control, workplace ergonomic improvements, tobacco control, and strengthened clinical management of LBP.

List of Abbreviations

APC	Age-period-cohort
ARIMA	Autoregressive integrated moving average
BMI	Body mass index
CI	Confidence interval
DALY	Disability-adjusted life year
EAPC	Estimated annual percentage change
ETS	Exponential smoothing state space
GBD	Global Burden of Disease
GCC	Gulf Cooperation Council
LBP	Low back pain
UAE	United Arab Emirates
UI	Uncertainty interval
YLD	Years lived with disability

Conflict of interests

The authors declare no competing interests.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Consent to publish

Does not apply. There was no involvement of new human participants in this study.

Ethical Approval

Ethical approval was not required because this study used publicly available, anonymized, population-level data from the GBD Study. No individual-level identifiable data were used. This study was reported in accordance with the STROBE guidelines where applicable.

Availability of data and materials

The data used in this study are publicly available from the Global Burden of Disease Study through the Global Health Data Exchange. No individual-level identifiable data were used.

Author details

Hussam A. Alzahrani[1], Elaf S. Althobaiti[2], Renad A. Altuwaiher[3], Manal I. Alrefaee[4], Abdulelah M. Alsakti[5], Faisal S. Alhafi[6], Duaa A. Qulasrar[7], Maram A. Almarhabi[8], Naif A. Alzahrani[9]

1. College of Medicine, Taif University, Taif, Saudi Arabia
2. College of Applied Medical Sciences, Taif University, Taif, Saudi Arabia
3. College of Medicine and Surgery, University of Hail, Hail, Saudi Arabia
4. College of Nursing, King Khalid University, Abha, Saudi Arabia
5. College of Medicine, King Khalid University, Abha, Saudi Arabia
6. College of Medicine, King Saud University, Riyadh, Saudi Arabia
7. Batterjee Medical College, Jeddah, Makkah Region, Saudi Arabia
8. College of Medicine and Surgery, Umm Al-Qura University, Al-Qunfudhah, Saudi Arabia
9. Family Medicine Department, Diabetes and Endocrinology Center, Prince Mansour Military Hospital, Taif, Saudi Arabia

Supplementary content (if any) is available online.

References

1. Li Y, Zou C, Guo W, Han F, Fan T, Zang L, et al. Global burden of low back pain and its attributable risk factors from 1990 to 2021: a comprehensive analysis from the global burden of disease study 2021. Front Public Health. 2024;12:1480779. https://doi.org/10.3389/fpubh.2024.1480779
2. Ferreira ML, de Luca K, Haile LM, Steinmetz JD, Culbreth GT, Cross M, et al.; GBD 2021 Low back pain collaborators. 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):e316–29. https://doi.org/10.2139/ssrn.4318392
3. Yang N, Di J, Wang W, Feng H. 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. https://doi.org/10.1186/s12889-025-23178-1
4. Alzahrani H, Alshehri MA, Alotaibi M, Alhowimel A, Alodaibi F, Alamam D, et al. Burden of musculoskeletal disorders in the gulf cooperation council countries, 1990-2019: findings from the global burden of disease study 2019. Front Med (Lausanne). 2022;9:855414. https://doi.org/10.3389/fmed.2022.855414
5. Aldera MA, Alexander CM, McGregor AH. Prevalence and incidence of low back pain in the Kingdom of Saudi Arabia: a systematic review. J Epidemiol Glob Health. 2020 Dec;10(4):269–75. https://doi.org/10.2991/jegh.k.200417.001
6. Al Amer HS. Low back pain prevalence and risk factors among health workers in Saudi Arabia: a systematic review and meta-analysis. J Occup Health. 2020;62(1):e12155. https://doi.org/10.1002/1348-9585.12155
7. Landry MD, Raman SR, Sulway C, Golightly YM, Hamdan E. Prevalence and risk factors associated with low back pain among health care providers in a Kuwait hospital. Spine. 2008;33(5):539–45. https://doi.org/10.1097/BRS.0b013e3181657df7
8. Alrowayeh HN, Alnaser MZ, Alshatti TA, Saeed RS. Prevalence and risk factors of work-related lower back pain among radiographers in the State of Kuwait. Radiol Res Pract. 2021;2021:5365260. https://doi.org/10.1155/2021/5365260
9. Bener A, Dafeeah EE, Alnaqbi K. Prevalence and correlates of low back pain in primary care: what are the contributing factors in a rapidly developing country. Asian Spine J. 2014;8(3):227–36. https://doi.org/10.4184/asj.2014.8.3.227
10. Abuhashem NA, Altahan Y, Selim N. Prevalence and predictors of back pain among primary healthcare workers in Qatar in 2023. Qatar Med J. 2025;2025(4):100. https://doi.org/10.5339/qmj.2025.100