

ORIGINAL RESEARCH ARTICLE

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

Supplementary Files

Supplementart methods

S1. Aggregate calculations of source data

The Global Burden of Disease (GBD) Study 2021, derived from repeated cross-sectional data from the Global Health Data Exchange, covers the global burden of 371 diseases and injuries, including neck pain and low back pain, and 88 risk factors in 21 regions and 204 countries and territories from 1990 to 2021 (GBD 2021 Diseases and Injuries Collaborators, 2024; GBD 2021 Risk Factors Collaborators, 2024). All data were identified through systematic reviews of published studies, searches of government and international organization websites, published reports, primary data sources (e.g., demographic and health surveys), and datasets provided by GBD collaborators (GBD 2021 Diseases and Injuries Collaborators, 2024). Bayesian meta-regression using DisMod-MR 2.1 (Institute for Health Metrics and Evaluation, United States of America [USA]) was used to estimate incidence and prevalence by combining epidemiologic data (GBD 2021 Low Back Pain Collaborators, 2023; GBD 2021 Neck Pain Collaborators, 2024). Years lived with disability (YLDs) were calculated by multiplying cause-age-sex-location-year-specific prevalence of sequelae by their respective disability weights, for each disease and injury. The general methodology has been previously published (GBD 2021 Low Back Pain Collaborators, 2023; GBD 2021 Neck Pain Collaborators, 2024; Yang *et al.*, 2025).

S2. Estimated annual percentage change calculation

The estimated annual percentage change (EAPC) describes the trend in the age-standardized rate (ASR) over a given time interval. We assumed a natural logarithm of ASR and fit a linear regression model:

$$\gamma = \alpha + \beta x + \varepsilon \quad (S1)$$

where γ denotes $\ln(\text{ASR})$, x denotes the calendar year, and ε denotes the error term. The EAPC was calculated as:

$$\text{EAPC}_{\text{with 95\% CI}} = 100 \times (\exp(\beta) - 1) \quad (S2)$$

When the EAPC and lower 95% confidence interval (CI) limits are positive, the ASR tends to increase. Conversely, when the EAPC and CI upper limits were negative, ASR tends to decrease (Sun *et al.*, 2024).

S3. Joinpoint regression analysis

Regression analysis to assess trends in the burden of disease using the Desktop version Joinpoint 5.2.0 provided by the National Cancer Institute Surveillance Research Program (USA). The joinpoint regression model is a statistical method used in the analysis of time-series data that identifies and quantifies mutation points (joinpoints), thereby partitioning the data into trend segments (Kim *et al.*, 2000). The annual percent change (APC) for each period is calculated to quantify the stage trends. $p < 0.05$ was considered statistically significant.

S4. Decomposition analysis

Based on the decomposition analysis described by Xie *et al.* (2018), it is possible to visualize the contributions of three factors (aging, demographics, and epidemiology) to changes in incidence, prevalence, and YLDs from 1990 to 2021. Epidemiologic changes are potential age- and population-adjusted YLD rates.

Take the decomposition analysis of YLDs as an example. We first used the composition methodology of Das Gupta (1994) and Chevan and Sutherland (2009) to decompose YLDs into components due to population age structure, population growth, and epidemiologic changes. The number of YLDs at each location was obtained from the following equation:

$$\text{YLD}_{ay, py, ey} = \sum_{i=1}^{17} (a_{i, y} * p_y * e_{i, y}) \quad (S3)$$

where $\text{YLD}_{ay, py, ey}$ represents YLD based on the factors of age structure, population, and YLD rate for specific year

y ; $a_{i,y}$ represents the proportion of population for the age category i of the 17 age groups in given year y ; p_y represents the total population in given year y ; and $e_{i,y}$ represents YLD rate given age category i in year y .

The contribution of each factor to the change in YLDs from 1990 to 2021 was defined as the effect of one factor when the other factors were held constant. For example, the effect of age structure was calculated as:

$$\text{Effect of age structure} = \frac{\text{YLDs}_{a2021,p1990,e1990} + \text{YLDs}_{a2021,e2021,p2021} + \text{YLDs}_{a2021,p2021,e1990} + \text{YLDs}_{a1990,p2021,e2021} + \text{YLDs}_{a1990,p1990,e1990} + \text{YLDs}_{a2021,p1990,e2021}}{6} \quad (\text{S4})$$

S5. Sociodemographic index calculation

Associations between national development levels and neck and low back pain were investigated using the sociodemographic index (SDI). The SDI is a composite score ranging from 0 to 1 and is calculated from the covariates: total fertility under the age of 25 (TFU25), average educational level among those over the age of 15 (Educ), and lag-distributed income per person (LDI). The SDI is computed as follows:

$$SDI = \sqrt[3]{I_{TFU25} * I_{Educ} * I_{Ln(LDI)}} \quad (\text{S5})$$

$$\text{where } I_{covariate} = \max\left(\frac{C_{location,year} - C_{lower\ bound}}{C_{upper\ bound} - C_{lower\ bound}}, 0.005\right)$$

$$\text{and } I_{TFU25} = 1 - I_{covariate}$$

S6. Cross-country inequality

The slope index of inequality (SII, absolute inequality index) was calculated by regressing the rates of national YLDs on the relative position scale associated with SDI on the population of all ages. Relative position was determined by the midpoint of the cumulative range of populations sorted by SDI. The SII was calculated and tested using linear regression models and heteroscedasticity. Heteroscedasticity was weighted using repeated iterations of robust regression to obtain the slope and intercept of the SII. The relative concentration index (RCI, relative inequality index) was calculated by numerically integrating the area under the Lorenz concentration curve and fitting it with the cumulative fraction of YLDs and the cumulative relative distribution of populations sorted by SDI.

Supplementary figures

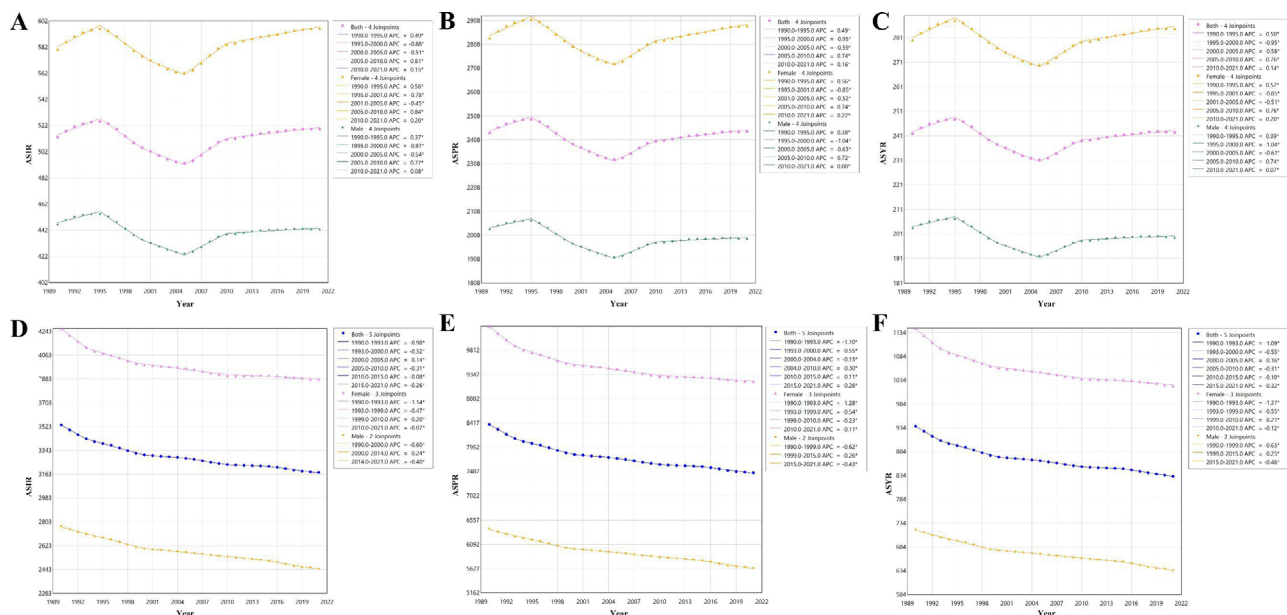


Figure S1. Global stage trends in ASIR, ASPR, and ASYR for (A–C) neck pain and (D–F) low back pain from 1990 to 2021

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

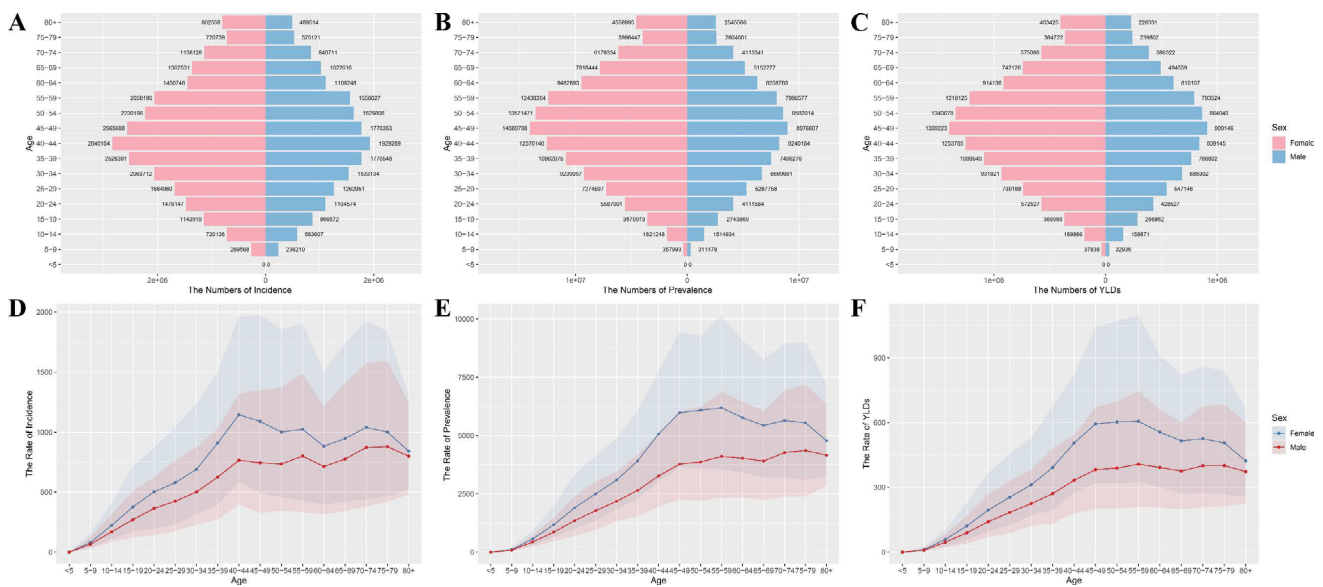


Figure S2. (A–C) Sex- and age-specific numbers and (D–F) rates of incidence, prevalence, and YLDs of neck pain
Abbreviation: YLDs: Years lived with disability.

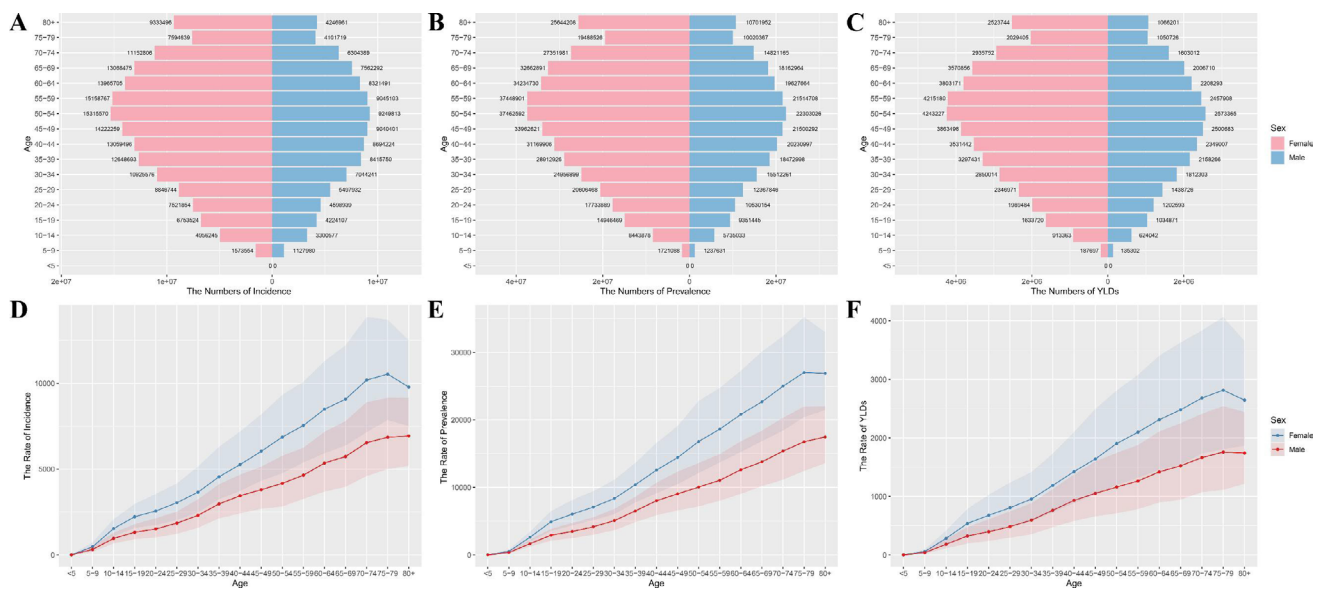


Figure S3. (A–C) Sex- and age-specific numbers and (D–F) rates of incidence, prevalence, and YLDs of low back pain.
Abbreviation: YLDs: Years lived with disability.

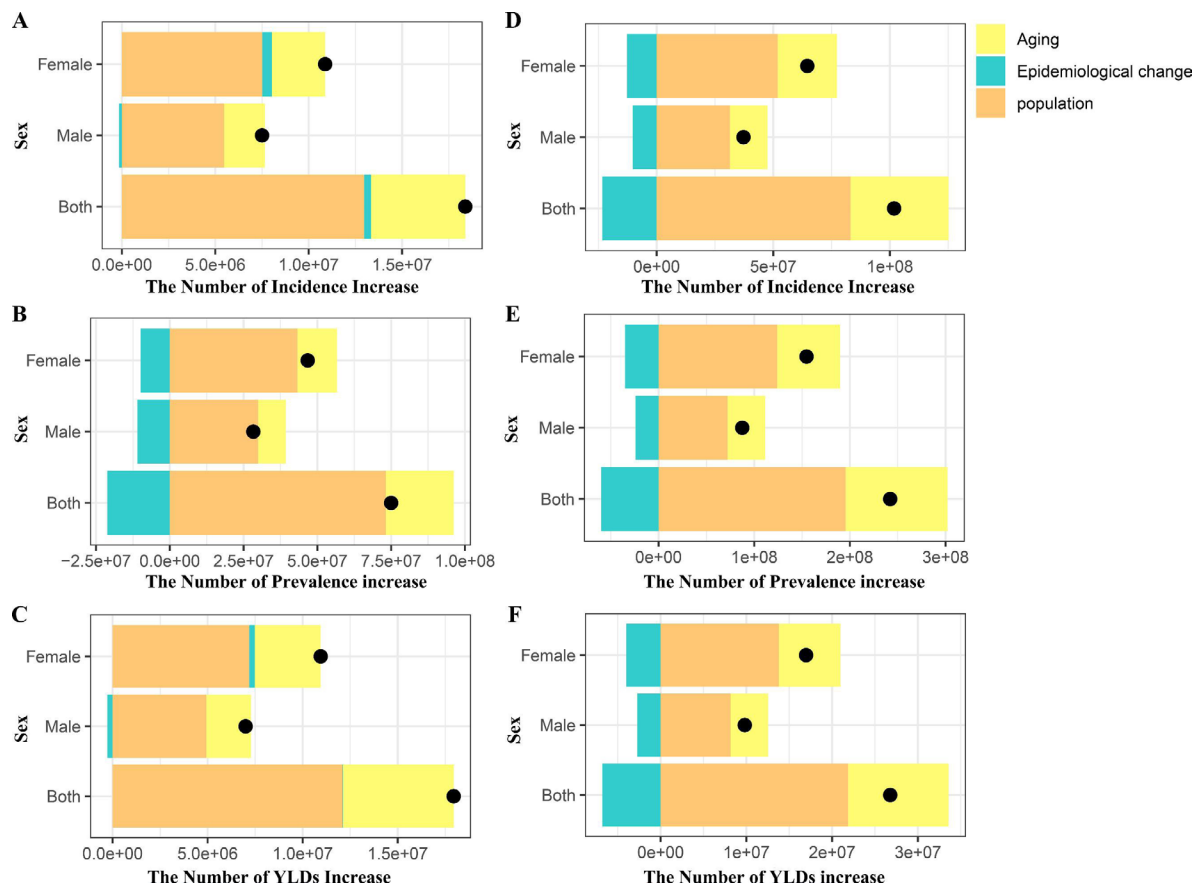


Figure S4. The decomposition analysis of the contribution of population aging, population growth, and epidemiologic changes to global changes in incidence, prevalence, and YLDs of (A–C) neck pain and (D–F) low back pain from 1990 to 2021. Notes: Black dots indicate the overall value of change contributed by all three components. For each component, the magnitude of a positive value indicates a corresponding increase in YLDs for that component, whereas the magnitude of a negative value indicates a corresponding decrease in YLDs for the relevant component. Abbreviation: YLDs: Years lived with disability.

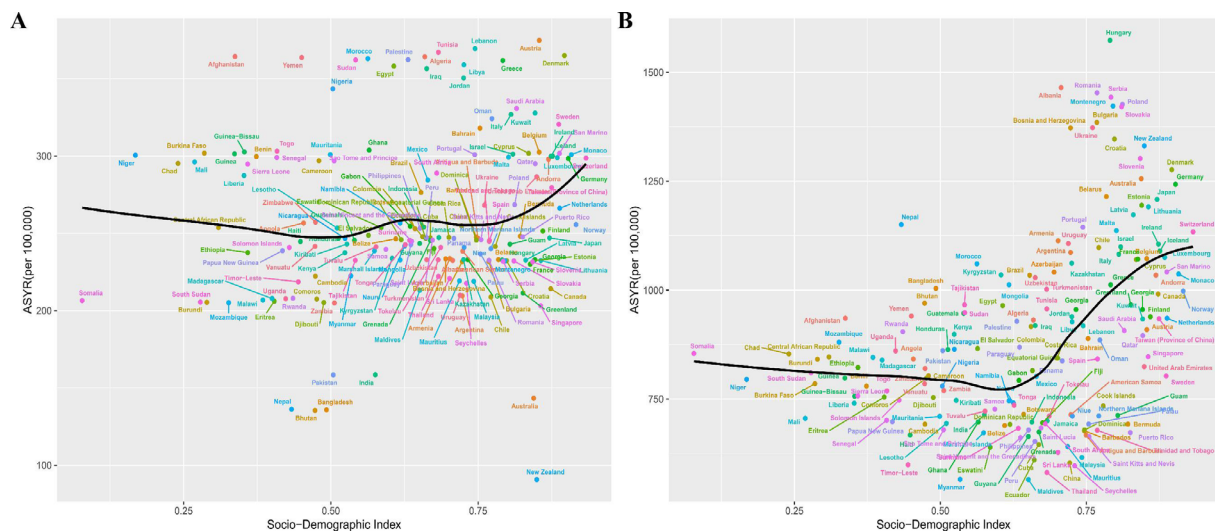


Figure S5. ASYR of (A) neck pain and (B) low back pain in 204 countries and territories based on the SDI in 2021. Abbreviations: ASYR: Age-standardized YLD rate; SDI: Sociodemographic index; YLDs: Years lived with disability.

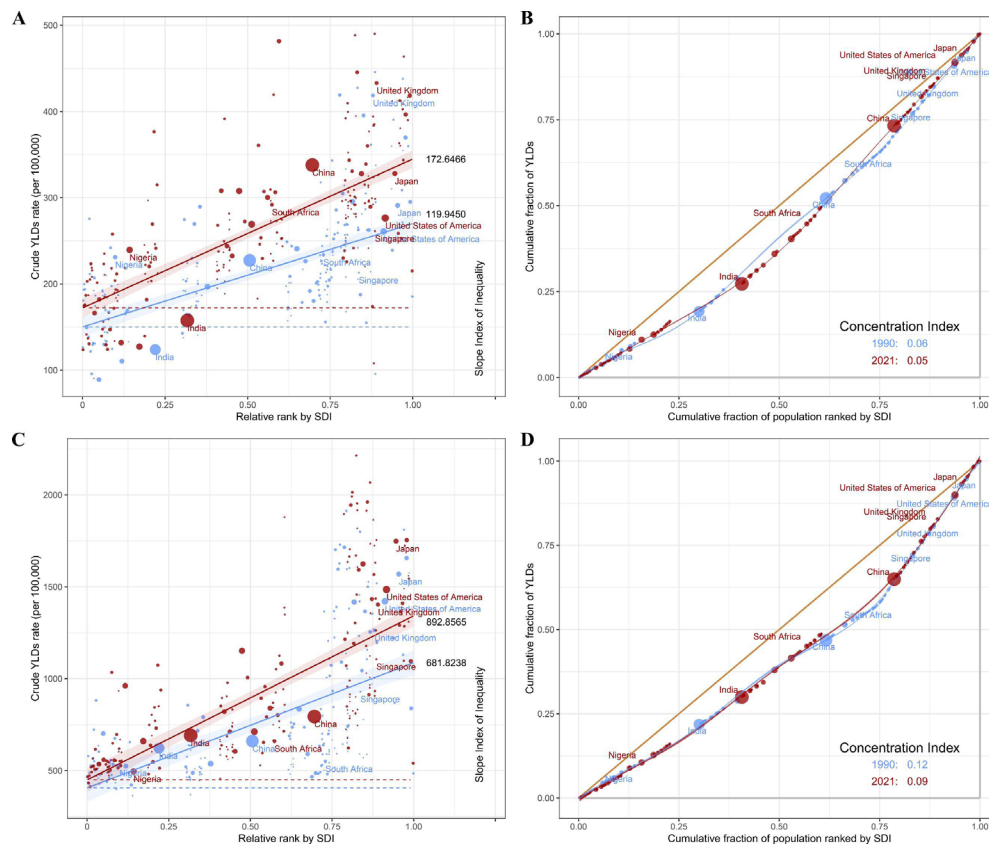


Figure S6. The global health inequality indices for neck and low back pain based on the SDI and ASYR for 204 countries and territories. (A) Slope index of neck pain. (B) Concentration index of neck pain. (C) Slope index of low back pain. (D) Concentration index of low back pain. The concentration index ranges from -1 to 1, where -1 indicates absolute inequality, 0 indicates equality, and 1 indicates absolute inequality. A negative value of the concentration index indicates that health resources or health status are more concentrated in lower-income groups; a positive value indicates that they are more concentrated in higher-income groups.

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

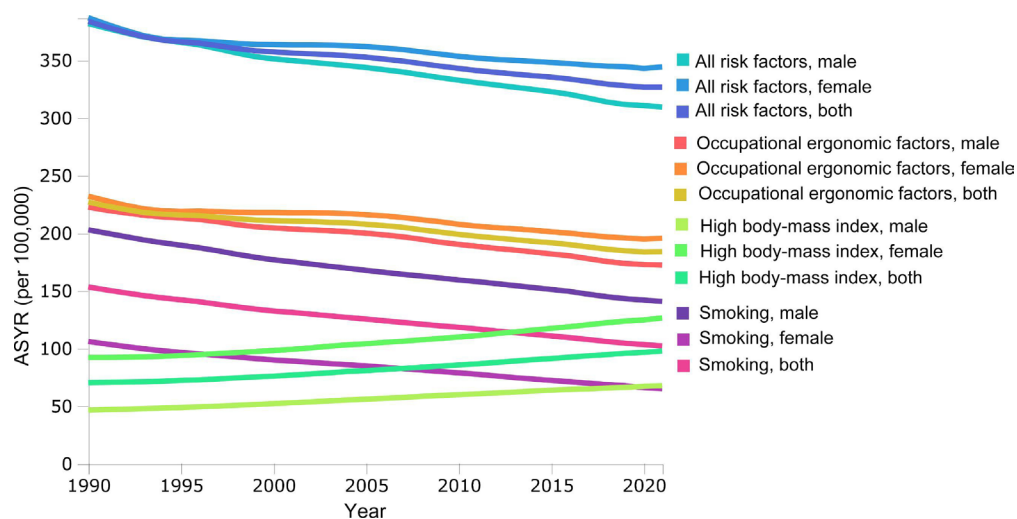


Figure S7. Global trends in the contribution of risk factors for low back pain to ASYR from 1990 to 2021

Abbreviations: ASYR: Age-standardized YLD rate; YLDs: Years lived with disability.

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