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Original Article

Time trends in the burden of low back pain and its associated risk factors in China from 1990 to 2019

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ABSTRACT

Background: From 1990 to 2019, low back pain (LBP) was the leading cause of years lived with disability (YLDs) in China. However, the change patterns of LBP and its risk factors in China remain unclear.
Methods: Data from the Global Burden of Disease Study 2019 were used. We used the join-point regression model and age-period-cohort analysis to evaluate the time trends of attributable risk factors on the burden of LBP.
Results: In 2019, the risk factors included in this analysis accounted for 4.36 million YLDs of LBP, representing 42.2% of all YLDs of LBP in China, with 2.86 million due to occupational ergonomic factors, 1.74 million due to smoking, and 0.46 million due to high body mass index (BMI). The age-standardized YLD rates of LBP showed downward trends during 1990–2019, while there was a faster decline between 1990 and 1994. The curves of local drifts, which reflected the average annual percentage change across age groups, showed an increasing trend with age for high BMI and smoking, and a downward trend for occupational ergonomic factors. The YLD rates for LBP increased dramatically with age for high BMI, while it reached a peak at 40–60 years old for occupational ergonomic factors, and 65–80 years old for smoking. The period and cohort rate ratios of LBP YLD decreased in the past 3 decades for occupational ergonomic factors and smoking, while increased for high BMI.
Conclusions: Our results provided strong evidence that there were diverse changing patterns for different risk factors, highlighting the need for risk-specific strategies.
The translational potential of this article: China has the largest senior population and the fastest aging population in the world. Given that LBP typically occurs in the senior population, there would be an increasing LBP burden on China's health system. This suggests that effective strategies for LBP prevention should be strictly implemented in China, particularly in the senior population, which is of crucial translational potential.

1. Introduction

Low back pain (LBP) encompasses a range of nonspecific pain, stiffness, or muscle tension located typically between the margin of the lower rib and the buttock creases, with or without sciatica [1]. LBP is a common musculoskeletal symptom that seriously limits activity and work capacity, and affects the quality of life and productivity, thereby inducing a substantial burden on individuals, families, and governments. According to the Global Burden of Disease (GBD) studies, 568.4 million cases and 63.7 million years lived with disability (YLDs) for LBP were estimated globally in 2019, much higher than diabetes (459.9 million cases and 36.7 million YLDs), chronic obstructive pulmonary disease (212.3 million cases and 19.8 million YLDs), and ischemic stroke (77.2 million cases and 13.1 million YLDs) [2]. With increasing life expectancy, China has become the country with the largest senior population and the fastest aging population in the world.

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The percentage of people aged 65 years or older in China increased substantially from 2012 (9.4%) to 2022 (14.2%) [3]. Given that LBP typically occurs in the senior population, there would be an increasing LBP burden on China's health system.

Currently available guidelines recommended for treatment in LBP, such as physiotherapy, pharmacological therapy, interventional therapy, and surgery, cannot completely cure the pain, rendering it particularly important to investigate risk factors that could be targeted by prevention and intervention [4]. Modifiable health factors, including occupational ergonomic exposure, smoking, and high body mass index (BMI), are strongly associated with LBP. Substantial exposure to ergonomic factors, such as lifting, forceful movements, awkward postures, and vibration, has been established as a risk factor for LBP [5,6]. For people with high BMI, there are higher risks of LBP due to higher mechanical forces exerted on the lumbar intervertebral disc in both normal and mechanical loading conditions [7]. Additionally, previous studies have suggested a potential association between smoking and disc degeneration [8]. Given the increased risk of LBP from these modifiable risk factors, priority setting for public health and clinical interventions requires information on the burden of LBP and its associated risk factors in China.

Over the last 20 years, China has implemented numerous national programs to control the burden of LBP and its associated risk factors. In 2003, China implemented universal health insurance coverage to all people, and in 2009, the government initiated a major health reform aimed at providing all citizens with equal access to basic health care of reasonable quality [9]. The Healthy China 2030 Strategy further expanded on the 2009 reform goals by emphasizing the importance of improving population health for long-term economic and social development objectives [10]. These policies targeted LBP and its associated risk factors. In this context, there is an urgent need to assess the long-term trends in LBP and the attributable risk factors in China.

Previous studies have reported the LBP burden in China, focusing on the incidence using the GBD 2019, and showed decreasing trends in both male and female individuals [1], but the time trends in the YLD of LBP and its associated risk factors in China are still unclear. Thus, our study aimed to explore and compare temporal trends in the burden of LBP and associated risk factors in China from 1990 to 2019 using the join-point regression and age-period-cohort methods.

2. Method

2.1. Overview

The Institute for Health Metrics and Evaluation conducted the GBD 2019 study to quantify the health losses, which is the most recent and comprehensive study available to understand the epidemiological levels and trends of diseases and injuries worldwide. Among the GBD studies, GBD 2019 study analyzed data from more countries, included additional causes that contribute to LBP, enhanced measurement methods and redistribution algorithms, increased coverage of uncertainty intervals (UIs), improved processing of clinical informatics data, adopted new standard locations, and increased available data sources, etc. Detailed information about these improvements was provided in a previous publication at https://vizhub.healthdata.org/gbd-results/ [11].

LBP burden and its associated risk factors in GBD 2019 were determined through following steps: (1) identifying risk-LBP pairs based on research studies, (2) estimating relative risks according to systematic reviews, (3) assessing the age-sex-location-year specific occupational ergonomic exposure, smoking, and high BMI levels and distributions, (4) determination of the counterfactual level of exposure; the level of exposure with minimum risk called the theoretical minimum risk exposure level, (5) computing population-attributable fractions and attributable YLD, and (6) estimating the mediation of different risk factors through other risk factors to compute the burden attributable to various combinations of risk factors.

All data were presented as counts and age-standardized rates per 100 000 individuals with UIs. The GBD study was approved by the University of Washington Institutional Review Board, and de-identified aggregated data were available with a waiver of informed consent.

2.2. Data sources

In our study, we obtained age-specific YLDs, YLD rates, and age-standardized YLD rates (ASYRs) of LBP. Successive 5-year age groups in China were conducted, with 15–19 years to 80–84 years for occupational ergonomic exposure, 30–34 years to 95 years for smoking, and 20–24 years to 95 years for high BMI. The ASYRs were standardized using the global age structure of 2019.

Data on LBP in the GBD 2019 were obtained from the World Health Survey and National Health Survey. PubMed, Embase, CINAHL, and Ovid Medline electronic databases were searched until the end of October 2017, and additional studies encountered during the data review were added for GBD 2019 [11]. Reported estimates of prevalence were split by age and sex using the Bayesian meta-regression model (DisMod-MR 2.1). The MR-BRT network crosswalk adjustment method was used to correct for bias among different definitions. Data with a median absolute deviation of 1.5 or more above the mean were considered outliers. The evaluation of disability weight in GBD was based on lay descriptions of sequelae, with a focus on major functional symptoms and consequences. The severity distributions were derived from an analysis conducted on the Medical Expenditure Panel Survey in the United States. In Table S1, the lay descriptions and disability weights for the LBP severity levels are presented. YLDs were estimated based on prevalence and disability weights. Moreover, as no evidence of mortality associated with LBP was found in the GBD study, the values of disability-adjusted life years and YLDs were equal. In this study, the term YLDs was used [12].

The associated risk factors in GBD 2019, including occupational ergonomic exposure, smoking, and high BMI, were estimated primarily from the International Labor Organization, cross-sectional nationally representative household surveys, and systematic reviews [13,14]. For high BMI, sex-specific MR-BRT models were fitted to the logit difference between the measured and self-reported data with a fixed effect on the super-region. For smoking, the supply side was estimated and used to rescale the estimates of cigarettes per smoker per day to the cigarette consumption envelope. After splitting the aggregated data into 5-year age-sex groups, spatiotemporal Gaussian process regression was used to generate estimates for all years and locations for the primary inputs.

2.3. Case definition

LBP is defined as acute or chronic pain in the back region of the body, spanning from the lower edge of the twelfth rib to the lower folds of the buttocks. LBP sometimes may extend to one or both lower limbs, and should last for at least one day. The International Classification of Diseases, Tenth Revision (ICD-10) codes for LBP are M54.3, M54.4, and M54.5.

Occupational ergonomic factors were defined as the proportion of the working population exposed to work that causes LBP based on population distributions across nine occupational categories. A high BMI for adults (age 20+ years) was defined as a BMI greater than 20–25 kg/m^2. Smoking was defined as current or former smoking of any tobacco product.

2.4. Statistical analysis

The join-point regression model was utilized to evaluate the time trends in ASYRs for LBP and the associated risk factors from 1990 to 2019. It segmented the long-term trends of the ASYRs and subsequently identified statistically significant trends within different segments [15]. To indicate the direction and magnitude of the trends, we calculated the average annual percentage change (AAPC), along with annual percentage change for each segment, and 95% confidence intervals (CIs).

The age-period-cohort analysis was utilized to assess the age, period, and cohort effects on associated risk factors contributing to YLDs of LBP. This approach disentangled the three trends and yielded relatively efficient estimation results [16]. The age effect refers to the biological and social processes of aging. The period effect reflects changes in YLDs of LBP and its associated risk factors over time that are simultaneously experienced by all age groups. The cohort effect is attributed to distinct risk factors and environmental exposures affecting a group of individuals (cohorts) over time [17]. In our research, we primarily concentrated on the estimation of local drift, longitudinal age curve, period, and cohort rate ratios (RRs) [18]. The number of YLDs and the population were organized into consecutive 5-year periods from 1990 to 2019 and successive 5-year age groups. As all individuals aged ≥95 years were combined into a single group in the GBD 2019 database, they were excluded from the age-period-cohort analysis.

Additionally, a log-linear model was utilized to evaluate the estimated annual percentage change (EAPC) of the age-standardized mortality rate: $AMSR = \exp(\beta_0 + \beta_1 year)$, where year stands for the calendar year, and $100 \times (\exp(\beta_1) - 1)$ represents the EAPC [19]. The join-point analysis was carried out using the JoinPoint software, version 5.0.2 (May 2023), developed by the National Cancer Institute (Rockville, MD, USA). The age-period-cohort web tool (Biostatistics Branch, National Cancer Institute, Bethesda, MD, USA; https://analysistools.nci.nih.gov/apc/) was utilized for the age-period-cohort analysis. Further analyses were conducted using R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria) and SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided, and statistical significance was set at $P < 0.05$.

3. Result

In 2019, the total number of YLDs for LBP attributable to all estimated risk factors was 4.36 million (95%UI, 3.07–5.96), accounting for 42.2% of all YLDs for LBP. There were 2.41 million (95%UI, 1.68–3.29) risk-attributable LBP YLDs in men and 1.95 million (95%UI, 1.35–2.74) risk-attributable LBP YLDs in women. We estimated that 2.86 million (95%UI, 1.99–3.96) YLDs of LBP were attributable to occupational ergonomic factors, 1.74 million (95%UI, 1.10–2.49) YLDs of LBP were attributable to smoking, and 0.46 million (95%UI, 0.18–0.90) YLDs of LBP were attributable to high BMI in 2019 (Table 1). Occupational ergonomic factors were the leading risk factors of LBP from 1990 to 2019; however, smoking became the leading risk factor in men after 2009 (Fig. 1).

From 1990 to 2019, we observed upward trends in the number of YLDs and downward trends in ASYRs, both in China and globally. The global YLDs for LBP increased by 37.89% from 18.37 million (95%UI, 12.76–24.83) in 1990 to 25.33 million (95%UI, 17.60–34.20) in 2019, while ASYRs declined by 23.13% from 397.70 per 100 000 (95%UI, 277.01–537.16) in 1990 to 305.69 per 100 000 (95%UI, 213.05–412.06) in 2019. China has a lower LBP burden and faster decline rate than the global level. The YLDs for LBP in China increased by 1.92% from 4.28 million (95%UI, 2.95–5.77) in 1990 to 4.36 million (95%UI, 3.07–5.96) in 2019, while ASYRs declined by 41.71% from 394.71 per 100 000 (95%UI, 272.87–535.10) in 1990 to 230.07 per 100 000 (95%UI, 160.80–315.80) in 2019 (Table 1, Fig. 1A). The EAPC of ASYRs for YLD was −1.50 (95% UI, −1.67 to −1.33) in China (Table S2).

The ASYRs of LBP showed downward trends from 1990 to 2019 in China, with an average annual percentage change of −1.86 (95% CI, −1.90 to −1.82) for all estimated risk factors, −2.37 (95% CI, −2.41 to −2.33) for occupational ergonomic factors, −1.47 (95% CI, −1.52 to −1.41) for smoking, and 1.48 (95% CI, 1.43 to 1.53) for high BMI (Table 2). Specifically, the smoking-related LBP burden showed a similar trend to the LBP burden attributable to all estimated risk factors (increased by 35.81% in YLDs and decreased by 34.76% in ASYRs). The occupational ergonomic factor-related burden showed decreasing trends from 1990 to 2019 (decreased by 17.98% in YLDs and 49.92% in the

Table 1
YLD and Age-standardized YLD rate for LBP and associated risk factors in China and the world.

	China				Global			
	Numbers of YLD (million), 2019	Age-standardized rate per 100 000, 2019	Percentage change in number, 1990–2019 (%)	Percentage change in ASR, 1990–2019 (%)	Numbers of YLDs (million), 2019	Age-standardized rate per 100 000, 2019	Percentage change in number, 1990–2019 (%)	Percentage change in ASR 1990–2019 (%)
Low back pain attributable to all estimated risk factors								
Both sexes	4.36 (3.07–5.96)	230.07 (160.80–315.80)	1.92	−41.71	25.33 (17.60–34.20)	305.69 (213.05–412.06)	37.89	−23.13
Male	2.41 (1.68–3.29)	254.02 (176.44–343.93)	5.04	−40.55	13.59 (9.51–18.39)	333.25 (233.66–451.91)	37.36	−23.58
Female	1.95 (1.35–2.74)	207.85 (143.76–287.72)	−1.69	−43.49	11.74 (8.31–15.91)	279.54 (197.19–379.24)	38.52	−23.00
Low back pain attributable to occupational ergonomic factors								
Both sexes	2.86 (1.99–3.96)	155.30 (108.11–213.30)	−17.98	−49.92	15.31 (10.54–20.76)	185.08 (127.57–250.55)	29.92	−24.61
Male	1.31 (0.90–1.81)	141.85 (96.49–195.70)	−20.49	−50.70	8.05 (5.53–10.94)	195.58 (134.07–265.83)	28.49	−25.19
Female	1.55 (1.07–2.15)	169.10 (116.63–236.32)	−15.72	−49.63	7.26 (5.01–9.87)	174.77 (120.66–236.59)	31.55	−24.21
Low back pain attributable to smoking								
Both sexes	1.74 (1.10–2.49)	86.48 (54.83–122.89)	35.81	−34.76	9.97 (6.44–14.04)	119.49 (77.12–167.97)	28.78	−32.45
Male	1.48 (0.95–2.12)	149.23 (95.21–209.97)	28.44	−36.92	6.76 (4.35–9.53)	166.09 (107.29–233.95)	32.29	−30.72
Female	0.26 (0.16–0.39)	25.00 (15.45–37.09)	102.03	−12.78	3.21 (2.07–4.53)	75.10 (48.35–105.97)	21.97	−36.37
Low back pain attributable to high body mass index								
Both sexes	0.46 (0.18–0.90)	23.37 (9.16–45.50)	196.29	52.23	4.24 (2.25–7.10)	51.15 (27.08–85.55)	133.5	24.57
Male	0.19 (0.07–0.36)	19.57 (7.46–38.53)	200.75	64.94	1.69 (0.85–2.90)	41.65 (21.02–71.11)	145.12	32.83
Female	0.27 (0.11–0.54)	26.96 (10.71–52.33)	193.33	42.66	2.55 (1.39–4.21)	60.03 (32.73–99.20)	126.38	20.30

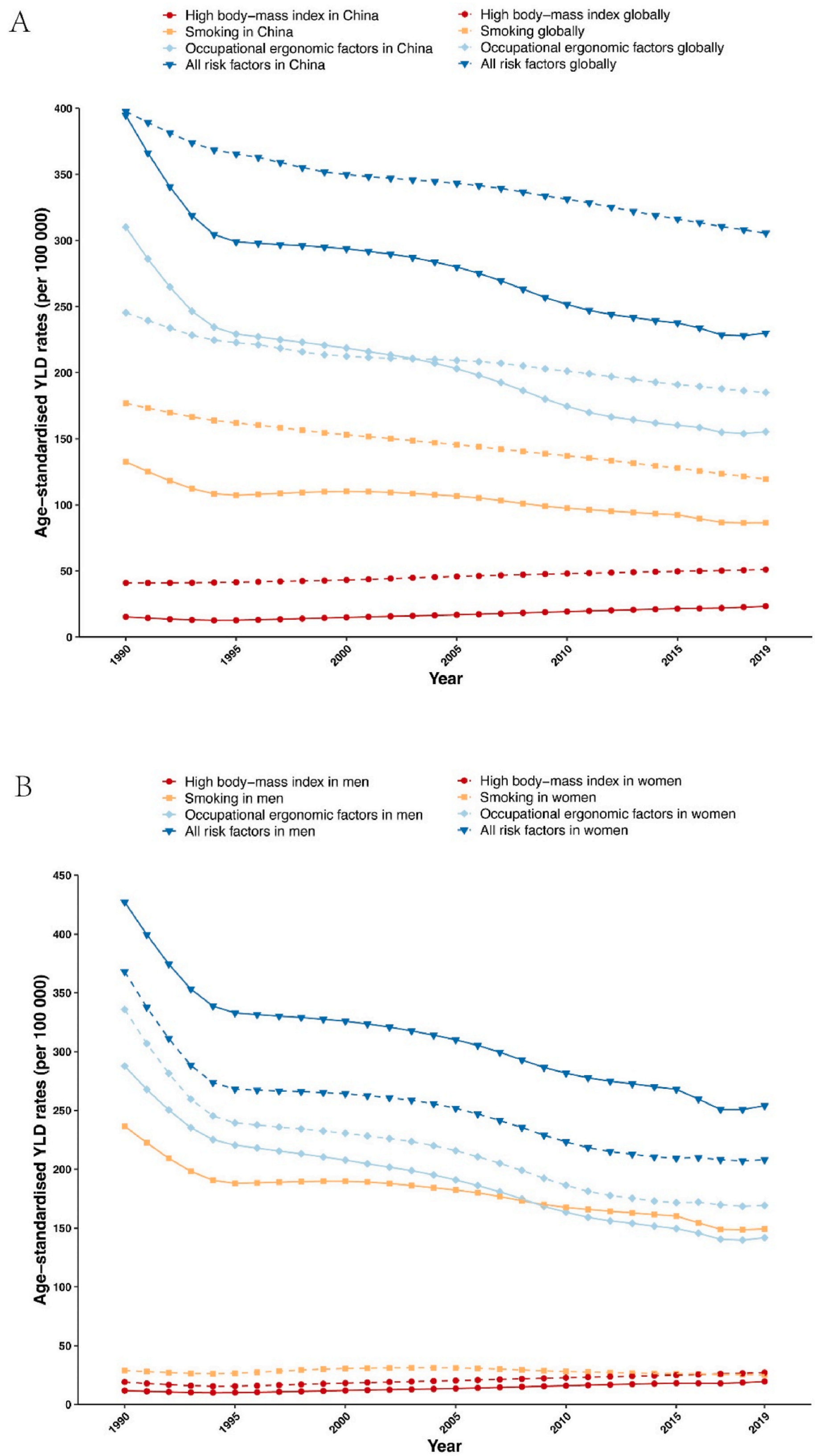

Figure 1. Trends in age-standardized YLD rates of low back pain attributable to different risk factors from 1990 to 2019. YLD, years lived with disability.

ASYR). Contrary to occupational ergonomic factors, high BMI-related burden showed obvious upward trends (increased by 196.29% in YLDs and 52.23% in ASYRs) (Table 1). For occupational ergonomic factors and high BMI, women had significantly higher ASYR for LBP than men. In contrast, we also observed that smoking-related ASYR continued to be significantly higher among men than women from 1990 to 2019, although the gap narrowed.

Our results demonstrated that the greatest decline occurred during

Table 2
Trends of Age-Standardized YLD Rates of LBP and associated risk factors from 1990 to 2019 in China Using join-point Regression.

	Both sexes			Men			Women		
	Segment	Period	APC(95%CI)	Segment	Period	APC(95%CI)	Segment	Period	APC(95%CI)
All estimated risk factors	1	1990–1994	−6.32 (-6.60,-6.02)	1	1990–1994	−5.72 (-6.00,-5.42)	1	1990–1994	−7.22 (-7.49,-6.90)
	2	1994–2004	−0.52 (-0.63,-0.39)	2	1994–2003	−0.51 (-0.65,-0.36)	2	1994–2004	−0.46 (-0.59,-0.34)
	3	2004–2011	−2.11 (-2.50,-1.87)	3	2003–2011	−1.78 (-2.25,-1.62)	3	2004–2012	−2.34 (-2.58,-2.14)
	4	2011–2019	−1.03 (-1.21,-0.79)	4	2011–2014	−0.67 (-1.25,-0.31)	4	2012–2019	−0.48 (-0.70,-0.17)
	5	—	—	5	2014–2017	−2.52 (-2.97,-1.97)	5	—	—
	6	—	—	6	2017–2019	0.27 (-0.59.0.99)	6	—	—
	AAPC	1990–2019	−1.86 (-1.90,-1.82)	AAPC	1990–2019	−1.77 (-1.82,-1.72)	AAPC	1990–2019	−1.94 (-1.98,-1.90)
Occupational ergonomic factors	1	1990–1994	−6.78 (-7.07,-6.48)	1	1990–1994	−5.91 (-6.30,-5.51)	1	1990–1994	−7.67 (-7.94,-7.38)
	2	1994–2004	−1.05 (-1.17,-0.92)	2	1994–2004	−1.26 (-1.56,-1.08)	2	1994–2004	−0.86 (-0.96,-0.74)
	3	2004–2012	−2.86 (-3.10,-2.67)	3	2004–2010	−3.03 (-3.70,-1.02)	3	2004–2012	−2.84 (-3.04,-2.67)
	4	2012–2019	−1.10 (-1.32,-0.82)	4	2010–2017	−2.03 (-3.06,-1.71)	4	2012–2019	−0.71 (-0.91,-0.49)
	5	—	—	5	2017–2019	−0.28 (-1.75.0.43)	5	—	—
	AAPC	1990–2019	−2.37 (-2.41,-2.33)	AAPC	1990–2019	−2.40 (-2.48,-2.35)	AAPC	1990–2019	−2.34 (-2.38,-2.30)
Smoking	1	1990–1994	−5.00 (-5.44,-4.51)	1	1990–1994	−5.37 (-5.85,-4.85)	1	1990–1994	−2.55 (-86,-2.22)
	2	1994–2002	0.39 (0.14.0.67)	2	1994–2002	0.05 (-0.19.0.36)	2	1994–2000	2.96 (2.76.3.18)
	3	2002–2019	−1.49 (-1.58,-1.41)	3	2002–2019	−1.44 (-1.53,-1.35)	3	2000–2005	0.29 (-0.03.0.64)
	4	—	—	4	—	—	4	2005–2012	−2.10 (-2.42,-1.89)
	5	—	—	5	—	—	5	2012–2019	−0.98 (-1.18,-0.69)
	AAPC	1990–2019	−1.47 (-1.52,-1.41)	AAPC	1990–2019	−1.58 (-1.64,-1.52)	AAPC	1990–2019	−0.45 (-0.49,-0.41)
High body mass index	1	1990–1994	−4.91 (-5.30,-4.55)	1	1990–1994	−4.19 (-4.58,-3.69)	1	1990–1994	−5.36 (-5.69,-5.11)
	2	1994–2001	3.02 (2.82.3.49)	2	1994–2014	3.00 (2.95.3.07)	2	1994–2001	2.96 (2.80.3.36)
	3	2001–2014	2.54 (2.36.2.64)	3	2014–2017	0.14 (-0.36.0.96)	3	2001–2010	2.28 (2.13.2.59)
	4	2014–2017	1.14 (0.81.2.55)	4	2017–2019	4.14 (2.98.5.08)	4	2010–2019	1.96 (1.60.2.06)
	5	2017–2019	3.04 (1.89.3.74)	5	—	—	5	—	—
	AAPC	1990–2019	1.48 (1.43.1.53)	AAPC	1990–2019	1.76 (1.69.1.83))	AAPC	1990–2019	1.25 (1.21.1.28)

1990–1994 in occupational ergonomic factors, smoking, and high BMI. Although there was a general decrease in smoking-related ASYR for LBP from 1990 to 2019, we observed an increase from 1994 to 2002, especially among women. After 1994, high BMI-related ASYR for LBP increased continuously. Similar trends were observed in both men and women, while men showed greater changes (greater declines in occupational ergonomic factors and smoking-related ASYR as well as greater increases in high BMI-related ASYR) than women (Table 2).

We further calculated local drifts using age-period-cohort analysis to estimate the average annual percentage change of LBP YLD in China attributable to associated risk factors across age groups, as shown in Fig. 2. The local drifts for LBP generally increased with age, with fluctuations in the age group of 45–74 years old. These fluctuations were significantly greater in men than in women. There were evident differences between the three associated risk factors. The curves showed a high and slowly increasing trend with age for high BMI, an increasing trend with age for smoking, and an evident declining trend for occupational ergonomic factors. The curve of local drifts for LBP attributable to smoking in women was U-shaped across the age groups, with the greatest increase observed before 39 years of age. Furthermore, high BMI was the fastest-growing risk factor regardless of sex and age.

The longitudinal age curves for LBP in China are shown in Fig. 3. The curve of the YLD rate for LBP was inverted U-shaped across age groups, with the highest YLD rate in the age group of 45–54 years. The YLD rate for LBP due to high BMI increased drastically with age, while it reaches a peak at 40–60 years for occupational ergonomic factor and 65–80 years for smoking. Among the three associated risk factors for both sexes, the first leading risk factor was occupational ergonomic factors before 65 years of age, followed by smoking. Smoking had a greater effect on LBP in men than in women. The leading risk factors were smoking after 40 years of age in men and after 80 years of age in women.

Figs. 4 and 5 show the estimated period and cohort effects of the YLD on LBP and its associated risk factors in China. The period RRs of the LBP YLDs decreased from 1990 to 2019. The RRs of smoking and occupational ergonomic factor decreased over the past three decades, while the RRs of high BMI increased. The results for cohort effects were similar to those for period effects.

4. Discussion

Using the data from GBD 2019 study, we estimated the time trends of the LBP burden and its associated risk factors between 1990 and 2019. We found that China had much lower ASYRs and faster rates of decrease in attributable LBP burden than the global level. There were obvious downward trends in the ASYRs, period, and cohort RRs for LBP attributable to all estimated risk factors from 1990 to 2019 in China, with the greatest decline for occupational ergonomic factors and the increase for high BMI. Notably, there was a rapid decline between 1990 and 1994.

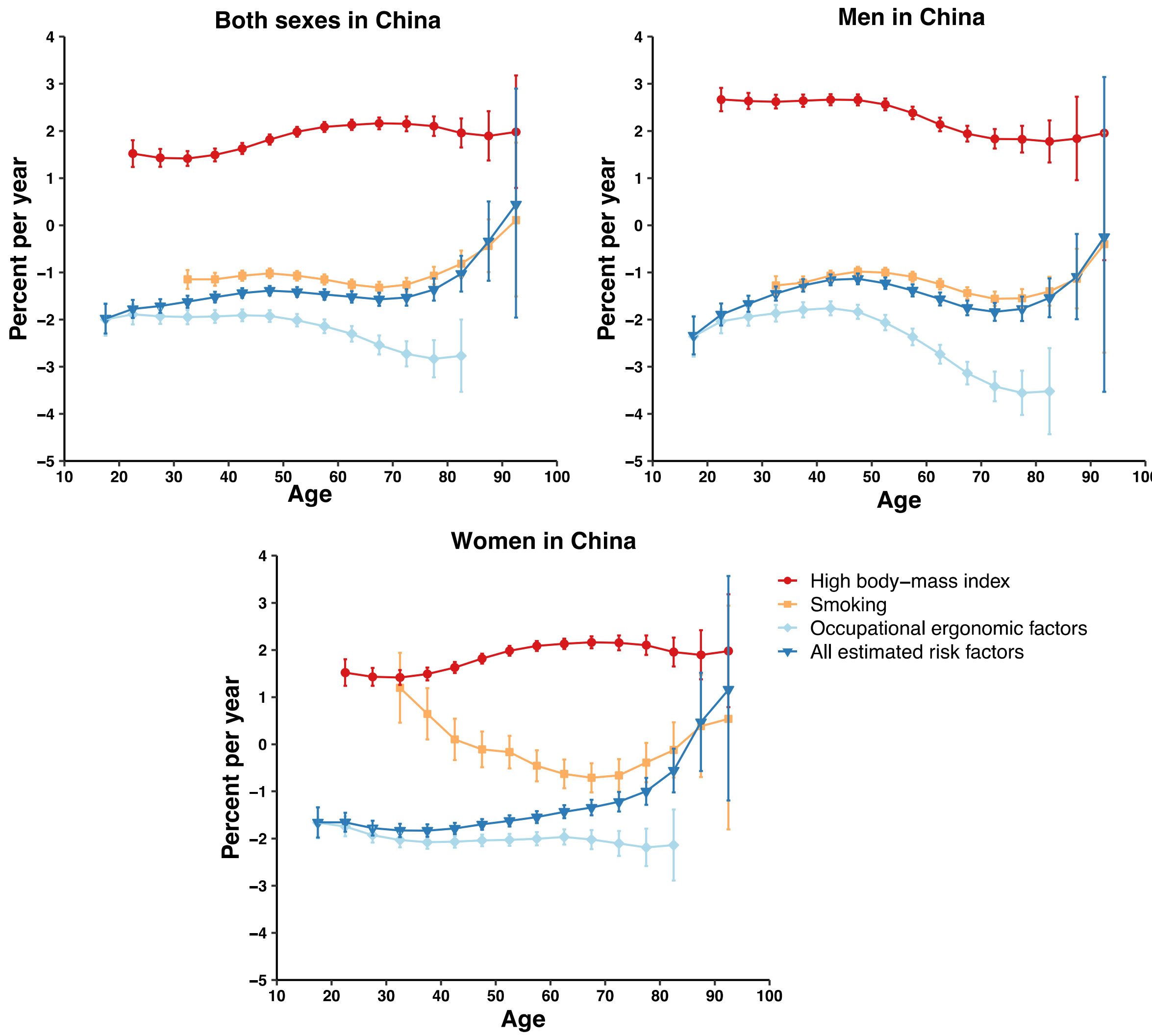

Figure 2. Local drift for YLD rates of low back pain attributable to different risk factors in China. YLD, years lived with disability.

Age is one of the most significant demographic factors associated with LBP. The age-period-cohort effect analysis showed a continuously increasing local drift with increasing age among men and women. Additionally, women had a significantly higher ASYR for LBP than men for occupational ergonomic factors and high BMI, while smoking-related ASYR for LBP continued to be significantly higher in men than in women.

In this study, there was a 41.71% decrease in the percentage change in ASYR for LBP attributable to all estimated risk factors from 1990 to 2019 in China. During the same period, a global decrease of 23.12% was observed. Previous studies have shown that China had the largest YLD for LBP, and the fastest decline in ASYR for LBP was attributed to all estimated risk factors among 204 countries and territories [11]. Given that the crude YLD rate in China is relatively low among countries and territories in the world, the absolute YLD of China is in line with its large population. For the decline in ASYR of China, it was likely that exercise alone or in combination with education contributed to the decline over time [4]. Previous study showed an example strategy in villages in rural Tibet, where 34% of people reported LBP, which consisted of training in back pain prevention and management in combination with a stand to support water containers. It evidently eased the burden of collecting water with the potential to also reduce back pain prevalence and associated disability [20]. Furthermore, developments in athletics facilities coverage, increased health awareness, and improved public health initiatives in LBP and associated risk factors prevention have also contributed to the decline [21]. The decrease in ASYR for LBP due to occupational ergonomic factors was the main component of the decline in China. The decreases in occupational ergonomic factors over time primarily reflected a proportional decrease in employment in high-risk occupations, such as agricultural and labor-intensive jobs [22]. Before the 1980s, the degree of automation and mechanization of industrial and agricultural production in China was inadequate. Manual labor and manual operations were the main occupational modes, resulting in a large number of patients with LBP caused by occupational ergonomic factors. China's emphasis on development, mechanization, and automation has shifted from an occupational model based on manual labor to one based on mechanical automation. There was evidence that the share of routine manual jobs declined from 57% in 1990 to 32% in 2015 [23]. Moreover, the promotion of national programmes such as smoking bans and Healthy China 2030 Strategy might have influenced the decrease in YLD for LBP [24–26].

Although there was a decrease in ASYR in YLD attributable to all estimated risk factors from 1990 to 2019, we observed a faster decrease between 1990 and 1994, which was generally consistent with the findings of LBP incidence at particular time points [21]. Specifically, the decline was significant in the ASYR for LBP attributable to occupational ergonomic factors, smoking, and high BMI between 1990 and 1994, regardless of sex. There are two possible reasons for this observation. First, the reform of state-owned enterprises (SOEs) and the relaxation of the restrictions on population mobility contributed to occupational

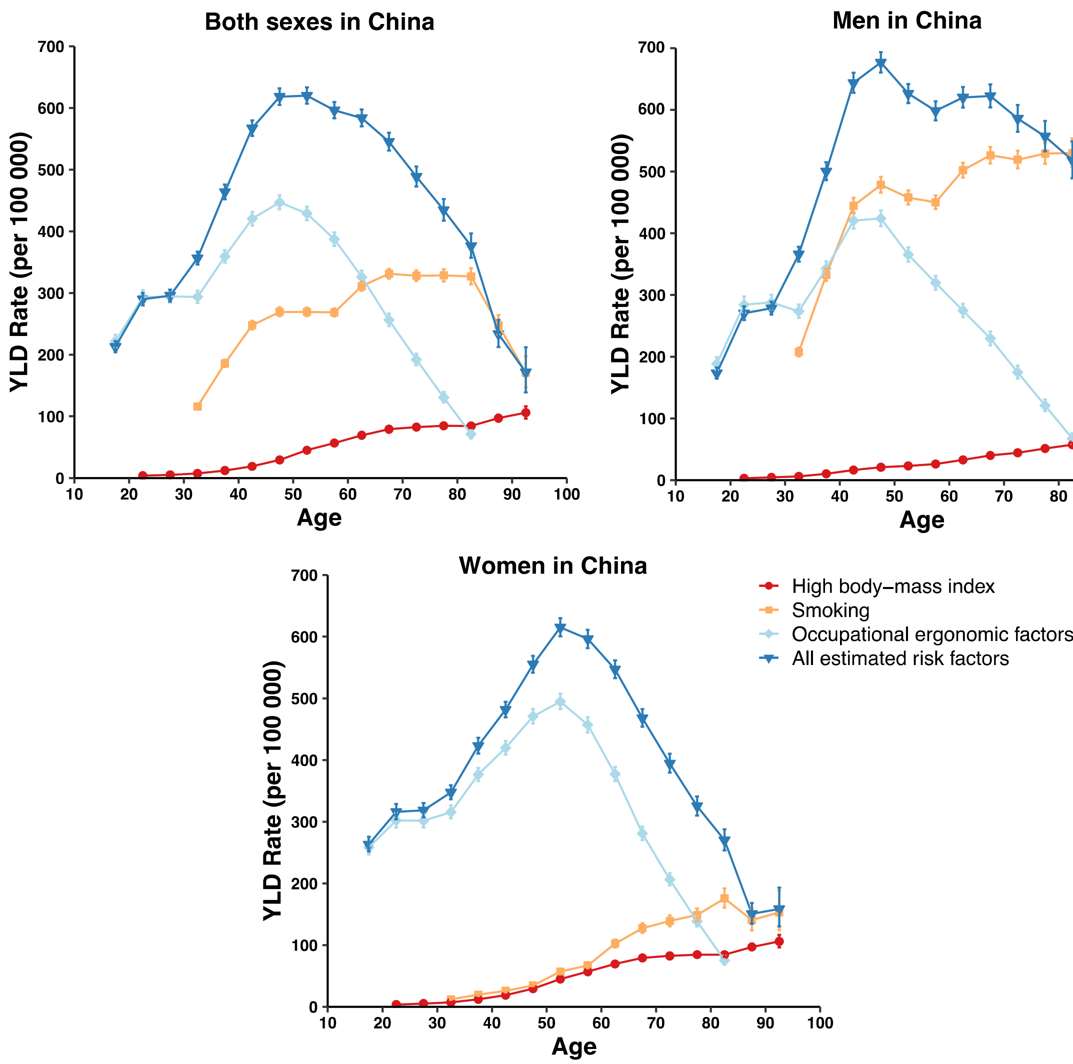

Figure 3. Longitudinal age curves for YLD rates of low back pain attributable to different risk factors in China. YLD, years lived with disability.

transitions in the late 1990s in China. From 1995, and especially after the Fifteenth Communist Party Congress, the government implemented a privatization policy of "retaining the large and letting go of the small," to privatize small and medium-sized SOEs. According to the official data, an estimated 34 million workers were laid off from the state sector to reduce redundant labor from 1995 to 2001 [27]. This has turned large numbers of workers with comfortable, secure jobs into unstable and manual work. Another biggest shock came from the relaxation of the restrictions on population mobility. Around 1995, the unique house-hold registration system to identify a person as a resident of a particular area of China, known as *hukou*, began to relax [28]. Since then, a large number of rural migrants flow into prosperous areas, taking on more routine manual jobs and low-paid jobs, which also increased the risk of low back injuries caused by occupational factors after 1995 [23]. Census data showed that the decline rate of agricultural-related production personnel in China after 1994 was less than half of that before 1994 [29]. Second, with the advent of the Internet era, desk work had become the main way of life for urban workers. The increasing proportion of the working-age population who spent most of their time in front of a computer and always sustained postures contributed to the increased LBP-related burden [21]. Moreover, the low awareness of serious LBP-related potential consequences created therapeutic inertia, which could further hinder the implementation of LBP prevention in a timely and effective manner.

Substantial gaps were apparent by sex in LBP burden. In this study, we observed a heavier LBP burden attributable to all estimated risk factors in men than in women, which is consistent with previous findings [11]. However, women had a heavier LBP burden than men. The main reason for this is that the estimated risk factors were limited and insufficient to fully represent the total LBP burden. Of the three risk factors identified thus far, we observed that women had a significantly higher ASYR for LBP than men for occupational ergonomic factors and high BMI, while smoking-related ASYR for LBP continued to be significantly higher among men than among women. There was a large difference in the YLD for LBP attributable to smoking between men and women, resulting in a higher YLD for LBP attributable to all estimated risk factors in men than in women. Probable explanations for sex differences could be physiological characteristics, disease risks, diagnosis, and management in different life stages between men and women [30]. Specifically, lower muscle content of the lower back, menstrual cycle fluctuations, and special hormonal factors in women may play an important role in the etiology and pathophysiology of LBP. Higher sensitivity to pain among women and a perceived greater willingness to report painful symptoms may also explain it [21]. Additionally, the lower smoking-related YLD for LBP in women than in men may be due to the lower prevalence of smoking. Nevertheless, the 102% increase in smoking-related YLD in women from 1990 to 2019 requires continued attention.

Age is one of the most significant demographic factors associated with LBP. A previous study demonstrated that older adults had a higher

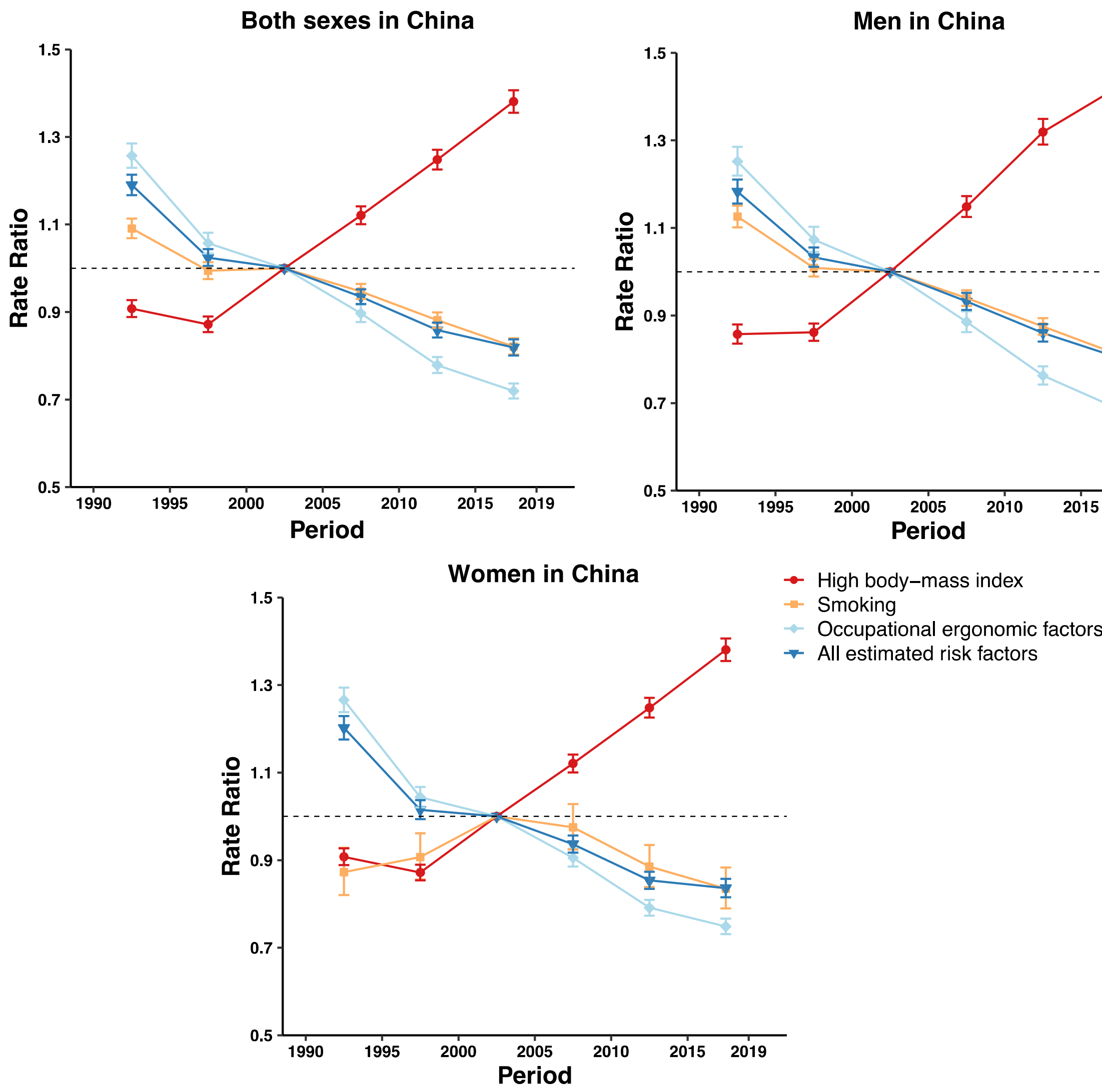

Figure 4. Period rate ratio for YLD rates of low back pain attributable to different risk factors in China. YLD, years lived with disability.

prevalence and poorer functional recovery than young adults, which resulted in higher YLD rates in the senior population [1,31]. In this study, age-period-cohort analysis showed a continuously increasing local drift with increasing age among men and women. Several factors may contribute to the effect of age on YLD for LBP. On the one hand, intervertebral disc degeneration is an important risk factor for LBP, and the degree of degeneration increases with age. A higher degree of intervertebral disc degeneration in older adults directly leads to a higher LBP burden. On the other hand, there is a vicious cycle of pain and inactivity that could be catalyzed by age. Aging is associated with pain. Clustering of musculoskeletal pain restricted physical activities. Insufficient physical activity accelerates deterioration of the musculoskeletal system, which is vulnerable to pain. In addition, the highest YLD rates of LBP were observed in the group aged 45–49 years in men, while in women, it was observed in the group aged 50–54 years. This indicates that these populations are vulnerable to LBP in China, directly impacting clinical practice and policy. Preventive and educational approaches targeting these specific groups should be encouraged.

The cohort effects of LBP showed monotonically decreasing trends between 1915–1919 and 2000–2004 birth cohorts in both men and women, which suggests that the population born in early birth cohorts had higher risks than those born in later birth cohorts. The downward trends in cohort effects may have been caused by economic development and environmental and educational improvements. A poor environment, low socioeconomic status, and early childhood malnutrition may have profound adverse effects on health status, leading to higher risks in adulthood. With the development of socioeconomic and healthcare systems, later generations, having better nutrition, awareness of physical activity, and healthy dietary patterns, might associated with lower risks of LBP [21].

To our knowledge, this is the first study to systematically investigate the time trends in YLD for LBP and its associated risk factors according to sex in China, which has remarkable public health implications. Using comparable data across time, we elaborated on the temporal trend in the attributable LBP burden in China from 1990 to 2019 and identified different changing patterns for LBP-associated risk factors. Although the LBP burden in China has decreased drastically over the past 30 years, China still has the highest YLD worldwide. Therefore, strategies for LBP prevention should be comprehensively implemented in China. Furthermore, these results may be valuable for identifying vulnerable subpopulations and improving LBP management in other countries or regions with similar conditions.

This study illuminated the temporal trends in YLD for LBP and associated risk factors in China using the GBD 2019 study, which provided the latest data and internally consistent estimates of age-sex-location-year-specific burden and had satisfactory quality to reduce the possibility of misclassification of outcomes [2,11]. However, there were a few limitations. First, data sources in the present study were

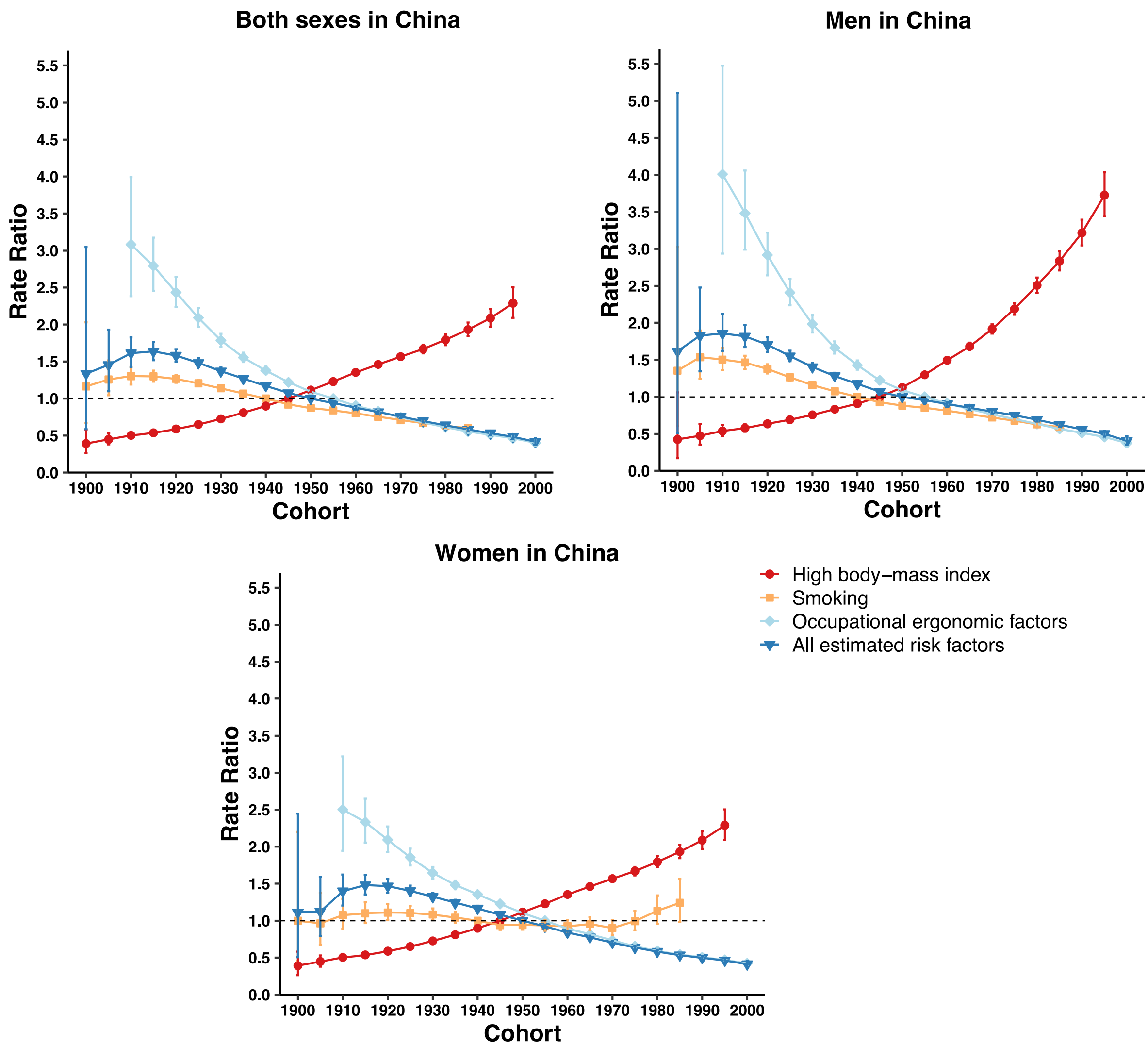

Figure 5. Cohort rate ratio for YLD rates of low back pain attributable to different risk factors in China. YLD, years lived with disability.

obtained from modeled data through processes in DisMod-MR 2.1, rather than direct measurements, resulting in an inevitable bias, as described previously [2,11]. The accuracy of the findings relies heavily on modeled data. It is important to emphasize that the estimates should serve as a complement rather than a substitute for the public health work to improve directly observed data in China. However, many adjusted methods were used to reduce bias in the GBD 2019, and the reliability of this source has been confirmed by previous literature and the IHME annual report. Second, most of the studies that contributed to the RR measures in the GBD 2019 study were based in developed countries rather than in developing countries such as China. Its applicability in China is worth discussing. Third, this study adopted a national perspective to analyze the burden of LBP and its associated risk factors in China. We only highlighted the benefits at the national level, which might not be guided at the individual level. Further research is necessary to confirm the new findings based on individual-level studies. Last, the age-period-cohort analysis in this study was based on estimated cross-sectional data of the GBD from 1990 to 2019, which was not a cohort study. Despite these limitations, this study is the first to comprehensively assess the time trends of attributable LBP burden in China and provide strong support for the need to identify, develop, and implement effective interventions, primarily by decreasing exposure to causative occupational ergonomic factors and smoking. These results can serve as a baseline for relevant policies and follow-up studies.

In conclusion, our results provided strong evidence that ASYRs and the risk of LBP attributable to all estimated risk factors in China have been declining over the past three decades, with different changing patterns for different associated risk factors. This suggested that effective strategies for LBP prevention should be strictly implemented in China, particularly in the senior population, which is of crucial translational potential.

The use of AI and AI-assisted technologies in scientific writing

We declare no AI or AI-assisted technology was used.

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Data sharing statement

Data used for the analyses in our study are publicly accessible from http://ghdx.healthdata.org/gbd-results-tool.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jot.2024.02.006.

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