BMJ Open

Global burden of musculoskeletal disorders and attributable factors in 204 countries and territories: a secondary analysis of the Global Burden of Disease 2019 study

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ABSTRACT

Objective To evaluate the global burden of musculoskeletal (MSK) disorders, as well as the five common conditions, and their relevant risk factors from 1990 to 2019.

Design Data from the Global Burden of Disease Study 2019 were used in this study.

Setting and participants Individuals of all ages and genders from 204 countries and territories in 21 regions.

Main outcome measures The outcomes were the numbers and age-standardised rates (ASRs) of incident cases, deaths and disability-adjusted life-years (DALYs) of MSK disorders. The average annual percent changes (AAPCs) in the ASRs were calculated using joinpoint regression analysis to estimate the trends.

Results There were 322.75 million incident cases, 117.54 thousand deaths and 150.08 million DALYs of MSK disorders in 2019. The age-standardised incidence rate and age-standardised DALY rate in 2019 (incidence: AAPC=−0.32, 95% CI −0.34 to −0.31; DALYs: AAPC=−0.05, 95% CI −0.06 to −0.04) were lower than those in 1990. However, the age-standardised death rate showed a stable trend (AAPC 0.05, 95% CI −0.05 to 0.15) from 1990 to 2019. The peak age of onset and DALYs of MSK disorders was 50–54 years in 2019. The burden of MSK disorders in females was much higher than that in males (1.29 times more incident cases, 2.24 times more deaths and 1.45 times more DALYs in females than in males). A significant negative correlation was observed between the AAPCs in the ASRs and the Sociodemographic Index (SDI) score. Occupational risk exhibited the highest contribution to MSK disorders, and tobacco use and high body mass index were also major risk factors.

Conclusions This study demonstrates that the burden of MSK disorders tends to be lower in high-SDI regions than in lower-SDI regions. Strengthening the effectiveness of preventive measures against occupational risks may reduce the burden of MSK disorders.

INTRODUCTION

Musculoskeletal (MSK) disorder is defined as any type of discomfort to irreversible and disabling injury affecting the motor organs, muscles, tendons, bones, cartilage, ligaments and nerves.[1] There are five common conditions, including rheumatoid arthritis (RA),[2] osteoarthritis (OA),[3] low-back pain (LBP),[4] neck pain (NP)[5 6] and gout,[7] and the rest are combined into a category titled 'other MSK disorders'. In 2017, MSK disorders ranked fifth among all diseases in disability-adjusted life-years (DALYs) and ranked first in years lost due to disability globally.[8] MSK disorders are common in adolescents to the elderly,[9–11] but it is also one of the largest factors leading to the need for rehabilitation services among children.[12] MSK disorders also often lead to psychological problems, along with pain and negative effects on mood, forming a vicious cycle.[13] Previous evidence demonstrates that people with MSK disorders are twice as likely to have other systemic chronic diseases than

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study provided a comprehensive estimate of the global burden of musculoskeletal (MSK) disorders and analysed the influence of geographical location, Sociodemographic Index (SDI), age and sex on the trends of the burden. The risk factors for MSK disorders and the five conditions were also analysed.

⇒ We used joinpoint regression model to calculate the average annual percent changes, which allowed us to rigorously characterise the epidemiological trends of MSK disorders by connecting linear line segments on a log scale.

⇒ This study was unable to detect the differences in the health progress of MSK disorders, even between countries with similar SDI values.

⇒ Some other conditions not included in the five conditions of MSK disorders were classified as 'other MSK disorders' and were not evaluated separately.

⇒ This study was a secondary analysis of the of the Global Burden of Disease Study 2019, which has its own limitations.

those without MSK disorders.[14] Therefore, good MSK health is necessary for personal functional, economic and social independence throughout one's life course.

To date, MSK disorders have received little attention by researchers, as they are rarely fatal, and it is assumed that they are irreversible.[15] However, the global burden of MSK disorders has continued to increase in recent years, mainly due to the serious population growth and ageing population.[11 16 17] Over the past few decades, the burden of MSK disorders has varied greatly among different countries.[11 15] The Sociodemographic Index (SDI) is known to be highly correlated with socioeconomic development and human health.[18 19] It is measured by the per capita income, average years of schooling for the population over the aged of 15 years, and total fertility rate in those younger than 25 years of age to represent the comprehensive development status of the country, and it is assessed a score ranging between 0 and 1. Previous studies demonstrated a decreasing trend in the age-standardised incidence rate (ASIR) of MSK disorders in high-middle-SDI and high-SDI regions,[15 20] but the age-standardised DALY rate increased as the SDI increased.[11 21]

Previous studies suggest that heavy physical labour and an awkward work posture increase the risk of MSK disorders. Particularly, an awkward work posture is a common cause of NP and LBP.[19 22] Smoking and high body mass index (BMI) are also positively associated with the occurrence and prognosis of MSK disorders.[9 10] For example, several dose–response meta-analyses demonstrated that the risk of developing RA was significantly increased among smokers, even among those with a low lifelong exposure,[23] and high BMI increased the risks of gout[24] and knee OA.[25] Other risk factors, such as psychosocial issues, poor diet, sedentary lifestyle and others, can also affect and exacerbate the progression of MSK disorders.[1 22]

Understanding the trends of the disease burden and associated risk factors can help to better characterise and prevent MSK disorders. This study is the first to use data from the Global Burden of Disease Study 2019 (GBD 2019) to examine the global patterns and trends of MSK disorders from 1990 to 2019 in detail, explore the association between the disease burden and SDI, and identify the attributable risk factors for establishing targeted intervention programmes.

METHODS
Overview
The GBD 2019 measured the burden of disease by reporting the incident cases, deaths and DALYs for diseases and injuries in 204 countries or territories from 1990 to 2019. The GBD updates and adds new data and methodological enhancements to the estimation of the entire time series after each change to adjust for bias. The GBD 2019 estimated the incidence, prevalence, mortality, cause-specific mortality and remission rates of various diseases. A Bayesian meta-regression tool, DisMod-MR 2.1, was used as the primary estimation method.[18 26]

Patient and public involvement
The patients and the public were not involved in the design, conduct, reporting or dissemination of our study. The data used in this study are publicly available.

Data
This study focused on analysing the global burden of MSK disorders and the five conditions. Detailed data, including the numbers and age-standardised rates (ASRs) of incident cases, deaths and DALYs by cause, sex, age and location, were downloaded from the Global Health Data Exchange website (http://ghdx.healthdata.org/gbd-results-tool). The DALY is a measure of health, quality of life and years of life lost from disability. The ASRs per 100 000 population were computed by referring to the world standard population.[27] Compared with the incidence and mortality rates, the DALY rate is a better descriptor of noncommunicable chronic diseases due to their consequences of low mortality and high disability rates. In addition, the SDI scores for 204 countries were downloaded for the following correlation analysis. The SDI scores were divided into quintiles, including the high-SDI, high-middle-SDI, middle-SDI, low-middle-SDI and low-SDI quintiles. To explore the age distributions of MSK disorders and the five conditions, we divided the individuals into age groups, including 5–9 years, 10–14 years, …, 90–94 years, 95 years and older, because MSK disorders did not occur in patients aged 0–4 years. Finally, we investigated the risk factors associated with MSK disorders and the trends in the ASRs for the risk factors to assess the contribution of each risk factor and improve the prognosis of MSK disorders.

Statistical analysis
Changes in the temporal trends of the outcomes were estimated using the annual percentage changes (APCs), which were computed by fitting a series of jointed straight lines to the ASR trends. The APC for each of the identified trends was calculated using a regression model of the natural logarithm of the ASR from year to year. The formula is as follows: $y = \alpha + \beta x + \varepsilon$, where y refers to $\ln(ASR)$, x represents the calendar year, and ε is an error term. The APC of each joinpoint was calculated using the formula, $APC = 100 \times (e^{\beta} - 1)$, and the average APC (AAPC) was defined as the geometrically weighted average of all of the APCs derived from the joinpoint trend analysis.[28] The AAPC can use the segmented APC to summarise and compare the rates of change over time and identify long-term trends in the rates of change, even if they are unstable.[29 30] The AAPC and 95% CI were calculated using the Joinpoint Regression Analysis software program (V.4.9.0.0) to establish the join point regression model. If the AAPC and the corresponding 95% CI are greater than 0, the ASR exhibits an increasing trend; when the AAPC and the corresponding 95% CI are less than 0,

the ASR exhibits a descending trend; otherwise, the ASR does not change. We also conducted Pearson correlation analysis between the AAPC and SDI from 1990 to 2019 in which we calculated the p value and R index. A p value of less than 0.05 was considered statistically significant.

RESULTS
Burden of MSK disorders at the global, regional and national levels

Globally, the numbers of incident cases, deaths and DALYs of MSK disorders in 2019 were 322.75 million (95% uncertainty interval (UI): 292.67 to 354.31), 117.54 thousand (95% UI 94.84 to 136.05) and 150.08 million (95% UI 108.78 to 197.82), respectively (table 1). The proportions of incident cases for the five conditions of MSK disorders in 2019 were 67.15% for LBP, 14.28% for NP, 12.46% for OA, 2.77% for gout and 0.32% for RA. LBP (42.44%) exhibited the highest contribution to DALYs, followed by NP (14.71%), OA (12.63%), RA (2.17%) and gout (1.12%). Moreover, RA was the only condition that exhibited fatalities, with 44.41 thousand deaths (95% UI 33.95 to 51.75) attributed to RA globally (online supplemental table S1). The results for OA, LBP, NP and gout are shown in online supplemental tables S2–S5.

The ASIR, age-standardised death rate (ASDR) and age-standardised DALY rate of MSK disorders in 2019 were 3944.53 per 100 000 (95% UI 3580.13 to 4325.84), 1.51 per 100 000 (95% UI 1.21 to 1.74) and 1825.56 per 100 000 (95% UI 1322.52 to 2402.00), respectively (table 1). The ASDR increased by 2.03% from 1990 to 2019, particularly in the low-SDI, low-middle-SDI and middle-SDI regions. In contrast, the ASIR decreased rapidly from 1990 to 2000, but the decreasing trend slowed after 2000. The age-standardised DALY rate decreased by 1.44% from 1990 to 2019. It decreased considerably from 1990 to 1999 but exhibited an increasing trend after 2000. Moreover, the ASIR and age-standardised DALY rate increased in magnitude as the SDI score increased (online supplemental figures S1 and S2). Among the 21 regions analysed in the GBD 2019, the highest ASIR (5321.53 per 100 000, 95% UI 4902.93 to 5808.64) and highest age-standardised DALY rate (3260.82 per 100 000, 95% UI 2374.13 to 4262.54) were observed in the high-income North America (online supplemental table S6).

At the national level, the ASIR and age-standardised DALY rate were correlated with the SDI score (online supplemental figure S3), and the ASRs were higher in regions with a high SDI score than in regions with a low SDI score. The USA had the highest ASIR (5471.08 per 100 000, 95% UI 5043.73 to 5965.44) and highest age-standardised DALY rate (3330.59 per 100,000, 95% UI 2425.68 to 4345.44) of MSK disorders in 2019. Barbados, Bahamas and Honduras had the highest ASDRs in 2019 (figure 1; online supplemental table S7). As for the changes in the ASRs from 1990 to 2019, Zambia exhibited the largest increases in the ASIR and age-standardised DALY rate. China exhibited the most dramatic decrease

in the ASIR, and the age-standardised DALY rate also decreased markedly, ranking third among all other countries. Paraguay and Kazakhstan exhibited the largest increases in the ASDR (online supplemental figure S4). The data on the five conditions of MSK disorders are shown in online supplemental tables S8–S12.

Burden of MSK disorders by age and gender

It is noteworthy that the peak age range of onset of MSK disorders shifted from to 35–39 years in 1990 to 50–54 years in 2019 (figure 2). Similarly, the burden of DALYs reached a peak in the age range of 50–54 years. In 2019, the peak age range of onset of RA, OA and LBP was 50–54 years old, and those of NP and gout were 40–44 years and 65–69 years, respectively. The peak age ranges of DALYs were 65–69 years for RA, 60–64 years for OA, 50–54 years for LBP, 45–49 years for NP and 65–69 years for gout. Moreover, LBP made the largest contribution to the burden of incident cases and the burden of DALYs across all age groups.

The burden of MSK disorders in females was higher than that in males (online supplemental figure S1B,C). The numbers of incident cases, deaths and DALYs were 1.29, 2.24 and 1.45 times higher, respectively, in men than in women. The burden of the five conditions of MSK disorders, except for that of gout, was consistently higher in females than in males (online supplemental figure S5 and tables S1–S5). For RA, the numbers of incident cases, deaths and DALYs were 2.25, 2.21 and 2.33 times higher, respectively, in females than in males. Also, there were gender differences in the burden of NP, as the number of incident cases in females (26.33 million, 95% UI 20.91 to 33.18) was 1.73 times higher than that in males (15.24 million, 95% UI 12.01 to 19.37). The number of incident cases of OA in females (11.56 million, 95% UI 5.85 to 22.23) was 1.56 times higher than that in males (7.39 million, 95% UI 3.72 to 14.68). Although the differences in the numbers of incident cases and DALYs of LBP between males and females were slight (1.35 and 1.37 times higher, respectively), females exhibited a higher number of incident cases than males (females: 128.21 million, 95% UI 113.80 to 144.67; males: 95.25 million, 95% UI 83.91 to 108.43) and a higher number of DALYs than males (females: 36.85 million, 95% UI 26.07 to 49.45; males: 26.84 million, 95% UI 18.90 to 35.92). In contrast, the numbers of incident cases and DALYs of gout were 2.94 and 3.16 times higher, respectively, in men than in females.

AAPCs of MSK disorders at the global and regional levels

At the global level, the AAPCs of the ASIR, ASDR and age-standardised DALY rate of MSK disorders from 1990 to 2019 were −0.32 (95% CI −0.34 to −0.31), 0.05 (95% CI −0.05 to 0.15) and −0.05 (95% CI −0.06 to −0.04), respectively (table 1). In most of the 21 regions, the ASIR and age-standardised DALY rate exhibited minor changes over time. Regarding the ASIR from 1990 to 2019, the most pronounced decrease was observed in

Table 1 The numbers (2019), ASRs per 100 000 (2019), and AAPCs (1990–2019) in incidence, death and DALY for MSK disorders

Characteristic	Incident cases			Deaths			DALYs		
	Numbers (95% UI)	ASIR (95% UI)	AAPC (95% CI)	Numbers (95% UI)	ASDR (95% UI)	AAPC (95% CI)	Numbers (95% UI)	Age-standardised DALY rate (95% UI)	AAPC (95% CI)
Global	322 749 424.63 (292 670 568.79, 354 309 332.15)	3944.53 (3580.13, 4325.84)	−0.32 (−0.34 to −0.31)	117 542.96 (94 835.29, 136 050.64)	1.51 (1.21,1.74)	0.05 (−0.05 to 0.15)	150 075 329.90 (108 781 543.95, 197 816 582.84)	1825.56 (1322.52, 2402.00)	−0.05 (−0.06 to −0.04)
Sex									
Male	140 763 091.79 (127 686 156.44, 154 832 715.80)	3505.66 (3181.04, 3848.53)	−0.32 (−0.34 to −0.31)	36 244.59 (31 727.41, 40 757.22)	1.06 (0.92,1.20)	−0.25 (−0.50 to 0.04)	61 362 430.46 (44 218 699.36, 81 097 415.50)	1526.65 (1100.01, 2016.24)	−0.03 (−0.04 to −0.03)
Female	181 986 332.85 (165 515 515.52, 199 873 406.23)	4368.03 (3972.83, 4797.58)	−0.32 (−0.34 to −0.30)	81 298.37 (58 261.29, 98 495.08)	1.89 (1.35,2.29)	0.22 (0.14 to 0.30)	88 712 899.45 (64 525 853.10, 116 721 253.93)	2110.94 (1536.35, 2777.34)	−0.06 (−0.07 to −0.05)
Sociodemographic Index									
Low	26 283 962.73 (23 613 280.42, 29 157 585.90)	3411.79 (3091.70, 3761.21)	−0.26 (−0.35 to −0.18)	7262.66 (5420.52, 8582.26)	1.58 (1.18,1.89)	0.52 (0.32 to 0.72)	10 779 355.30 (7 775 186.29, 14 278 126.12)	1464.30 (1058.97, 1937.57)	0.08 (0.07 to 0.09)
Low middle	57 265 132.85 (51 693 895.64, 63 358 926.03)	3572.51 (3238.80, 3935.34)	−0.38 (−0.41 to −0.35)	27 198.64 (20 414.54, 31 225.38)	2.28 (1.71,2.63)	0.72 (0.28 to 1.16)	27 108 961.61 (19 650 376.20, 35 551 541.09)	1704.31 (1237.75, 2232.58)	0.04 (0.02 to 0.05)
Middle	101 011 638.08 (91 538 520.61, 111 472 535.18)	3881.80 (3518.38, 4268.04)	−0.44 (−0.56 to −0.31)	30 978.84 (25 993.69, 36 461.55)	1.39 (1.17,1.65)	0.68 (0.52 to 0.86)	45 941 567.94 (33 368 148.34, 60 795 865.22)	1749.36 (1265.84, 2309.99)	0.00 (0.00 to 0.00)
Middle high	72 860 764.95 (66 152 640.10, 80 419 830.65)	4066.51 (3688.66, 4461.78)	−0.36 (−0.38 to −0.34)	20 740.38 (16 724.81, 25 785.59)	1.09 (0.88,1.36)	−0.45 (−0.56 to −0.33)	31 763 021.13 (22 839 125.81, 42 061 479.99)	1729.44 (1250.28, 2289.64)	−0.02 (−0.06 to 0.02)
High	59 601 598.82 (54 856 244.05, 64 910 162.29)	4600.60 (4218.44, 5032.18)	−0.03 (−0.06 to −0.01)	31 301.94 (21 309.60, 40 404.04)	1.59 (1.13,2.12)	−0.47 (−0.57 to −0.38)	34 405 512.83 (24 834 305.56, 45 285 903.56)	2517.69 (1822.75, 3313.58)	0.01 (0 to 0.02)

AAPC, average annual percentage change; ASDR, age-standardised death rate; ASIR, age-standardised incidence rate; ASR, age-standardised rate; DALY, disability-adjusted life-year; MSK, musculoskeletal; UI, uncertainty interval.
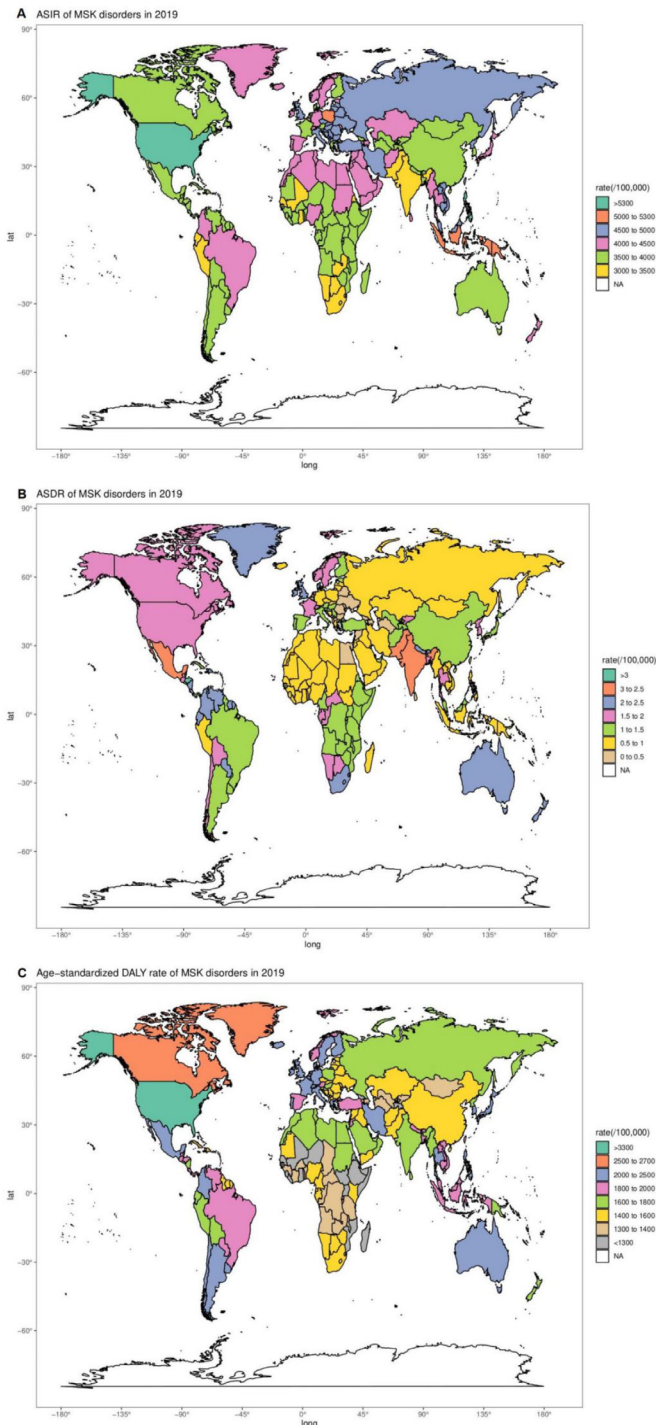
Figure 1 Age-standardised rates (per 100 000 population) in MSK disorders of Worldwide in 2019. (A) Age-standardised incidence rate. (B) Age-standardised death rate. (C) Age-standardised DALY rate. DALY, disability-adjusted life-year; MSK, musculoskeletal; N/A, not applicable.
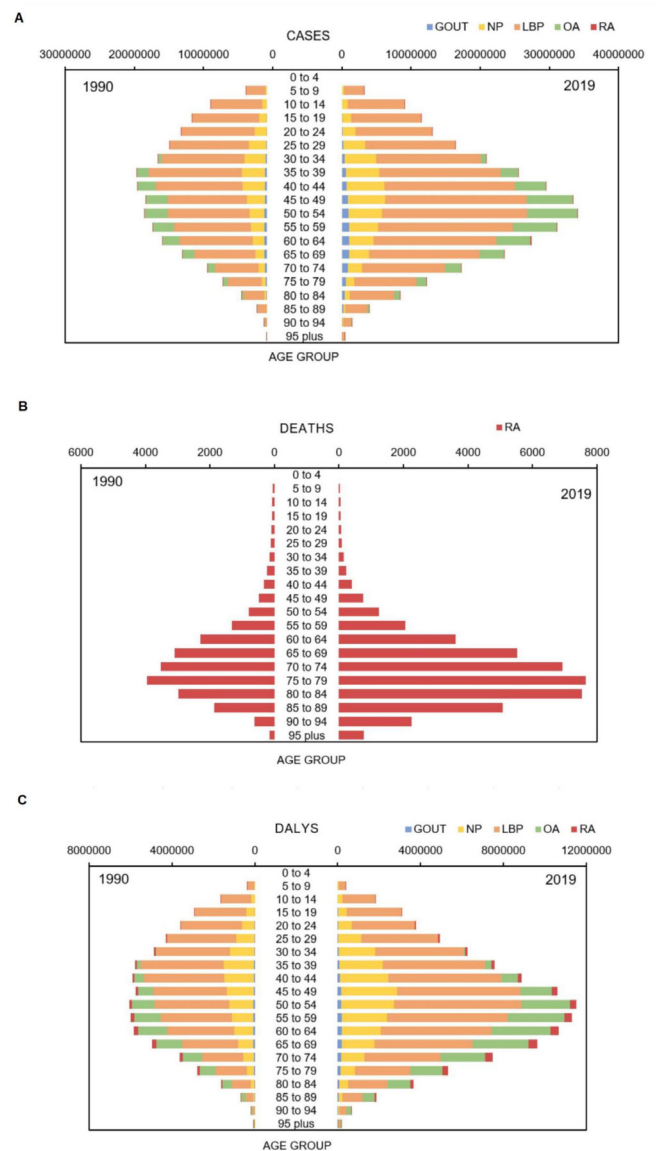

Figure 2 The age distribution of cases due to five common conditions in 1990 and 2019. (A) Incident cases. (B) Deaths. (C) DALYs. DALY, disability-adjusted life-year; NP, neck pain; OA, osteoarthritis; RA, rheumatoid arthritis.

East Asia (AAPC=−0.66, 95% CI −0.69 to −0.62), followed by South Asia (AAPC=−0.53, 95% CI −0.58 to −0.48). The most remarkable increasing trend in the age-standardised DALY rate was detected in Andean Latin America (AAPC=0.25, 95% CI 0.23 to 0.27), and the most remarkable decreasing trend was observed in East Asia

(AAPC=−0.23, 95% CI −0.32 to −0.13) (online supplemental figure S6 and table S6).

For the five conditions of MSK disorders, it was obvious that the ASRs presented different temporal trends, as the global AAPCs in the ASIR of RA, OA, LBP, NP and gout were 0.21 (95% CI 0.18 to 0.21), 0.13 (95% CI 0.11 to 0.15), −0.49 (95% CI −0.52 to −0,46), −0.02 (95% CI −0.02 to −0.01) and 0.58 (95% CI 0.51 to 0.66), respectively (online supplemental tables S1–S5). The AAPCs in the age-standardised DALY rate varied greatly among the five conditions, with the most pronounced decrease being observed for LBP (AAPC=−0.61, 95% CI −0.65 to −0.57) and the most pronounced increase being observed for gout (AAPC=0.71, 95% CI 0.61 to 0.80) (online supplemental tables S3 and S5).

Among the five conditions of MSK disorders, the AAPCs differed across different regions (online supplemental tables S1–S5). As for the AAPCs of the ASIR, Andean Latin America was the fastest-growing region for RA (AAPC=1.35, 95% CI 1.33 to 1.37) and OA (AAPC=0.34, 95% CI 0.33 to 0.36) and high-income North America was the fastest increasing region for gout (AAPC=1.55, 95% CI 1.38 to 1.71). Tropical Latin America had the fastest decreasing AAPC in the LBP (AAPC=−1.11, 95% CI −1.18 to −1.05), and Australasia had the fastest decreasing AAPC in the NP (AAPC=−0.138, 95% CI −0.141 to −0.136). With respect to the age-standardised DALY rate, LBP exhibited a decreasing trend in most regions, with the greatest decline in East Asia (AAPC=−1.15, 95% CI −1.22 to −1.09). The increase in the age-standardised DALY rate of gout was particularly dramatic in High-income North America (AAPC=2.03, 95% CI 1.94 to 2.13).

Correlation between the AAPCs and SDI score

The relationship between the AAPCs in the ASRs of MSK disorders and the SDI score for 204 countries is shown in figure 3. A negative correlation was observed between the AAPC in the ASIR and the SDI score (R=−0.14, p=0.043). Generally, the AAPC in the ASDR was negatively correlated with the SDI score (R=−0.22, p=0.0017). The correlation curve demonstrated that the AAPC in the ASDR increased and decreased when the SDI score was less than 0.5 and greater than 0.65, respectively. The AAPC in the age-standardised DALY rate was negatively correlated with the SDI score (R=−0.21, p=0.0023). More specifically, the AAPC increased as the SDI score increased when SDI score was less than 0.5, and it then stabilised at a higher level when the SDI score was between 0.5 and 0.75 and gradually decreased to a negative value when the SDI score exceeded 0.75.

Risk factors for MSK disorders in 2019

In 2019, occupational risks, tobacco use and high BMI were the main contributors to DALYs of MSK disorders, accounting for 15.31 million DALYs (95% UI 10.54 to 20.76), 10.29 million DALYs (95% UI 6.60 to 14.39) and 7.44 million DALYs (95% UI 3.83 to 12.53) in global, respectively. Kidney dysfunction also contributed to the DALYs, but it had a relatively small effect (0.23 million, 95% UI 0.14 to 0.33) (online supplemental table S13). These four risk factors explained approximately 22.16% of DALYs of MSK disorders globally.

Occupational risks had the greatest influence on DALYs in middle-SDI regions (4.85 million, 95% UI 3.33 to 6.61) and low-middle-SDI regions (3.32 million, 95% UI 2.29 to 4.51), especially in Asian countries. At the regional level, occupational risks had the highest contribution to DALYs in East Asia (2.98 million, 95% UI 2.07 to 4.12), South Asia (2.55 million, 95% UI 1.76 to 3.48) and Southeast Asia (2.04 million, 95% UI 1.39 to 2.77) (figure 4; online supplemental table S13). However, tobacco use had the highest contribution to DALYs in high-SDI regions (3.27 million, 95% UI 2.08 to 4.61) and high-middle-SDI regions
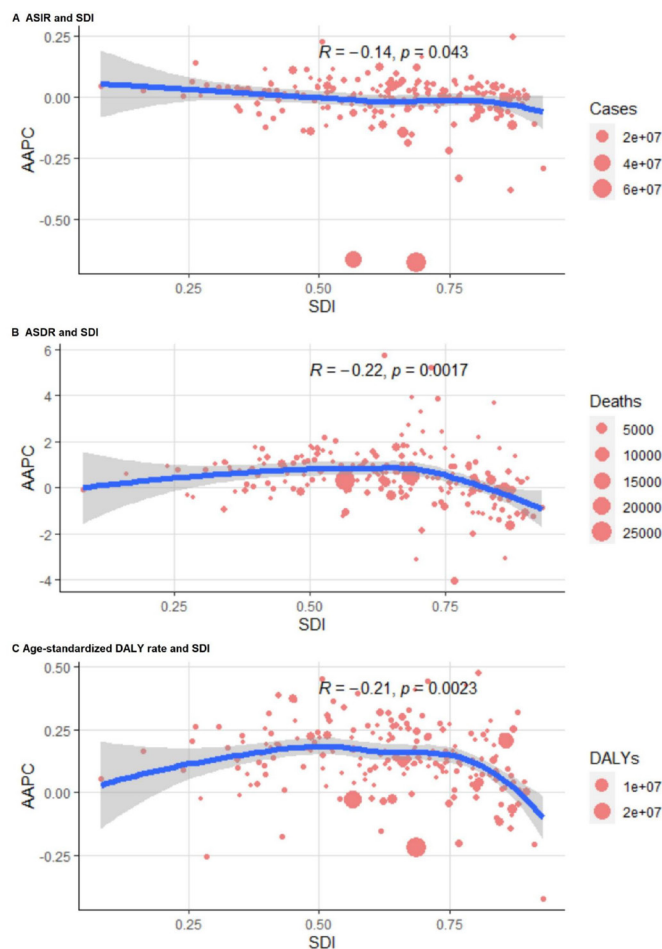

Figure 3 The correlation of AAPCs in ASR with SDI value in 204 countries in 2019. (A) ASIR. (B) ASDR. (C) Age-standardised DALY rate. The size of circle indicates the number of cases and one circle represents a specific country. The R indices and p values presented were derived from Pearson correlation analysis. AAPC, average annual percentage change; ASDR, age-standardised death rate; ASIR, age-standardised incidence rate; ASR, age-standardised rate; DALY, disability-adjusted life-year; SDI, Sociodemographic Index.

(2.88 million, 95% UI 1.88 to 4.03) (online supplemental table S13). In regional level, tobacco use had a great contribution to DALYs in East Asia (1.92 million, 95% UI 1.24 to 2.72; online supplemental table S13). Notably, in Western Europe, high-income North America, Eastern Europe, Central Asia and high-income Asia Pacific, DALYs attributed to tobacco use were greater than those attributed to occupational risks (figure 4). In addition, in the middle-SDI, high-middle-SDI and high-SDI regions, the contribution of a high BMI to DALYs was not significantly different but was much higher than that in the low-SDI regions. East Asia (1.18 million, 95% UI 0.45 to 2.35) and high-income North America (1.17 million, 95% UI 0.66 to 1.84) exhibited the highest DALYs from a high BMI (online supplemental table S13).

The temporal trends in MSK disorders attributable to risk factors from 1990 to 2019 are shown in figure 4. A linear increase in the age-standardised DALY rate of
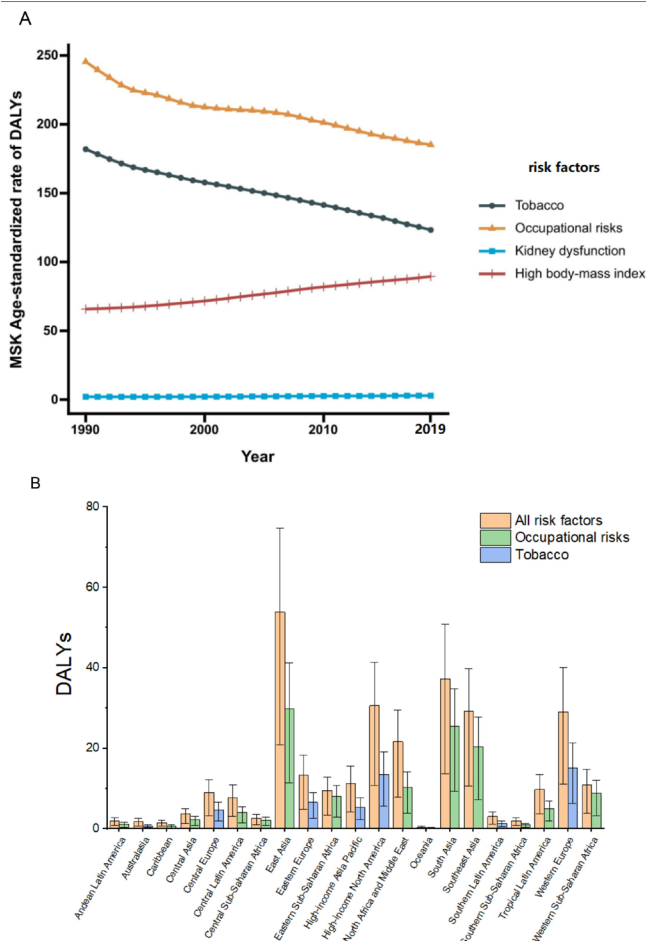
Figure 4 (A) The age-standardised DALY rate (per 100 000 population) for MSK disorders attributable to risk factors from 1990 to 2019. (B) The MSK disorders DALYs attributable to risk factors in 21 regions in 2019; Only the overall DALYs and the most pronounced one attributable to specific risk factors were presented. DALY, disability-adjusted life-year; MSK, musculoskeletal.

MSK disorders between 1990 and 2019 associated with high BMI was observed. Although the age-standardised DALY rates caused by occupational risks and tobacco use were the highest, the age-standardised DALY rate declined during the 30-year study period. The contribution of kidney dysfunction to the age-standardised DALY rate remained stable. In the five conditions of MSK disorders, the age-standardised DALY rates attributable to risk factors were similar to those of MSK disorders. The age-standardised DALY rates for conditions with high BMI as a major risk factor, such as OA and LBP, exhibited an increasing trend (online supplemental figure S7).

DISCUSSION
Summary of the global burden of MSK disorders
In the current study, we analysed the trend of the disease burden of MSK disorders, along with their five conditions at the global, regional and national levels. In general, MSK disorders are serious and have a high burden.

The numbers of incident cases, deaths and DALYs of MSK disorders increased by 59.86%, 116.02% and 77.39%, respectively, from 1990 to 2019. Similarly, an increasing trend has been demonstrated in previous reports analysing the GBD 2017.[11 15] Moreover, the AAPC in the ASIR and age-standardised DALY rate decreased significantly, and that in the ASDR increased slightly from 1990 to 2019. The influence of sex on global trends showed that the peak age of onset of MSK disorders shifted from 35–39 years in 1990 to 50–54 years in 2019, and the highest number of deaths also shifted to the population over 70 years of age. Compared with the reports on the GBD 2017, the peak age of onset also shifted to elder age ranges.[15] This can be explained by population growth and ageing. According to United Nations statistics, the global population increased by 47.54% from 5.28 billion in 1990 to 7.79 billion in the last census.[31] With the improvement of living standards, medical and health conditions, as well as the increase of health awareness and rate of medical visits,[11 15 32] the global life expectancy had increased from 65.4 years (95% UI 65.0 to 65.8) in 1990 to 73.5 years (95% UI 72.8 to 74.3) in 2019.[33] In 2019, there were 1 billion people aged 60 years or older in the world.[34] The number and proportion of the global population aged 60 years or older are both increasing. Ageing growth is occurring at an unprecedented rate and will accelerate in the coming decades.[34]

Sex differences in MSK disorders burden
There are gender differences in the global cases and ASRs of MSK disorders because the values are significantly larger in females than in males at all ages. After stratification by subtype, the burden of RA, OA, LBP and NP was consistently higher in females than in males for MSK disorders, except for gout, which was also mentioned in previous reports on MSK disorders and its main subtypes.[2 3 10 35–37] Current research suggests that sex disparity in the burden of MSK disorders may be due to genetic, hormonal, environmental and social factors, such as ligament relaxation, oestrogen, progesterone, exercise and work posture.[38 39] In particular, pregnancy and menopausal events have a great impact on the development and prognosis of MSK disorders in females.[40]

SDI value and MSK disorders burden
It is worth noting that ASIR and age-standardised DALY rates were significantly associated with the SDI values in 2019. Unexpectedly, the ASIR and age-standardised DALY rates increased with an increase in SDI. Considering that population ageing may be a critical driver of the burden of MSK disorders, the fact that the ageing phenomenon is more severe in higher SDI regions may account for the situation.[17] In addition, we found that tobacco use contributed more to DALYs in high SDI regions and high-middle regions. Study have shown that regions with a higher SDI have a higher prevalence of daily smoking and higher dependence on marijuana, opioids and cocaine.[41] And industrial development will also increase

the burden to a certain extent. People in industrialised countries are more likely to engage in related exposure occupations.[42] However, there was a significant decrease in AAPCs of ASDR and DALY rates in high SDI regions, indicating that these countries are also actively dealing with this problem. With the improvement in the level of national economic development, bringing greater living and health conditions to the general population and health awareness in the community.[43–45] Uruguay and Switzerland had the lowest AAPC of ASDR and AAPC of DALY, respectively. Thus, their policies deserve further study and can be used as references.

Risk factors for MSK disorders

Research on the risk factors related to MSK disorders is helpful in taking active measures and formulating relevant policies to alleviate the burden of MSK disorders. Occupation risk contributed the most to MSK disorders, especially LBP. It has been suggested that large postural changes, prolonged static postures and high-intensity dynamic exercise can increase spinal load and spinal contraction, leading to local changes in biomechanics, physiology and neurological function, which may promote the occurrence of LBP.[46] Tobacco use is the second major risk factor for premature disability and death globally,[47] and the relative ranking of tobacco-attributable disease burden as measured by DALYs has moved to second.[48] For MSK disorders, tobacco use is the main contributor to the DALYs of LBP and RA. In view of biological mechanisms, smoking may have an influence on LBP and RA through oxidative stress, systemic proinflammatory state formation, autoantibody formation, epigenetic changes and synovial hyperplasia.[49] Fortunately, as the results indicated, the age-standardised DALY rate caused by occupation risks and tobacco use declined from 1990 to 2019. However, the contribution of high BMI to OA, LBP and gout continues to increase. The global obesity epidemic is poorly controlled, especially in regions with low-SDI, with a significant increase in the number of deaths and DALYs caused by high BMI.[44 50] Our study found that in regions with high SDI, high BMI contributed the most to DALYs in high-income North America, second only to East Asia among the 21 regions. According to previous studies, the age-standardised DALY rate associated with high BMI showed a downward trend in regions with high SDI, but the burden caused by obesity was particularly severe in high-income North America, and no downward trend was found.[44] This suggests that interventions to control BMI are necessary in high-income North America. In addition, kidney dysfunction is a particularly important risk factor for gout, kidney dysfunction impedes urate excretion and uric acid deposition in articular and non-articular structures to form the tophus is the most important cause of gout.[51 52] Similarly, there was a net increase in the number of DALYs for kidney dysfunction in regions with all SDI quartiles between 1990 and 2017.[53] This also highlights the need for health education interventions that can target common causes such as diet, alcohol consumption,

physical inactivity and obesity.[54] Control of these risk factors can not only reduce the burden of gout, but also address the reduction of all-cause mortality.[55]

Study strength

This study has several advantages. First, we used the latest data from the GBD 2019, which improved the method and model of data correction compared with previous studies. Second, we provided a comprehensive estimate of the global burden of MSK disorders and analysed the influence of geographical location, SDI, age and sex on the trends of disease burden. In addition, we focused on time trends which were evaluated by AAPCs using join-point regression model. The AAPCs consider the shift in rates over time, which can provide a better summary and comparison of annual percentage trends. Furthermore, we analysed the risk factors for MSK disorders and their five common conditions.

Study limitation

Our study had several limitations. First, it was a secondary data analysis of the GBD 2019. Thus, the accuracy of the results depends largely on the quality and quantity of available data, even though the results of this study cannot be verified externally.[12 18] Second, health progress varies widely, even between countries with similar SDI. However, we were unable to take this into account in the current study because of the lack of data on the impact of different health systems in various countries or regions. Third, some other conditions of MSK disorders were classified as 'other MSK disorders' and were not evaluated separately.

Conclusion

In this study, the number of incident cases, deaths, DALYs and ASDR increased globally, signifying an increasing global burden of MSK disorders between 1990 and 2019. LBP was the common condition in incident cases and DALYs, and RA was the main cause of death. ASIR and age-standardised DALY rate decreased globally, and the AAPC of ASRs was negatively correlated with SDI, indicating that the burden was reduced in higher SDI regions. Reducing occupational risks, limiting tobacco use and lowering BMI can help control the burden of MSK disorders.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Ethical approval was not obtained because the data included in this study were publicly available and deidentified data.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information. Data are available in a public, open access repository. The datasets analysed during the current study are available in the http://ghdx.healthdata.org/gbd-results-tool.

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