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Original Article

Epidemiological trends and characteristics of osteoarthritis in China during 1990–2021

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ABSTRACT

Background: This study aimed to comprehensively analyze the incidence, prevalence, and disability-adjusted life years (DALYs) of osteoarthritis (OA) in China from 1990 to 2021 by age, sex, joint sites, high body mass index (BMI) and sociodemographic index (SDI).
Methods: Data and methodologies from the Global Burden of Diseases (GBD) Study 2021 were obtained to evaluate the burden of OA in China. This assessment was conducted by estimating the number of incident cases, prevalent cases, DALYs, and corresponding age-standardized rates (ASRs). The estimated annual percentage change was employed to delineate the trends over time.
Results: In China, the number of OA incidence cases, prevalence cases, and DALYs increased to 11.65 million, 152.85 million and 5.33 million in 2021, respectively, exhibiting a consistent upward trend over the years. The ASRs of OA incidence, prevalence, and DALYs rose 13.86 %, 14.34 %, and 16.23 % from 1990 to 2021, respectively, with knee OA most affected. In 2021, OA incidence, prevalence, and DALYs were higher in women than in men, and increased with age for both sexes, peaking at ages 50–54 for incidence and 55–59 for prevalence and DALYs. DALYs of OA attributed to high BMI increased rapidly, and high BMI contributed to 21.64 % of the total age-standardized DALYs rate of OA in China. Positive correlations were observed between ASRs and China's SDI from 1990 to 2021.
Conclusion: OA constitutes a significant public health challenge in China, with a persistently high disease burden. There is a pressing need to enhance public understanding of the risk factors associated with OA and to promote preventive strategies to mitigate the future burden of this disorder.
The translational potential of this article China has the largest elderly population and the highest prevalence of OA globally. Updating and analyzing epidemiological data of OA in China will offer the public, healthcare professionals, and policymakers the most current, comprehensive, and comparable information, which holds significant translational potential.

1. Introduction

Osteoarthritis (OA), a widespread musculoskeletal disorder globally, predominantly affects individuals in the middle-aged and elderly [1]. During the onset of OA, affected individuals commonly exhibit symptoms of pain and reduced mobility in joints, such as the knees, hips, and hands. As the disease progresses, individuals with more severe forms may eventually experience a decline in joint function or develop disability after several years [2,3]. OA also significantly contributes to healthcare costs, which accounted for an estimated $80 billion in health care spending in the United States in 2016 [4]. With global population aging and increasing obesity rates, the prevalence of OA has risen substantially, leading to a marked growth in the number of affected individuals and years lived with disability (YLDs) [5]. From 1990 to 2020,

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there was a 9.5 % escalation in the global age-standardized rate of YLDs for osteoarthritis, rising from 233.0 to 255.0 YLDs per 100000 [6]. Given OA as a chronic and progressive condition characterized by irreversible structural alterations, the importance of early and proactive intervention cannot be overstated. Nonetheless, the absence of well-established diagnostic criteria for early-stage OA, coupled with limited evidence supporting the efficacy of non-surgical interventions, pose significant barriers to the implementation of effective management and preventative strategies for the disease. Consequently, it is imperative that the general public, healthcare professionals, and policymakers, particularly in countries with a large population base and severe aging issues, should recognize the substantial burden imposed by OA.

In 2019, China was estimated to be the country with the highest prevalence of cases of OA, with India and the United States ranking second and third, respectively [7]. In China, the population aged 60 and above reached 264.02 million, constituting 18.70 % of the total population, and the number of individuals aged 65 and above stood at 190.64 million, accounting for 13.50 % of the total population, according to the seventh national census conducted in China in 2020 [8]. However, the proportion of elderly individuals aged 65 and above was only 7 % in 2000, implying that China nearly doubled the share of its older adults aged more than 65 in 20 years [9]. Simultaneously, over the past four decades, China has witnessed a marked increase in the prevalence of overweight and obesity, alongside with the country's rapid economic expansion, increasing globalization, and urbanization [10]. These trends, combined with China's aging population and substantial population size, are anticipated to intensify the healthcare and economic challenges posed by OA in the near future. Therefore, a timely update of the epidemiological data is essential for researchers and healthcare policy makers to make effective public health strategies and policy interventions for OA. In this study, we conducted a systematic analysis of the modeled incidence, prevalence, and disability-adjusted life years (DALYs) of OA in China, utilizing the publicly available data from the Global Burden of Disease (GBD) Study 2021 [11]. Our analysis was stratified by age, sex, and Socio-demographic Index (SDI) to provide the most current, comprehensive, and comparable insights into the burden of OA in China. The results of our analysis can enhance our understanding of OA, assess existing prevention strategies, facilitate the planning for nationwide management of OA-related burdens, and contribute to the improvement of health management systems in anticipation of future challenges.

2. Materials and methods

2.1. Overview

The GBD Study 2021, led by the Institute for Health Metrics and Evaluation (IHME), represents the most extensive and systematic efforts to evaluate the global impact of diseases, injuries, and risk factors on public health. This study synthesized data through comprehensive systematic reviews of epidemiological studies, searches of published reports, analysis of international organization and government databases, and inputs from a global network of GBD collaborators. All data sources underwent rigorous risk-of-bias assessments and were adjusted using DisMod-MR 2.1 to ensure consistency and reliability in the estimates. Data collected using diverse diagnostic criteria, including self-reporting and ICD coding in insurance claims, underwent adjustments to account for systematic bias. This process is known as crosswalking. To estimate adjustment factors, studies were matched based on location, gender, and age. Subsequently, a trimmed constrained mixed effects model was employed to conduct a meta-analysis, examining the logit difference between the prevalence reported by alternative definitions and that reported by the reference definition [6]. For OA, primary data inputs for estimating incidence, prevalence, and DALYs were drawn from population-based studies and registries. Specific data sources used to assess the burden of OA in China from 1990 to 2021 can be found in the GBD Study 2021 Input Sources Tool [11].

2.2. Definition and data collection

Data on the incidence, prevalence, and DALYs associated with osteoarthritis (OA) in China were obtained through the Global Health Data Exchange (GHDx) query tool [6,11]. This information was disaggregated by age (in five-year intervals), sex (male and female), and anatomical site affected (knee, hip, hand, and other OA). In the GBD Study 2021, the prior settings included setting remission and excess mortality due to OA to zero and assuming no incidence or prevalence of OA before the age of 30. Data sources for estimating the incidence, prevalence, and DALYs of OA included scientific literature, household survey data, epidemiological surveillance data, disease registry data, clinical informatics data, and other sources. Only a small fraction of these available data appears in published literature, while sources such as survey data, disease registries, notification data, and hospital inpatient data are more predominant [12].

Following the GBD Study 2021 reference criteria, knee and hip OA was categorized as symptomatic conditions that require radiographic confirmation at Kellgren–Lawrence grades 2 to 4. This classification was mirrored for hand OA, where the reference case definition included symptomatic, radiographically confirmed OA affecting any individual hand joint, consistent with the approach taken for hip and knee OA modeling. The category of 'Other OA' encompassed additional sites of OA, such as the elbow and shoulder, but it is important to note that this classification did not include spinal OA. Since OA was not attributed to mortality in the GBD 2021, DALY estimates equated to YLDs. The analysis identified high body mass index (BMI $\geq$25 kg/m^2) as the sole modifiable risk factor contributing to OA. The Socio-demographic Index (SDI), a measure ranging from 0 to 1, reflecting a region's socioeconomic development, is derived from indicators, such as the fertility rate in individuals under 25, per capita income, and educational attainment among those aged 15 and older. Historical SDI data for China from 1990 to 2021 were sourced from the GHDx record on the SDI values for all estimated GBD 2021 locations, 1990–2021.

2.3. Statistical analyses

This study is a secondary analysis of the publicly available GBD 2021 database. For osteoarthritis, prevalence and incidence were modeled using DisMod-MR 2.1, a Bayesian disease modelling meta-regression tool that produces internally consistent estimates of prevalence, incidence, remission, and mortality by sex, location, year, and age group. Prevalence estimates were multiplied by disability weights for mutually exclusive sequelae of diseases and injuries to calculate DALYs [12]. We analyzed the incidence, prevalence, DALYs, and their percentage changes across demographic groups of OA in China from 1990 to 2021. Data were presented as number and age-standardized rates (ASRs) per 100000 population with 95 % uncertainty intervals (UIs). Estimates were based on 1000 model iterations, sampling from distributions rather than single-point values, with UIs determined by the 25th and 975th ranks of ordered results [6,11]. Temporal trends in OA burden were analyzed using ASRs and estimated annual percentage changes (EAPCs), derived through regression of the natural logarithm of ASRs. Positive EAPCs indicated increasing trends, negative values signaled declines, and EAPCs with 95 % confidence intervals (CIs) overlapping zero suggested stability. Meanwhile, we focused on evaluating high BMI as a significant risk factor for OA-related DALYs and its variation across demographics. Pearson's correlation analyses were used to explore relationships between ASRs and the Socio-demographic Index (SDI) for overall OA and joint-specific burdens in China, stratified by sex and high BMI. All analyses were performed using Excel (version 2021), GraphPad (version 6.01), and R software (version 4.2.0), The data used in this study were publicly available through the GHDx query tool at https://vizhub.healthdata.org/gbd-results/. As this research involved secondary analysis of publicly accessible datasets and did not include direct interaction with human or animal subjects, ethical approval was not required.

3. Results

3.1. Disease burden of OA in China

In China, the number of OA incident cases was 11.65 million (95 % UI 10.21–13.11) in 2021, with an age-standardized incidence rate (ASIR) of 554.61 (95 % UI 486.85–619.54) per 100,000 people, and there was a moderate increase of 13.86 % from 1990 to 2021 (Table 1; Supplementary Tables 1–3). Besides, there were 152.85 million (95 % UI 134.66–170.84) prevalent cases of OA in China in 2021, with an age-standardized prevalence rate (ASPR) of 7030.66 (95 % UI 6211.20–7831.69) per 100,000 people, and there was a substantial increase of 14.34 % since 1990 (Table 1; Supplementary Tables 1–3). Moreover, 5.33 million (95 % UI 2.54–10.68) DALYs were caused by OA in China in 2021, with an age-standardized DALYs rate (ASDR) of 244.79 (95 % UI 117.30–491.91), and there was a noticeable increase of 16.23 % between 1990 and 2021 (Table 1; Supplementary Tables 1–3).

3.2. Age and sex patterns of OA in China

Data showed that the numbers of incident cases, prevalent cases, and DALYs of OA were higher in women than in men in all age groups in China in 2021(Supplementary Figs. 1 and 3). The number of incident case increased with age for both sexes and peaked at 50–54 years, and then the decreasing trends were observed up to the oldest age group (Fig. 1; Supplementary Table 6). The numbers of prevalent cases and DALYs also increased with age for both sexes, and stood at the all-age group high at the 55–59 years. Then, they decreased slightly in the 60–64 years, and reached a secondary peak at the 65–69 years before embarking on a steady decline (Figs. 2 and 3; Supplementary Tables 7 and 8). Moreover, results showed that the Chinese ASIR, ASPR, and ASDR were higher in women than in men in all age groups (Supplementary Figs. 2 and 4). The ASIR increased with age for both sexes, and reached the all-age group high at the 50–54 years. Then, it exhibited a fluctuating descent, with two small increases at the 75–79 years and 95+ years (Fig. 1; Supplementary Figs. 3 and 4). The ASPR and ASDR increased with age for both sexes, and the trend started with a sharp increase that tapered off into a slower climb over age (Figs. 2 and 3; Supplementary Figs. 3 and 4).

3.3. Joint sites patterns of OA in China

By anatomic sites, the knee was the leading OA site with the highest numbers of incident cases (8.51 million), prevalent cases (109.58 million), and DALYs (3.55 million) (Figs. 1–3). From 1990 to 2021, the numbers of OA incident cases, prevalent cases, and DALYs at all four anatomic sites increased, by 133.16 %, 166.97 %, and 165.32 % for knee OA, respectively; 196.32 %, 217.94 %, and 213.93 % for hip OA, respectively; 263.39 %, 330.61 %, and 327.54 % for hand OA, respectively; and 143.32 %, 183.06 %, and 180.97 % for OA at other sites, respectively (Figs. 1–3; Supplementary Tables 1–3). The ASIR, ASPR, and ASDR were higher in women than in men with knee OA and hand OA, lower in women than in men with hip OA and other OA (Supplementary Tables 1–3; Supplementary Figs. 1 and 2). EAPCs of ASIR for knee OA, hip OA, hand OA, and OA at other sites were 0.47 (95 % CI 0.37–0.56), 1.03 (95 % CI 0.95–1.12), 1.37 (95 % CI 1.18 to 1.56), and 0.18 (95 % CI 0.17–0.19), respectively. ASPR and ASDR showed the same trends with ASIR for the four anatomic sites. The ASIR, ASPR and ASDR at four anatomic sites differed by sex, with women having the highest EAPC in knee OA, hip OA, and hand OA and men having the highest EAPC in OA at other sites (Supplementary Tables 1–3). The trends of incident cases, prevalent cases, DALYs, and the corresponding ASRs of knee OA, hip OA, and other OA in both sexes showed relatively steady ascent. In hand OA, the incident cases, prevalent cases, DALYs, and the corresponding ASRs in men showed a fluctuating ascent, with a small decrease from 2006 to 2010, while the trends in women were relatively stable (Supplementary Figs. 1 and 2; Supplementary Tables 4 and 5).

3.4. High BMI contributing to OA in China

High BMI emerged as the sole attributable GBD risk factor for OA, which was responsible for 1.16 million (95 % UI -0.11–3.30) DALYs of OA in China in 2021 (Table 2; Supplementary Table 9). After adjusting for differences in the age distribution, high BMI was responsible for 52.98 DALYs per 100,000 people (95 % UI -4.73–150.74) in 2021, representing 21.64 % of the total ASDR of OA (Table 2; Fig. 4). From 1990 to 2021, DALYs of OA attributed to high BMI increased rapidly, with an increase of 469.28 % for knee OA and 552.22 % for hip OA (Table 2; Supplementary Table 10). The ASDR attributed to high BMI also showed increasing trends for knee OA and hip OA, with EAPCs of 2.47 (95 % CI 2.33–2.60) and 2.89 (95 % CI 2.79–3.00), respectively. The average annual increase of ASDR attributed to high BMI was higher in female than in male in knee OA and hip OA (Table 2; Supplementary Figs. 5 and 6). The proportions of ASDR attributable to high BMI from 1990 to 2021 in China increased in both knee OA and hip OA (Fig. 4).

3.5. SDI contributing to OA in China

From 1990 to 2021, the SDI in China increased from 0.459 to 0.722 (Supplementary Table 11). As illustrated in Fig. 5, significant positive correlations between the ASRs (including ASIR, ASPR, ASDR, and ASDR attributed to high BMI) and the SDI of China from 1990 to 2021 were observed in ASIR (r = 0.942, P < 0.0001), ASPR (r = 0.943, P < 0.0001), and ASDR (r = 0.946, P < 0.0001). Meanwhile, positive correlations between the ASRs and the SDI of China from 1990 to 2021 were also observed for different sexes and joint sites (Supplementary Figs. 7–10).

Table 1
The incident cases, prevalent cases, DALYs, and ASRs for OA in 1990 and 2021, and changing trends from 1990 to 2021 in China.

	1990 (95 % UI)		2021 (95 % UI)		Change from 1990 to 2021		
	Cases (no. × 10^5)	ASR (per 100,000)	Cases (no. × 10^5)	ASR (per 100,000)	% change of cases	% change of ASR	EAPC (95 % CI)
Incidence	46.54 (40.75, 52.13)	487.11 (428.13, 543.75)	116.53 (102.08, 131.08)	554.61 (486.85, 619.54)	150.37	13.86	0.58 (0.51, 0.66)
Prevalence	533.53 (466.03, 596.86)	6148.92 (5417.29, 6855.85)	1528.48 (1346.56, 1708.42)	7030.66 (6211.20, 7831.69)	186.49	14.34	0.61 (0.53, 0.69)
DALYs	18.29 (8.80, 36.83)	210.61 (101.91, 423.86)	53.27 (25.42, 106.79)	244.79 (117.30, 491.91)	191.21	16.23	0.67 (0.59, 0.76)

Abbreviations: DALYs, disability-adjusted life years; ASR, age-standardized rate; OA, osteoarthritis; 95 % UI, 95 % uncertainty interval; EAPC, estimated annual percentage change; 95 % CI, 95 % confidence interval.

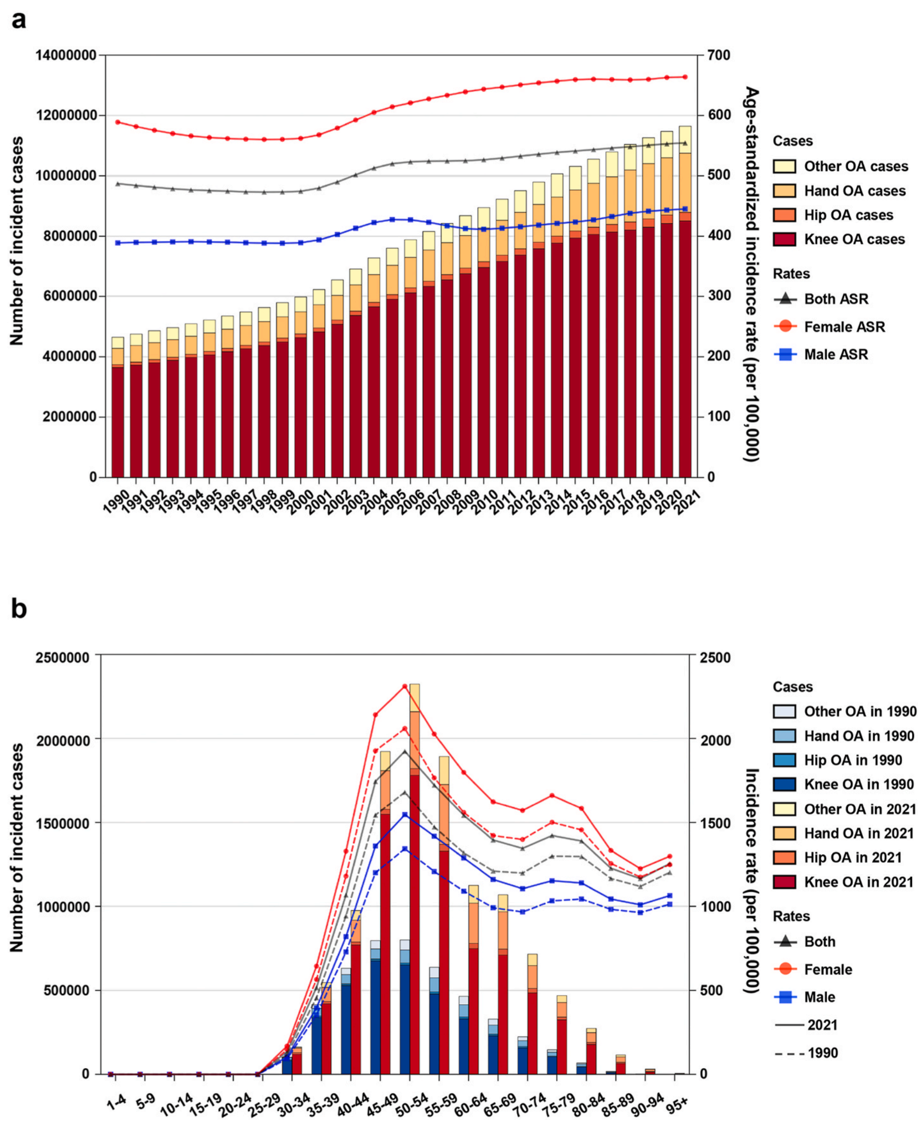

Fig. 1. Incident cases and age-standardized incidence rate (per 100,000) of osteoarthritis (OA) according to different joint sites and genders by time and age group in China. (a) Number of OA incident cases by joint sites (the bar graph with left Y-axis) and age-standardized incidence rate by gender (the line graph with right Y-axis) from 1990 to 2021. The number of OA incident cases was increased to 11.65 million in 2021 from 4.65 million in 1990, with an age-standardized incidence rate (ASIR) of 554.61 per 100,000 people, and there was a moderate increase of 13.86 % from 1990 to 2021. (b) Number of OA incident cases by joint sites (the bar graph with left Y-axis) and age-standardized incidence rate by gender (the line graph with right Y-axis) in 1990 and 2021 according to different age groups. The number of incident case increased with age for both sexes and peaked at 2.33 million in the 50 to 54 age group, and then the decreasing trends were observed up to the oldest age group.

4. Discussion

Utilizing the data and methods from the GBD Study 2021, this study provides the latest, comparable, and comprehensive statistics on the incidence, prevalence, and DALYs for OA in China [11]. In 2021, OA was responsible for 11.65 million incident cases, 152.85 million prevalent cases in China, and resulted in 5.33 million DALYs. Between 1990 and 2021, there was a significant rise in the ASIR, ASPR, and ASDR of OA in China. A systematic study summarized and analyzed publications on OA epidemiology in China from 2000 to 2018 and reported that the prevalence of knee OA in middle-aged and elderly individuals was 21.51 % [13]. Another cross-sectional survey found that the prevalence of knee OA in individuals over 50 years old in Nanjing, China, was 23.64 % [14]. Additionally, the prevalence of knee OA increased with age but slightly declined after a certain threshold, aligning with the OA prevalence trend analyzed in this study. In addition, heavy social and economic costs were incurred in the treatment and management of OA. Although data on the cost of OA in China is limited, it is reported that the direct costs associated with OA constitute 1–2.5 % of the Gross National Product in developed market economies, such as the United States, Australia, Canada, and the United Kingdom [15]. If these data were translated into China's context, the economic burden would undoubtedly be enormous. As evidenced, OA is a prevalent disorder with a heavy burden in China, underscoring the necessity for prioritizing preventative measures, management, and therapeutic interventions for OA within the nation.

As shown in this study, in China, the burden of OA is higher in females than in males in 2021. This gender disparity of OA burden is similar to what was reported in the GBD study 2019 [2,7,16–19]. OA disproportionately affects women compared with men, with a variety of biological, hormonal, and lifestyle factors contributing to the disparity [20,21]. Anatomical and biomechanical differences, such as thinner cartilage and a propensity for certain joint alignments, render women more susceptible to cartilage wear and tear [22]. Numerous joint components, such as synovium, bone, cartilage, and ligaments, have been

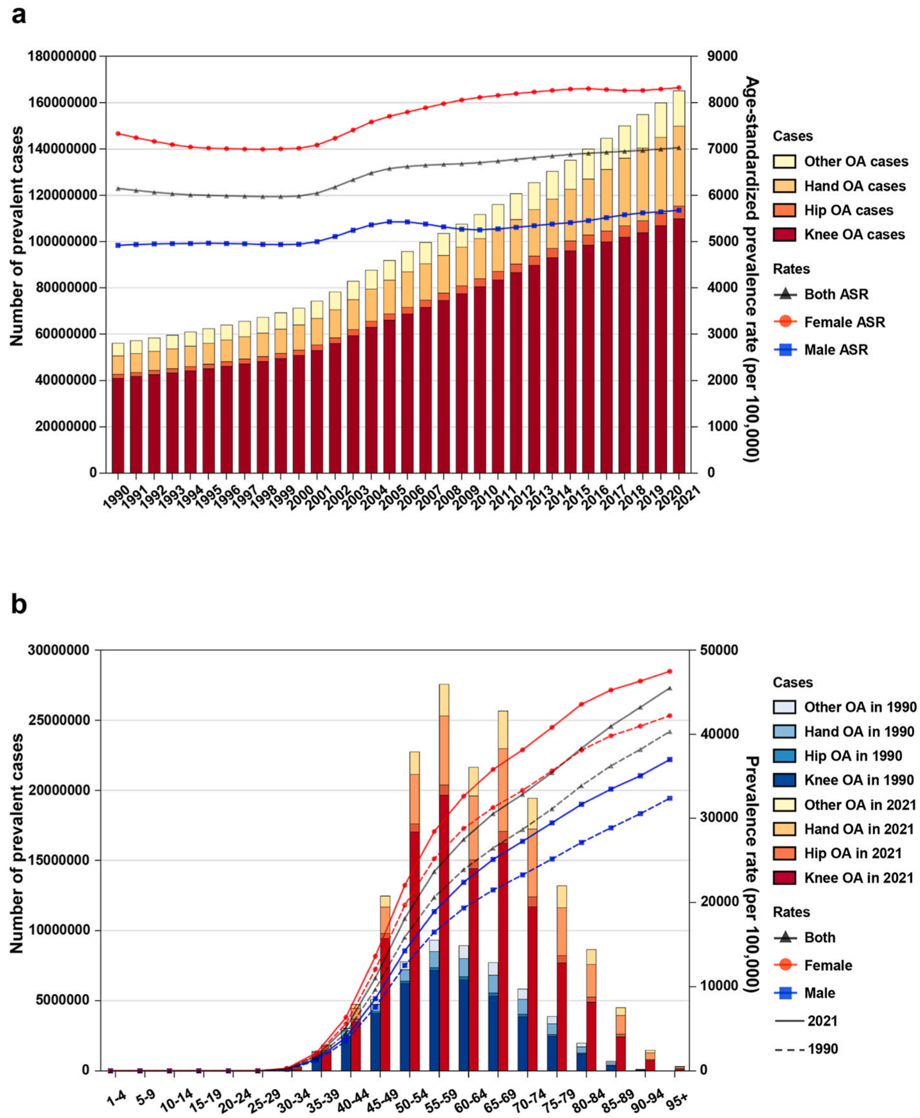

Fig. 2. Prevalent cases and age-standardized prevalence rate (per 100,000) of osteoarthritis (OA) according to different joint sites and genders by time and age group in China. (a) Number of OA prevalent cases by joint sites (the bar graph with left Y-axis) and age-standardized prevalence rate by gender (the line graph with right Y-axis) from 1990 to 2021. The number of OA prevalent cases was increased to 152.85 million in 2021 from 53.35 million in 1990, with an age-standardized prevalence rate (ASPR) of 7033.66 per 100,000 people, and there was a substantial increase of 14.34 % from 1990 to 2021. (b) Number of OA prevalent cases by joint sites (the bar graph with left Y-axis) and age-standardized prevalence rate by gender (the line graph with right Y-axis) in 1990 and 2021 according to different age groups. The number of prevalent cases increased with age for both sexes and peaked at 27.59 million in the 55 to 59 age group, and reached a secondary peak at 25.67 million in the 65 to 69 age group, and then the decreasing trends were observed up to the oldest age group.

found to possess estrogen receptors, indicating that estrogen plays a crucial role in regulating and preserving these tissues. Comparative studies between ovariectomized (OVX) and non-OVX animals reveal that OVX animals exhibit more extensive cartilage erosion, subchondral bone alterations, and increased articular cartilage surface erosion. However, supplementing with estrogen has been shown to ameliorate OA. In human, the substantial decline in estrogen levels following menopause is considered detrimental to cartilage health, intensifying the symptoms of OA [23,24]. Genetic factors may also play a role, with some predispositions potentially being more common in women, although further research is needed to elucidate these genetic influences. Obesity, a well-known risk factor for OA, is more prevalent among women, particularly affecting weight-bearing joints and increasing the mechanical stress on these areas. Women may also have a higher sensitivity to pain as well as different strategies for coping with pain, which can lead to a greater perception of pain severity at similar levels of OA severity in men. Furthermore, women typically have lower muscle strength, which can contribute to increased joint stress and the development of OA [25]. These factors, when considered together, may highlight the importance of understanding the gender-specific aspects of OA and the need for tailored research, prevention, and treatment strategies that address the unique challenges faced by women in managing and preventing this debilitating condition.

The age patterns of OA for Chinese prevalent cases, incidence cases, DALYs and corresponding ASRs in GBD Study 2021 were slightly different from what was reported in GBD Study 2019 [16]. Given the two-year interval between the 2019 and 2021 GBD updates, this difference is unlikely to represent a true change; rather, it is more likely due to the expanded data coverage and improvements in statistical methodologies. The results in this study demonstrated that the number of incident case and ASIR of OA in China increased with age for both sexes and peaked at 50–54 years both in 1990 and 2021. The observed trend suggests that there is a need to focus on the 50–54 age cohort, with a particular emphasis on women in this age group, for early intervention

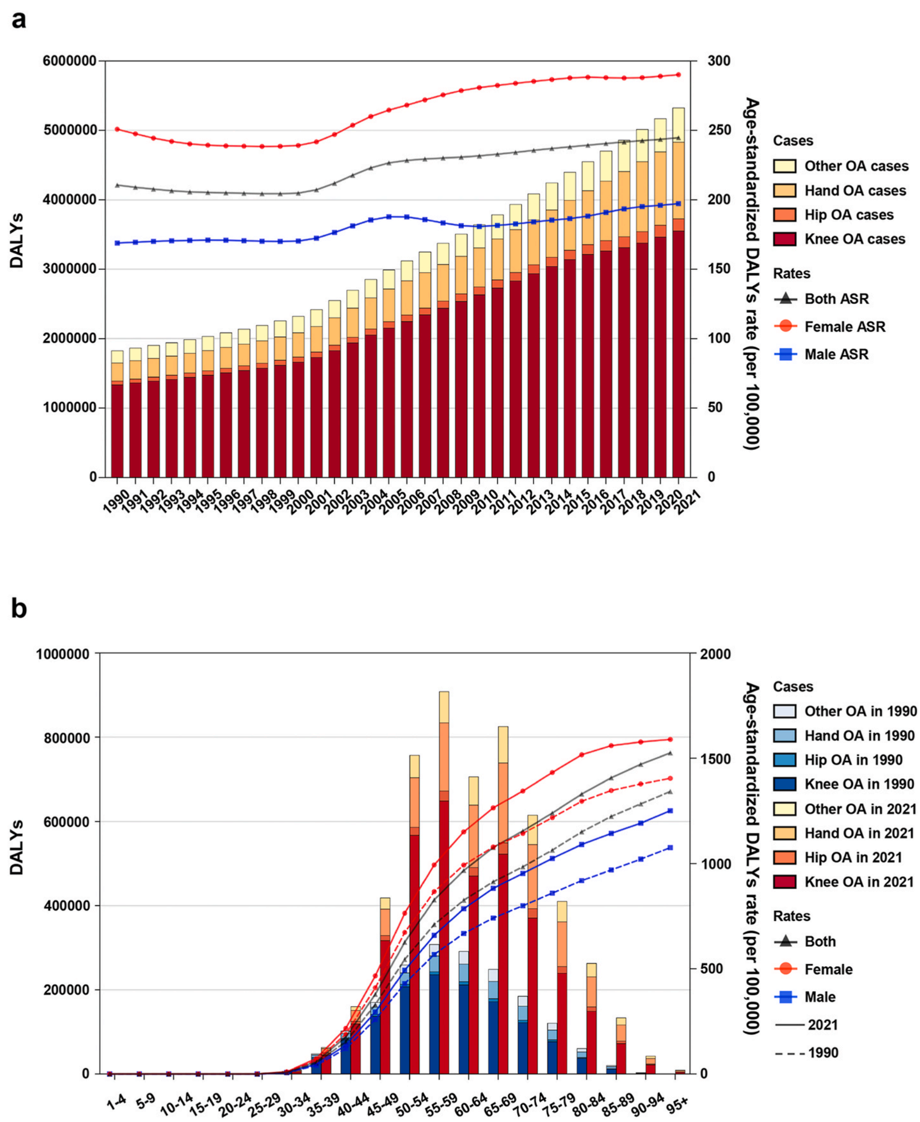

Fig. 3. Disability-adjusted life years (DALYs) and age-standardized DALYs rate (per 100,000) of osteoarthritis (OA) according to different joint sites and genders by time and age group in China. (a) Number of OA DALYs by joint sites (the bar graph with left Y-axis) and age-standardized DALYs rate by gender (the line graph with right Y-axis) from 1990 to 2021. The number of OA DALYs was increased to 5.33 million in 2021 from 1.83 million in 1990, with an age-standardized DALYs rate (ASDR) of 244.79 per 100,000 people, and there was a noticeable increase of 16.23 % from 1990 to 2021. (b) Number of OA DALYs by joint sites (the bar graph with left Y-axis) and age-standardized DALYs rate by gender (the line graph with right Y-axis) in 1990 and 2021 according to different age groups. The number of DALYs increased with age for both sexes and peaked at 0.91 million in the 55 to 59 age group, and reached a secondary peak at 0.83 million in the 65 to 69 age group, and then the decreasing trends were observed up to the oldest age group.

through science-based public education and OA prevention strategies. Such targeted efforts could significantly contribute to alleviating the burden of OA in China. The trends of ASPR and ASDR in 2021 were similar and increased with age for both sexes. Aging stands as a notable risk factor for the onset of OA [26,27]. As individuals age, distinct aging hallmarks emerge within joint tissues, inducing cellular senescence and the senescence-associated secretory phenotype (SASP). These SASP factors, in turn, exacerbate chronic inflammation and facilitate the degradation of joint tissue [28]. Additionally, advancing age is accompanied by a decline in bone mineral density and heightened natural wear and tear on joints. These physiological changes collectively elevate the risk of OA and contribute to the age-related pattern of OA burden [29–31]. The numbers of prevalent cases and DALYs also increased with age for both sexes and reached at the all-age group high at the 55–59 years age group in 2021 in China. However, a secondary peak at the 65–69 years age group was observed before a steady decline, which was not observed in GBD Study 2019. The transition to retirement (common at ages 60–65 in China) may lead to abrupt changes in physical activity patterns, potentially influencing OA risk. In addition, increased healthcare utilization post-retirement, such as routine check-ups and chronic disease management, might improve OA detection. In China, this change suggests that the prevalence of OA among individuals aged 65–69 may exceed previous estimates, underscoring the importance of not overlooking the diagnosis and treatment of this demographic.

In this study, the data showed that the knee remained the most commonly affected joint, followed by the hand, other non-spinal joints, and the hip. The pattern of affected joint sites may be attributed to specific mechanical stress on the knee, as well as occupational and lifestyle factors in China [32]. The knee joint experiences higher mechanical stress due to its role in bearing the weight of the body during activities, such as walking, running, and jumping. This repetitive stress can lead to a higher rate of cartilage degradation and the development of OA. Moreover, activities that involve frequent squatting or kneeling, such as certain occupations or daily activities, are associated with an

Table 2
The number and ASR of DALYs for OA due to a high BMI in 1990 and 2021 and changing trends from 1990 to 2021 in China.

	1990 (95 % UI)		2021 (95 % UI)		Change from 1990 to 2021		
	DALYs (no. x 10^5)	ASDR (per 100,000)	DALYs (no. x 10^5)	ASDR (per 100,000)	% change of DALYs	% change of ASDR	EAPC (95 % CI)
All OA							
Both	246468.73 (−20130.69, 727780.59)	27.43 (−2.22, 81.50)	1164587.77 (−104718.16, 3297087.97)	52.98 (−4.73, 150.74)	472.51	193.13	2.48 (2.35, 2.62)
Male	85733.96 (−7091.46, 252442.45)	18.78 (−1.54, 55.93)	389747.62 (−34134.55, 1114560.90)	36.14 (−3.14, 103.75)	454.60	192.41	2.47 (2.32, 2.61)
Female	160734.77 (−13040.44, 472273.43)	35.96 (−2.90, 105.91)	774840.15 (−70583.61, 2182527.08)	69.20 (−6.28, 195.48)	482.06	192.44	2.47 (2.34, 2.60)
Hip OA							
Both	9591.97 (−696.04, 27354.59)	1.09 (−0.08, 3.06)	52969.04 (−4432.08, 148690.00)	2.49 (−0.21, 6.99)	552.22	228.00	2.89 (2.79, 3.00)
Male	4946.66 (−357.96, 14016.39)	1.14 (−0.08, 3.16)	26776.56 (−2226.08, 75873.18)	2.60 (−0.21, 7.35)	541.31	229.04	2.85 (2.77, 2.94)
Female	4645.31 (−338.08, 13219.75)	1.06 (−0.08, 2.97)	26192.48 (−2206.00, 72816.82)	2.39 (−0.20, 6.64)	563.85	226.37	2.93 (2.80, 3.06)
Knee OA							
Both	236876.75 (−19470.52, 702283.28)	26.34 (−2.15, 78.70)	1111618.73 (−100286.08, 3158801.27)	50.49 (−4.53, 144.23)	469.28	191.68	2.47 (2.33, 2.60)
Male	80787.30 (−6748.52, 239144.16)	17.65 (−1.46, 52.83)	362971.06 (−31908.47, 1043788.55)	33.54 (−2.93, 96.82)	449.29	190.06	2.44 (2.29, 2.59)
Female	156089.46 (−12722.10, 460375.64)	34.90 (−2.83, 103.14)	748647.67 (−68377.61, 2115012.72)	66.80 (−6.08, 189.31)	479.63	191.42	2.46 (2.33, 2.58)

Abbreviations: ASR, age-standardized rate; DALYs, disability-adjusted life years; OA, osteoarthritis; BMI, body mass index; ASDR, age-standardized DALYs rate; 95 % UI, 95 % uncertainty interval; EAPC, estimated annual percentage change; 95 % CI, 95 % confidence interval.

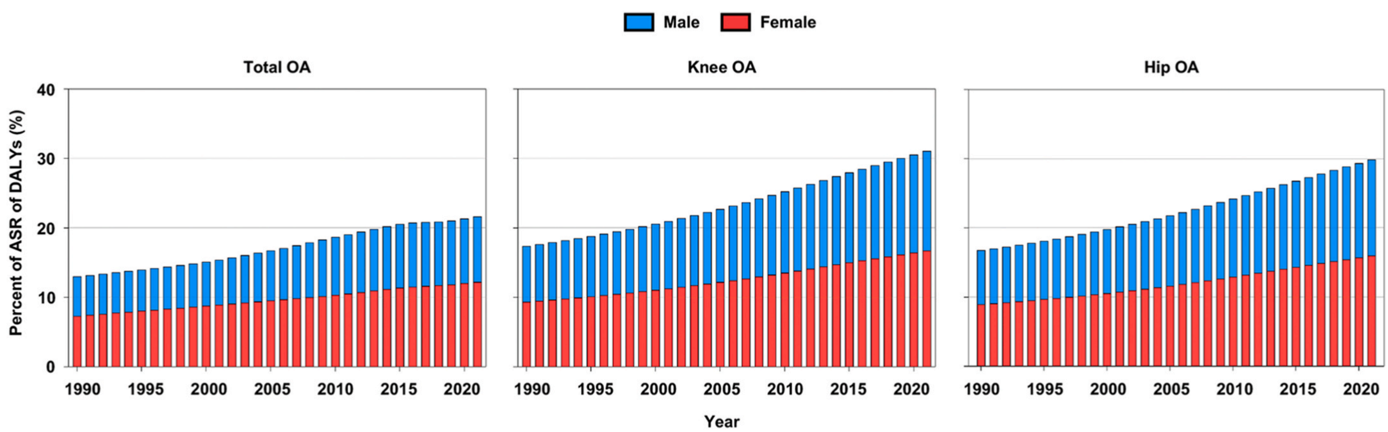

Fig. 4. Proportions of age-standardized rate (ASR) of disability-adjusted life years (DALYs) for osteoarthritis (OA) attributable to a high body mass index (BMI) by gender and joint sites from 1990 to 2021 in China. ASDR attributable to high BMI accounted for 13.02 % of the total ASDR of total OA in 1990 and increased to 21.64 % in 2021. ASDR attributable to high BMI accounted for 17.41 % of the knee ASDR of total OA in 1990 and increased to 31.08 % in 2021. ASDR attributable to high BMI accounted for 16.79 % of the total ASDR of hip OA in 1990 and increased to 29.88 % in 2021.

increased risk of knee OA. Prolonged squatting is a strong risk factor for knee OA, especially among the elderly, obese individuals, and inactive people [26,32,33]. Interestingly, the incidence, prevalence, and DALYs in men showed a small decrease from 2006 to 2010 in hand OA, while the trends in women were relatively stable. The observed pattern may be influenced by the factors previously discussed, such as those related to hormones and lifestyle, highlighting the necessity for a targeted approach towards women in hand OA prevention strategies.

Our analysis highlights high BMI as a critical risk factor contributing to the OA burden, particularly for knee and hip OA. Given the significant increase in obesity rates in China, the future OA burden may be underestimated unless this risk factor is adequately considered [34,35]. Effective weight management is therefore essential for preventing OA onset and mitigating its progression. Addressing high BMI should be a cornerstone of comprehensive OA care plans, due to its modifiable nature. The study also found a strong positive correlation between OA ASRs and China's SDI from 1990 to 2021, suggesting that socioeconomic changes have played a significant role in shaping the OA burden. Improvements in life expectancy, coupled with lifestyle changes, such as reduced physical activity, sedentary behavior, and unhealthy diets, particularly among wealthier populations, are likely to be contributing factors [36,37]. These findings underscore the importance of integrating early screening, diagnosis, and effective treatment into healthcare systems during periods of rapid economic development. The Healthy China 2030 initiative prioritizes the prevention of chronic diseases with high mortality and disability rates, promoting physical activity, especially for older adults. However, the adoption of exercise therapy for OA remains limited in China, and proper health education remains inaccessible to many patients [38,39]. Greater emphasis on primary prevention strategies, such as lifestyle modifications and weight control, could prove more effective in curbing the growing OA burden. Our findings provide crucial insights for policymakers and healthcare providers to design targeted interventions and public health campaigns to reduce the OA burden in the country.

Despite its strengths, our study has certain limitations. Potential diagnostic overlaps and the exclusion of individuals aged 0 to 29 from

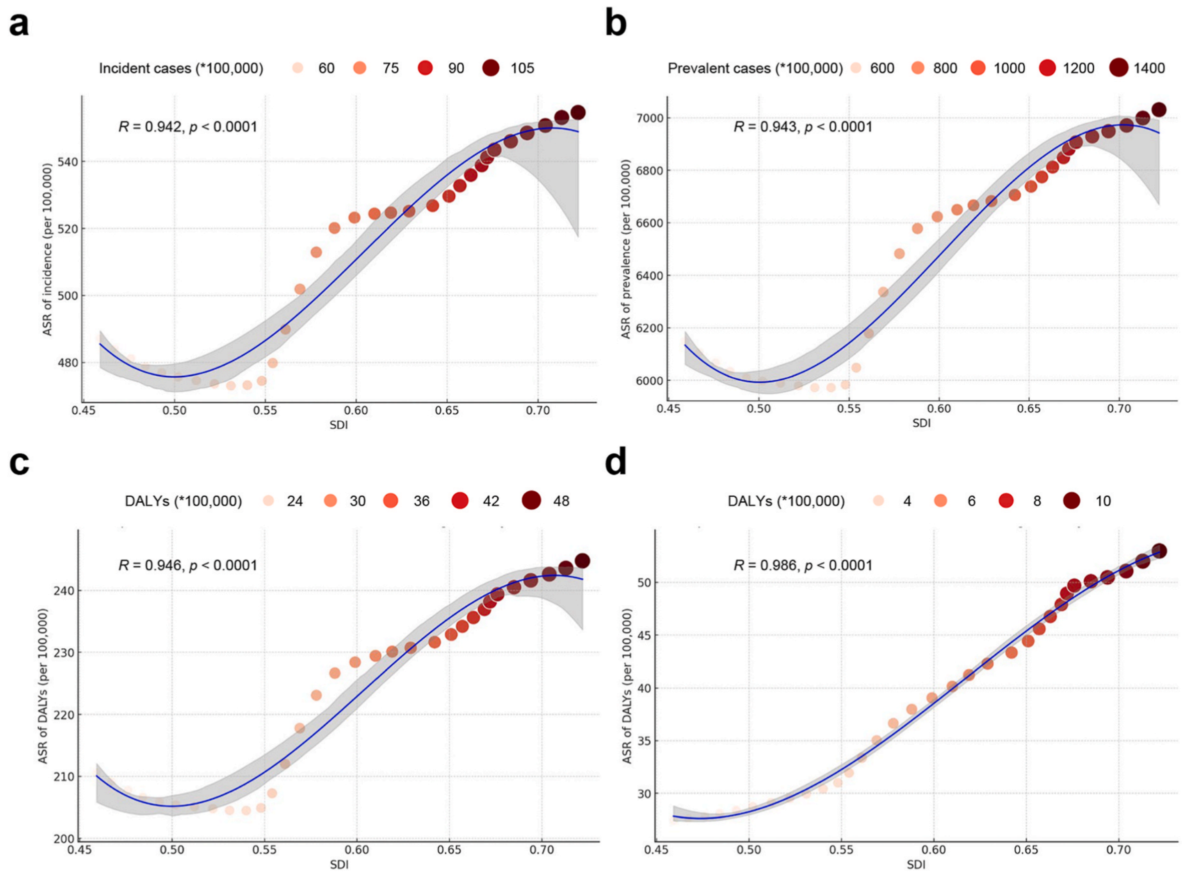

Fig. 5. Correlation between age-standardized rate (ASR) of osteoarthritis (OA) and sociodemographic index (SDI) in China from 1990 to 2021. Correlation between (a) ASR of incidence and SDI, (b) ASR of prevalence and SDI, (c) ASR of disability-adjusted life years (DALYs) and SDI of OA in China from 1990 to 2021. (d) Correlation between ASR of DALYs and SDI of OA due to high body mass index (BMI) in China from 1990 to 2021. Circles represent the number of OA cases. The shaded part of the line represents the 95 % CI.

the GBD dataset may have introduced biases. Additionally, the lack of subnational data precludes a detailed analysis of regional disparities in OA burden. Furthermore, GBD estimates of hand OA prevalence are lower than those reported in other studies, suggesting a need for more extensive primary data collection in China. In addition, although high BMI is a recognized risk factor for OA in this study, other contributing factors, such as genetics or occupational influences, low bone mineral density, low physical activity, tobacco use, low temperature, occupational injuries, and occupational ergonomic factors, were not examined due to data constraints.

In conclusion, this study highlights the significant and growing public health challenge posed by OA in China. To effectively address this issue, China's healthcare system must focus on preventive measures, early intervention, and comprehensive management strategies. These efforts will be critical in mitigating the rising burden of OA and ensuring better health outcomes for affected populations.

Patient and public involvement

Patients and/or the public were not involved in this research.

Patient consent for publication

Not required.

Authorship

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication.

Indicate the specific contributions made by each author (list the authors' initials followed by their surnames, e.g., Y.L. Cheung). The name of each author must appear at least once in each of the three categories below.

Contributors

Conception and design of study: G.Z. Xiao, Z.W. Shao, and S Chen; Acquisition of data: S Chen, M.J. Chen, C Chen, C Xie, and Y.H. Yu; Analysis and/or interpretation of data: S Chen, M.J. Chen, C Chen, Z.W. Shao, and G.Z. Xiao; Drafting the manuscript: G.Z. Xiao, S Chen. Revising the manuscript critically for important intellectual content: G. Z. Xiao, S Chen. All authors take the responsibility for the integrity of the data analyses and approve the final version of the manuscript.

Ethics approval

Not required.

Data availability statement

Data used for the analyses are publicly available from http://ghdx.healthdata.org/gbd-results-tool.

Author note

This study is based on publicly available data and solely reflects the opinion of its authors and not that of the Institute for Health Metrics and Evaluation.

The translational potential of this article

China has the largest elderly population and the highest prevalence of OA globally. Updating and analyzing epidemiological data of OA in China will offer the public, healthcare professionals, and policymakers the most current, comprehensive, and comparable information, which holds significant translational potential.

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Conflicts of interest

A conflict of interest occurs when an individual's objectivity is potentially compromised by a desire for financial gain, prominence, professional advancement or a successful outcome. The Editors of the *Journal of Orthopaedic Translation* strive to ensure that what is published in the Journal is as balanced, objective and evidence-based as possible. Since it can be difficult to distinguish between an actual conflict of interest and a perceived conflict of interest, the Journal requires authors to disclose all and any potential conflicts of interest.

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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.2025.02.006.

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