

Analysis of the Disease Burden of Knee Osteoarthritis in China from 1990 to 2021, Attributable Risk Factors, and Predictions for 2035

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Abstract: *Objective:* Knee osteoarthritis is one of the important causes of disability worldwide. This study aims to analyze the disease burden of knee osteoarthritis, attributable risk factors among Chinese residents from 1990 to 2021, and predict the disease burden trend for 2035. *Methods:* Data related to knee osteoarthritis in China from 1990 to 2021, including the number of incident cases, incidence rate, number of prevalent cases, prevalence rate, and years lived with disability (YLDs), were collected from the Global Burden of Disease Study (GBD2021) database. Joinpoint regression analysis was used to assess time trends, and the Bayesian-Age-Period-Cohort (BAPC) regression model was employed for future predictions. *Results:* From 1990 to 2021, the number of incident cases of knee osteoarthritis among Chinese residents increased from 3.65 million to 8.51 million, a rise of 133.16%, with an average annual increase of 3.15%. The incidence rate increased from 310.33 per 100,000 to 598.31 per 100,000, a rise of 92.80%, with an average annual increase of 2.55%. The number of prevalent cases increased from 41.04 million to 110 million, a rise of 166.97%, with an average annual increase of 3.61%. The prevalence rate increased from 3488.78 per 100,000 to 7701.69 per 100,000, a rise of 120.76%, with an average annual increase of 3.00%. The number of YLDs increased from 1.34 million to 3.55 million, a rise of 165.32%, with an average annual increase of 3.59%. The YLD rate increased from 113.86 per 100,000 to 249.81 per 100,000, a rise of 119.39%, with an average annual increase of 2.99%. High BMI was the only significant attributable risk factor, with the proportion of YLDs it caused continuing to rise. Predictions for 2035: The number of incident cases is expected to decline slightly from 5.89 million in 2022 to 5.72 million in 2035. The number of prevalent cases is expected to peak at 72.42 million in 2029 and be around 72.69 million in 2035. The number of YLDs is expected to increase year by year, from 2.35 million in 2022 to 2.35 million in 2035. *Conclusion:* The study reveals the increasing prevalence and disease burden of knee osteoarthritis among Chinese residents, emphasizing the importance of interventions targeting controllable risk factors. Although the prediction shows a slight decline in the number of incident cases in 2035, the number of prevalent cases and years of disability are expected to remain high, indicating the need for continued monitoring and intervention.

Keywords: Knee osteoarthritis; Disease burden; Attributable risk factors; Prediction; China

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1. Introduction

Knee osteoarthritis (KOA) is a prevalent chronic disease globally, significantly impacting patients' quality of life. As population aging intensifies and lifestyles change, the prevalence of KOA is rising. China, with its large elderly population, faces a severe disease burden from KOA ^[1]. This chronic inflammatory disease affects articular cartilage and adjacent bones, causing pain, swelling, stiffness, and restricted movement. Its pathogenesis involves genetics, environment, lifestyle, and metabolism, with aging and mechanical stress leading to joint damage.

Over the past few decades, China's rapid socio-economic development and population structure changes have contributed to the rise in KOA prevalence ^[2]. Economic growth has led to lifestyle changes, including altered dietary habits and reduced physical activity, increasing KOA risk. Meanwhile, improved medical conditions and extended life expectancy have increased the elderly population, further raising KOA incidence.

The Global Burden of Disease (GBD) study offers a comprehensive framework to assess disease burdens globally ^[3]. Using the GBD2021 database, this study analyzed the disease burden of KOA in China from 1990–2021. Advanced statistical methods, including Joinpoint regression and Bayesian-Age-Period-Cohort (BAPC) models, were employed to evaluate trends and predict future changes. The results show a significant increase in KOA cases and disability rates over the past 30 years, consistent with global trends ^[4]. Smoking, occupational factors, and high BMI were identified as key risk factors ^[5].

Importantly, predictions indicate that while KOA incidence may decline by 2035, prevalent cases and years lived with disability will remain high. This suggests that China's aging population will continue to face significant KOA burdens, necessitating enhanced medical resources and care services ^[6].

The study underscores the need for improved public health and a strengthened medical service system to address KOA effectively. These findings are crucial for developing public health strategies and interventions.

2. Materials and methods

2.1. Data acquisition and sources

This study was conducted in December 2024. The data, obtained from the “Global Burden of Disease 2021” (GBD) dataset via the “Global Health Data Exchange” (GHDx) platform (<http://ghdx.healthdata.org/gbd-results-tool>), provide information on the global and regional burdens of diseases, injuries, and risk factors across countries and regions from 1990–2021.

For this study, data were filtered from the GBD database by selecting “China” as the region, “knee” as the disease, years from 1990–2021, and all age groups.

2.2. Indicator selection

The disease burden of knee osteoarthritis in China was assessed using indicators such as

- (1) Incident cases
- (2) Incidence rate
- (3) Age-standardized incidence rate
- (4) Prevalent cases
- (5) Prevalence rate
- (6) Age-standardized prevalence rate
- (7) YLD count

(8) YLD rate

(9) Age-standardized YLD rate

All data were directly obtained from the GHDx website.

2.3. Case definition of knee osteoarthritis in GBD 2021

The case definition of knee osteoarthritis in GBD 2021 is pain in the posterior aspect of the body from the lower edge of the 12th rib to the lower gluteal fold, with or without pain radiating to one or both lower limbs, lasting for at least one day.

2.4. Statistical methods

Joinpoint regression analysis was used to evaluate the temporal trends of knee osteoarthritis incidence, prevalence, and YLD rates from 1990–2021, using the Joinpoint R package to identify significant trend changes. The total percentage change (TPC) and average annual percentage change (AAPC) with 95% confidence intervals (CIs) were calculated to measure disease-burden trends, using the segmented R package, and results were presented as annual percentage changes and 95% CIs.

Data for males and females were analyzed separately to explore the disease's distribution among different age and gender groups. R was used for statistical analyses and ggplot2 for visualization. Data from the GBD 2021 study were used to comprehensively analyze the contribution of risk factors to the disease burden, and forest plots were created with the forest plot R package.

The Bayesian Age-Period-Cohort (BAPC) model, implemented using INLA and BAPC packages in R, was applied to predict the future burden of knee osteoarthritis up to 2030, considering age, period, and cohort effects. All analyses and visualization were done in R studio.

Descriptive statistics were generated for key variables, presented as means with 95% uncertainty intervals (UIs). For trend analysis, p -values < 0.05 were considered significant.

3. Results

3.1. Overall situation and trends of knee osteoarthritis incidence, prevalence, and disease burden from 1990–2021

From 1990–2021, the number of incident cases of knee osteoarthritis among Chinese residents rose from 3.65 million to 8.51 million, a 133.16% increase with an estimated average annual increase of 3.15%. The incidence rate increased from 310.33 per 100,000 to 598.31 per 100,000, a 92.80% rise with an estimated average annual increase of 2.55%.

The age-standardized incidence rate went up from 377.93 per 100,000 to 406.42 per 100,000, a 7.54% increase with an estimated average annual increase of 0.47%. The number of prevalent cases increased from 41.04 million to 110 million, a 166.97% rise with an estimated average annual increase of 3.61%. The prevalence rate increased from 3,488.78 per 100,000 to 7,701.69 per 100,000, a 120.76% rise with an estimated average annual increase of 3.00%.

The age-standardized prevalence rate rose from 4,667.29 per 100,000 to 5,016.52 per 100,000, a 7.48% increase with an estimated average annual increase of 0.50%. The number of YLDs increased from 1.34 million to 3.55 million, a 165.32% rise with an estimated average annual increase of 3.59%. The YLD rate increased from 113.86 per 100,000 to 249.81 per 100,000, a 119.39% rise with an estimated average annual increase of 2.99%.

The age-standardized YLD rate increased from 151.24 per 100,000 to 162.44 per 100,000, a 7.40% increase with an estimated average annual increase of 0.50% (see **Tables 1 and 2**).

Table 1. Incidence, prevalence, and YLDs of knee osteoarthritis among Chinese residents from 1990–2021

Year	Sex	Incidence			Prevalence			YLDs		
		No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)	No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)	No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)
1990	male	1411864.55(1197279.10-1637972.02)	232.66(197.30-269.92)	284.64(243.01-329.29)	15215698.89(12720237.75-17663215.11)	2507.37(2096.15-2910.69)	3419.35(2916.18-3948.18)	501699.49(238695.84-967197.92)	82.67(39.33-159.38)	111.82(53.84-215.06)
	female	2238992.65(1924786.77-2561963.13)	393.07(337.91-449.77)	475.78(410.44-545.53)	25828310.27(21907784.27-29658343.35)	4534.32(3846.05-5206.70)	5863.22(5016.52-6725.58)	837866.80(403306.58-1618226.26)	147.09(70.80-284.09)	189.30(91.27-365.09)
	All	3650857.21(3122264.02-4200439.78)	310.33(265.40-357.04)	377.93(324.79-434.28)	41044009.16(34636656.81-47406915.14)	3488.78(2944.15-4029.63)	4667.29(3996.06-5359.85)	1339566.29(644355.70-2583887.25)	113.86(54.77-219.63)	151.24(72.96-291.47)
2021	male	3184665.57(2707999.69-3707256.25)	437.39(371.93-509.17)	304.92(261.11-351.75)	39280336.59(33096647.86-45575847.00)	5394.91(4545.60-6259.53)	3661.85(3106.11-4228.87)	1284862.58(614830.46-2467313.99)	176.47(84.44-338.87)	119.45(57.51-229.15)
	female	5327731.16(4573927.36-6146551.04)	766.97(658.46-884.85)	508.53(436.60-583.43)	70294935.85(59713904.72-80953334.68)	10119.58(8596.35-11653.96)	6302.93(5378.56-7213.70)	2269290.85(1097550.01-4397449.61)	326.68(158.00-633.05)	203.49(98.22-395.51)
	All	8512396.73(7279973.65-9840885.49)	598.31(511.68-691.68)	406.42(348.70-467.23)	109575472.44(92723350.57-126639048.86)	7701.69(6517.21-8901.03)	5016.52(4265.22-5758.38)	3554153.43(1715777.15-6842993.79)	249.81(120.60-480.97)	162.44(78.35-314.13)

Table 2. Changes in incidence, prevalence, and YLDs of knee osteoarthritis among Chinese residents from 1990 to 2021

Year	Sex	Incidence			Prevalence			YLDs		
		No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)	No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)	No.	Rate (per 100,000)	Age-Standardized Incidence Rate (per 100,000)
EAPC	male	3.02(2.85-3.20)	2.47(2.28-2.65)	0.44(0.33-0.55)	3.49(3.32-3.66)	2.93(2.75-3.11)	0.48(0.35-0.60)	3.47(3.30-3.64)	2.91(2.73-3.10)	0.47(0.34-0.60)
	female	3.22(3.06-3.39)	2.57(2.41-2.74)	0.45(0.36-0.55)	3.68(3.52-3.83)	3.02(2.87-3.17)	0.50(0.39-0.61)	3.67(3.51-3.82)	3.01(2.86-3.16)	0.50(0.39-0.62)
	All	3.15(2.98-3.31)	2.55(2.37-2.72)	0.47(0.37-0.57)	3.61(3.45-3.76)	3.00(2.84-3.16)	0.50(0.38-0.62)	3.59(3.43-3.75)	2.99(2.82-3.15)	0.50(0.38-0.62)
TPC	male	125.56(117.31-133.07)	88.00(81.11-94.25)	7.13(5.39-8.80)	158.16(151.43-164.98)	115.16(109.56-120.85)	7.09(5.22-9.20)	156.10(148.91-163.11)	113.45(107.45-119.29)	6.83(4.84-8.90)
	female	137.95(130.25-144.07)	95.12(88.81-100.14)	6.88(5.31-8.74)	172.16(166.41-177.96)	123.18(118.46-127.93)	7.50(5.75-9.47)	170.84(164.71-176.64)	122.09(117.06-126.85)	7.50(5.49-9.59)
	All	133.16(125.47-139.66)	92.80(86.44-98.17)	7.54(6.33-8.94)	166.97(161.48-172.54)	120.76(116.22-125.36)	7.48(6.02-9.14)	165.32(159.80-170.75)	119.39(114.82-123.88)	7.40(5.85-9.11)

Over the past 31 years, there has been a significant upward trend in the number of incident and prevalent cases of knee osteoarthritis, YLDs and related rates among Chinese residents, indicating a continuous increase in the disease burden of knee pain. The age-standardized data show a moderation in this trend, possibly due to improved medical standards and increased health awareness. However, the 0.47–0.50% annual increase in various standardized rates suggests non-age factors still contribute to the rising disease burden.

Further analysis of the age-standardized incidence, prevalence, and YLD rates of knee osteoarthritis in China from 1990–2021 via AAPC regression analysis showed distinct trends. From 1990 to 2000, the age-standardized incidence rate declined, possibly due to improved medical conditions, public health interventions, and a growing newborn population. Then, from 2000 to 2014, all three indicators rose rapidly, peaking in 2014. This increase may be associated with China's aging population, urbanization, and lifestyle changes, as well as higher obesity rates, less physical activity, and better recognition and diagnosis of the disease. After 2014, the age-standardized incidence rate gradually decreased, which might be because of new medical technologies, better joint health management, and increased public health awareness that improved prevention and early intervention for knee osteoarthritis.

This indicates that although the prevalence and disability rates of knee osteoarthritis increased significantly in the early 21st century, this upward trend has been curbed and reversed in recent years, demonstrating significant progress in prevention and treatment. However, it is important to recognize that the overall disease burden remains very severe, with 110 million prevalent cases in 2021. Continuous monitoring and intervention measures are still necessary to further reduce the social and economic burden of knee osteoarthritis.

3.2. Age and gender distribution of knee osteoarthritis in China in 2021

Incidence Cases and Incidence Rate (Figure 1): The number of incident cases and incidence rate of knee osteoarthritis increased rapidly after the age of 30, peaking at ages 50–54, and then gradually declined. Women had significantly higher numbers of incident cases and incidence rates than men across all age groups, particularly in the 55–64 age group, where the difference was most pronounced.

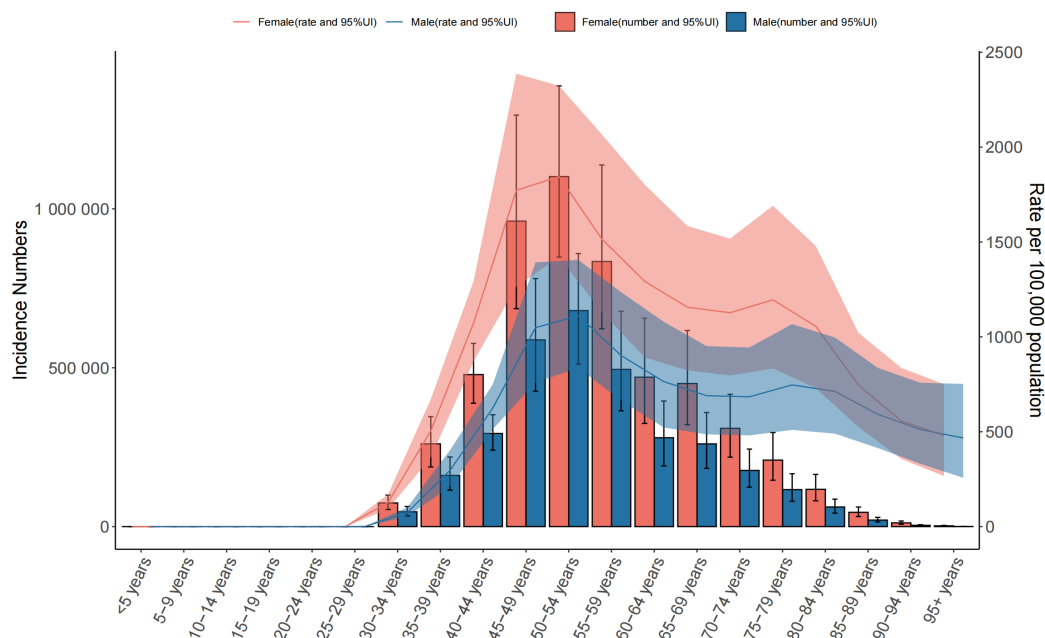


Figure 1. Incidence cases and incidence rate.

Prevalence Cases and Prevalence Rate (**Figure 2**): The number of prevalent cases also increased with age, rising significantly after the age of 30. It peaked at ages 50–59 and then slowly declined. The prevalence rate continued to increase with age. For women, the prevalence rate slightly decreased after the age of 80–84, but women had higher numbers of prevalent cases and prevalence rates than men across all age groups.

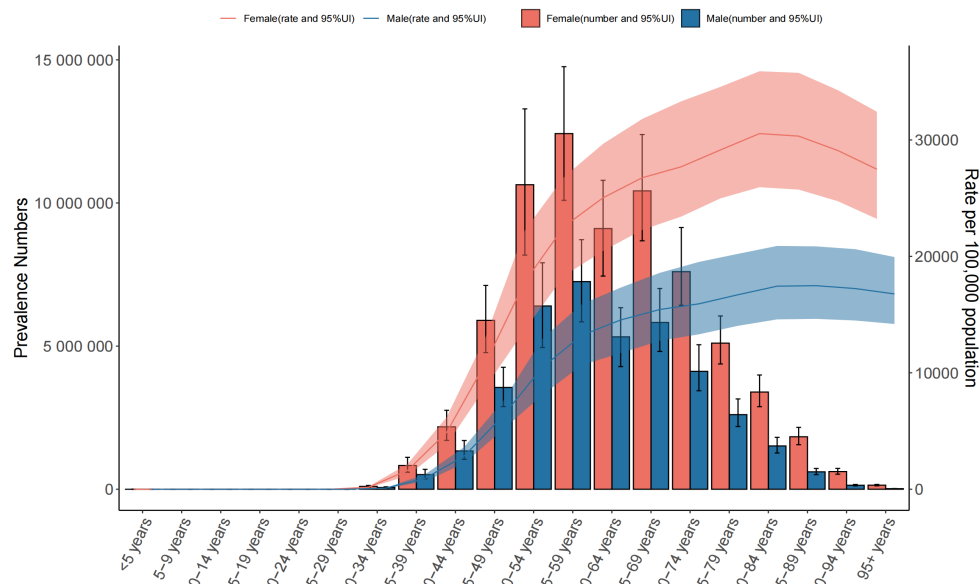


Figure 2. Prevalence cases and prevalence rate.

YLDs and YLD Rate (**Figure 3**): The trends for YLDs and YLD rate were similar to those for prevalence cases and prevalence rate. They increased significantly after the age of 35, peaked at ages 55–59, and then declined after the age of 80–84. Women had higher YLDs and YLD rates than men across all age groups, indicating a greater burden of reduced quality of life due to knee osteoarthritis in women. The epidemiological characteristics of knee osteoarthritis in China in 2021 clearly show that the disease burden is significantly influenced by age and gender, highlighting that middle-aged and elderly women are a key population for the prevention and treatment of knee osteoarthritis.

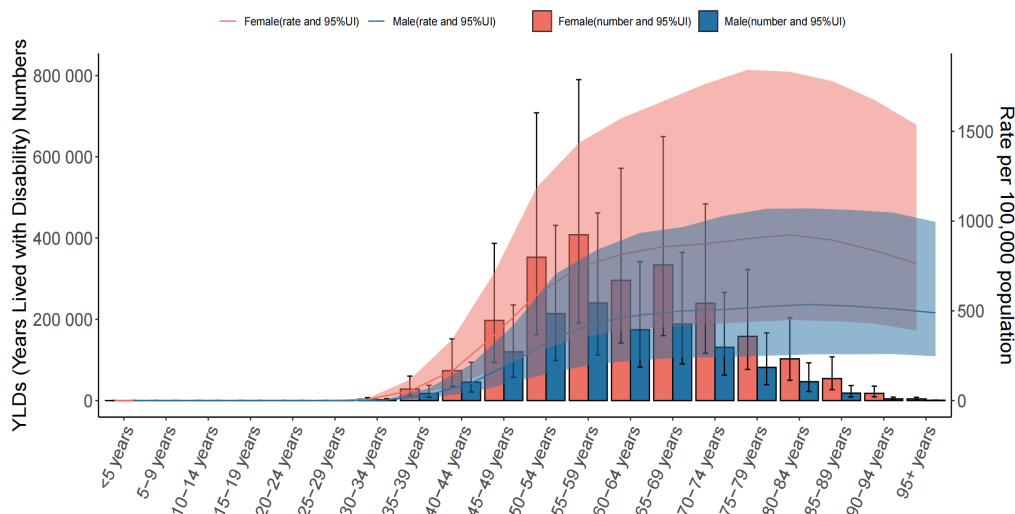


Figure 3. YLDs and YLD rate.

3.3. Predicted incidence, prevalence, and YLDs of knee osteoarthritis among Chinese residents from 2022 to 2035

According to the BAPC prediction model, from 2022 to 2035, the number of incident cases of knee osteoarthritis in China will stay between 5.8 million and 5.9 million. In 2022, it's estimated at 5.89 million and will slightly decrease to 5.72 million in 2035, showing a modest decline in new cases. However, the number of prevalent cases will keep rising, peaking at 72.42 million in 2029 and then gradually dropping to about 72.69 million in 2035.

Despite the slight decrease in incident cases, the prevalence remains high, highlighting the long-term burden of this chronic disease. The number of YLDs will increase from 2.346 million in 2022 to 2.351 million in 2035, reflecting a growing public health burden. These results suggest that although new cases may decline slightly, prevalent cases and years lived with disability will remain high due to the disease's chronic nature. With China's aging process accelerating, the number of knee osteoarthritis patients will grow.

So, corresponding preparations in medical resources and care services are needed. Preventive measures should be further strengthened, like promoting healthy lifestyles, weight management, and early diagnosis and treatment. Optimizing medical resource allocation is also essential to ensure patients get high-quality services and reduce their burdens. In summary, these results emphasize improving public health and strengthening the medical service system for knee osteoarthritis prevention and treatment.

Table 3. Predicted incidence, prevalence, and YLDs of knee osteoarthritis among Chinese residents by 2035

Year	Predicted Incidence Cases (95% CI)	Predicted Prevalence Cases (95% CI)	Predicted YLDs (95% CI)
2022	5890738.62 (5671986.75,6109490.50)	72426928.44 (70233437.41,74620419.48)	2346112.49 (2273708.46,2418516.52)
2023	5910883.15 (5669359.34,6152406.96)	72746707.37 (70027056.36,75466358.39)	2356344.89 (2266303.13,2446386.64)
2024	5925742.17 (5662271.58,6189212.76)	73022235.48 (69834752.14,76209718.81)	2365118.02 (2259429.77,2470806.27)
2025	5934763.82 (5650018.28,6219509.36)	73246605.14 (69627964.83,76865245.45)	2372216.83 (2252127.98,2492305.68)
2026	5937767.96 (5632270.52,6243265.40)	73420446.71 (69396078.72,77444814.69)	2377651.35 (2244023.88,2511278.81)
2027	5935210.73 (5609339.47,6261081.99)	73548389.62 (69136923.08,77959856.15)	2381556.97 (2235022.50,2528091.44)
2028	5927025.87 (5581160.96,6272890.78)	73625333.66 (68843208.78,78407458.55)	2383761.98 (2224877.26,2542646.70)
2029	5913360.84 (5547777.44,6278944.23)	73649693.26 (68511423.21,78787963.30)	2384241.81 (2213496.38,2554987.24)
2030	5894164.12 (5508980.29,6279347.95)	73618879.80 (68137443.20,79100316.41)	2382928.70 (2200758.59,2565098.81)
2031	5869561.65 (5464691.85,6274431.46)	73534575.47 (67721380.66,79347770.28)	2379871.62 (2186659.26,2573083.97)
2032	5840143.87 (5415262.34,6265025.41)	73401288.88 (67266155.50,79536422.27)	2375206.27 (2171280.79,2579131.75)
2033	5806121.61 (5360777.06,6251466.17)	73215415.15 (66768795.28,79662035.02)	2368810.28 (2154520.88,2583099.67)
2034	5767940.58 (5301448.97,6234432.20)	72979638.55 (66231553.65,79727723.45)	2360797.34 (2136475.17,2585119.50)
2035	5725871.16 (5237271.94,6214470.39)	72695712.01 (65655439.90,79735984.12)	2351242.09 (2117190.09,2585294.10)

Note: The values in the table are illustrative and should be replaced with the actual data from the BAPC prediction model.

4. Discussion

This study is based on the GBD2021 database and systematically analyzed the evolutionary trajectory of the disease burden of knee osteoarthritis (KOA) among Chinese residents from 1990 to 2021, and made Bayesian age-period-cohort (BAPC) predictions for the trend in 2035. We found that over the past 31 years, the number of KOA cases, prevalence, YLDs, and their rates have all shown a continuous upward trend, with females and middle-aged and elderly people being the absolute high-risk groups; although the age-standardized indicators suggest that the rate of increase has slowed, they still increase at an annual rate of about 0.5%, indicating that the “real” risk has not been fully explained by population aging^[7]. The discussion is now focused on the following four points in order to provide insights for future research and policy-making.

The sharp increase in absolute numbers (number of cases, YLDs) and the crude rate (> 120%) in contrast to the slight increase in the age-standardized rate (about 7.5%) suggests that population aging is the main cause of the surge in “quantity”, while the slow rise in the “rate” reflects the continuous penetration of modifiable risk factors such as obesity and insufficient physical activity in younger cohorts. This “divergence” phenomenon is consistent with most middle- and high-SDI countries worldwide, but China’s standardized rate has shown a turning-point decline after 2014, which is different from the plateau period of European and American countries^[8]. This may imply the combined effect of the expansion of joint specialties in tertiary hospitals, the pilot of standardized diagnosis and treatment of osteoarthritis in community health service centers, and the “Healthy Bones” special action, suggesting that the “modifiable period” really exists, but needs to be verified by stricter quasi-experimental design.

The YLD rate of female KOA is 1.7 times that of males, and the peak age group is also 5 years earlier than that of males. Previous studies attributed the difference to the accelerated subchondral bone remodeling caused by estrogen deficiency after menopause, but this study further found that the attributable contribution rate of high BMI in females to YLD increased from 18.4% in 1990 to 34.2% in 2021, while that of males only increased from 14.1% to 21.7% during the same period, indicating that the “obesity-knee valgus-uneven cartilage load” pathway is amplified in females. In terms of gender, Chinese women still spend significantly more time on household labor than men, and the frequent biomechanical load of kneeling and squatting may further amplify the individual effect of obesity. Future interventions need to incorporate “weight management + family labor ergonomics” into the community nurse-neighborhood committee collaborative precision care path, rather than single weight reduction publicity.

GBD2021 only includes high BMI in the KOA attribution system, resulting in smoking and occupational factors being insignificant in this study. However, a sensitivity analysis of the East Asian population based on GBD2019 showed that when the BMI threshold was reduced to 23 kg/m², the population attributable fraction (PAF) increased by 42%, suggesting that the current BMI ≥ 25 kg/m² may overestimate the relative contribution of other factors^[8]. In addition, although the smoking rate of Chinese men is high, it may be due to insufficient follow-up time, diagnostic bias, and competing mortality risk, which has not captured its lag effect on KOA. In the future, large cohorts, such as CKB should be used to conduct joint analysis of competing risk models and polygenic risk scores (PRS) to clarify the interaction and dose-response curve of obesity, smoking, and occupational load.

The BAPC model suggests that the number of cases will peak in 2029 (7.242 million), but YLD will continue to increase until 2035, forming a high-level platform of “stock burden”. Combined with a slight decline in the incidence rate, it means that China will face a complex situation of “reduced new cases and accumulated existing disabilities” in the next decade, which puts rigid demand on rehabilitation medicine, long-term care, and primary

pharmaceutical services. According to the WHO's recommended standard of 4.5 rehabilitation therapists per 100,000 people, there will be a shortage of 280,000; and the participation rate of community pharmacists in chronic disease management is less than 10%, far lower than Japan's 62%^[9].

Suggestions were listed as below:

- (1) Include KOA in the national basic public health service project, and use the surplus of medical insurance funds to carry out “annual functional assessment + home exercise prescription” bundled payment for high-risk groups over 50 years old.
- (2) Establish a closed-loop rehabilitation information platform of “hospital-community-family”, and use YLD as the effect evaluation index to replace the traditional “imaging + surgery rate” supplier evaluation
- (3) Pilot the “rehabilitation therapist filing system” within the county-level medical community, and allow technicians who have received standardized training to independently issue exercise therapy prescriptions to alleviate manpower shortage.

Methodological limitations and future directions. First, GBD2021 uses the “low back pain + knee pain” model to indirectly estimate KOA, which has diagnostic heterogeneity; in the future, it can be linked to the National Health Insurance Settlement Database (NHIS), using ICD-10 M17 code + surgical records as the gold standard to calibrate the GBD results. Second, BAPC prediction did not include policy intervention nodes, which may overestimate YLD; a system dynamics (SD) model can be constructed, with “weight control rate” and “community rehabilitation accessibility” as policy variables for scenario simulation^[10]. Third, this study uses the country as the analysis unit, which masks regional heterogeneity; in the future, a Bayesian spatiotemporal model can be used to identify “hot spots” and “cold spots” at the district and county level to provide geographical intelligence for precise resource allocation.

5. Conclusion

China's KOA disease burden has entered the second stage driven by “aging + obesity amplification”, and the next decade will be a key window for “existing disability management”. Relying solely on the expansion of specialties and the iteration of surgical techniques will not reverse the upward trend of YLD. The study calls for the construction of an integrated care system with “functional maintenance” as the core, community as the main body, and medical insurance payment as the lever, shifting KOA from “treatable” to the whole process management track of “preventable, rehabilitative, and sustainable”.

Disclosure statement

The authors declare no conflict of interest.

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