

Long-term trends in the burden of malignant neoplasm of bone and articular cartilage in China: findings from the global burden of disease study 2021

Lizhen Zhuang

Putian University

Weiqiang Zhang

Putian University

Xin Lu

Putian University

Xi Lin

linxi6952@163.com

Putian University

Research Article

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Abstract

Background

Malignant neoplasm of bone and articular cartilage (MNBAC) is a significant public health issue due to the extremely poor prognosis in China. This study aims to analyze long-term trends in the burden of MNBAC in China from 1990 to 2021 and provide projections.

Methods

Data extracted from the Global Burden of Disease (GBD) database (1990–2021) was utilized to evaluate MNBAC metrics, including incidence, prevalence, mortality, disability-adjusted life years (DALYs), years lived with disability (YLDs) and years of life lost (YLLs). We used joinpoint and age-period-cohort (APC) analysis methods to interpret the effects of age, period, and cohort. A decomposition analysis identified factors influencing changes in MNBAC. Projections were made using Bayesian age-period-cohort (BAPC) analysis for future trends up to 2030.

Results

In 2021, MNBAC impacted China significantly, with higher incidence, prevalence, mortality, DALYs, YLLs and YLDs in males. From 1990 to 2021, all the MNBAC metrics except YLLs were statistically significantly increased in China, while globally mortality and YLLs declined. Decomposition analysis highlighted epidemiological changes and aging as major contributors to the MNBAC burden. BAPC analysis indicated no significant decline in MNBAC burden up to 2030, particularly in males.

Conclusion

MNBAC remains a significant public health issue in China, particularly in Male or elderly population. Future research should focus more on the relationship between MNBAC and living habit or occupational exposures for better understanding and more precise public health interventions.

Contributions to the Literature

- This study provides the first comprehensive analysis of long-term trends in MNBAC burden in China, using GBD 2021 data.
- It highlights the higher burden of MNBAC in males and the elderly, calling for targeted interventions.
- The findings emphasize the role of aging and demographic changes in the rising disease burden.
- Bayesian projections offer insights into future trends, helping to guide public health strategies.

Introduction

Malignant neoplasm of bone and articular cartilage (MNBAC) is relatively rare yet highly aggressive tumors with extremely poor prognosis[1]. The overall incidence rate of bone sarcoma ranges between 0.8–0.9 cases per 100,000/year, with single types having no more than 0.3 incident cases per 100,000/year[2]. Although the incidence of MNBAC remains no more than many other neoplasms, its public disease burden is significant due to the poor therapeutic effect[3, 4]. Examining long-term trends in MNBAC burden is of great significance for better management.

According to a systematic analysis for the disease burden of MNBAC in United State[5], 18,205 adults aged 65 and older died from MNBAC from 1999 to 2020. And the age-standardized mortality rate (ASMR) started at 20 per 100,000 in 1999 and increased sharply to 23.8 by 2020. Another global, regional, and national burden and trends analysis revealed that the global cases of incidence and deaths of MNBAC showed a significant upward trend[6]. Notably, China had the highest number of incidence cases and deaths in 2021, and the region with the highest incidence cases, deaths, and age-standardized incidence rate (ASIR) was East Asia. Therefore, long-term trends and projections in MNBAC burden in China are crucial. However, the national MNBAC registry remains inadequate in China, which leads to the limitation of relevant epidemiological reports.

The Global Burden of Disease (GBD) Study 2021 includes health statistics from over 200 countries containing China, providing updated estimates and methodologies[7–9]. Many scholars utilized GBD to examine disease burden, attributable burdens across a series of risk factors and long-term trends in China, and made significant discoveries[10–12]. This study utilizes the latest GBD 2021 data to conduct a comprehensive analysis of the incidence, prevalence, deaths, disability-adjusted life years (DALYs), years lived with disability (YLDs), years of life lost (YLLs) of MNBAC in China over the past 30 years. We employed joinpoint regression to identify significant changes in trends and age-period-cohort (APC) analyses to understand the effects of age, period, and cohort on MNBAC metrics. Next, decomposition analysis was conducted to clarify the contributions of aging, epidemiological changes, and population growth to the MNBAC burden. Lastly, Bayesian age-period-cohort (BAPC) analysis was utilized to project future trends up to 2030.

Methods

Data sources and procedures

We extracted data on MNBAC incidence, prevalence, mortality, DALYs, YLDs and YLLs in China from 1990 to 2021 from the GBD Study 2021 database (<https://ghdx.healthdata.org/gbd-results-tool>). The Cause of Death Ensemble model (CODEm), spatiotemporal Gaussian process regression (ST-GPR), and Bayesian meta-regression tool DisMod-MR were the main methods to assess health metrics[9]. In the GBD, MNBAC is classified under codes 170-170.9 in revision 9 of the International Classification of Disease and Injuries (ICD-9), and C40- C41 in ICD-10[8]. GBD provides age-adjusted rates, specific-age rates, and

95% uncertainty intervals[12]. This study adheres to the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) to ensure the accuracy and transparency of health estimates[13]. Due to the public availability of the secondary data, no ethical approval was required. No direct intervention or human sample collection was proceeded, ensuring compliance with ethical standards.

Joinpoint regression analysis

The joinpoint regression model is a collection of linear statistical models that were used to identify significant changes in MNBAC trends. This model's calculating approach is to estimate the changing rule of illness rates using the least square method, avoiding the non-objectivity of typical trend analyses based on linear trends[14]. This analysis contributes to understand the temporal dynamics of incidence, prevalence, and mortality rates. Joinpoint Regression Program version 5.2.0 (National Cancer Institute, Rockville, MD, USA) was used to conduct this analysis, with statistical significance set at a *P*-value less than 0.05.

Age-period-cohort analysis

APC analysis was conducted to differentiate the influences of age, time period, and birth cohort on MNBAC metrics. This model helps in facilitating an evaluation of the independent impacts of each factor on observed trends. The intrinsic estimator (IE) method was employed to solve the collinearity challenges typical in APC models, yielding more precise estimates of age, period, and cohort effects[15]. For our analysis, we accessed the GBD data to gather incidence and mortality figures by five-year age groups from 1990 to 2021, including annual population estimates. Cases under 5 years old and over 95 years old were combined into one class for modeling purposes, while specific age ranges were defined as 0–4, 5–9 and so on, with the under 5 years old group marked as “0.” We calculated cumulative incidence and mortality rates for various age groups over five-year intervals. The Epi package (version 2.46) in R (version 4.3.1) was used for fitting the APC model, comparing residual deviations and AIC values to identify the most suitable model.

Decomposition analysis

Decomposition analysis[16] was conducted to quantify the contributions of aging, epidemiological changes, and population to the observed changes in MNBAC burden. This method reveals components attributable to each factor, providing a clearer understanding of the forming reason behind the observed trends in incidence, prevalence, and DALYs. Decomposition analysis was indispensable for identifying specific areas where public health interventions could be most effective[17].

Bayesian age-period-cohort analysis

We employed BAPC analysis to project future trends in NPC incidence, prevalence, and DALYs up to 2030[18]. BAPC analysis is a common method used in epidemiological research to predict future trends based on historical data. We utilized BAPC model to provide probabilistic forecasts of disease burden based on the integration of prior knowledge and observed data. Data from 1990 to 2021 were used to fit the model, and the projections for 2030 were generated, showing gender-specific trends. Bayesian inference was used to calculate uncertainty intervals, providing robust estimates for future trends[19].

Statistical analysis

Statistical analysis was conducted by open-source R software (version 4.3.1). $P < 0.05$ were considered statistically significant.

Results

Descriptive analysis

In China, there were 25,938 (95% CI: 16243, 34274) new MNBAC cases and 18,085 (95% CI: 11288, 24126) deaths due to MNBAC in 2021. By 2021, the number of patients with MNBAC has exceeded 100,000 in China, with a total prevalence of 166,569 (95% CI: 104517, 219818) cases. The ASIR, ASPR, ASMR were 1.78 new cases (95% CI: 1.02, 2.47) per 100,000, 11.28 cases (95% CI: 6.53, 15.64) per 100,000, 1.17 deaths (95% CI: 0.67, 1.64) per 100,000 respectively, reflecting higher rates than female. Males experienced higher disease burden of MNBAC, as shown by 36.86 DALYs (95% CI: 21.40, 51.25) per 100,000, 1.31 YLDs (95% CI: 0.66, 2.00) per 100,000, and 35.55 YLLs (95% CI: 20.68, 49.47) per 100,000 (Table 1). The incidence, prevalence, mortality numbers and age-standardized rates of MNBAC for the different age and gender were illustrated in Fig. 1. The highest incidence, prevalence, mortality rates were observed in older age groups, and it is the same in men and women. **Supplementary Fig. 1** presents the distribution of DALYs, YLDs, and YLLs due to MNBAC, showing similar trends in different gender or age groups.

Table 1

All-age cases and age-standardized incidence, prevalence, deaths, DALYs, YLDs, and YLLs rates in 2021 for MNBAC in China. (MNBAC, malignant neoplasm of bone and articular cartilage; DALYs, disability-adjusted life-years; YLDs, years lived with disability; YLLs, years of life lost.)

Measure	All-ages cases			Age-standardized rates per 100, 000 people		
	Total	Male	Female	Total	Male	Female
Incidence	25,938 (16243, 34274)	15,799 (8943, 22305)	10,139 (5955, 14563)	1.42 (0.9, 1.86)	1.78 (1.02, 2.47)	1.07 (0.63, 1.54)
Prevalence	166,569 (104517, 219818)	100,982 (57393, 142645)	65,587 (38468, 94478)	9.16 (5.82, 11.97)	11.28 (6.53, 15.64)	7.02 (4.15, 10.12)
Deaths	18,085 (11288, 24126)	10,833 (6169, 15354)	7,251 (4258, 10319)	0.93 (0.58, 1.23)	1.17 (0.67, 1.64)	0.71 (0.42, 1.01)
DALYs	527,284 (331727, 699456)	324,213 (186905, 460068)	203,071 (120616, 291485)	29.52 (18.92, 38.67)	36.86 (21.4, 51.25)	22.2 (13.29, 31.85)
YLDs	18,731 (10327, 27621)	11,644 (5852, 17989)	7,087 (4072, 11128)	1.03 (0.57, 1.51)	1.31 (0.66, 2)	0.75 (0.43, 1.17)
YLLs	508,552 (320505, 672215)	312,568 (180269, 442178)	195,984 (116572, 281700)	28.5 (18.31, 37.2)	35.55 (20.68, 49.47)	21.45 (12.85, 30.84)

Figure 2 illustrates the trends in the gender-specific all-age number and age-standardized rates of MNBAC metrics in China from 1990 to 2021. In Fig. 2A, the number of new cases increases year by year, particularly in male. The ASIR shows an increase from 1990 to 2009, followed by a steady decrease from 2010 to 2021. Figure 2B illustrates that the prevalence of MNBAC also increases annually and the ASPR increases from 1990 to 2009 before declining from 2010 to 2021. Figure 2C depicts that the annual number of deaths showed similar trends as the prevalence and incidence. The annual ASMR shows marked fluctuations, as shown by a downtrend from 1980 to 1990 and 2010 to 2021, an increase from 1990 to 2009. In Fig. 2D and 2E, the number of DALYs and YLDs increases annually, particularly for males. Age-standardized DALYs and YLDs rates obviously increase before steady decreasing. Figure 2F reflects a similar trend in the number and age-standardized rates of YLLs as seen in the mortality data.

Table 2 and **Supplementary Fig. 2** present a comprehensive analysis of variation trend in MNBAC metrics between China and global data from 1990 to 2021. In China, even with fluctuations in the process, all the MNBAC metrics except YLLs in 2021 were statistically significantly higher than those in 1990. On the other hand, from the global perspective, the mortality burden in 2021 decreased compared with 1990, and the rest of the data showed a similar trend as that in China. Figure 3 presents an age-specific comparison of MNBAC metrics in China between 1990 and 2021. Figure 3A, Fig. 3B and Fig. 3E

show that the incidence, prevalence and YLDs number in 2021 is higher than those in 1990 for most age groups except for < 5 group, while the corresponding age-standardized rates is also higher. Figure 3C, Fig. 3D and Fig. 3F show that the deaths, DALYs and YLLs number in 2021 is higher than those in 1990 for most age groups except for < 25, while the corresponding age-standardized rates is also higher.

Table 2

Change of age-standardized rates in incidence, prevalence, deaths, DALYs, YLDs, and YLLs for MNBAC between 1990 and 2021 in China and Global level. (MNBAC, malignant neoplasm of bone and articular cartilage; DALYs, disability-adjusted life-years; YLDs, years lived with disability; YLLs, years of life lost; *, $p < 0.05$.)

Measure	China			Global		
	1990	2021	Change	1990	2021	Change
Incidence	0.65 (0.42, 1.15)	1.42 (0.9, 1.86)	2.59 (2.30–2.87) *	0.97 (0.89, 1.13)	1.11 (0.9, 1.25)	0.44 (0.31–0.58) *
Prevalence	4.06 (2.66, 7.15)	9.16 (5.82, 11.97)	2.71 (2.37–3.05) *	6.25 (5.69, 7.24)	7.3 (5.92, 8.22)	0.51 (0.40–0.62) *
Deaths	0.58 (0.38, 1.03)	0.93 (0.58, 1.23)	0.44 (0.23–0.66) *	0.79 (0.73, 0.93)	0.79 (0.64, 0.89)	-0.27 (-0.36 - -0.19) *
DALYs	20.16 (13.12, 35.68)	29.52 (18.92, 38.67)	1.26 (1.01–1.51) *	31.03 (27.79, 36.86)	31.06 (25.44, 35.03)	0.02 (-0.05–0.10)
YLDs	0.48 (0.26, 0.9)	1.03 (0.57, 1.51)	2.51 (2.23–2.78) *	0.71 (0.5, 0.94)	0.81 (0.56, 1.09)	0.42 (0.29–0.55) *
YLLs	19.68 (12.77, 34.82)	28.5 (18.31, 37.2)	0.17 (-0.10–0.44)	30.32 (27.19, 35.98)	30.25 (24.79, 34.14)	-0.25 (-0.33 - -0.16) *

Joinpoint regression analysis

Joinpoint regression analyses of the MNBAC metrics in China from 1990 to 2019 are shown in Fig. 4, **Supplementary Table 1** and **Supplementary Table 2**. Figure 4A and Fig. 4B illustrate that the most significant increasing of ASIR and ASPR were in 2001 to 2004 for female and total population, while those for male were in 1999 to 2004. Figure 4C and Fig. 4F show that the most significant increasing of ASMR and age-standardized YLLs were in 2000 to 2004 for female and total population, while those for male were in 1999 to 2004. Similarly, age-standardized DALYs and YLDs significantly increased around 1999 to 2004 (Fig. 4D, Fig. 4E).

APC analysis

Figure 5 shows that the recent incidence rate of MNBAC is generally increasing. However, a precipitous decline in the incidence rate occurred in about 15–50 age group. **Supplementary Fig. 3** reveals a rising trend in prevalence rates. It is worth noting that the 15–20 and > 90 age groups experienced a significant decrease in prevalence. In contrast, **Supplementary Fig. 4** illustrates that DALYs associated with MNBAC are increasing across various age groups, diagnosis periods and birth time, reflecting challenges in disease management and outcomes.

Decomposition analysis

Figure 6 shows a decomposition analysis of factors influencing MNBAC incidence, prevalence, and DALYs in China from 1990 to 2021. Epidemiological changes, aging and population contribute to an overall promoting effect on MNBAC incidence, prevalence and DALYs. In Fig. 6A, epidemiological changes are identified as a greater impact on incidence for both genders. In Fig. 6B illustrates that aging contributes most for prevalence. Figure 6C indicates that epidemiological changes and aging are more significant factors for DALYs for females, and epidemiological changes act a greater influence on males.

Future trends

Figure 7 presents future trends in MNBAC metrics in China up to 2030. The projected age-standardized MNBAC metrics indicate a decrease for both females and males, with females showing a more pronounced decline. The projected ASIR and ASPR for males tend to remain flat, suggesting that while the overall incidence and prevalence of MNBAC are expected to decrease, the burden of disease for males is still high.

Discussion

This study offers a comprehensive analysis of the trends in the burden of MNBAC in China from 1990 to 2021. As far as we know, this is the first analysis of the epidemiological trends of MNBAC in China using GBD database. Based on the data we collected, MNBAC takes a greater toll on men than on women, which is consistent with previous literature reports. According to the ESMO-EURACAN-GENTURIS-ERN PaedCan clinical practice guideline of bone sarcoma, the male to female incidence ratio of osteosarcoma is 1.4:1.0[2]. An epidemiological investigation based on National Central Cancer Registry of China showed that the incidence and mortality rates of malignant bone tumors were higher in males than those in females[20]. A study of Twenty-year outcome of prevalence, incidence, mortality and survival rate in patients with malignant bone tumors indicated a gender-specific association, stronger pronounced among males, than females[21]. Some scholars believed that this gender specificity may be related to the differences in hormones in the body[22].

According to the results of our study, there is a significant peak of MNBAC incidence, prevalence and mortality rates in the seventh and eighth decades of life. Furthermore, the overall trend in MNBAC DALYs, YLDs and YLLs were shown to increase with age. In China, the burden of MNBAC is more pronounced in

elderly patients. According to some previous retrospective cross-sectional studies, older patients may experience a worse prognosis[23, 24]. Therefore, targeted preventive and control measures should focus more on the elderly and the male population. There was an overall upward trend in incidence, prevalence, mortality, DALYs, YLDs and YLLs of MNBAC from 1990 to 2021 in China. Although there are many researches on the treatment of bone sarcoma, the progress is not satisfactory. For localized disease, the primary treatment option is surgical resection of the tumor with adjuvant or neoadjuvant radiation therapy in selected cases. However, recurrence occurs in more than half of the patients, often with the development of distant metastasis[25]. In recent years, some large-scale clinical targeted drug trials aimed at strengthening the therapeutic effect of bone sarcoma have failed to achieve higher survival rates[26]. For the immunotherapy of bone sarcoma, there are still many obstacles to achieve ideal efficacy[25]. Based on the comparative analysis between China and global data of our study, the situation of MNBAC mortality and YLLs in China was even worse. A global study on the disease burden of MNBAC indicated that China had the highest number of incidence cases and deaths all around the world in 2021[6]. Thus, it can be seen that more effective measures are needed to reverse the overall upward trend of disease burden in China.

APC analysis revealed that the burden of MNBAC showed a downward trend in the second and third decades of life, which may be related to the age distribution of common malignant bone tumors[2]. According to the decomposition analysis of factors influencing MNBAC incidence, prevalence, and DALYs, epidemiological changes and aging are main impact factors for disease burden in China. This situation is likely to become more pronounced as China's population ages[27]. BAPC analysis showed that the burden of MNBAC will continue to be high in men in the future. Enhancing targeted health initiatives are essential to effectively reduce the burden of MNBAC in China, particularly for the elderly and male population. An investigation study in a Japanese population showed that smoking is a risk factor for bone sarcoma[28]. Another study indicated that smoking status is a significant prognostic factor for 3-year event-free survival in adult patients with Ewing sarcoma treated with whole lung irradiation for pulmonary metastases[29]. Therefore, public health campaigns should focus on educating communities about the dangers of smoking, which may be linked to MNBAC development. Some researchers have suggested that one way to target the metabolism of bone cancer cells is through dietary interventions and proposed avenues of research in dietary intervention that could potentially be effective to target OS metabolism[30]. However, there are few studies on dietary interventions as both stand-alone or combination therapies as subject of future avenues of research in bone sarcoma. In order to strengthen the public health intervention of bone tumors, more studies on the impact of lifestyle and dietary habits on bone tumors are essential.

Despite the comprehensive analysis provided by this study, several limitations remain. Firstly, our study is a secondary data analysis based on the GBD 2021 MNBAC data, which has unavoidable shortcomings such as the no determinacy of data quality[31]. The study here involved different regions with the culture difference, the health care systems difference, and other difference between regions when conducting cross-region comparisons. These could potentially impact the research results[32]. Moreover, the study also did not account for changes in diagnostic criteria and technologies or improvements in therapeutic

methods over time, which may have influenced trends in MNBAC incidence and prevalence. Finally, since the data collected after 2021 was not available, trends in the recent years could not be evaluated[33].

Conclusion

In conclusion, MNBAC remains a significant public health issue in China, particularly in Male or elderly population. Comprehensive and region-specific prevention strategies, such as public health campaigns, improved screening programs, and risk factor management, are critical to minimize the burden of MNBAC due to the epidemiological changes and growing trend of aging. Future research should focus more on the relationship between MNBAC and living habit or occupational exposures for better understanding and more precise public health interventions.

Abbreviations

MNBAC Malignant neoplasm of bone and articular cartilage

ASMR Age-standardized mortality rate

ASIR Age-standardized incidence rate

GBD Global Burden of Disease

DALYs Disability-adjusted life-years

YLDs Years lived with disability

YLLs Years of life lost

APC Age-period cohort

BAPC Bayesian age-period-cohort

CODEm Cause of Death Ensemble model

ST-GPR Spatiotemporal Gaussian process regression

ICD-9 the International Classification of Disease and Injuries, 9th

GATHER Guidelines for Accurate and Transparent Health Estimates Reporting

IE Intrinsic estimator

Declarations

Ethics approval and consent to participate

Our study is a secondary analysis of publicly available summary statistics and requires no specific ethical approval and consent to participate.

Consent for publication

Not applicable.

Availability of data and materials

Data for this study are accessible via the Institute for Health Metrics and Evaluation (IHME)'s online platform, found at <https://vizhub.healthdata.org/gbd-results/>.

Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Authors' contributions

Lizhen Zhuang: Conceptualization, Methodology, Investigation, Writing-original draft, Writing-review & editing

Weiqiang Zhang: Conceptualization, Writing-original draft, Writing-review & editing, Visualization, Validation

Xin Lu: Methodology, Investigation, Data curation, Validation, Formal analysis

Xi Lin: Writing-review & editing, Writing-original draft, Conceptualization, Supervision, Project administration, Resources, Funding acquisition

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References

1. Hu X, Deng K, Ye H, et al. Trends in Tumor Site-Specific Survival of Bone Sarcomas from 1980 to 2018: A Surveillance, Epidemiology and End Results-Based Study. *Cancers (Basel)*. 2021;13(21):5381.

2. Strauss SJ, Frezza AM, Abecassis N, et al. Bone sarcomas: ESMO-EURACAN-GENTURIS-ERN PaedCan Clinical Practice Guideline for diagnosis, treatment and follow-up. *Ann Oncol*. 2021;32(12):1520–36.
3. Zhao J, Dean DC, Hornicek FJ, et al. Emerging next-generation sequencing-based discoveries for targeted osteosarcoma therapy. *Cancer Lett*. 2020;474:156–67.
4. Lilienthal INA-O, Herold. Targeting Molecular Mechanisms Underlying Treatment Efficacy and Resistance in Osteosarcoma: A Review of Current and Future Strategies. *Int J Mol Sci*. 2020;21(18):6885.
5. Haseeb A, Muhammad Umer Nasrullah R, Siddiq MA, et al. Trends in malignant neoplasm of bone and articular cartilage related mortality among older adults in United States (1999–2020). *Ann Med Surg (Lond)*. 2024;86(11):6645–52.
6. Lai J, Li X, Liu W et al. *Global, regional, and national burden and trends analysis of malignant neoplasm of bone and articular cartilage from 1990 to 2021: A systematic analysis for the Global Burden of Disease Study 2021*. bone, 2024. 188: p. 117212.
7. Murray CJL. Findings from the Global Burden of Disease Study 2021. *Lancet*. 2024;403(10440):2259–62.
8. Ferrari AJ, Santomauro DF, Aali A, et al. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet*. 2024;403(10440):2133–61.
9. Naghavi, M., K.L. Ong, A. Aali, et al. *Global burden of 288 causes of death and life expectancy decomposition in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021*. The Lancet, 2024. 403(10440): pp. 2100–2132.
10. Liu J, Liu M, Chai Z, et al. Projected rapid growth in diabetes disease burden and economic burden in China: a spatio-temporal study from 2020 to 2030. *The Lancet Regional Health – Western Pacific*; 2023. p. 33.
11. Ma, Q., R. Li, L. Wang, et al. *Temporal trend and attributable risk factors of stroke burden in China, 1990–2019:an analysis for the Global Burden of Disease Study 2019*. The Lancet Public Health, 2021. 6(12): pp. e897-e906.
12. Zhou, M., H. Wang, X. Zeng, et al. *Mortality, morbidity, and risk factors in China and its provinces, 1990–2017:a systematic analysis for the Global Burden of Disease Study 2017*. The Lancet, 2019. 394(10204): pp. 1145–1158.
13. Stevens GA, Alkema L, Black RE, et al. Guidelines for Accurate and Transparent Health Estimates Reporting: the GATHER statement. *Lancet*. 2016;388(10062):e19–23.
14. Zhang Y, Liu J, Han X, et al. Long-term trends in the burden of inflammatory bowel disease in China over three decades: A joinpoint regression and age-period-cohort analysis based on GBD 2019. *Front Public Health*. 2022;10:994619.

15. Luo L. Assessing validity and application scope of the intrinsic estimator approach to the age-period-cohort problem. *Demography*. 2013;50(6):1945–67.
16. Das Gupta P. A general method of decomposing a difference between two rates into several components. *Demography*. 1978;15(1):99–112.
17. Pan H, Zhao Z, Deng Y, et al. The global, regional, and national early-onset colorectal cancer burden and trends from 1990 to 2019: results from the Global Burden of Disease Study 2019. *BMC Public Health*. 2022;22(1):1896.
18. Li S, Chen H, Man J, et al. Changing trends in the disease burden of esophageal cancer in China from 1990 to 2017 and its predicted level in 25 years. *Cancer Med*. 2021;10(5):1889–99.
19. Wu X, Du J, Li L, et al. Bayesian Age-Period-Cohort Prediction of Mortality of Type 2 Diabetic Kidney Disease in China: A Modeling Study. *Front Endocrinol (Lausanne)*. 2021;12:767263.
20. Xi Y, Qiao L, Na B, et al. Primary malignant bone tumors incidence, mortality, and trends in China from 2000 to 2015. *Chin Med J (Engl)*. 2023;136(17):2037–43.
21. Xu Y, Shi F, Zhang Y, et al. Twenty-year outcome of prevalence, incidence, mortality and survival rate in patients with malignant bone tumors. *Int J Cancer*. 2024;154(2):226–40.
22. Cole S, Gianferante DA-O, Zhu B, et al. Osteosarcoma: A Surveillance, Epidemiology, and End Results program-based analysis from 1975 to 2017. *Cancer*. 2022;128(11):2107–18.
23. Xu G, Wu H, Xu Y, et al. Homogenous and Heterogenous Prognostic Factors for Patients with Bone Sarcoma. *Orthop Surg*. 2021;13(1):134–44.
24. Anderson AB, Kim AB, Auid- Orcid E et al. --- Fau - Park, K. Park Ab Fau - Zhu,. *Bone Sarcoma Survival in the US Military Health System: Comparison With the SEER Program*. *J Am Acad Orthop Surg*, 2024. 32(13): pp. e651-e660.
25. Panagi M, Pilavaki P, Constantinidou A, et al. Immunotherapy in soft tissue and bone sarcoma: unraveling the barriers to effectiveness. *Theranostics*. 2022;12(14):6106–29.
26. Lilienthal INA-O, Herold. Targeting Molecular Mechanisms Underlying Treatment Efficacy and Resistance in Osteosarcoma: A Review of Current and Future Strategies. *Int J Mol Sci* 21(18): p. 6885.
27. The L. Population ageing in China: crisis or opportunity? *Lancet*. 2022;400(10366):1821.
28. Araki Y, Yamamoto N, Tanzawa Y, et al. Family cancer history and smoking habit associated with sarcoma in a Japanese population study. *Sci Rep*. 2022;12(1):17129.
29. Casey DL, Alektiar KM, Gerber NK, et al. Whole Lung Irradiation for Adults With Pulmonary Metastases From Ewing Sarcoma. *Int J Radiat Oncol Biol Phys*. 2014;89(5):1069–75.
30. Leite TC, Watters RJ, Weiss KR, et al. Avenues of research in dietary interventions to target tumor metabolism in osteosarcoma. *J Translational Med*. 2021;19(1):450.
31. Jiang Q, Shu Y, Jiang Z, et al. Burdens of stomach and esophageal cancer from 1990 to 2019 and projection to 2030 in China: Findings from the 2019 Global Burden of Disease Study. *J Glob Health*. 2024;14:04025.

32. Chen S, Sun H, Song Y, et al. Transition and trend analysis of the burden of depression in China and different income countries: Based on GBD database and joinpoint regression model. *J Affect Disord.* 2024;362:437–49.

33. Qiu HA-O, Xu SCRA-O. Cancer incidence, mortality, and burden in China: a time-trend analysis and comparison with the United States and United Kingdom based on the global epidemiological data released in 2020. *Cancer Commun (Lond).* 2021;41(10):1037–48.

Figures

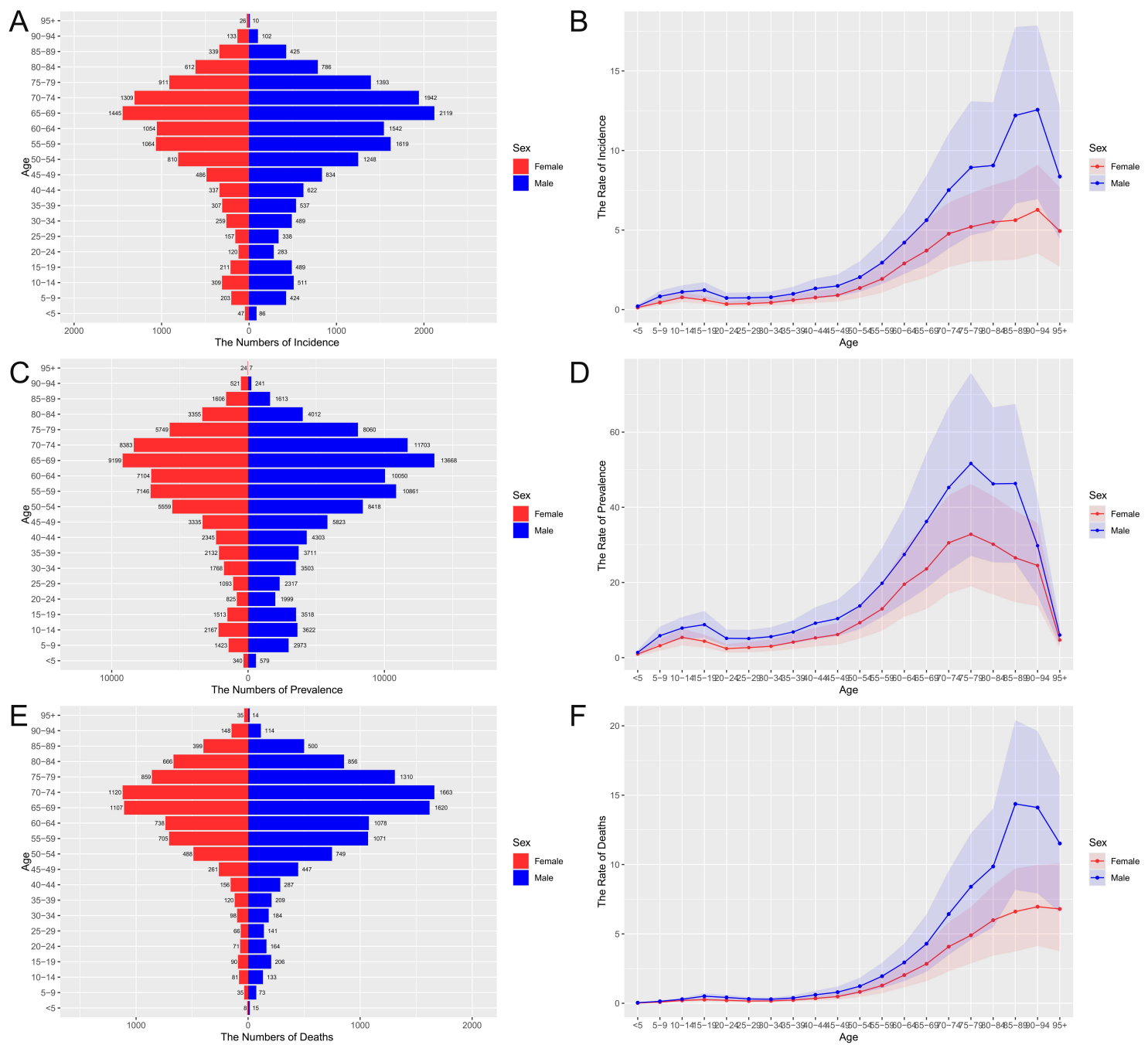


Figure 1

Distribution and rates of incidence, prevalence, and mortality of MNBAC in China in 2021. (A) Total new cases by age and sex. (B) ASIRs per 100,000 by age and sex. (C) Total prevalence cases by age and sex. (D) ASPRs per 100,000 by age and sex. (E) Total new deaths by age and sex. (F) ASMRs per 100,000 by age and sex.

(MNBAC, malignant neoplasm of bone and articular cartilage; ASIR, age-standardized incidence rate; ASPR, age-standardized prevalence rate; ASMR, age-standardized mortality rate.)

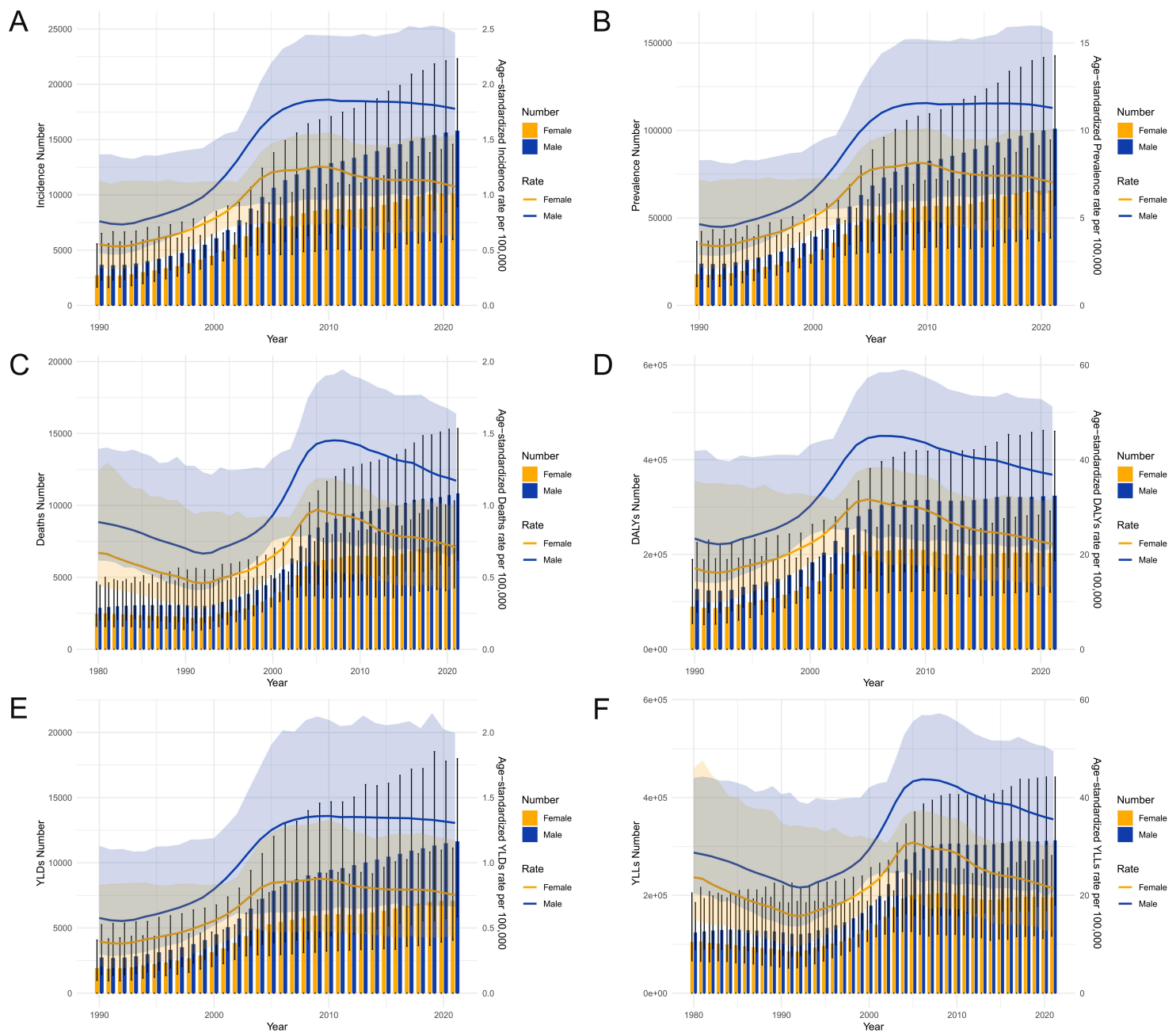


Figure 2

Gender-specific Trends in MNBAC metrics in China from 1990 to 2021. (A) Trends in ASIRs per 100,000 for males and females. (B) Trends in ASPRs per 100,000 for males and females. (C) Trends in

ASMRs per 100,000 for males and females. (D) Trends in DALYs due to NPC for males and females. (E) Trends in YLDs for males and females. (F) Trends in YLLs for males and females.

(MNBAC, malignant neoplasm of bone and articular cartilage; ASIR, age-standardized incidence rate; ASPR, age-standardized prevalence rate; ASMR, age-standardized mortality rate; DALYs, disability-adjusted life years; YLDs, years lived with disability; YLLs, years of life lost.)

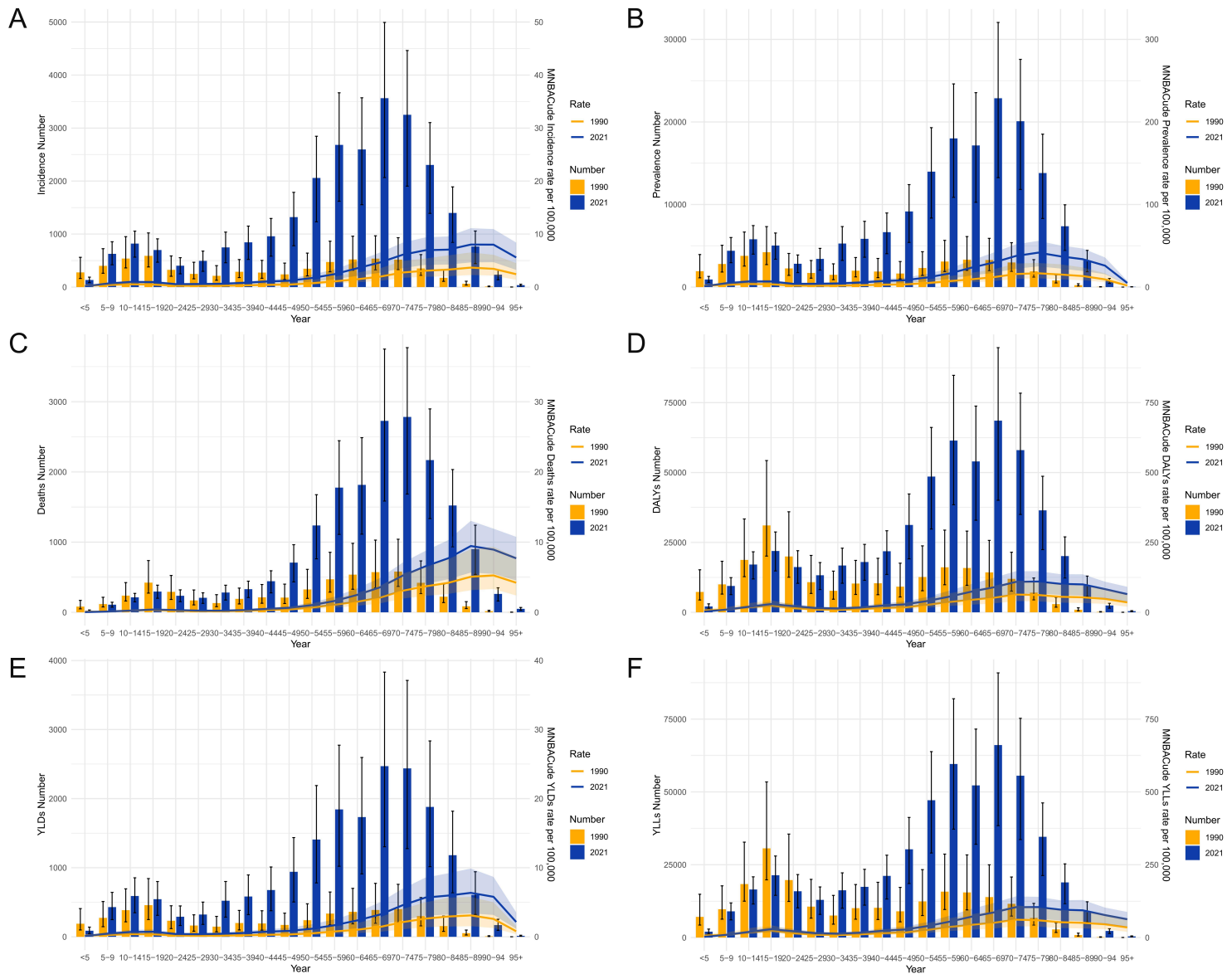


Figure 3

Age-specific comparison of MNBAC metrics in China between 1990 and 2021. (A) Age-specific comparison of incidence number and ASIRs per 100,000 in China between 1990 and 2021. (B) Age-specific comparison of prevalence number and ASPRs per 100,000 in China between 1990 and 2021. (C) Age-specific comparison of death number ASMRs per 100,000 in China between 1990 and 2021. (D) Age-specific comparison of DALYs number and rates Age-specific comparison of death number. (E)

Age-specific comparison of YLDs number and rates Age-specific comparison of death number. (F)
Age-specific comparison of YLLs number and rates Age-specific comparison of death number.

(MNBAC, malignant neoplasm of bone and articular cartilage; ASIR, age-standardized incidence rate; ASPR, age-standardized prevalence rate; ASMR, age-standardized mortality rate; DALYs, disability-adjusted life years; YLDs, years lived with disability; YLLs, years of life lost.)

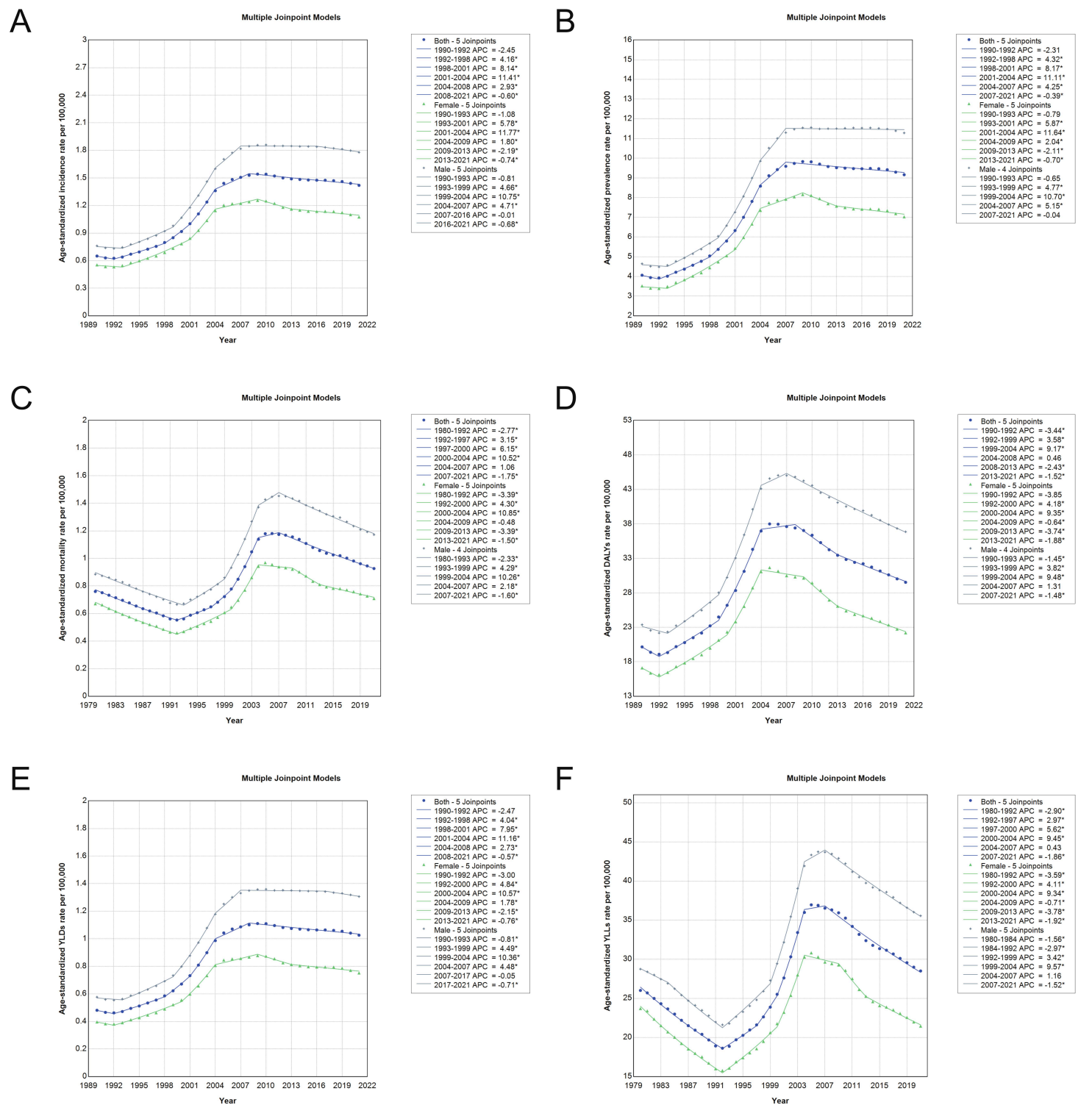


Figure 4

Joinpoint regression analysis of age-standardized rates for MNBAC in China from 1990 to 2021. (A) Trends by years in ASIRs for males, females and overall population. (B) Trends by years in ASPRs for males, females and overall population. (C) Trends by years in ASMRs for males, females and overall population. (D) Trends by years in DALYs for males, females and overall population. (E) Trends by years in YLDs for males, females and overall population. (F) Trends by years in YLLs for males, females and overall population.

(MNBAC, malignant neoplasm of bone and articular cartilage; ASIR, age-standardized incidence rate; ASPR, age-standardized prevalence rate; ASMR, age-standardized mortality rate; DALYs, disability-adjusted life years; YLDs, years lived with disability; YLLs, years of life lost.)

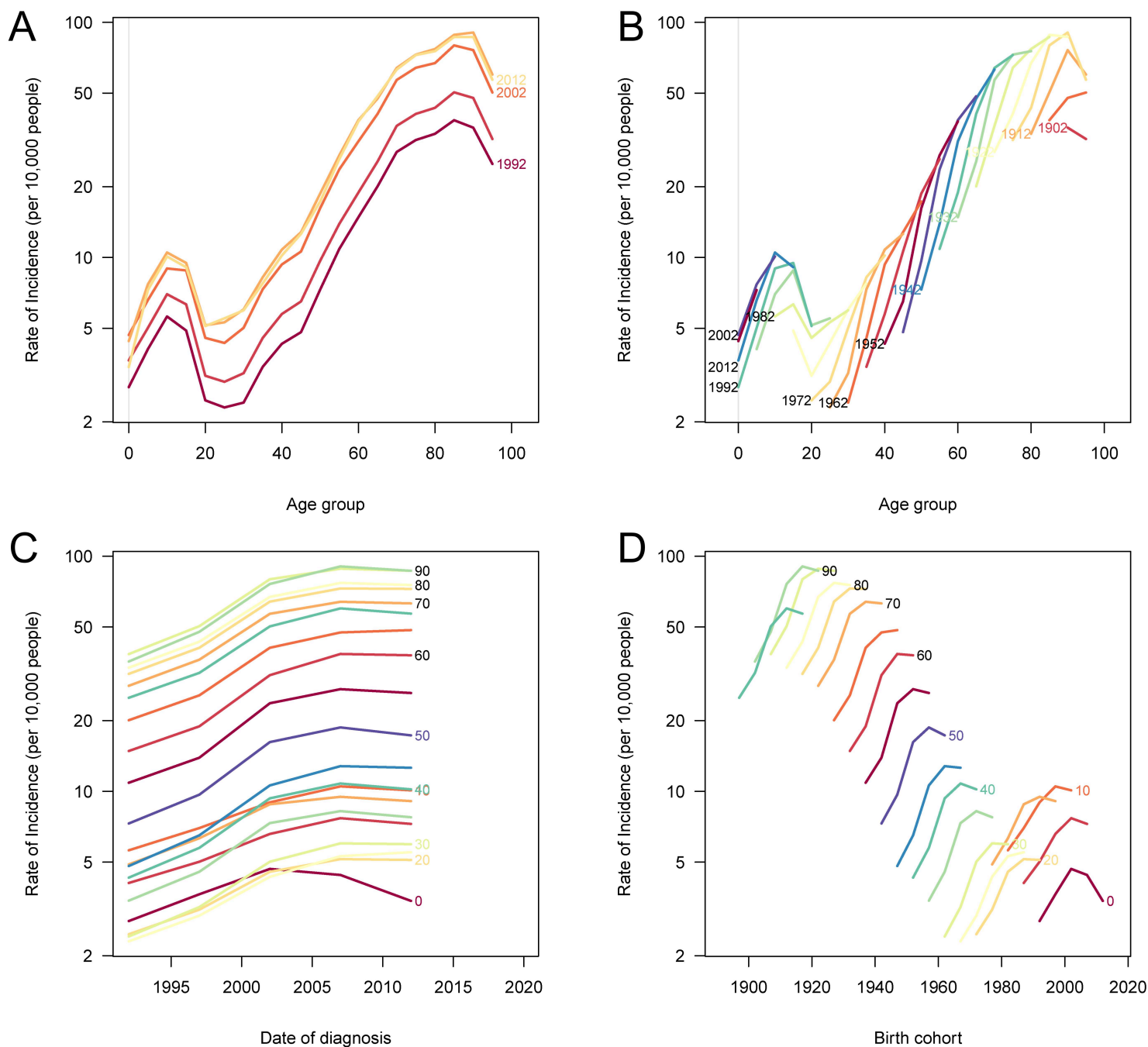


Figure 5

Age, period, and cohort effects on the incidence of MNBAC in China. (A) Age-specific incidence rates of MNBAC according to time periods. (B) Age-specific incidence rates of MNBAC according to birth cohort. (C) Period-specific incidence rates of MNBAC according to age groups. (D) Birth cohort-specific incidence rates of MNBAC according to age groups.

(MNBAC, malignant neoplasm of bone and articular cartilage. each line for a 5-year period.)

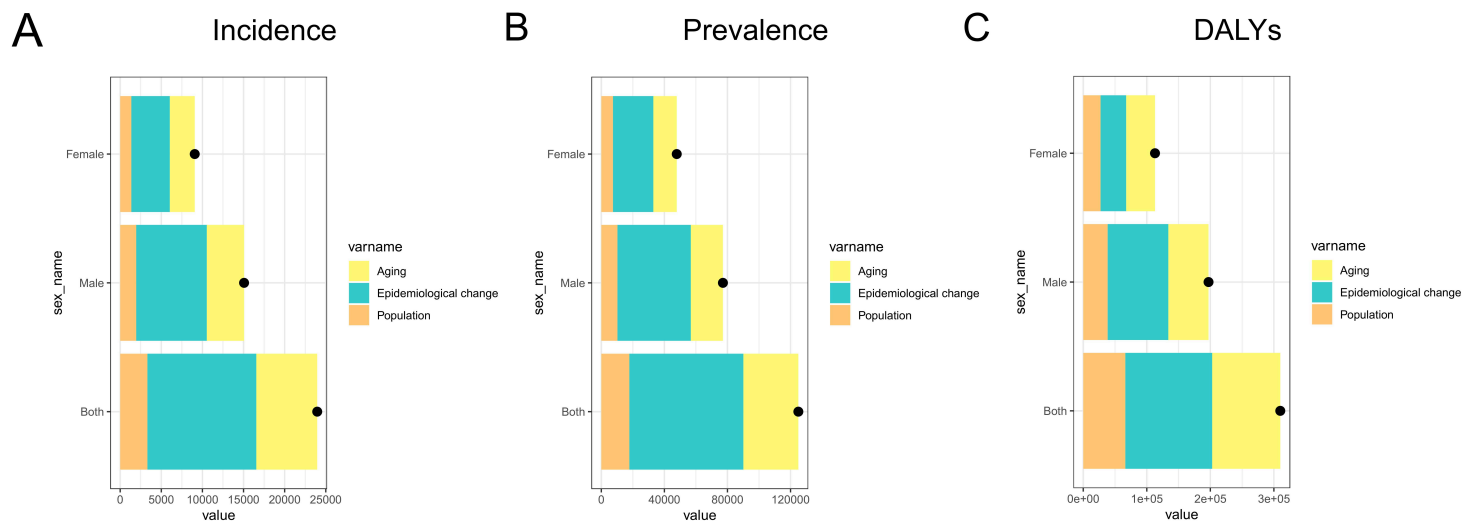


Figure 6

Decomposition analysis of factors contributing to MNBAC incidence, prevalence, and DALYs in China from 1990 to 2021. Contributions are shown for population growth (orange), aging (yellow), and epidemiological changes (green). The black dots represent the cumulative effect of these three factors. (A) Decomposition of the changes in MNBAC incidence. (B) Decomposition of the changes in MNBAC prevalence. (C) Decomposition of the changes in DALYs associated with MNBAC.

(MNBAC, malignant neoplasm of bone and articular cartilage; DALYs, disability-adjusted life years.)

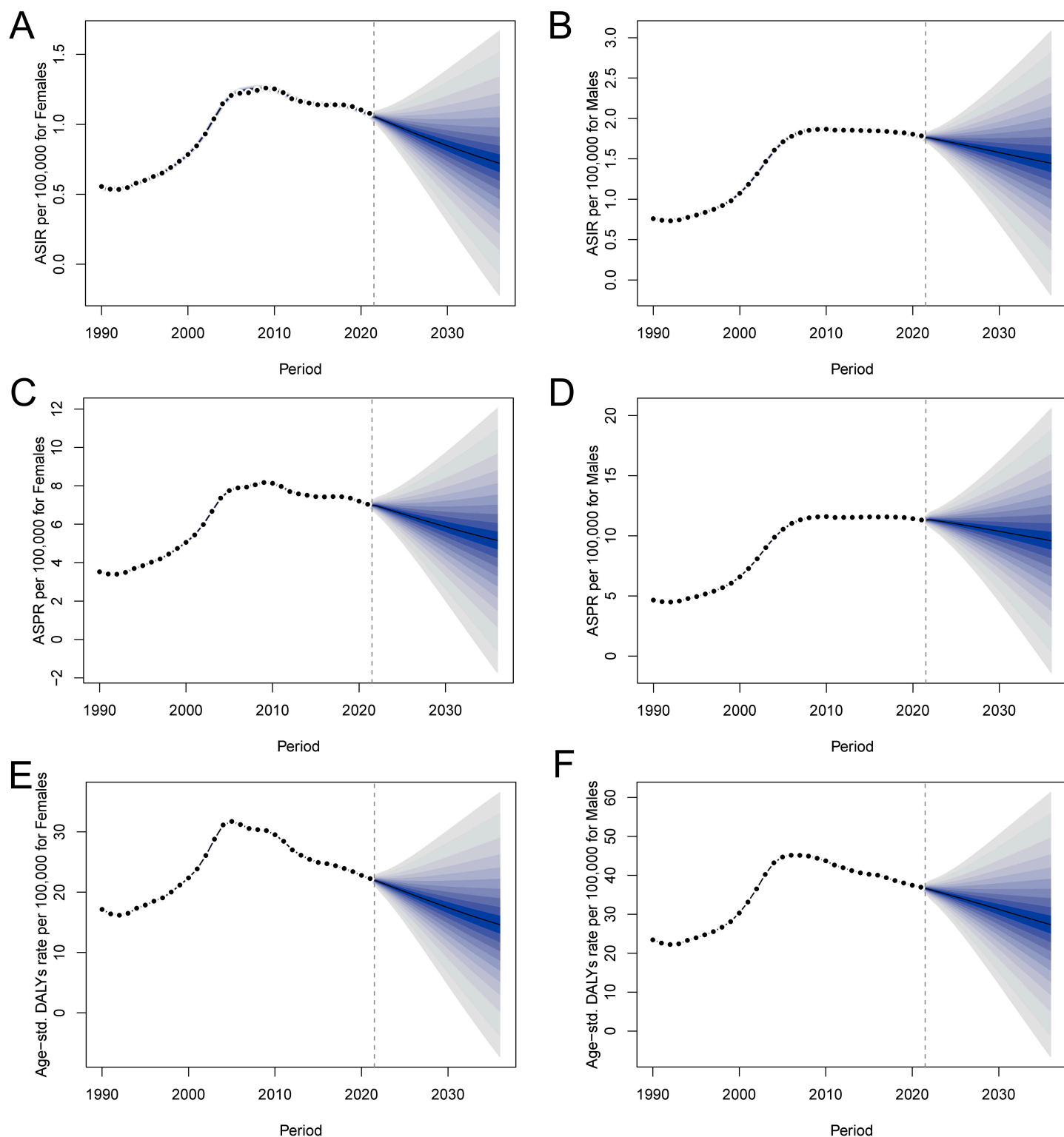


Figure 7

Projections of future trends in MNBAC metrics in China up to 2030. (A) Projected ASIRs per 100,000 for females. (B) Projected ASIRs per 100,000 for males. (C) Projected ASPRs per 100,000 for females. (D) Projected ASPRs per 100,000 for males. (E) Projected age-standardized DALYs rate per 100,000 for females. (F) Projected age-standardized DALYs rate per 100,000 for males.

(MNBAC, malignant neoplasm of bone and articular cartilage; ASIR, age-standardized incidence rate; ASPR, age-standardized prevalence rate; DALYs, disability-adjusted life years.)

Supplementary Files

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