Analysis of Breast Cancer Burden Trends in China (1990–2021) Using the GBD Database

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Abstract: Objective: To gain a comprehensive understanding of the long-term evolutionary patterns and gender disparities in breast cancer burden in China from 1990 to 2021, and to explore the association between the Age-Standardized Incidence Rate (ASIR) and the Socio-Demographic Index (SDI), so as to provide a scientific basis for formulating targeted prevention and control strategies.

Methods: Based on the 2021 Global Burden of Disease (GBD) dataset, four core indicators of breast cancer were extracted: number of deaths, Disability-Adjusted Life Years (DALYs), prevalence cases, and incidence cases. Descriptive statistics were used to analyze the distribution characteristics of indicators stratified by gender. The Joinpoint regression model was applied to calculate the Average Annual Percent Change (AAPC) and analyze the temporal trend of indicators. Pearson correlation analysis was conducted to examine the correlation between ASIR and SDI.

Results: From 1990 to 2021, the overall burden of breast cancer in China showed a significant upward trend, with the largest increase in prevalence (366.40%), followed by incidence (364.50%). The growth rate and annual average growth rate of all disease burden indicators in males were higher than those in females, while females accounted for the vast majority of the absolute disease burden. The age-standardized rates showed a fluctuating upward trend. Projections indicated that the female ASIR would continue to rise from 2021 to 2040 and remain much higher than that of males. There were significant regional differences in the incidence and prevalence of breast cancer worldwide, with obvious geographical clustering characteristics. ASIR was significantly positively correlated with SDI ($r = 0.767$, $P < 0.001$).

Conclusion: The burden of breast cancer in China continues to increase, posing an increasingly severe challenge to the healthcare system. Among them, the male disease burden grows rapidly and requires targeted attention. The levels of disease prevention and control vary significantly across regions. There is an urgent need to develop differentiated prevention and control strategies combining gender characteristics and regional epidemiological features to address this increasingly prominent public health issue.

Keywords: Breast cancer; Disease burden; Gender difference; Socio-Demographic Index; Age-standardized incidence rate

1. Introduction

Breast cancer is the most commonly diagnosed cancer in women worldwide and a major cause of cancer-related disability and premature mortality [1,2]. Its burden is shaped by population ageing, changes in reproductive and lifestyle patterns, and differences in access to screening and treatment [1].

The epidemiology of breast cancer is heterogeneous across countries and social groups [3]. Incidence and outcomes are influenced by age structure, socioeconomic conditions, reproductive patterns, lifestyle, environmental exposures, and diagnostic capacity [4]. China is undergoing rapid population ageing, accompanied by substantial changes in living patterns and improved detection capacity. Among the spectrum of malignant tumors in China, breast cancer severely impairs patients' quality of life and brings heavy care pressure to families and the healthcare system, posing great challenges to the public health service system [5]. From 1990 to 2021, China witnessed rapid socioeconomic development, continuous improvement of the medical and health system, and gradually increasing public awareness of cancer screening. This special historical background provides a valuable research scenario for exploring the dynamic changes in breast cancer burden, and the evolutionary trends of relevant core indicators have important guiding significance for public health practice [6].

Gender difference is a key research area in breast cancer epidemiology. Although breast cancer predominantly affects females, male breast cancer, despite its low absolute number, has unique epidemiological features and poorer prognosis. Gender differences in physiological characteristics, risk factor exposure, genetic susceptibility, and health-seeking behavior may lead to inconsistent trends in incidence, prevalence, mortality, and disability burden between males and females. Such discrepancies are closely related to sex-specific endocrine and biological factors, as well as differences in external risk exposure and screening accessibility. Clarifying gender differences in breast cancer is essential for developing gender-specific precise prevention and control measures and guiding the rational allocation of breast cancer medical resources among different populations.

On this basis, this study aims to analyze the long-term changes in breast cancer burden in China from 1990 to 2021, systematically describe the temporal evolution patterns of core burden indicators, and focus on gender differences and their influencing factors. Combined with the characteristics of standardized rates and correlation analysis with the Socio-Demographic Index, this study comprehensively evaluates the current status and development trajectory of breast cancer burden in China. It is expected to provide reliable evidence-based references for optimizing breast cancer prevention and control strategies, reducing individual and social losses caused by the disease, and promoting population health.

2. Materials and Methods

2.1 Research Design

This study adopted a population-based retrospective trend analysis method, focusing on the burden of breast cancer in China from 1990 to 2021. The core analysis focused on the long-term trends of four core indicators: mortality rate, Disability-Adjusted Life Years, prevalence rate, and incidence rate. Meanwhile, the gender disparities in disease burden were explored to provide data support and theoretical basis for precise prevention and strategic management of breast cancer in China.

2.2 Data Source

The research data were obtained from the Chinese component of the Global Burden of Disease

Study 2021 (GBD 2021) dataset. This comprehensive database integrates multi-source data including population census data, national health monitoring networks, and cancer registry records, and is constructed based on unified disease classification standards, rigorous data correction methods, and precise algorithm calibration. The GBD framework has been described in detail, including its data sources, modeling strategy, and uncertainty estimation procedures.

In this study, we extracted gender-stratified (male, female, total population) core disease burden indicators of breast cancer in China in 1990 and 2021, including original indicator values, percentage change (PC), average annual percentage change (AAPC), and corresponding uncertainty intervals (UI).

2.3 Research Indicators and Definitions

All core indicators were defined in accordance with the unified GBD research standards:

① Deaths: the total number of deaths attributable to breast cancer within the study year;

② DALYs (Disability-Adjusted Life Years): the sum of Years of Life Lost (YLLs) due to premature mortality and Years Lived with Disability (YLDs), which can comprehensively quantify the overall health loss caused by the disease;

③ Prevalence: the total number of existing breast cancer cases at a specific time point during the study year;

④ Incidence: the total number of newly diagnosed breast cancer cases occurring within the study year.

For trend evaluation, the percentage change was calculated as: PC = (2021 indicator value − 1990 indicator value) / 1990 indicator value × 100%. The AAPC with corresponding uncertainty interval was used to quantify the annual change magnitude and statistical reliability of long-term temporal trends in disease burden indicators.

2.4 Statistical Analysis Methods

Data processing and statistical analysis were performed using SPSS 26.0 software. Outlier screening was conducted according to gender stratification, and extreme values beyond ±3 standard deviations from the mean were excluded to ensure data robustness. The Joinpoint Regression Program was applied to construct piecewise linear regression models for temporal trend analysis. The AAPC and corresponding 95% uncertainty intervals were calculated, with a two-tailed $P < 0.05$ considered statistically significant.

All age-related rate indicators were standardized using the World Health Organization standard population to eliminate the confounding effect of temporal changes in population structure on the analytical results.

2.5 Quality Control

Rigorous verification was carried out throughout the data inclusion process to confirm the consistency of breast cancer diagnostic definitions, so as to ensure the homogeneity of data from different time periods. Gender-stratified data underwent cross-validation to maintain internal logical consistency. The entire research workflow complied with the standardized quality control specifications of the GBD database, ensuring data accuracy and reliable analytical results.

3. Results

3.1 Overall Trend of Breast Cancer Burden in China from 1990 to 2021

Over the three decades from 1990 to 2021, the overall health impact of breast cancer in China increased significantly and continuously, with all four core disease burden indicators showing substantial growth, reflecting the deepening impact of breast cancer on population health in China during this period.

From 1990 to 2021, breast cancer-related deaths in China rose from 41,218 to 91,484, an increase of approximately 50,000 cases over three decades, with a percentage increase of 122.00% and an average annual growth rate of 2.40%, indicating a continuously rising mortality burden. Meanwhile, DALYs increased from 1,495,722 to 3,029,405, a net increase of more than 1.5 million healthy life years lost, with a percentage increase of 102.50% and an average annual growth rate of 2.14%, comprehensively reflecting the increasing damage of breast cancer to population health through both death and disability.

Among all indicators, prevalence showed the most dramatic increase, soaring from 834,844 to 3,893,549 cases, with a percentage increase of 366.40% and an average annual growth rate of 5.39%, far exceeding other indicators, suggesting a particularly severe accumulation of prevalent breast cancer cases in the population. New incident cases also increased significantly, from 86,709 to 402,794, with a percentage increase of 364.50% and an average annual growth rate of 5.22%. Its growth magnitude was second only to prevalence, reflecting the continuously rising risk of new breast cancer diagnoses in the Chinese population and a worsening public health situation (Table 1).

3.2 Gender Differences in Breast Cancer Burden

From 1990 to 2021, the burden of breast cancer in both males and females in China showed a continuous upward trend, but there were significant gender differences in absolute values, growth magnitude, and average annual growth rate. Overall, the absolute scale of breast cancer burden in females was much larger than that in males, but the growth rate of disease burden in males was significantly faster.

In 1990, the number of breast cancer deaths in males was 861, and increased to 3,377 in 2021, with a net increase of 2,516, a percentage change of 292.20%, and an average annual percentage change of 5.99%. For females, the number of deaths was 40,357 in 1990 and rose to 88,107 in 2021, with a net increase of 47,750, a percentage change of 118.30%, and an average annual percentage change of 2.30%. Although the absolute number of female deaths was much higher than that of males, the growth magnitude of male deaths was 2.47 times that of females, and the annual growth rate was 2.60 times higher, indicating a significant gender disparity in the growth rate of mortality burden.

In terms of DALYs, male DALYs were 29,236 in 1990 and climbed to 108,308 in 2021, a net increase of 79,072, representing a percentage change of 270.50% and an average annual percentage change of 5.84%. Female DALYs were 1,466,486 in 1990 and increased to 2,921,096 in 2021, with a net increase of 1,454,610, a percentage change of 99.20%, and an average annual percentage change of 2.04%. The growth magnitude of male DALYs was 2.73 times greater and the annual growth rate was 2.86 times higher than that of females, reflecting that the relative growth rate of comprehensive health loss attributable to breast cancer was significantly higher in males than in females.

For prevalence, the baseline number of prevalent cases in males (15,758) was far lower than that in females (819,086) in 1990. By 2021, the gap in growth rate further widened: the net increase in male prevalence reached 129,691, with a percentage change of 823.00% and an average annual percentage change of 9.16%; while the net increase for females was 2,929,014, with a percentage change of 357.60%

and an annual growth rate of 5.29%. The rapid growth of male prevalence suggests that this population is an easily overlooked high-risk group for breast cancer.

As for incidence, the number of new cases in males was 1,916 in 1990 and increased to 16,956 in 2021, a net increase of 15,040, corresponding to a percentage change of 785.00% and an average annual percentage change of 9.20%. In females, the incidence count was 84,793 in 1990 and rose to 385,838 in 2021, with a net increase of 301,045, a percentage change of 355.00%, and an annual growth rate of 5.09%. Both the growth magnitude and annual growth rate of male incidence were significantly higher than those of females, suggesting a persistent gender disparity in the relative growth rate of new-onset breast cancer risk (Table 1).

Table 1: Burden Indicators and Trends of Breast Cancer in China Between 1990 and 2021 (By Sex).

Indicator	Sex	1990 Value	2021 Value	PC	AAPC_UI
Deaths	Male	861	3377	292.20%	5.99%
Deaths	Female	40357	88107	118.30%	2.30%
Deaths	Both	41218	91484	122.00%	2.40%
DALYs	Male	29236	108308	270.50%	5.84%
DALYs	Female	1466486	2921096	99.20%	2.04%
DALYs	Both	1495722	3029405	102.50%	2.14%
Prevalence	Male	15758	145449	823.00%	9.16%
Prevalence	Female	819086	3748100	357.60%	5.29%
Prevalence	Both	834844	3893549	366.40%	5.39%
Incidence	Male	1916	16956	785.00%	9.20%
Incidence	Female	84793	385838	355.00%	5.09%
Incidence	Both	86709	402794	364.50%	5.22%

3.3 Age-Standardized Rate Trends and Future Projections

From 1990 to 2021, the age-standardized prevalence rate (ASPR) of breast cancer in China rose continuously and significantly, registering the largest growth among all indicators. The DALY rate first peaked around 2005, then declined and stabilized after 2010. The age-standardized incidence rate (ASIR) showed a steady upward trend, while the age-standardized mortality rate (ASMR) remained relatively stable with minor fluctuations. Age standardization eliminated the interference of population age structure, verifying the characteristics of rising prevalence and incidence risk and relatively stable mortality risk of breast cancer (Figure 1).

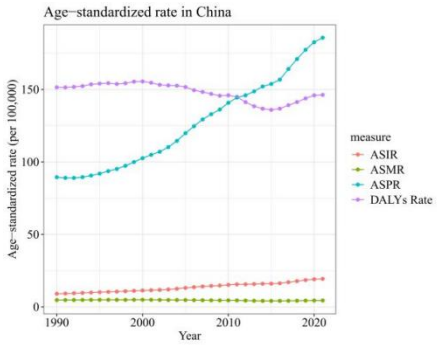


Figure 1: Trend in age-standardized rate of breast cancer in China, 1990-2021.

Based on observed data from 1990 to 2021, projections indicate that from 2021 to 2040, female ASIR will continue to rise, while male ASIR will tend to stabilize after an earlier increase. Female ASIR remains consistently and significantly higher than male ASIR, and is projected to reach nearly 50 per 100,000 by 2040 (compared with about 1.6 per 100,000 in males), with no narrowing of the absolute gender gap.

In terms of mortality, male ASMR stabilized at around 0.33 per 100,000 in 2021 and will remain steady; female ASMR will remain at approximately 8.2 per 100,000 by 2040. Female ASMR remains far higher throughout the projection period, suggesting that females will remain the priority population for breast cancer prevention and control, while the rapid relative growth in males deserves increased attention (Figure 2).

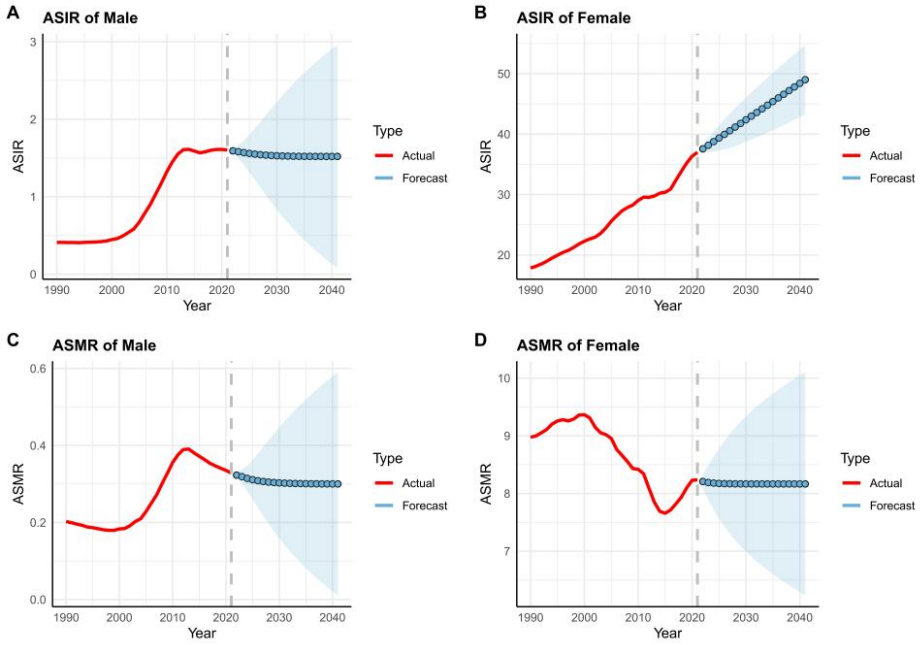


Figure 2: Gender-Specific Trends in Breast Cancer Incidence and Mortality: 1990-2040.

3.4 Regional Distribution Characteristics of Breast Cancer Onset and Prevalence

The incidence rates of breast cancer vary significantly across different regions worldwide. The age-standardized incidence rate ranges from 2.64 to 68.35 per 100,000 population, and incidence in some high-incidence areas exceeds 68.35 per 100,000, showing an obvious geographical clustering trend (Figure 3). High-income regions such as North America and Western Europe have the highest incidence, while low-income regions such as Africa have the lowest incidence, reflecting significant differences in breast cancer risk among populations in different regions.

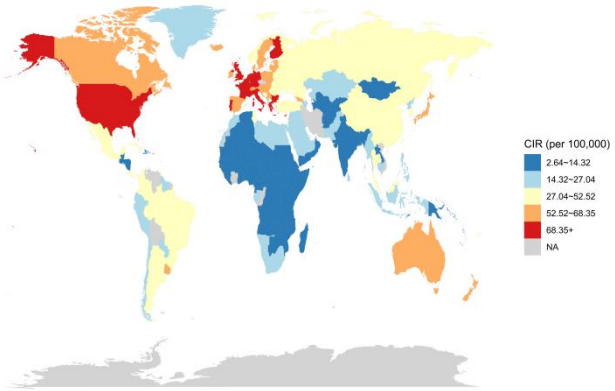


Figure 3: Geographical distribution of age-standardized incidence rates (CIR) of breast cancer globally.

The crude prevalence rate (CPR) of breast cancer also shows significant regional differences worldwide, ranging from 19.11 to 763.06 per 100,000 population. Prevalence in some regions exceeds 763.06 per 100,000, highlighting the huge gap in breast cancer burden across regions and reflecting the imbalance in disease prevention and control strategies and capacities across different regions of the world (Figure 4).

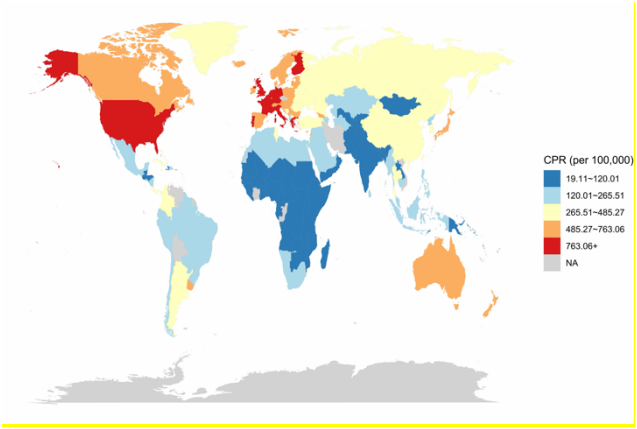


Figure 4: Geographical distribution of age-standardized prevalence rate (CPR) of breast cancer globally.

3.5 Correlation Between ASIR and Socio-Demographic Index

Correlation analysis results showed that the global age-standardized incidence rate of breast cancer was significantly positively correlated with the Socio-Demographic Index ($r = 0.767$, $P < 0.001$), and the fitted trend line suggested a non-linear association between the two indicators (Figure 5).

In the low SDI range (SDI < 0.5), the ASIR of breast cancer showed a slow upward trend with the increase of SDI, and incidence rates in low-SDI countries represented by sub-Saharan African countries were mostly below 15 per 100,000 population. In the middle SDI range (approximately 0.5–0.7), the rising trend of incidence accelerated, with substantial heterogeneity in incidence levels across countries. When SDI > 0.7, incidence continued to rise and remained at high levels; high-SDI economies including China, the United States, and most European countries were clustered in this interval, with their ASIR generally higher than 30 per 100,000 population and that of some countries exceeding 50 per 100,000 population.

The above positive correlation suggests that factors closely related to SDI, such as population aging degree, socioeconomic development level, reproductive pattern changes, and medical diagnostic capacity, are strongly associated with breast cancer risk, These associations support risk-stratified prevention and regionally tailored health-system planning.

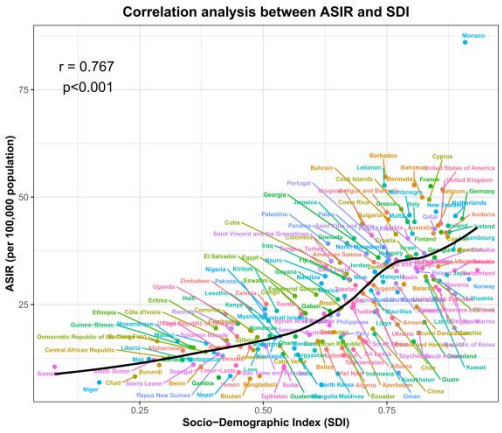


Figure 5: Correlation analysis of the ASIR of breast cancer with the SDI.

4. Discussion

Breast cancer is a major global public health problem [7]. In-depth analysis of the characteristics of breast cancer burden in China is of great significance for breast cancer prevention and control both in China and globally. China's unique demographic and socioeconomic characteristics make it an important sample for global breast cancer research [8]. We interpret the findings in the context of existing epidemiological evidence and discuss their implications for prevention and health-service planning.

The global burden of breast cancer is characterized by significant regional heterogeneity, with a continuous upward trend observed in middle- and high-income regions [9]. Previous domestic epidemiological studies have confirmed that breast cancer in China has obvious geographical clustering features, with heavier disease burden in economically developed and highly urbanized regions, which is consistent with the regional distribution observed in this study. Population aging, socioeconomic development, and improved medical diagnostic capacity are common drivers of the evolving breast cancer burden, providing a solid theoretical foundation for interpreting the changing epidemiological patterns of breast cancer in China [10].

Sex differences in breast cancer burden are clinically and epidemiologically important. Existing epidemiological studies have demonstrated that although females bear the overwhelming absolute burden of breast cancer, males show faster growth in incidence and mortality. This pattern may reflect differences in baseline risk, awareness, stage at diagnosis, and access to care; the present ecological analysis cannot establish the contribution of any single mechanism. In contrast, females have benefited more from widespread breast cancer screening programs and improved treatment accessibility, which have partly mitigated the growth of mortality. Male breast cancer is often diagnosed at a later stage due to lack of awareness and screening, resulting in poorer prognosis and faster-growing burden. Biological and hormonal factors contribute to sex differences in breast cancer risk, but their relative contributions cannot be quantified from GBD estimates alone. These findings are highly consistent with the gender-stratified results of this study, further complementing and

supporting our core research conclusions [11].

Changes in socioeconomic and demographic factors are the core drivers of the dynamic evolution of breast cancer burden. Established risk factors include reproductive and hormonal exposures, excess body weight, alcohol use, and limited physical activity. Meanwhile, improved medical accessibility and diagnostic accuracy in high-SDI regions significantly elevate disease detection rates, further expanding the recorded disease burden. Systematically analyzing the correlation between socioeconomic development level and breast cancer epidemiological indicators can provide a scientific basis for formulating regionally differentiated and multi-targeted prevention and control strategies.

This study is aligned with both global trends in cancer prevention and China's public health development objectives. By integrating the global epidemiological characteristics of breast cancer and the practical demands of China's chronic disease prevention and control system, our analysis of disease burden trends, gender differences, and socioeconomic influencing factors can provide valuable insights for optimizing targeted intervention strategies, thereby and may inform targeted prevention and control strategies.

This study still has certain limitations. The research data were derived from the secondary dataset of GBD 2021, which relies on unified global data collection and coding standards. Nevertheless, regional differences in medical diagnostic capacity and data reporting quality may cause potential bias in the estimation of epidemiological indicators. Future studies should combine multi-source primary epidemiological data for further verification and explore the heterogeneity of disease burden across different disease stages and clinical subtypes, so as to provide more refined evidence support for precise prevention and management of breast cancer in China[12].

5. Conclusions

In conclusion, the evolutionary characteristics and targeted prevention of breast cancer burden are core issues in global public health. Based on China’s demographic and socioeconomic national conditions and building upon existing epidemiological evidence, this study systematically explored the temporal trends, gender disparities, and socioeconomic correlates of breast cancer burden, further enriching the research field of cancer epidemiology. The findings provide reliable scientific support for the formulation of precise, regionally differentiated, and gender-targeted breast cancer prevention and control strategies. Future multidimensional and in-depth investigations are essential to further clarify the influencing mechanisms of disease burden changes and effectively reduce the overall health burden caused by breast cancer in China.

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