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Trend Analysis of Cervical Cancer Disease Burden in China from 1990-2021 and Forecast Study for 2022-2035: A Postprint

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Abstract

Background: Cervical cancer is the fourth most common cancer among women worldwide, imposing a substantial disease burden on all countries and representing a significant public health challenge globally, particularly in developing countries.

Objective: To examine the trends in cervical cancer disease burden in China from 1990 to 2021 and to project the disease burden from 2022 to 2035, thereby providing scientific evidence for formulating and adjusting prevention and control strategies.

Methods: Utilizing data from the 2021 Global Burden of Disease study, we analyzed temporal trends in incidence, mortality, and disability-adjusted life years (DALYs) for cervical cancer in China from 1990 to 2021 using estimated annual percentage change (EAPC), with comparisons made to the United Kingdom, United States, and Australia. Projections for China' s cervical cancer disease burden from 2022 to 2035 were generated using a Bayesian age-period-cohort (BAPC) model.

Results: China' s age-standardized incidence rate of cervical cancer increased from 11.80/100,000 in 1990 to 13.37/100,000 in 2021 (EAPC=0.88, 95%CI=0.70-1.07); the age-standardized mortality rate decreased from 6.98/100,000 in 1990 to 4.64/100,000 in 2021 (EAPC=-1.05, 95%CI=-1.20 to -0.89); and the age-standardized DALY rate declined from 228.2/100,000 in 1990 to 149.8/100,000 in 2021 (EAPC=-1.07, 95%CI=-1.22 to -0.92). In 2021, China' s age-standardized mortality rate was 2.11 times that of the United Kingdom, 1.73 times that of Australia, and 2.45 times that of the United States, while the age-standardized DALY rate was 2.01, 2.38, and 1.59 times higher than these countries, respectively. From 1990 to 2021, the proportion

of incident cases among women aged 35+ years increased from 86.41% to 92.12%, and DALYs from 88.48% to 95.07%; deaths among women aged 40+ years rose from 86.42% to 95.54%. The 25-54 age group showed a marked increase in incidence, most pronounced in the 45-49 age group (EAPC=1.49, 95%CI=1.20-1.78); this group also experienced the smallest declines in mortality and DALY rates among those under 60. Projections indicate that by 2035, China' s age-standardized incidence, mortality, and DALY rates will decrease to 11.8/100,000, 3.4/100,000, and 112.8/100,000, respectively.

Conclusion: China' s cervical cancer disease burden remains heavy, exceeding that of developed countries such as the United Kingdom. The population aged 35 years and above constitutes the main component of this burden and represents the key target group for prevention and control. We recommend gradually promoting nationwide HPV vaccination for girls aged 9-14 years based on existing experience, and exploring its inclusion in the national immunization program. Simultaneously, screening coverage should be further increased among those aged 35-44 years, combined with strengthened health education and awareness campaigns, to establish a comprehensive life-course prevention and control system that reduces China' s cervical cancer disease burden.

Full Text

Trends in Cervical Cancer Burden in China from 1990 to 2021 and Projections for 2022 to 2035

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Abstract

Background: Cervical cancer is the fourth most common cancer among women worldwide, imposing a substantial disease burden on countries globally and representing a critical public health challenge, particularly for developing nations. **Objective:** To examine trends in cervical cancer burden in China from 1990 to 2021 and project disease burden from 2022 to 2035, providing a scientific basis for formulating and adjusting prevention and control strategies. **Methods:** Using data from the 2021 Global Burden of Disease (GBD) study, we analyzed temporal trends in cervical cancer incidence, mortality, and disability-adjusted life years (DALYs) in China from 1990 to 2021 using estimated annual percentage change (EAPC) and compared these with trends in the United Kingdom, United

States, and Australia. Projections for China' s cervical cancer burden from 2022 to 2035 were generated using the Bayesian age-period-cohort (BAPC) model. **Results:** China' s age-standardized incidence rate (ASIR) increased from 11.80 per 100,000 in 1990 to 13.37 per 100,000 in 2021 (EAPC=0.88, 95%CI=0.70-1.07). The age-standardized mortality rate (ASMR) decreased from 6.98 per 100,000 in 1990 to 4.64 per 100,000 in 2021 (EAPC=-1.05, 95%CI=-1.20 to -0.89), and the age-standardized DALYs rate declined from 228.2 per 100,000 in 1990 to 149.8 per 100,000 in 2021 (EAPC=-1.07, 95%CI=-1.22 to -0.92). In 2021, China' s ASMR was 2.11 times that of the United Kingdom, 1.73 times that of Australia, and 2.45 times that of the United States, while the age-standardized DALYs rate was 2.01, 2.38, and 1.59 times higher, respectively. From 1990 to 2021, the proportion of incident cases among women aged $ $35 years increased from 86.41% to 92.12%, and DALYs in this age group rose from 88.48% to 95.07%; deaths among women aged $ $40 years increased from 86.42% to 95.54%. Notably, incidence rates showed upward trends in the 25–54 age group, with the most pronounced increase in the 45–49 age group (EAPC=1.49, 95%CI=1.2–1.78). The 45–49 age group also exhibited the smallest declines in mortality and DALYs rates among those under 60. Projections indicate that by 2035, China' s age-standardized incidence, mortality, and DALYs rates will decrease to 11.8, 3.4, and 112.8 per 100,000, respectively. **Conclusion:** China faces a substantial cervical cancer burden that exceeds that of developed countries such as the United Kingdom. Women aged 35 and older constitute the primary disease burden and represent a key target population for prevention and control. We recommend gradually promoting nationwide HPV vaccination for girls aged 9–14 years based on existing experience and exploring its inclusion in the national immunization program. Simultaneously, screening coverage should be improved among women aged 35–44 years, complemented by strengthened health education to build a comprehensive life-cycle prevention and control system that reduces cervical cancer burden in China.

Keywords: Cervical cancer; Disease burden; Incidence; Mortality; Disability-adjusted life years; Trend analysis

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Cervical cancer, primarily caused by persistent high-risk human papillomavirus (HPV) infection [1-2], is the fourth most common cancer among women worldwide. In 2022, global cervical cancer cases reached 661,000 with 348,000 deaths [3], while China reported 150,700 new cases and 55,700 deaths, ranking fifth and sixth among female malignant tumors in China, respectively [4-5]. Domestic research on temporal trends in cervical cancer burden remains limited. Therefore, this study utilizes the latest publicly available data from the Global Burden of Disease (GBD) 2021 to analyze the current status and long-term trends of cervical cancer burden among Chinese women from 1990 to 2021, while projecting disease burden from 2022 to 2035, thereby providing scientific evidence for research and policy development in cervical cancer prevention and control.

Methods

Data Sources Cervical cancer burden data were obtained from the Institute for Health Metrics and Evaluation (IHME, https://vizhub.healthdata.org/gbd-results/). The GBD 2021 report provides the most recent epidemiological estimates for 371 diseases and injuries across 21 GBD regions and 204 countries from 1990 to 2021 [6-7]. For data extraction, we selected "cervical cancer" as the disease, "China" as the region, and "Deaths, Incidence, DALYs" as metrics for the period 1990–2021, with "Female" as gender and 15 age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, $ $85 years). Statistical indicators included incident cases, deaths, and DALYs by age group with corresponding age-standardized rates. Population projection data were derived from 2017 GBD forecasts for 2018–2035.

Trend Analysis We employed descriptive epidemiological methods to analyze incidence, mortality, and DALYs with corresponding age-standardized rates from 1990 to 2021. EAPC, standardized incidence rates, standardized mortality rates, and standardized DALYs rates were used to compare temporal trends in cervical cancer burden between China, global averages, and three developed countries (United Kingdom, Australia, United States). EAPC was calculated by fitting a regression model to the natural logarithm of rates over time, where each observation' s natural logarithm is fitted to a linear trend. The formula is:

$$y = \alpha + \beta x + \varepsilon$$

$$\text{EAPC} = 100 \times (\exp(\beta) - 1)$$

where x represents year, y represents the natural logarithm of the age-standardized rate, α is the intercept, β is the slope, and ε is random error. An EAPC with 95% confidence interval (CI) lower bound >0 indicates an increasing trend, while an upper bound <0 indicates a decreasing trend. If the 95%CI includes 0, the trend is not statistically significant [8-9].

Prediction Model Using 1990–2021 cervical cancer burden data, we applied Bayesian age-period-cohort (BAPC) analysis to project China' s cervical cancer burden from 2022 to 2035. The BAPC model is a log-linear Poisson model assuming multiplicative effects of age, period, and cohort:

$$\log(\lambda_{ij}) = \mu + \alpha_i + \beta_j + \gamma_k$$

where λ_{ij} represents case counts, μ is the intercept, and α_i, β_j, and γ_k denote age, period, and cohort effects, respectively. Projections were implemented using the BAPC and INLA packages in R [10-12].

Statistical Methods Data from 1990–2021 were compiled using Excel 2016. Statistical analyses were performed using R version 4.4.1, with $P < 0.05$ considered statistically significant.

Results

Temporal Trends in Cervical Cancer Burden in China, 1990–2021 In 2021, China reported 133,000 new cervical cancer cases (19.9% of global cases), representing a 129.6% increase since 1990. The ASIR rose from 11.80 per 100,000 in 1990 to 13.37 per 100,000 in 2021 (EAPC=0.88, 95%CI=0.70–1.07). Cervical cancer caused 49,800 deaths (16.8% of global deaths), a 56.8% increase since 1990, while the ASMR decreased from 6.98 per 100,000 in 1990 to 4.64 per 100,000 in 2021 (EAPC=-1.05, 95%CI=-1.20 to -0.89). DALYs totaled 1,547,786 person-years (15.6% of global DALYs), a 38.7% increase since 1990, with the age-standardized DALYs rate declining from 228.2 per 100,000 in 1990 to 149.8 per 100,000 in 2021 (EAPC=-1.07, 95%CI=-1.22 to -0.92) (Tables 1–3).

Figure 1 shows that from 1990 to 2021, cervical cancer incidence rates declined globally (EAPC=-1.27, 95%CI=-1.36 to -1.18) and in the United Kingdom (EAPC=-3.17, 95%CI=-3.55 to -2.80), United States (EAPC=-1.51, 95%CI=-1.72 to -1.29), and Australia (EAPC=-3.07, 95%CI=-3.28 to -2.85). Global and national mortality and DALYs rates also decreased, with the United Kingdom (mortality EAPC=-2.88, 95%CI=-3.14 to -2.61; DALYs EAPC=-2.97, 95%CI=-3.24 to -2.69) and Australia (mortality EAPC=-3.07, 95%CI=-3.28 to -2.85; DALYs EAPC=-2.95, 95%CI=-3.20 to -2.71) showing larger reductions, while the United States exhibited smaller declines (mortality EAPC=-1.02, 95%CI=-1.13 to -0.92; DALYs EAPC=-1.10, 95%CI=-1.22 to -0.98).

Age-Specific Trends in Cervical Cancer Burden, 1990–2021 From 1990 to 2021, incidence and DALYs rates among Chinese women aged $ $35 years exceeded overall standardized rates, with the proportion of incident cases in this age group rising from 86.41% to 92.12% and DALYs increasing from 88.48% to 95.07%. Mortality rates among women aged $ $40 years also exceeded overall rates, with deaths in this group rising from 86.42% to 95.54% of total deaths. Notably, incidence rates increased significantly in the 25–54 age group, particularly in the 45–49 age group (EAPC=1.49, 95%CI=1.2–1.78). Among women under 60, the 45–49 age group showed the smallest declines in mortality (EAPC=-0.87, 95%CI=-1.08 to -0.65) and DALYs rates (EAPC=-0.78, 95%CI=-0.99 to -0.56) (Figure 2).

Projections of Cervical Cancer Burden in China, 2022–2035 By 2035, China's cervical cancer cases, deaths, and DALYs are projected to reach 147,545, 54,733, and 1,579,839, respectively, representing increases of 11.1%, 9.8%, and 2.1% from 2021. Age-standardized rates are projected to decline to 11.8 per

100,000 for incidence, 3.4 per 100,000 for mortality, and 112.8 per 100,000 for DALYs (Figure 3).

Discussion

This study analyzed temporal trends in China' s cervical cancer burden from 1990 to 2021 using GBD 2021 data, standardized rates, and EAPC. Results show that while China' s ASIR remained below global averages, it increased slowly (0.88% annually). In contrast, the United Kingdom, United States, and Australia experienced declining ASIRs, likely attributable to national HPV vaccination programs [13-15]. China' s ASMR and age-standardized DALYs rates declined slowly (1.05% and 1.07% annually, respectively), both below global averages. In 2021, China' s ASMR was 2.11, 1.73, and 2.45 times higher than that of the United Kingdom, Australia, and the United States, respectively, while the age-standardized DALYs rate was 2.01, 2.38, and 1.59 times higher. China' s new cases, deaths, and DALYs accounted for substantial global proportions (19.9%, 16.8%, and 15.6%, respectively). These findings indicate that over the 32-year period, China' s cervical cancer burden has remained heavy, exceeding that of developed countries and highlighting a serious prevention and control situation.

From 1990 to 2021, incidence and DALYs rates among Chinese women aged $ $35 years exceeded overall standardized rates, with case and DALYs proportions increasing to 92.12% and 95.07%, respectively. Mortality among women aged $ $40 years also exceeded overall rates, with death proportions rising to 95.54%. These results indicate that women aged $ $35 years constitute the primary disease burden and represent a key target population. Previous studies show that cervical cancer predominantly occurs after age 35, concentrating in the 45–54 age group [16], possibly due to cumulative HPV infection effects [17], declining immune function [18], and long-term reproductive physiological factors that increase susceptibility to cervical intraepithelial neoplasia and carcinogenesis. Early screening in high-risk populations is crucial for timely detection and improved survival.

To reduce cervical cancer' s health impact, China launched free screening services for rural women aged 35–64 years in 2009. However, screening coverage among women aged 35–44 years was only 43.4% in 2018–2019 [19], with rural areas significantly lagging behind urban regions. This falls short of WHO' s 2030 target of 70% screening coverage. To improve awareness and coverage, we recommend health education through popular platforms such as WeChat, TikTok, and short videos, and implementing comprehensive outreach programs that bring cervical cancer prevention knowledge into hospitals, schools, communities, and households, particularly in rural and remote areas.

Cervical cancer is both preventable and treatable. WHO has set a global elimination target for 2030: 90% of girls vaccinated against HPV by age 15, 70% of women screened by age 35 and again by 45, and 90% of women with precan-

cerous lesions or cancer receiving treatment [20]. Our projections indicate that China' s age-standardized incidence, mortality, and DALYs rates will decline to 11.8, 3.4, and 112.8 per 100,000, respectively, from 2022 to 2035. While these declining trends reflect recent progress in prevention and control, the modest reduction in ASIR suggests that without intensified efforts, China' s cervical cancer burden will remain high.

HPV vaccination is a key preventive measure. The United States included HPV vaccine in its immunization schedule for 11–12-year-old girls in 2006, with studies showing vaccine-type HPV prevalence decreasing from 13.1% (2007) to 2.9% (2015–2016) among women aged 20–29 [21]. After the United Kingdom introduced HPV vaccine (Cervarix) in 2008, vaccinated populations showed a 97% reduced risk of cervical intraepithelial neoplasia grade 3 (CIN3) and 34% lower cervical cancer risk [14]. Australia' s national HPV vaccination program, implemented in 2007, is projected to reduce incidence below WHO standards by 2028, potentially making it the first country to eliminate cervical cancer [13]. These successes demonstrate that early HPV vaccine introduction with high coverage significantly reduces HPV infection and related cervical lesions.

As of December 2023, 140 of 194 WHO member states (70%) have included HPV vaccine in their national immunization programs [22]. China approved HPV vaccines in 2016, but national coverage among females aged 9–45 years was below 3% during 2018–2020, with coverage among eligible girls aged 10–14 years under 1% [23-24], far from WHO' s 2030 target of 90% coverage in those under 15. As of May 2024, nine Chinese provinces (autonomous regions, municipalities) have included HPV vaccination in government public welfare projects, offering free or subsidized vaccines to eligible girls. To reduce disease burden and achieve WHO elimination goals, we recommend: (1) intensifying research on these pilot programs while accelerating evidence-based decision-making for national inclusion of HPV vaccine in the immunization schedule, and (2) strengthening collaboration among schools, communities, and healthcare facilities to improve public awareness and vaccination rates among eligible girls (9–14 years) through multichannel health education.

This study has several limitations. First, GBD data rely on healthcare information and disease surveillance systems from various countries that may use different data collection standards and methods, potentially causing inconsistencies. Second, GBD 2021 provides national-level data, precluding detailed analysis of regional, provincial, or urban-rural disparities in cervical cancer burden. Third, our projections are based on assumed conditions, and information lags in the GBD database may introduce deviations from actual outcomes.

Author Contributions: SHANG Zhonghua conceptualized the study, analyzed data, created visualizations, and drafted the manuscript. ZHANG Li revised the manuscript, provided quality control, assumed overall responsibility, and secured funding support.

Conflict of Interest: The authors declare no conflicts of interest.

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