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ORIGINAL ARTICLE

Cervical cancer burden and trends in China, 2000–2020: Asia-Pacific international comparisons and insights for elimination goals

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ABSTRACT

Objective: Cervical cancer is a growing concern in China, especially among women who reside in rural areas and older women. Understanding age- and region-specific trends in cervical cancer is vital for informing policy and assessing progress toward WHO elimination targets.

Methods: The 2000–2020 data from 22 long-standing registries contributing to the China national cancer registry was analyzed to estimate age-standardized incidence and mortality rates (ASIR and ASMR, respectively). Joinpoint regression yielded an average annual percentage change (AAPC) stratified by age group (<35, 35–64, 65–74, and ≥75 y) and by urban-rural area. The comparative analysis included GLOBOCAN Overtime data from selected Asia-Pacific countries.

Results: The ASIR tripled in China between 2000 and 2020 before stabilizing (AAPC = 6.5%), while the ASMR rose steadily (AAPC = 3.9%). The urban incidence declined after 2009 among women <35 y, while rural trends were broadly stable. The ASIR and ASMR increased in urban areas among women 35–64 y of age, while rural areas had a rising ASIR and a stable ASMR, suggesting potential screening effects. In contrast, women ≥65 y of age had a steadily increasing incidence and mortality in rural and urban areas. Australia and Republic of Korea had consistent declines in the ASIRs and ASMRs compared to other Asia-Pacific countries, whereas Japan exhibited rising trends. The Philippines experienced a surge in mortality rates, despite incidence rates remaining stable or declining.

Conclusions: The cervical cancer burden in China has begun to plateau but large disparities persist by age and geography. To achieve elimination of cervical cancer, it is imperative to implement tailored strategies that prioritize the urgent expansion of HPV vaccination programs, the deployment of high-efficacy screening methods, and the universal access to treatment throughout the nation.

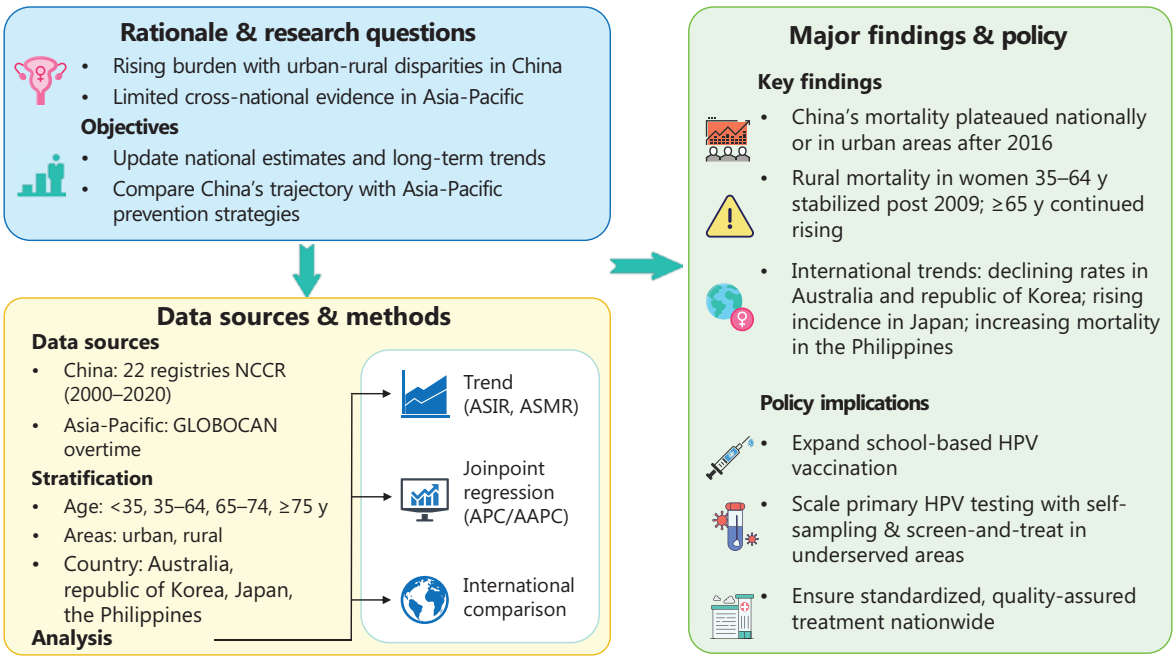
KEYWORDS Cervical cancer; incidence; mortality; HPV vaccination; screening; China; Asia-Pacific; epidemiology

Introduction

Cervical cancer is among the most preventable malignancies, yet cervical cancer remains the fourth most common cancer and the fourth leading cause of cancer-related deaths among women globally[1]. In 2022, approximately 662,301 new cases and 348,874 deaths occurred worldwide with nearly 60% of the burden was concentrated in Asia[1,2]. Motivated by these avoidable losses, the World Health Organization (WHO) announced the Global Cervical Cancer Elimination Initiative in 2020. The WHO set "90-70-90" targets, as follows: 90% of girls should be vaccinated against human papilloma virus (HPV) by 15 y of age; 70% of women 35–45 y of age should undergo high-quality cervical screening; and 90% of women with cervical disease should receive treatment. The overall aim of the 2020 Global Cervical Cancer Elimination Initiative was to reduce the incidence of cervical cancer to <4 per 100,000 by 2100[3].

Nearly one-fifth of the world's women reside in China. Therefore, progress toward achieving global elimination of cervical cancer within China is critical. China reported approximately 150,659 new cervical cancer cases and 55,694

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Study flowchart Cervical cancer burden and trends in China and selected Asia-Pacific countries, 2000–2020. This study flow summarizes the rationale, methods, main findings, and policy implications of the study. National data were derived from 22 long-standing cancer registries in China (2000–2020), complemented by GLOBOCAN Overtime data for Australia, the Republic of Korea, Japan, and the Philippines. Analyses estimated age-standardized incidence and mortality rates (ASIR, ASMR) by age group (<35, 35–64, 65–74, ≥75 y) and by urban–rural areas, using joinpoint regression to calculate annual percent change (APC) and average annual percent change (AAPC) with reference to key policy milestones (2009 national screening program, 2016–2017 HPV vaccine introduction). The results highlighted a plateau in incidence and mortality nationally and in urban areas after 2016, persistent increases among older women (≥65 years), and widening urban–rural disparities. International comparisons showed favorable declines in Australia and republic of Korea, in contrast to rising incidence in Japan and increasing mortality in the Philippines. Policy implications emphasize expanding HPV vaccination, scaling up HPV-based screening with self-sampling in underserved areas, and ensuring nationwide access to quality-assured treatment to achieve elimination goals.

related deaths in 2022 according to the International Agency for Research on Cancer (IARC) GLOBOCAN 2022 and the National Central Cancer Registry (NCCR). It was reported that 85,459 cases and 30,194 deaths occurred in urban areas, while 65,200 cases and 25,500 deaths occurred in rural areas[2,4,5]. Over the past two decades, the age-standardised incidence rate (ASIR) has increased from 3.1 per 100,000 in 2000 to >13 per 100,000 in 2022, while the age-standardised mortality rate (ASMR) has risen nearly 4-fold during the same period[4-6]. Projections from Cancer Tomorrow suggest that this upward trend will not persist indefinitely. The number of new cases is expected to increase to 168,605 by 2035 (+11.9% compared to 2022) before declining slightly to 165,597 by 2045 (+9.9% compared to 2022)[7]. These estimates indicate that the national burden is likely to peak around 2040, then stabilise rather than continuing to increase steeply.

To address this challenge, China has implemented several large-scale interventions. The National Cervical and Breast Cancer Screening Programme for Rural Women, which was launched in 2009, currently covers nearly all county-level regions and offers cytology or visual inspection using acetic acid/visual inspection with Lugol's iodine (VIA/VILI) screening to women 35–64 y of age. However, population coverage remains suboptimal. Specifically, only 37% of women in this age group were screened for cervical cancer in 2018–2019[8]. After intensified efforts, the rate increased to approximately 52% by 2023. But the cervical cancer screening rate was still well below the WHO 70% target[9]. Although HPV vaccines were first licensed in China in 2016, limited domestic supply, high out-of-pocket costs, and insufficient public financing have kept the full-course uptake rate at only 10.2% and the first-dose uptake rate at approximately 6.2% among adolescent girls in 2022[10]. Pilot initiatives involving HPV self-sampling, screen-and-treat algorithms, and artificial intelligence-assisted cytology show promise but remain unevenly implemented, while persistent geographic inequities in

healthcare resources and health literacy continue to hamper nationwide progress[11].

It was essential to place the China experience within the broader Asia–Pacific context to strengthen the regional relevance of our analysis. Comparisons within this region, particularly among East Asian countries, are especially meaningful because these nations share relatively similar socio-demographic profiles, yet differ with respect to specific cervical cancer prevention strategies, programme coverage, and implementation timelines. Such similarities reduce unmeasured confounding, while differences provide opportunities to identify policy-relevant drivers of divergent trends[12,13]. For example, the Republic of Korea has maintained a nationwide, organised cytology screening programme since 1999 (biennial Pap smears) and introduced adolescent HPV vaccination into the National Immunization Program in 2016, achieving high screening participation with growing vaccine uptake[14-16]. Cervical cancer screening in Japan remains primarily cytology-based with a 2-y interval and national coverage between 50% and 60%. Moreover, the proactive recommendation by the government for HPV vaccination was suspended from 2013 until the nationwide resumption in 2022, which contributed to a persistently low vaccine uptake[17-20]. In contrast, the Philippines bears a comparatively higher burden than these peers with very low HPV vaccine coverage and limited population-level screening (primarily VIA), reflecting fragmented implementation and low participation[13,21,22].

Even though China has a pivotal role in Asia-Pacific region, few studies have compared the Asia-Pacific burden and programme progress with neighbouring countries that have similar demographics but different disease prevention and control policies. Understanding how China compares to regional leaders, strong improvers, countries with partial-progress and high-burden late adopters can help identify transferrable strategies and gaps[23].

Against this backdrop, a comprehensive evaluation of the cervical cancer burden and control in China was undertaken, integrating NCCR registry data (2000–2020) with GLOBOCAN 2022 and GLOBOCAN Overtime estimates for cross-national benchmarking. Specifically, the aims of the current study were as follows: (1) provide the most recent national estimates of ASIR and ASMR and the temporal trends; (2) compare the trajectory in China with selected Asia-Pacific comparators that span the full burden of the region and programme spectrum; and (3) relate observed trends to HPV-vaccination and screening coverage to highlight strategic priorities for achieving the WHO elimination targets in China.

Materials and methods

Study design and setting

A population-based time-trend analysis of cervical cancer in China was performed between 2000 and 2020. In addition, a parallel cross-national comparison was carried out among the selected countries within the Asia-Pacific region. Reporting of this study adhered to the STROBE checklist for observational time-series studies. The international comparative component is policy-anchored, so the time trends were aligned with prespecified country-specific milestones in vaccination and screening to enable descriptive interpretation across programme archetypes.

Data sources and case ascertainment in China

Incidence and mortality data were extracted from 22 long-standing, high-quality cancer registries (11 urban and 11 rural) certified by the NCCR[24]. All registries provided individual-level records for each calendar year. Mid-year population denominators, categorized into 5-y age groups (0–4 to ≥85 y) and stratified by urban/rural classification and calendar year, were obtained from the National Bureau of Statistics.

Female cases diagnosed with invasive cervical carcinoma (ICD-10 C53) were extracted from the datasets. Records were aggregated into eighteen 5-y age categories for the purposes of standardization. Cases were grouped into three clinically significant age bands for descriptive analyses: (1) 0–34 y age group, representing the young population potentially impacted by the HPV vaccination policies; (2) 35–64 y age group, representing the target population for cancer screening programmes; and (3) 65–74 and ≥75 y age group, representing the elderly population.

Selection of comparator countries and international data sources

Two predefined eligibility criteria for selecting comparator countries were applied to evaluate the cervical cancer trends in China in a broader regional context: (1) availability of consistently reported, high-quality cervical cancer incidence and mortality data for 2000–2020 from GLOBOCAN/IARC (**Table S1**); and (2) documented national prevention and control strategies, including HPV vaccination and organised

screening programmes. Within this eligible pool a subset that spans the full regional gradient from a very low-to-a very high disease burden and from a high-to-low programme coverage were deliberately selected so that China could be benchmarked against both advanced and lagging settings.

"Programme archetypes" were operationalized to further enhance interpretability, as follows: (a) high-coverage, integrated programmes (Australia); (b) organised cytology screening with rising vaccination (the Republic of Korea); (c) mixed progress characterised by vaccination disruption and cytology-based screening (Japan); and (d) late/low-coverage adopters (the Philippines). Country-specific policy milestones (e.g., introduction/suspension/resumption of HPV vaccination, transitions to primary HPV testing *vs.* continued cytology, and national recall/triage systems) were curated for each comparator and used as contextual anchors in the comparative analysis. Although Australia differs in ethnic composition from East Asian settings, it represents the current global benchmark for cervical cancer prevention with near-optimal HPV vaccination coverage and nationwide HPV-based screening, thereby providing a "best-practice" reference point against which the progress in China can be assessed (**Table 1**).

Age-specific standardised incidence and mortality for 2022 were extracted from GLOBOCAN 2022 (IARC) for these comparators[2]. Retrospective trend estimates for 2000–2020 were downloaded from GLOBOCAN Overtime (International Agency for Research on Cancer, May 2025 release)[36], which provides retrospectively harmonised estimates for every country[14]. National HPV-vaccination coverage (girls 9–14 y of age) and organised screening participation (women 30/35–64 y of age) for 2009–2022 were collated from the WHO/United Nations International Children's Emergency Fund (UNICEF) Joint Reporting Forms[37], National Immunisation Programme bulletins[38,39], the Catalan Institute of Oncology (ICO) and the International Agency for Research on Cancer (IARC) Information Centre on HPV and Cancer (HPV Information Centre)[40], and the Ministry of Health statistical yearbooks[26,41], which ensured harmonised, policy-relevant inputs for cross-country comparisons.

Statistical analysis

Age-specific incidence and mortality rates were calculated per 100,000 woman-years. ASIR and ASMR were computed using the direct method and standardised to the Segi/WHO world standard population. This adjustment accounted for population ageing and allowed valid comparisons across time periods, geographic regions, and demographic subgroups. Due to data availability, incidence trends were analyzed through 2017 (or 2015 for Japan), while mortality extended to 2020 (or 2019 for the Philippines), which may obscure late-phase divergence between incidence and mortality.

Temporal trends in the ASIR and ASMR from 2000–2020 were analysed using the Joinpoint Regression Program (version 5.4.0; National Cancer Institute, Bethesda, MD, USA). Candidate models allowed up to 3 joinpoints as per NCI guidance for a 21-y series with model selection based on Monte Carlo permutation tests (two-sided $\alpha = 0.05$) and the Bayesian information criterion (BIC). Annual percent change (APC) and the 95% confidence intervals (CIs) were calculated for each segment. The average annual percent change (AAPC) was used to summarise overall trends across the entire study period[42]. To aid interpretation, 2 policy anchors were pre-specified: 2009 for the launch of the National Screening Programme and 2016–2017 for HPV vaccine licensing and introduction. These anchors guided the description of segments before and after key policies but were not imposed as joinpoints in model fitting.

All data management, rate estimation, and visualisation were performed in R version 4.2.2 using the epitools, dplyr, stringr, ggplot2, and cowplot packages. Joinpoint analyses were performed independently using the Joinpoint Regression Program.

Results

Incidence trends in China, 2000–2020

National and urban-rural patterns

The cervical cancer ASIR escalated from approximately 3 to 10 per 100,000 from 2000–2016, representing an almost 3-fold increase. The rate then reached a relatively stable state. The cervical cancer ASIR in rural areas was lower than urban areas before 2014. After 2014 the cervical cancer ASIR increased and exceeded the urban rate, reaching >11 per 100,000 in 2018–2019 (**Figure 1A**).

Joinpoint regression analysis identified two phases in the trend (**Table 2**). The cervical cancer national ASIR increased steadily during 2000–2020 (AAPC = 6.5%, 95% CI: 6.0%~7.1%) with a rapid rise in the early 2000s followed by a slower but still significant growth thereafter. Both urban (AAPC = 6.2%, 95% CI: 5.6%~6.8%) and rural areas (AAPC = 8.2%, 95% CI: 7.1%~9.4%) had significant increases but the overall growth was steeper in rural areas. Comparison of APCs

Table 1 Cervical cancer incidence, mortality, and control strategies in selected Asia-Pacific countries

Country	Incidence in 2022		Mortality in 2022		Cervical cancer control policy					Cervical cancer control metrics	
	Cases	ASIR ($1/10^5$)	Death	ASMR ($1/10^5$)	Screening test modality & rollout year	HPV vaccination schedule (recommended age & doses)	National clinical guidelines	Financing (vaccine & screening)	Other policy domains highlights	HPV vaccine coverage 9–14 y (2023, %)	Screening uptake 35–64 y (2023, %)
Australia[25]	898	5.3	323	1.4	1991 NCSP (Pap q2y, 20–69) → Dec 2017 transition to primary HPV q5y (25–74); universal self-collection from July 2022	School-based programme since 2007; girls & boys 12–13 y; 9-valent; switched to single-dose in 2023	Comprehensive national guidelines & elimination roadmap	Federally/ state-funded program with Medicare coverage	Diagnostic & treatment capacity: Broad access to radiotherapy and brachytherapy. Data systems: NCSR (2016-) centralizes invitations/recall and data	2023 HPV vaccination coverage in adolescents was 83.0% (84.2% in females and 81.8% in males)[26]	82.8% of women aged 35–39 y screened at least once with an HPV test, and 79.8% of women aged 45–49 y had been screened at least twice[26]
China[9,27,28]	150,659	13.8	55,694	4.5	2009 launch of rural women's free screening program (cytology or VIA/VILI); 2021–2023 national guidance endorses primary hr-HPV testing (preferred) with cytology as alternative, transition progressing unevenly	Girls 9–14 y 2-dose; ≥ 15 y 3-dose; vaccine not yet in national immunisation programme	National screening scheme & Chinese gynaecologic-oncology guidelines	Government-subsidized rural screening; local expansion of fiscal support	Diagnostic & treatment capacity: Colposcopy/LEEP and chemoradiation are available in higher-level hospitals, but urban–rural gaps persist Data systems: NCCR expanding coverage and annual reporting	≈4% (1 dose in girls 9–14 y)[10]	≈52% in women 35–64 y (2023 survey)[9]
Japan[19,29]	10,958	12.5	3,864	2.6	Municipality-invited biennial Pap cytology (20–69 y) long-standing; 2020 guideline also allows physician-collected primary HPV every 5 y; HPV vaccine proactive recommendation suspended 2013–2022, then resumed	Girls 12–16 y 3-dose (routine); catch-up for 1997–2006 cohorts free of charge (since 2022);	National cervical-cancer screening & treatment guidelines	Municipal vouchers/ subsidies to improve uptake	Diagnostic & treatment capacity: Tertiary centers provide colposcopy/LEEP and chemoradiation including brachytherapy Data systems: National Cancer Registry began 2016 under the Cancer Registry Promotion Act	Highly cohort-specific: 53.3–79.5% (1994–1999 births) *vs.* < 1% (2000–2003 births)[30]	51% of women 25–65 y (57% in 30–49 y) screened within 3 y[18]

Table 1 Continued

Country	Incidence in 2022		Mortality in 2022		Cervical cancer control policy					Cervical cancer control metrics	
	Cases	ASIR ($1/10^5$)	Death	ASMR ($1/10^5$)	Screening test modality & rollout year	HPV vaccination schedule (recommended age & doses)	National clinical guidelines	Financing (vaccine & screening)	Other policy domains highlights	HPV vaccine coverage 9–14 y (2023, %)	Screening uptake 35–64 y (2023, %)
Republic of Korea[14-16,31]	3,397	8.6	1,143	2.0	NCSP launched 1999 with biennial Pap (initially ≥ 30 y; expanded to ≥ 20 y in 2016); hr-HPV as adjunct in some contexts; adolescent HPV vaccination introduced 2016	Girls 12 y 2-dose (since 2016); limited catch-up to 17 y (2022)	National screening & management guideline	Free or low-copay under Medical Aid/ NHI	Diagnostic & treatment capacity: Well-established oncology and radiotherapy services nationwide Data systems: NCSIS enables tracking of results and follow-up	25% of all women ever vaccinated (one dose); 87% of target girls (≥ 1 dose)[12]	59% of women 25–65 y (64% in 30–49 y) screened within 3 y[32]
Philippines[13,33-35]	8,549	15.5	4,380	8.0	Opportunistic VIA (and Pap where available); DOH guidance historically VIA every 5–7 y for ages 25–55 y; more recent national recommendations allow Pap q3y or hr-HPV q5y for 30–65 y where feasible	Pilot free 2-dose programme for girls 9–14 y in selected provinces (since 2015)	DOH screening guidance; limited implementation	NICCA (2019) established a national framework and financing tools, implementation ongoing	Diagnostic & treatment capacity: Radiotherapy and brachytherapy capacity remains limited and uneven; access gaps persist Data systems: National cancer registry strengthening under NICCA	28% of target girls (≥ 1 dose)[12]	1% of women 25–65 y ever screened[21]

ASIR, Age-standardized incidence rate; ASMR, Age-standardized mortality rate; Dec, December; DOH, Department of Health; HPV, human papilloma virus; hr-HPV, High-risk Human Papilloma virus; LEEP, Loop Electrosurgical Excision Procedure; NCCR, National Central Cancer Registry; NCSIS, National Cancer Screening Information System; NCSP, National Cancer Screening Program; NCSR, National Cancer Screening Registry; NHI, National Health Insurance; NICCA, National Integrated Cancer Control Act; Pap, Papanicolaou test; VIA/VILI, Visual inspection with acetic acid/visual inspection with Lugol's iodine; y, Year(s).

across periods indicated that while early growth rates were similar between urban and rural women, rural areas maintained positive trends for a longer duration after 2007 (APC = 4.8%, 95% CI: 2.6%~6.3%), contributing to the higher overall AAPC.

Age-specific patterns

Across all areas, women 35–64 y of age consistently exhibited the highest ASIRs. The 35–64 y age group had a sharp rise in incidence until 2013, stabilising thereafter at approximately 26 per 100,000. In comparison, The 65–74 y age group curve increased more gradually but continuously, nearly converging with the 35–64 y age group plateau by 2020 (**Figure 1B**). Urban trajectories exhibited a similar path at slightly lower levels with a clearer taper after 2013 (**Figure 1C**). In rural areas incidence increased most rapidly in women 35–64 y of age with a sustained rise through 2020 and no clear plateau. The rates in 65–74 y age group also climbed with stepwise accelerations after the early 2010s and the ≥75-y curve had a net upward trend, although more variable (**Figure 1D**). The incidence in women 0–34 y of age remained 1–2 per 100,000 in both geographic areas.

Table 2 summarises long-term gradients. By age group, women 0–34 y of age experienced the most rapid early increase (APC = 36.3%, 95% CI: 22.4%~60.1% during 2000–2004), followed by a significant decline thereafter, especially in urban areas (APC = −4.6%, 95% CI: −6.0%~−3.2%). Among women 35–64 y of age the incidence rose sharply in the early 2000s in both settings with higher APCs in urban areas during the initial growth phase but the increase in rural women persisted for a longer period. The incidence transitioned from an early decline to sustained growth in women 65–74 y of age, yielding national, urban, and rural AAPCs between 2000 and 2020 of 4.5% (95% CI: 3.9%~5.4%), 4.1% (95% CI: 3.1%~5.8%), and 6.3% (95% CI: 4.6%~7.9%), respectively. The long-period trend in national and urban areas was near stable for women ≥75 y of age, while rural areas increased throughout (AAPC = 4.7%, 95% CI: 3.1%~6.4%).

Mortality trends in China, 2000–2020

National and urban-rural patterns

Nationally, the ASMR increased from 1.0 to 2.2 per 100,000, then plateaued off after 2016. The urban curve was comparable to the national curve. In contrast, the rural ASMR was consistently higher and had greater fluctuations than the urban ASMR during the entire period (**Figure 1E**).

Nationally, the ASMR increased significantly from 2000–2016 (APC = 5.5%, 95% CI: 4.9%~6.5%) before stabilising or declining slightly between 2016 and 2020, resulting in an overall positive AAPC of 3.9% (95% CI: 3.0%~4.6%; **Table 3**). Urban areas followed a similar trajectory (AAPC = 4.1%, 95% CI: 3.0%~5.0%), whereas rural areas showed a more sustained increase (AAPC = 4.9%, 95% CI: 3.4%~6.3%). APC comparisons revealed that while both areas had significant early increases, recent years show no significant decline in urban mortality and no significant acceleration in rural mortality, consistent with a national plateau rather than a clear reversal.

Age-specific patterns

The ASMR for the ≥75 y age group was the highest in both areas. Nationally, the ≥75-y curve consistently remained above the threshold of 10 per 100,000 and fluctuated at approximately 13 per 100,000. The ASMR among women 65–74 and 35–64 y of age ascended until 2016, after which the ASMR stabilised at a level of 8 and 5 per 100,000 (**Figure 1F**). Urban profiles had a comparable shape (**Figure 1G**). The rural ASMR for the ≥75 y age group peaked near 21 per 100,000 in the late 2010s, which was higher than the corresponding urban rate of approximately 12 per 100,000. Similarly, among women 65–74 and 35–64 y of age, rural mortality was modestly higher than urban areas throughout the period (**Figure 1H**). In contrast, fatality rates among women <35 y of age remained low and stable across all areas.

Joinpoint outputs highlight pronounced heterogeneity (**Table 3**). In women 0–34 y of age, mortality remained low and stable overall. In the 35–64 y age group, mortality increased steadily in both settings; specifically, urban women exhibited a steeper early rise (AAPC = 6.5%, 95% CI: 6.0%~7.1%) than rural women (AAPC = 4.7%, 95% CI: 3.2%~6.6%). Urban mortality continued modest but significant rise after 2009 (AAPC = 2.0%, 95 CI: 1.2%~3.1%), whereas rural mortality was essentially stable (AAPC = 1.3%, 95% CI: −1.2%~3.8%).

Mortality among urban women in the 65–74 y age group increased (AAPC 2000–2020 = 2.4%, 95% CI: 1.2%~4.6%) and continued to rise after 2009 (AAPC 2009–2020 = 4.8%, 3.1%~6.9%). In contrast, mortality in women ≥75 y of age was broadly stable over the entire period (AAPC=−1.5% −2.5%~0.1%). Mortality rose in rural areas in both age groups (65–74 y age group: AAPC = 3.6%, 95% CI: 1.2%~5.9%; ≥75 y age group: AAPC = 3.9%, 95% CI: 2.1%~5.5%) with the ≥75 y age group exhibiting a relatively higher increase. Since 2009, Mortality has declined or remained stable in all women <35 y of age, in rural women 35–64 y of age, and in urban women ≥75 y of age; increases are concentrated outside these age groups.

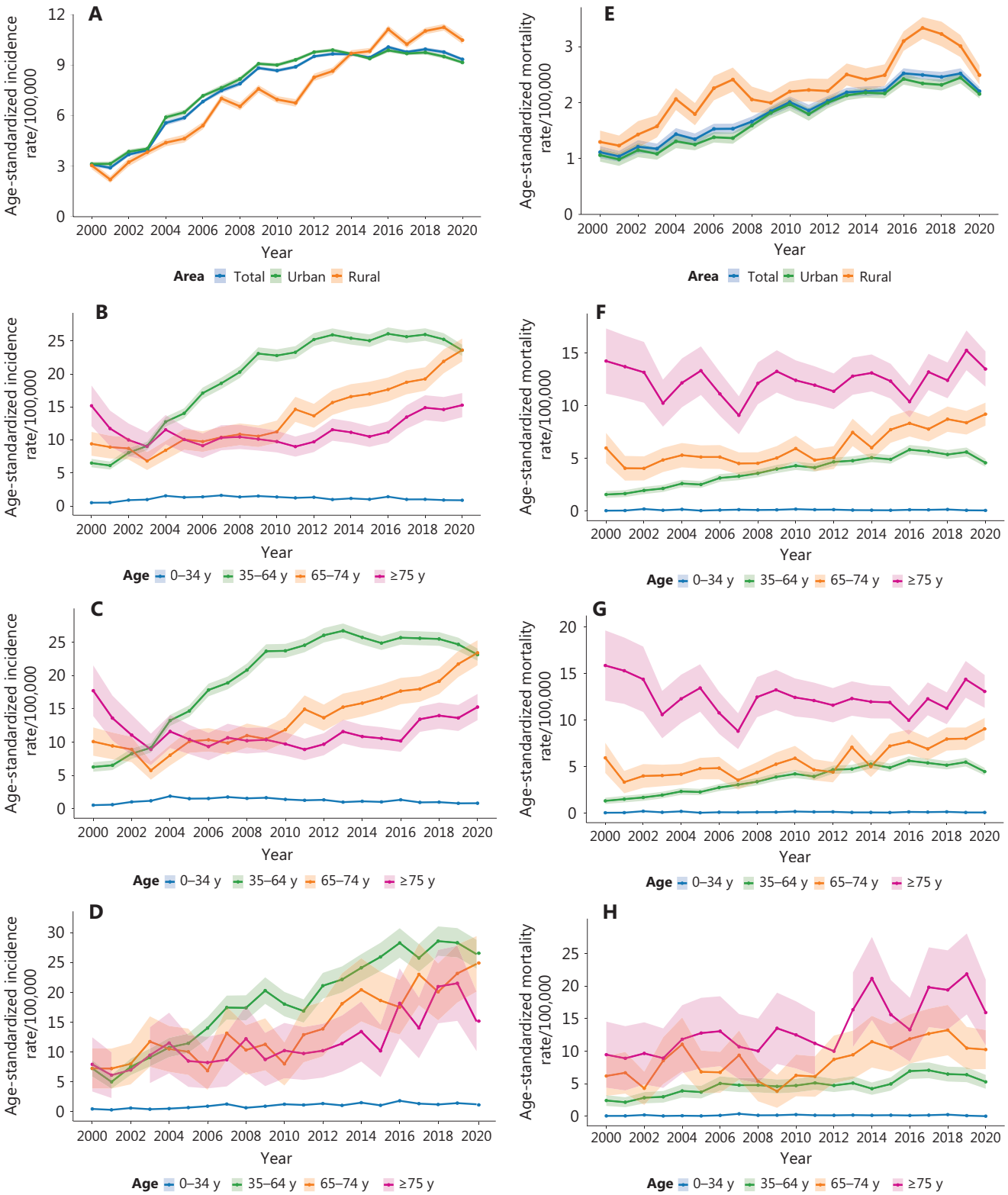


Figure 1 Trends in age-standardized cervical cancer rates by area and age group in China, 2000–2020. (A) Total incidence by areas; (B) Total incidence by age group; (C) Urban incidence by age group; (D) Rural incidence by age group; (E) Total mortality by areas; (F) Total mortality by age group; (G) Urban mortality by age group; (H) Rural mortality by age group. Shaded areas represent 95% confidence intervals (CIs). CIs were calculated directly from the standard errors of annual ASIR and ASMR values rather than from fitted joinpoint regression curves.

Table 2 Joinpoint analysis of age-standardised cervical cancer incidence trends by area and age group in China, 2000–2020

Areas	Age	Trend 1		Trend 2		Trend 3		2000–2020	2009–2020	2017–2020
		Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	AAPC (95% CI)	AAPC (95% CI)	AAPC (95% CI)
Total	0–85 y	2000–2008	15.1* (13.0~17.7)	2008–2020	1.2* (0.1~2.2)	–	–	6.5* (6.0~7.1)	1.2* (0.1~2.2)	1.2* (0.1~2.2)
	0–34 y	2000–2004	36.3* (22.4~60.1)	2004–2020	−3.0* (−4.7~−1.4)	–	–	3.9* (2.5~5.8)	−3.0* (−4.7~−1.4)	−3.0* (−4.7~−1.4)
	35–64 y	2000–2007	19.0* (16.8~22.8)	2007–2013	4.9* (2.2~13.0)	2013–2020	−0.8 (−5.7~1.0)	7.5* (6.8~8.1)	1.2* (0.1~2.0)	−0.8 (−5.1~1.0)
	65–74 y	2000–2003	−6.2 (−15.4~0.9)	2003–2020	6.6* (5.9~7.5)	–	–	4.5* (3.9~5.4)	6.6* (5.9~7.5)	6.6* (5.9~7.5)
	≥ 75 y	2000–2002	−17.9* (−24.0~−4.3)	2002–2012	−0.2 (−3.3~2.9)	2012–2020	5.9* (3.4~14.6)	0.2 (−0.6~1.4)	4.2* (3.0~5.5)	5.9* (3.4~13.0)
Urban	0–85 y	2000–2008	15.1* (13.0~17.7)	2008–2020	0.6 (−0.5~1.6)	–	–	6.2* (5.6~6.8)	0.6 (−0.5~1.6)	0.6 (−0.5~1.6)
	0–34 y	2000–2004	38.2* (24.9~59.8)	2004–2020	−4.6* (−6.0~−3.2)	–	–	2.8* (1.5~4.5)	−4.6* (−6.0~−3.2)	−4.6* (−6.0~−3.2)
	35–64 y	2000–2006	21.0* (18.4~24.6)	2006–2012	6.9* (3.9~10.6)	2012–2020	−1.4 (−3.4~0.0)	7.4* (6.9~8.0)	0.8* (0.0~1.5)	−1.4 (−3.4~0.0)
	65–74 y	2000–2003	−9.6 (−22.0~3.2)	2003–2020	6.8* (5.6~9.3)	–	–	4.1* (3.1~5.8)	6.8* (5.6~8.7)	6.8* (5.6~9.3)
	≥ 75 y	2000–2002	−22.9* (−28.9~−10.0)	2002–2012	−0.9 (−3.8~1.5)	2012–2020	5.5* (3.2~13.0)	−0.9 (−1.7~0.3)	3.7* (2.6~5.0)	5.5* (3.2~11.9)
Rural	0–85 y	2000–2007	14.7* (11.0~23.0)	2007–2020	4.8* (2.6~6.3)	–	–	8.2* (7.1~9.4)	4.8* (3.0~6.3)	4.8* (2.6~6.3)
	0–34 y	2000–2010	12.5* (7.5~58.0)	2010–2020	1.6 (−25.4~6.6)	–	–	6.9* (2.7~11.5)	2.6 (−3.1~6.7)	1.6 (−22.1~6.6)
	35–64 y	2000–2007	16.8* (12.4~26.5)	2007–2020	4.7* (2.2~6.4)	–	–	8.7* (7.5~10.1)	4.7* (2.7~6.4)	4.7* (2.2~6.4)
	65–74 y	2000–2020	6.3* (4.6~7.9)	–	–	–	–	6.3* (4.6~7.9)	6.3* (4.6~7.9)	6.3* (4.6~7.9)
	≥ 75 y	2000–2020	4.7* (3.1~6.4)	–	–	–	–	4.7* (3.1~6.4)	4.7* (3.1~6.4)	4.7* (3.1~6.4)

Trend metrics: APC, annual percent change; AAPC, average annual percent change; CIs are 95% based on Joinpoint permutation tests. "–" means no estimations in this time period.
*$P < 0.05$.

Table 3 Joinpoint analysis of age-standardised cervical cancer mortality trends by area and age group in China, 2000–2020

Areas	Age	Trend 1		Trend 2		Trend 3		2000–2020	2009–2020	2017–220
		Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	AAPC (95% CI)	AAPC (95% CI)	AAPC (95% CI)
Total	0–85 y	2000–2016	5.5* (4.9~6.5)	2016–2020	−2.1 (−10.6~2.3)	–	–	3.9* (3.0~4.6)	2.7* (1.1~3.5)	−2.1 (−9.1~2.3)
	0–34 y	2000–2002	63.2 (−0.9–175.2)	2002–2020	−1.0 (−34.1~6.4)	–	–	4.1 (−3.1~9.2)	−1.0 (−8.1~4.0)	−1.0 (−26.6~6.4)
	35–64 y	2000–2008	11.5* (9.2~17.5)	2008–2017	5.0* (3.3~9.0)	2017–2020	−5.9 (−17.9~1.5)	5.8* (4.7~6.7)	1.9 (−0.1~3.1)	−5.9 (−12.1~1.5)
	65–74 y	2000–2008	−0.5 (−13.8~3.8)	2008–2020	5.9* (3.3~18.4)	–	–	3.3* (1.9~4.9)	5.9* (3.3~8.3)	5.9* (3.3~16.6)
	≥ 75 y	2000–2003	−8.7 (−19.4~0.4)	2003–2020	1.0 (−1.1~6.2)	–	–	−0.5 (−1.4~6.2)	1.0 (−0.4~2.6)	1.0 (−1.1~5.6)
Urban	0–85 y	2000–2016	5.8* (5.1~7.2)	2016–2020	−2.3 (−12.8~2.9)	–	–	4.1* (3.0~5.0)	2.8* (0.8~3.8)	−2.3 (−10.8~2.9)
	0–34 y	2000–2002	64.3 (−0.6~165.9)	2002–2020	−1.3 (−24.2~5.2)	–	–	3.9 (−2.4~8.6)	−1.3 (−7.3~3.1)	−1.3 (−21.6~5.2)
	35–64 y	2000–2009	12.4* (11.2~14.4)	2009–2016	5.4* (3.2~8.1)	2016–2020	−3.6* (−8.9~−0.4)	6.5* (6.0~7.1)	2.0* (1.2~3.1)	−3.6* (−7.7~−0.4)
	65–74 y	2000–2002	−16.9 (−26.5~3.8)	2002–2020	4.8* (3.1~10.3)	–	–	2.4* (1.2~4.6)	4.8* (3.1~6.9)	4.8* (3.1~10.1)
	≥ 75 y	2000–2003	−11.8* (−23.6~−0.8)	2003–2020	0.4 (−0.9~4.4)	–	–	−1.5 (−2.5~0.1)	0.4 (−0.9~2.2)	0.4 (−0.9~4.3)
Rural	0–85 y	2000–2004	12.6* (4.8–33.7)	2004–2020	3.0 (−1.8~4.2)	–	–	4.9* (3.4~6.3)	3.0* (1.2~4.2)	3.0 (−1.7~4.2)
	0–34 y	2000–2018	5.3* (1.5~12.2)	2018–2020	−63.1* (−79.4~−13.5)	–	–	−5.2 (−10.0~0.9)	−13.0* (−21.3~−4.5)	−47.7* (−64.6~−13.2)
	35–64 y	2000–2006	12.1 (−2.9~32.9)	2006–2018	2.9 (−5.3~24.2)	2018–2020	−5.7 (−18.9~6.4)	4.7* (3.2~6.6)	1.3 (−1.2~3.8)	−2.9 (−12.1~6.1)
	65–74 y	2000–2020	3.6* (1.2~5.9)	–	–	–	–	3.6* (1.2~5.9)	3.6* (1.2~5.9)	3.6* (1.2~5.9)
	≥ 75 y	2000–2020	3.9* (2.1~5.5)	–	–	–	–	3.9* (2.1~5.5)	3.9* (2.1~5.5)	3.9* (2.1~5.5)

Trend metrics: APC, annual percent change; AAPC, average annual percent change; CIs are 95% based on Joinpoint permutation tests. "–" means no estimations in this time period.
*$P < 0.05$.

International comparison of cervical cancer control and age-specific trends

National patterns

The ASIR decreased in 2 of the 4 countries between 2000 and 2017 [the Republic of Korea (AAPC = −3.4%, 95% CI: −3.8%~−3.0%) and the Philippines (AAPC = −1.8%, 95% CI: −2.7%~−1.0%)], while increasing in Japan (AAPC = 4.1%, 95% CI: 3.3%~5.0%) and remaining stable in Australia (AAPC = −0.5%, 95% CI: −0.9%~0.2%), as shown in **Figure 2** and **Table 4**.

The ASMR decreased in Australia (AAPC = −2.1%, 95% CI: −2.7%~−1.5%) and the Republic of Korea (AAPC = −2.5%, 95% CI: −2.9%~−1.8%) from 2000–2020 but increased in Japan (AAPC = 0.5%, 95% CI: 0.1%~0.8%) and the Philippines (national AAPC = 1.9%, 95% CI: 1.4%~2.3%), as shown in **Figure 2** and **Table 5**.

Age-specific patterns

Age-specific trend analysis distinguished archetypal patterns of change among the four comparator countries (**Figure 2, Tables 4 & 5**). The ASIR and ASMR remained constant in Australia among women < 35 y of age. The ASIR rose significantly in Japan (AAPC = 5.9%, 95% CI: 3.2%~8.6%) and the Republic of Korea (AAPC = 1.7%, 95% CI: 1.0%~2.4%), while the ASMR was stable. In contrast, the Philippines had a stable ASIR but a marked increase in the ASMR (AAPC = 5.7%, 95% CI: 4.4%~6.7%).

Australia maintained a stable ASIR with a significant ASMR decline (35–64 y of age group AAPC = −1.4%, 95% CI: −2.1%~−0.5%; 65–74 y of age group AAPC = −6.4%, 95% CI: −8.0%~−4.5%) among women 35–74 y of age. Both ASIR and ASMR declined in the Republic of Korea (ASIR: 35–64 y of age group AAPC = −3.6%, 95% CI: −4.1%~−3.2%; 65–74 y of age group AAPC = −5.4%, 95% CI: −5.8%~−4.9%; ASMR: 35–64 y of age group AAPC = −2.2%, 95% CI: −2.7%~−1.6%; 65–74 y of age group AAPC = −4.2%, 95% CI: −4.9%~−3.4%). The ASIR decreased in the Philippines in the 35–64 y of age group (AAPC = −1.9%, 95% CI: −2.6%~−1.1%) and 65–74 y of age group (AAPC = −2.6%, 95% CI: −3.9%~−1.4%), whereas the ASMR increased in both groups (35–64 y age group AAPC = 2.4%, 95% CI: 1.7%~2.9% and 65–74 y age group AAPC = 1.1%, 95% CI: 0.3%~1.9%). The ASIR increased across both age groups in Japan (35–64 y age group AAPC = 4.3%, 95% CI: 3.3%~5.2%; 65–74 y age group AAPC = 2.5%, 95% CI: 0.3%~4.8%), accompanied by a slower ASMR rise only in women 35–64 y of age (AAPC = 0.9%, 95% CI: 0.6%~1.2%).

There were marked declines in the ASIRs and ASMRs in Australia and the Republic of Korea for the population > 75 y of age. The ASIR was stable while ASMR decreased significantly in Japan (AAPC = −1.5%, 95% CI: −1.9%~−1.1%). The ASIR was stable but there was a borderline decline in the ASMR in the Philippines (AAPC = −1.0%, 95% CI: −1.9%~0.0%).

Discussion

This study provided a comprehensive age- and region-stratified assessment of long-term cervical cancer trends in China and evaluated these patterns within four comparator Asia-Pacific countries. The incidence of cervical cancer and cervical cancer-associated mortality increased in China from 2000 to 2020 with more rapid and sustained increases in rural areas and among older women. The incidence of cervical cancer in younger women declined after the mid-2000s, whereas the incidence of cervical cancer in older age groups continued to increase, particularly in rural areas. Cervical cancer-associated mortality has begun to stabilise nationally and in urban areas since 2016. Notably, mortality among rural women 35–64 y of age also leveled after 2009, while mortality in rural women ≥65 y of age continued to increase, underscoring persistent inequities in prevention, early detection, and timely, effective treatment.

International comparisons of the incidence of cervical cancer and cervical cancer-associated mortality highlight divergent trajectories in cervical cancer control. Australia and the Republic of Korea achieved sustained declines in the incidence and mortality rates, especially among older women, which reflect early, high-coverage HPV vaccination and organized screening are essential. Japan had a rising incidence of cervical cancer across most age groups with only modest reductions in mortality, while the Philippines had a decrease in the incidence among middle-to-older ages but persistent or increasing mortality, pointing to gaps in screening coverage and timely treatment.

These findings indicated that although the national prevention and control measures in China may be starting to yield benefits in some subpopulations, further progress will require narrowing the persistent urban-rural gap. Tailored interventions are needed to sustain the decline among younger women, reverse the continuing increases in older age groups, and address structural barriers to screening, vaccination, and treatment in underserved rural communities. Lessons from high-performing regional neighbours suggest that integrated,

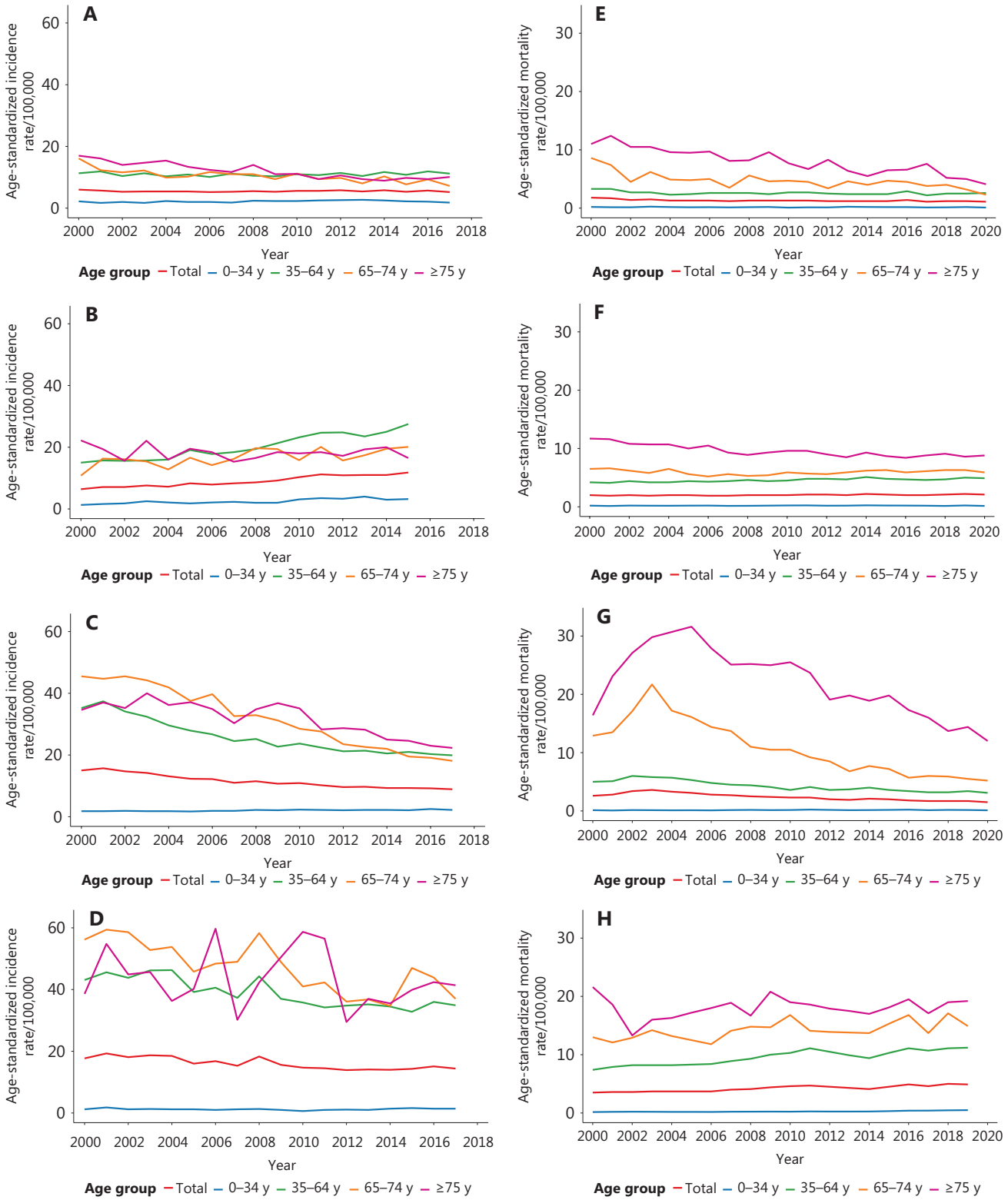


Figure 2 Trends in age-standardised cervical cancer rates by age group in selected Asia-Pacific countries. (A) Incidence in Australia; (B) Incidence in Japan; (C) Incidence in Republic of Korea; (D) Incidence in the Philippines; (E) Mortality in Australia; (F) Mortality in Japan; (G) Mortality in the Republic of Korea; (H) Mortality in Philippines. Data source: GLOBOCAN Overtime (IARC, 2025 edition).

Table 4 Joinpoint analysis of age-standardised cervical cancer incidence trends by country and age group in selected Asia-Pacific countries, 2000–2017

Country	Age (year)	Trend 1		Trend 2		2000–2017	2009–2017
		Years	APC (95% CI)	Years	APC (95% CI)	AAPC (95% CI)	AAPC (95% CI)
Australia	0–85 y	2000–2002	−5.7 (−8.8~0.1)	2002–2017	0.2 (−0.7~2.6)	−0.5 (−0.9~0.2)	0.2 (−0.4~1.2)
	0–34 y	2000–2014	2.5* (1.3~4.7)	2014–2017	−11.2* (−24.6~−1.9)	−0.1 (−1.5~1.3)	−2.9* (−5.6~−0.8)
	35–64 y	2000–2017	0.1 (−0.6~0.8)	–	–	0.1 (−0.6~0.8)	0.1 (−0.6~0.8)
	65–74 y	2000–2017	−2.9* (−4.2~−1.5)	–	–	−2.9* (−4.2~−1.5)	−2.9* (−4.2~−1.5)
	≥ 75 y	2000–2014	−4.2* (−7.5~−3.4)	2014–2017	3.1 (−3.2~13.6)	−3.0* (−4.1~−2.1)	−1.6 (−3.2~0.3)
Japan[#]	0–85 y	2000–2015	4.1* (3.3~5.0)	–	–	4.1* (3.3~5.0)	4.1* (3.3~5.0)
	0–34 y	2000–2015	5.9* (3.2~8.6)	–	–	5.9* (3.2~8.6)	5.9* (3.2~8.6)
	35–64 y	2000–2015	4.3* (3.3~5.2)	–	–	4.3* (3.3~5.2)	4.3* (3.3~5.2)
	65–74 y	2000–2015	2.5* (0.3~4.8)	–	–	2.5* (0.3~4.8)	2.5* (0.3~4.8)
	≥ 75 y	2000–2015	−0.5 (−2.0~1.1)	–	–	−0.5 (−2.0~1.1)	−0.5 (−2.0~1.1)
Republic of Korea	0–85 y	2000–2007	−4.6* (−8.4~−3.5)	2007–2017	−2.6 (−3.3~0.6)	−3.4* (−3.8~−3.0)	−2.6* (−3.3~−1.7)
	0–34 y	2000–2017	1.7* (1.0~2.4)	–	–	1.7* (1.0~2.4)	1.7* (1.0~2.4)
	35–64 y	2000–2009	−5.2* (−7.3~−4.3)	2009–2017	−1.8 (−2.9~1.1)	−3.6* (−4.1~−3.2)	−1.8* (−2.9~−1.1)
	65–74 y	2000–2003	−0.4 (−4.1~5.7)	2003–2017	−6.4* (−7.0~−6.0)	−5.4* (−5.8~−4.9)	−6.4* (−7.0~−6.0)
	≥ 75 y	2000–2009	−0.6 (−2.0~2.3)	2009–2017	−5.6* (−9.2~−4.0)	−3.0* (−3.8~−2.2)	−5.6* (−6.9~−3.9)
Philippines	0–85 y	2000–2017	−1.8* (−2.7~−1.0)	–	–	−1.8* (−2.7~−1.0)	−1.8* (−2.7~−1.0)
	0–34 y	2000–2010	−4.8* (−19.6~−0.9)	2010–2017	8.2* (1.2~36.8)	0.4 (−2.3~2.7)	6.5* (1.1~11.4)
	35–64 y	2000–2017	−1.9* (−2.6~−1.1)	–	–	−1.9* (−2.6~−1.1)	−1.9* (−2.6~−1.1)
	65–74 y	2000–2017	−2.6* (−3.9~−1.4)	–	–	−2.6* (−3.9~−1.4)	−2.6* (−3.9~−1.4)
	≥ 75 y	2000–2017	−0.7 (−3.2~1.9)	–	–	−0.7 (−3.2~1.9)	−0.7 (−3.2~1.9)

AAPC, average annual percent change; APC, annual percent change; CI, confidence interval (based on Joinpoint permutation tests). "–" indicates no estimable trend for the specified period. *$P < 0.05$. [#]Data from GLOBOCAN Overtime (IARC, 2025 release). Incidence data for Japan are only available from 2000–2015, whereas incidence for all other comparator countries runs through 2000–2017.

Table 5 Joinpoint analysis of age-standardised cervical cancer mortality trends by country and age group in selected Asia-Pacific countries, 2000–2020

Country	Age (year)	Trend 1		Trend 2		Trend 3		2000–2020	2009–2020	2017–2020
		Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	AAPC (95% CI)	AAPC (95% CI)	AAPC (95% CI)
Australia	0–85 y	2000–2004	−7.3* (−14.4~−3.3)	2004–2020	−0.7 (−1.3~0.2)	–	–	−2.1* (−2.7~−1.5)	−0.7 (−1.3~0.1)	−0.7 (−1.3~0.2)
	0–34 y	2000–2020	−1.2 (−3.6~1.1)	–	–	–	–	−1.2 (−3.6~1.1)	−1.2 (−3.6~1.1)	−1.2 (−3.6~1.1)
	35–64 y	2000–2004	−7.2* (−16.3~−1.9)	2004–2020	0.1 (−0.7~2.0)	–	–	−1.4* (−2.1~−0.5)	0.1 (−0.7~1.3)	0.1 (−0.7~2.0)
	65–74 y	2000–2002	−24.6* (−33.6~−4.7)	2002–2018	−1.5 (−2.5~8.9)	2018–2020	−23.3* (−35.1~−4.5)	−6.4* (−8.0~−4.5)	−5.9* (−8.2~−3.6)	−16.6* (−25.3~−4.5)
	≥ 75 y	2000–2020	−4.2* (−5.1~−3.3)	–	–	–	–	−4.2* (−5.1~−3.3)	−4.2* (−5.1~−3.3)	−4.2* (−5.1~−3.3)
Japan	0–85 y	2000–2020	0.5* (0.1~0.8)	–	–	–	–	0.5* (0.1~0.8)	0.5* (0.1~0.8)	0.5* (0.1~0.8)
	0–34 y	2000–2020	0.3 (−0.9~1.5)	–	–	–	–	0.3 (−0.9~1.5)	0.3 (−0.9~1.5)	0.3 (−0.9~1.5)
	35–64 y	2000–2020	0.9* (0.6~1.2)	–	–	–	–	0.9* (0.6~1.2)	0.9* (0.6~1.2)	0.9* (0.6~1.2)
	65–74 y	2000–2006	−3.4* (−9.5~−1.0)	2006–2020	1.0* (0.4~2.7)	–	–	−0.3 (−0.8~0.3)	1.0* (0.4~2.0)	1.0* (0.4~2.7)
	≥ 75 y	2000–2008	−2.9* (−6.9~−1.7)	2008–2020	−0.6 (−1.3~2.2)	–	–	−1.5* (−1.9~−1.1)	−0.6 (−1.3~0.0)	−0.6 (−1.3~2.0)
Republic of Korea	0–85 y	2000–2003	11.7* (6.1~19.7)	2003–2008	−7.2* (−10.9~−4.7)	2008–2020	−3.8* (−4.6~−0.1)	−2.5* (−2.9~−1.8)	−3.8* (−4.6~−3.0)	−3.8* (−4.6~−0.6)
	0–34 y	2000–2020	1.8 (−0.3~3.9)	–	–	–	–	1.8 (−0.3~3.9)	1.8 (−0.3~3.9)	1.8 (−0.3~3.9)
	35–64 y	2000–2003	6.4* (1.2~15.4)	2003–2009	−6.4* (−11.0~−4.4)	2009–2020	−2.2 (−3.0~0.1)	−2.2* (−2.7~−1.6)	−2.2* (−3.0~−1.5)	−2.2 (−3.0~0.1)
	65–74 y	2000–2003	16.8* (8.1~26.9)	2003–2013	−9.3* (−13.5~−8.1)	2013–2020	−4.9 (−7.0~2.5)	−4.2* (−4.9~−3.4)	−6.5* (−7.4~−5.6)	−4.9 (−7.0~1.0)
	≥ 75 y	2000–2003	24.5* (13.9~37.4)	2003–2020	−5.2* (−6.0~−4.5)	–	–	−1.2* (−2.0~−0.4)	−5.2* (−6.0~−4.5)	−5.2* (−6.0~−4.5)
Philippines[#]	0–85 y	2000–2019	1.9* (1.4~2.3)	–	–	–	–	1.9* (1.4~2.3)	1.9* (1.4~2.3)	1.9* (1.4~2.3)
	0–34 y	2000–2013	2.7 (−0.4~4.1)	2013–2019	12.3* (7.5~26.9)	–	–	5.7* (4.4~6.7)	8.4* (6.5~10.1)	12.3* (7.5~26.9)
	35–64 y	2000–2011	3.3 (−0.7~6.5)	2011–2014	−2.2 (−4.8~7.1)	2014–2019	3.1* (0.4~9.1)	2.4* (1.7~2.9)	1.5* (0.6~2.3)	3.1* (0.4~9.1)
	65–74 y	2000–2019	1.1* (0.3~1.9)	–	–	–	–	1.1* (0.3~1.9)	1.1* (0.3~1.9)	1.1* (0.3~1.9)
	≥ 75 y	2000–2002	−19.8* (−26.8~−9.6)	2002–2006	6.6* (2.1~14.6)	2006–2019	−0.0 (−2.1~0.8)	−1.0* (−1.7~−0.0)	−0.0 (−1.3~0.8)	−0.0 (−2.0~0.8)

AAPC, average annual percent change; APC, annual percent change; CI, confidence interval (based on Joinpoint permutation tests). "–" indicates no estimable trend for the specified period. *$P < 0.05$. [#]Data from GLOBOCAN Overtime (IARC, 2025 release). Mortality data are available through 2020 for all countries, except the Philippines (2000–2019).

high-coverage HPV vaccination and HPV-based screening programmes combined with equitable access to diagnostic and treatment services, are essential to accelerate progress towards the WHO elimination targets.

Age- and region-specific trends

The early increases in ASIR and ASMR were followed by declines or stabilisation after 2009 among women 0–34 y of age, particularly in urban China. These patterns are consistent with a later sexual debut, higher school enrolment rate, and the gradual diffusion of pilot HPV vaccination initiatives. The benefits of a later sexual debut, higher school enrolment, and the gradual diffusion of pilot HPV vaccination initiatives were less in rural areas, where there was early marriage, limited sexual health education, and restricted access to affordable HPV vaccination[43].

Australia maintained a low and stable incidence of cervical cancer and cervical cancer-associated mortality in this age group in the setting of long-standing, school-based vaccination and organised screening[25,26,44,45]. In contrast, the Republic of Korea and Japan documented a rising incidence of cervical cancer despite relatively strong program platforms and the Philippines recorded a stable incidence of cervical cancer but a higher cervical cancer-associated mortality[12,19,31,46]. Divergence between incidence and mortality in several settings indicates that vaccination alone may not offset behavioral and service-related risks in the short term.

Given these patterns, China should prioritise a publicly funded, school-based HPV vaccination programme for girls 9–14 y of age and catch-up to 26 y of age with particular emphasis on rural counties where affordability and awareness remain low. Vaccination efforts will be strengthened by age-appropriate sexuality education and by sentinel monitoring of emerging behavioural and virologic risk factors that could erode cohort gains.

Outcome disparities were most pronounced in women 35–64 y of age who contribute to most cases and deaths. The incidence of cervical cancer continued to rise in rural China while mortality was comparatively stable, a pattern compatible with expanded detection at earlier stages. In contrast, the incidence of cervical cancer and cervical cancer-associated mortality increased in many urban prefectures, indicating that screening quality, coverage, and linkage to treatment remain suboptimal. These dynamics imply that screening impact depends on the entire cascade, including sensitive primary testing with HPV DNA, timely triage, and definitive treatment.

International comparisons reinforce these findings. Australia achieved a stable incidence of cervical cancer with a sustained reduction in cervical cancer-associated mortality through high-coverage HPV-based screening integrated with vaccination[25,26,47]. The Republic of Korea recorded consistent declines in incidence and mortality with long-running organized screening and increased vaccine uptake[32,46]. Japan experienced a rising incidence with a modest improvement in mortality, whereas the Philippines had a decreasing incidence in some mid-to-older age groups but persistent or rising mortality, indicating gaps in screening reach and timely treatment[19,21,30,33,48].

To further strengthen cervical cancer prevention and control in China, three additional priorities should be addressed. First, screening should transition to high-performance HPV-based testing. Current reliance on cytology or VIA/VILI limits detection accuracy and long-term impact. Nationwide adoption of HPV DNA testing, integrated with once- or twice-in-a-lifetime screening for women 35–64 y of age, could markedly improve early diagnosis[49,50]. Second, self-sampling and screen-and-treat models represent feasible and cost-effective options to expand coverage in resource-limited or rural areas. Third, urban areas with rising mortality need tailored cervical cancer screening strategies and efficient referral and treatment pathways to ensure timely management of screen-positive women.

China had concurrent increases in the incidence of cervical cancer and cervical cancer-associated mortality among women 65–74 y of age, especially in rural regions, which likely reflects historically low screening exposure and later-stage presentation. In contrast, Australia and the Republic of Korea demonstrated declines in both indicators, while Japan exhibited rising incidence with falling mortality, consistent with earlier diagnosis and improved treatment. The Philippines had mixed progress, with incidence reductions not matched by mortality gains, suggesting constraints in treatment access and quality.

These comparisons indicate that extending prevention to older cohorts is feasible and impactful when coupled with effective diagnostic and therapeutic services. China should consider raising the upper age boundary for screening of women with limited prior screening, offer a one-time HPV test in the late 60 y age group for never-screened individuals, and reinforce geriatric-informed care pathways that reduce delays from abnormal results to definitive treatment.

The incidence of cervical cancer and cervical cancer-associated mortality continued to rise in rural China in women ≥75 y of age, whereas urban rates were broadly stable, consistent with unscreened birth cohorts and late presentation. Australia and the Republic of Korea recorded declines in both measures, while Japan exhibited a stable incidence with declining mortality and the Philippines showed little change in the incidence with a borderline decline in mortality. These trajectories illustrate that benefits from vaccination, HPV-based screening, and timely treatment can extend into late life when high coverage is achieved over preceding decades. China can mitigate the growing burden in this age group by promoting symptom awareness and prompt referral in primary care, facilitating opportunistic HPV testing or risk-based assessment where resources permit, standardising evidence-based treatment for fit older adults, and strengthening supportive and palliative services to reduce avoidable mortality.

Overall, the early effects of the cervical cancer control strategy in China are visible in the screening target population. Nevertheless, progress remains limited in urban areas and among older adults in rural communities. To close these gaps, the national programme should be adjusted and investment increased with priorities to expand HPV vaccination, scale up HPV DNA testing as the primary screening method with self-sampling options, strengthen referral and treatment capacity and quality assurance, and improve equity focused financing and data systems.

Strengths and limitations

This study leveraged continuous, high-quality data from 22 long-standing Chinese cancer registries (2000–2020) alongside authoritative GLOBOCAN/IARC series, enabling internally consistent analyses of temporal trends. Cross-national benchmarking followed prespecified criteria that required continuous incidence and mortality data for 2000–2020 (2000–2017) and documented HPV vaccination and organized screening. Comparator countries were selected from the Asia–Pacific region to reduce unmeasured confounding, with Australia retained as a high-performance benchmark to provide a policy reference point.

Several limitations should be noted. First, restricting analyses to 22 registries improves internal validity but limits national representativeness, particularly for less-developed areas. The registry panel, although high quality, was concentrated in historically high-risk counties and better-resourced municipalities. This method may inflate incidence trends through superior ascertainment while understating mortality in underserved regions where treatment access is constrained, so national generalisation should be interpreted with caution and be equity-sensitive. Second, differences in data completeness and quality across comparator countries, together with the exclusion of some nations, such as Thailand and India due to incomplete long-term mortality data, may affect the generalizability of cross-country comparisons. Third, the ecologic design precluded causal inference. The observed changes may reflect vaccination and screening as well as shifts in behaviour, diagnostic protocols, treatment access, or herd-immunity thresholds. The absence of individual-level information on vaccine uptake, HPV genotype, and behavioural factors limits its mechanistic interpretation. Given the ecologic design and the expected lag between screening scale-up and mortality reductions, the observed post-2009 increases should not be taken as evidence of screening ineffectiveness but as a signal to strengthen coverage, test sensitivity, and post-screen treatment completion. Finally, formal comparator selection was limited to countries with documented HPV vaccination and organized screening because these are the most effective primary and secondary prevention measures with standardized, comparable indicators across the study period. Other relevant policies (treatment capacity, follow-up quality, health education, risk-factor control, financing, and data systems) are heterogeneous across settings and are therefore summarized descriptively and considered qualitatively in the Discussion.

Conclusions

A comprehensive analysis and comparison of the incidence and mortality rates across four distinct age groups in various regions were used in the current study, demonstrating that the positive impacts of cervical cancer prevention and control strategies are already evident among the younger population across all areas, as well as among the middle-aged demographic in rural regions. However, the cervical cancer-associated mortality rate continued to climb among middle-aged individuals in urban settings and the elderly population, highlighting these groups as priorities for further attention.

Through comparisons with Asia-Pacific countries at different programme maturities, earlier, high-coverage HPV vaccination and primary HPV testing with robust follow-up

were consistently shown to be associated with sustained declines in the incidence of cervical cancer and cervical cancer-associated mortality. Against this benchmark, it is imperative for China to build upon existing efforts to accelerate progress toward WHO targets. Priorities include broadening vaccination coverage *via* publicly funded, school-based delivery, scaling up primary HPV testing through self-sampling and screen-and-treat models in underserved areas, and ensuring timely, standardised, quality assured treatment nationwide. These actions will help close urban-rural and age-related gaps and hasten cervical cancer elimination.

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Conflict of interest statement

No potential conflicts of interest are disclosed.

Authors' contributions

Conceived and designed the analysis: Wenqiang Wei.
Collected the data: Kexin Sun, Bingfeng Han, Rongshou Zheng.
Contributed data or analysis tools: Bingfeng Han, Rongshou Zheng.
Performed the analysis: Shanrui Ma.
Wrote the paper: Shanrui Ma, Kexin Sun.

Data availability statement

The data generated in this study are available upon request from the corresponding author.

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