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ORIGINAL RESEARCH

Maternal Mortality Transition and Subnational Inequities in China, 1990–2023: Comparative Analysis of GBD 2023 and National Surveillance Data

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Background: The maternal mortality ratio (MMR) is a core indicator of health-system performance and equity. In China, interpretation of recent maternal mortality trends is increasingly influenced by differences between modeled global estimates and national surveillance data. We aimed to characterize the maternal mortality transition and subnational inequities in China from 1990 to 2023 by comparing Global Burden of Disease (GBD) 2023 estimates with data from the National Maternal Mortality Surveillance System (NMMSS).

Methods: We integrated model-based estimates from the GBD 2023 with real-world data from China's NMMSS. Assessment focused on key burden metrics, including disability-adjusted life years, MMR, mortality and incidence. Joinpoint regression was used to identify temporal trend changes. Scenario-based projections and Bayesian age-period-cohort (BAPC) models were applied to forecast progress toward the "Healthy China 2030 target". Subnational inequalities in maternal healthcare service coverage were also examined.

Results: GBD estimates showed China's MMR declined from 121.9 (1990) to 10.7 (2023) per 100,000 live births, while NMMSS reported 15.1 per 100,000 live births in 2023. According to GBD, the leading cause shifted from maternal hemorrhage to indirect disorders, whereas NMMSS consistently identified obstetric hemorrhage as the primary cause. The urban–rural disparity narrowed substantially, but subnational inequities persisted, particularly in western provinces. The MMR rapid decline during 2004–2015 was followed by a plateau. Scenario-based projections indicate that sustaining recent progress would enable China to achieve the Healthy China 2030 target (MMR <12 per 100,000 live births).

Conclusion: China has made remarkable progress in maternal health and significantly reduced urban–rural disparities. However, critical differences between GBD estimates and NMMSS data underscore the need for improved local data collection. Targeted strategies, such as integrating cardiovascular risk screening in eastern provinces and strengthening obstetric emergency capacity in western regions, are essential to further reduce maternal mortality and achieve the Healthy China 2030 goal.

Keywords: maternal mortality ratio, maternal disorders, disease burden, China, global burden of disease, epidemiological transition, health policy

Introduction

Reducing maternal mortality remains a core priority in public health worldwide and also a critical indicator of a national healthcare system's performance and societal development.[1,2] Over the past several decades, global collaborative efforts have achieved significant improvements in decreasing the maternal mortality ratio (MMR).[3,4] However, the slowdown in progress over recent years resulted in most countries failing to realize Millennium Development Goal (MDG) 5.[5] Stark

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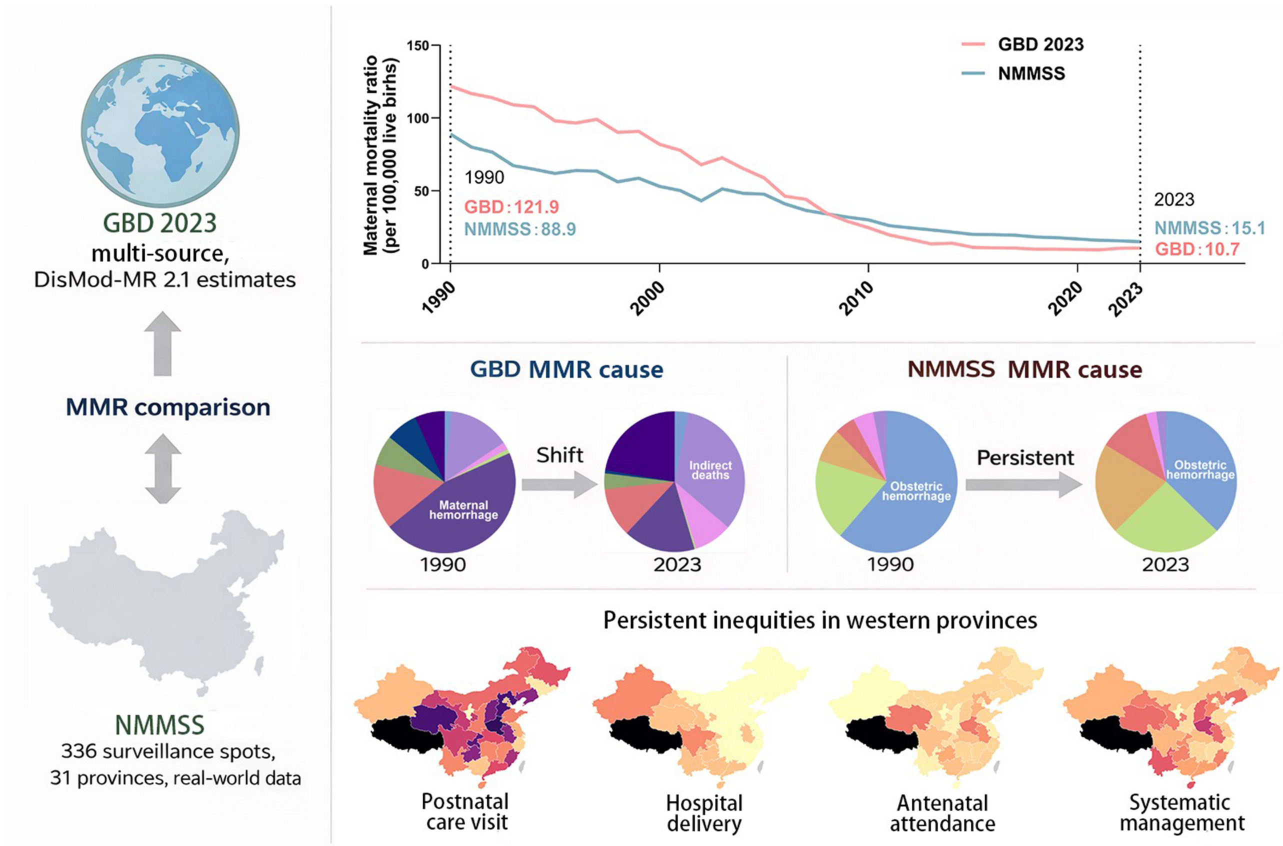
Graphical Abstract



regional inequalities persist, with the vast proportion of preventable maternal mortality concentrated in low- and middle-income countries.[3] To reinvigorate global momentum, the World Health Organization (WHO) established Sustainable Development Goal (SDG) 3.1, which set a global target of reducing the MMR below 70 per 100,000 live births by 2030, as well as aiming for all countries to maintain a threshold below 140 per 100,000 live births.[6]

In addressing global maternal health challenges, China presents a compelling and instructive case study. As one of the world's most populous and largest developing countries, China has realized a precipitous decline in its MMR, from approximately 95.2 per 100,000 live births in 1990 to 15.7 per 100,000 in 2022.[7,8] This remarkable achievement signifies that China had achieved the targets of both MDG 5 and SDG 3.1 ahead of schedule.[3,9] Furthermore, China proposed the higher-standard "Healthy China 2030" in 2016, aiming to reduce the MMR to 12.0 per 100,000 live births by 2030.[10]

Over the past decade, China has undergone a fundamental reproductive transition, shifting from decades of one-child policy to a three-child policy.[11] It has profoundly changed the risk profile of the obstetric population, leading to an increase in advanced maternal age (AMA) and a higher prevalence of complex comorbidities.[12,13] This rapidly evolving risk landscape presents stark new challenges to the national maternal healthcare system, necessitating comprehensive and up-to-date quantitative assessments.

While previous studies have documented China's progress in reducing maternal mortality using either Global Burden of Disease (GBD) estimates or national surveillance data separately, few have systematically compared these two data sources.[8,9] Understanding such discrepancies is essential for accurate policy interpretation and effective resource allocation. Furthermore, this discrepancy has rarely been interpreted in relation to subnational inequalities in maternal health service coverage and workforce distribution. Addressing these gaps is important for improving resource allocation, identifying provinces where quality improvement should be prioritized, and informing future refinement of maternal health surveillance and monitoring systems.

This investigation is designed to undertake a systematic examination of China's maternal health transformation from 1990 to 2023 by integrating the model-based estimates from the GBD 2023 with robust national surveillance data from the National Maternal Mortality Surveillance System (NMMSS). The findings are intended not only to inform strategies for addressing the next challenges of the "Healthy China 2030" initiative but also to provide critical, evidence-based lessons for other nations undergoing rapid socioeconomic transitions.

Methods

Data Sources

Data on the annual burden of maternal disorders for China and globally from 1990 to 2023 were primarily sourced from the GBD Study 2023. The latest GBD 2023 study provides standardized burden estimates spanning 204 nations and 660 subnational locations.[14] For estimating maternal mortality and disease burden, the GBD framework employs DisMod-MR 2.1, which synthesizes data from vital registration systems, population-based surveys, hospital discharge, claims data, and published scientific literature. The modeling process systematically adjusts for known biases in raw data, such as under-reporting and misclassification of causes of death, and addresses data gaps to generate a complete, spatiotemporally coherent, and internally consistent set of estimates.

This study follows the standard GBD research framework.[15] We used the Global Health Data Exchange (GHDx) query tool (https://vizhub.healthdata.org/gbd-results/) to retrieve estimates specifically for China (national level) with the following filters: female, age groups 10–54 years, all maternal disorder causes, and years 1990–2023. The metrics (incidence, DALYs, mortality, and MMR) were extracted as age-standardized rates with corresponding 95% uncertainty intervals (UIs). No missing values were encountered in the extracted GBD dataset, as the GBD modeling framework generates complete spatiotemporally continuous estimates.

The other data source for this study was the China Health Statistics Yearbook (1990–2024), which contains real-world data from the NMMSS.[16,17] The NMMSS integrates reported data from 336 surveillance spots across China's 31 provinces.[18,19] This system facilitates the collection of individual-level real-world data on live births and maternal deaths, which are then aggregated to calculate provincial and national MMRs. The surveillance mechanism includes case identification, verification, and review processes to ensure data completeness and accuracy. Individual-level microdata and raw counts from NMMSS are not publicly downloadable, therefore, the present study relied on yearbook-reported aggregated indicators (https://www.stats.gov.cn/english/Statisticaldata/yearbook/). From the annual yearbooks, we extracted national-level MMR data, as well as data stratified by urban and rural areas, for the period 1990–2023. To further assess health inequalities at the subnational level, we also extracted key indicators for maternal healthcare service utilization across provinces. The national-level MMR data and provincial-level healthcare service indicators were complete, as these are mandatory reporting metrics within the national surveillance system. NMMSS data are presented as point estimates from the national surveillance system and are considered deterministic for the purposes of this comparative analysis.

In this study, all primary outcome metrics were derived from aggregated population-level estimates with non-zero values at the geographic levels analyzed, therefore, no special handling for zero counts was required.

Definitions of Diseases and Indicators

Maternal disorders were defined and categorized strictly according to the GBD classification system, which includes seven specific diseases: (1) Maternal hypertensive disorders; (2) Ectopic pregnancy; (3) Maternal obstructed labor and uterine rupture; (4) Maternal hemorrhage; (5) Other direct maternal disorders; (6) Maternal abortion and miscarriage; (7) Maternal sepsis and other maternal infections, and three types of deaths caused by complicated reasons: (1) Maternal deaths aggravated by HIV/AIDS; (2) Indirect maternal deaths; (3) Late maternal deaths. Detailed classifications and definitions for these diseases are provided in Table S1.

Adopting the WHO standard, we defined a maternal death as the demise of a woman during pregnancy or within 42 days of its termination, from any cause related to or aggravated by the pregnancy but excluding accidental or incidental causes.[20] The MMR was calculated as the number of such deaths per 100,000 live births in a given period.[21]

The prenatal care coverage, postnatal care coverage, institutional delivery rate, and systematic management rate are derived from the NMMSS.[22,23] Detailed definitions for these metrics are provided in Table S2.

Joinpoint Regression Modeling

To more precisely characterize temporal shifts in disease burden trends, we employed Joinpoint regression analysis. Compared to single trend-line models (such as EAPC), this method was more capable of identifying discrete points in time where the magnitude or direction of a trend underwent a significant change. Such "joinpoints" were critical for identifying periods of accelerated or decelerated progress, which might correspond to the implementation of key health system reforms or other public health interventions.

The model fits the data by connecting a series of logarithmic linear segments, identifying the optimum number of joinpoints for which the trend slope changes. For each outcome metric, including incidence, DALYs, and MMR, this analysis yields the annual percent change (APC) with corresponding 95% CI. Furthermore, the average annual percent change (AAPC) is calculated as a summary measure. Statistical significance of the trends was determined by assessing whether the 95% CIs for the APC and AAPC estimates included zero. The permutation test was used to determine the optimal number of joinpoints, with a significance level of $p < 0.05$.

Scenario-Based Projections to 2030

To explore potential future trajectories of the national MMR and to evaluate the likelihood of achieving the "Healthy China 2030" target, we developed a scenario-based projection model. This method has been extensively used in relevant research in public health, epidemiology, and strategic health planning.[24,25] It forecasts future MMR values by extrapolating from different assumptions regarding the Annual Rate of Reduction (ARR).

We defined four evidence-based scenarios, each reflecting a distinct and plausible future pathway, using the historical MMR data from NMMSS (1990–2023) as the foundation: (1) achieving Health China 2030 target: this goal-oriented scenario calculates the constant ARR required to decrease the MMR from its observed 2023 value to the "Healthy China 2030" target of 12.0 per 100,000 live births by 2030. This scenario serves as a benchmark against which the other projections can be compared; (2) current trends scenario: the ARR was calculated based on the historical trend from 2015 to 2023, a period characterized by the "plateauing" effect often observed in low-mortality settings; (3) optimistic scenario: the ARR was calculated based on the historical trend from 2004 to 2015, a "golden era" of rapid decline that coincided with major national initiatives such as the promotion of hospital delivery and the expansion of health insurance; (4) pessimistic scenario: the ARR for this scenario was defined as half of the rate observed in the reference period (2015–2023), to model the increasing difficulty of achieving further reductions and the impact of emerging demographic challenges, such as the rising proportion of high-risk pregnancies.

For each historical period, the average ARR was calculated using the standard formula: $ARR = 1 - exp$. Starting from the last observed MMR value in 2023, we projected the MMR for each subsequent year until 2030 by applying the corresponding ARR for each of the three scenarios. It is noteworthy that these scenario definitions are partly judgment-based and are intended to support policy appraisal rather than to provide deterministic forecasts. They do not explicitly model potential disruptions such as fertility-policy shifts, post-COVID service changes, or future changes in case mix and referral efficiency.

BAPC Forecast Model

To project additional indicators of maternal disorder burden in China, we applied a Bayesian age-period-cohort (BAPC) model using the Integrated Nested Laplace Approximation (INLA) framework in R. We extracted female data for China from GBD 2023 for nine 5-year age groups (10–14 to 50–54 years) over 1990–2023 and modeled age-specific counts for incidence, deaths, and DALYs together with the corresponding population denominators. Age-standardized estimates were then derived using standard population weights.

To improve reproducibility, age, period, and cohort effects were smoothed using second-order random walks, and an overdispersion term was included. Default prior settings from the BAPC package were used in the main analysis. Future projections were generated to 2030 based on the observed 1990–2023 trajectories and the corresponding population structure.

To evaluate model performance, we compared the fitted values for 1990–2023 with the observed GBD estimates and summarized agreement using mean absolute error (MAE), root mean squared error (RMSE), and mean absolute percentage error (MAPE), overall and by age group. Because these comparisons were based on historical fitted-versus-observed values, they were interpreted as goodness-of-fit assessments rather than strict out-of-sample validation. The R code used for scenario projection and BAPC analysis is provided in Supplementary Files 1 and 2.

Statistical Analysis

To control for confounding effects from changing age distributions and to enhance comparability across years and regions, we calculated age-standardized rates (ASRs) for all rate-based metrics using the GBD global standard population with the following formula:

$$ASR = \frac{\sum_{i=1}^{A} w_i a_i}{\sum_{i=1}^{A} w_i} \times 100,000$$

Where w_i represents the weight for age group i and a_i is the corresponding rate.

To quantify the overall trend of each indicator over the study period, the estimated annual percentage change (EAPC) was calculated. Specifically, the analysis involved fitting a linear model to $In(ASR)$ against time x, expressed as $y = a + \beta x + \varepsilon$. Based on the regression coefficient β, the EAPC and its 95% CI were computed as $100 \times \left(e^{\beta} - 1\right)$. Trend significance was defined by the EAPC and its 95% CI: an increase required both > 0, a decrease required both < 0, and a stable trend was indicated by a CI encompassing 0.

All statistical analyses were conducted in R (version 4.3.1). Joinpoint analyses were performed using the Joinpoint Regression Program (National Cancer Institute, version 5.4.0.0). Because this was a population-level descriptive and forecasting study based on secondary aggregated data, no conventional sample-size or power calculation was applicable.

This study is a secondary analysis of publicly available, anonymized aggregate data from the Global Burden of Disease Study 2023 and the China Health Statistics Yearbook. No individual-level or identifiable information was accessed, and informed consent was therefore not applicable. In accordance with Article 32 (Items 1 and 2) of China's Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects (2023), research using legally obtained public data that does not involve personal identifiers is exempt from institutional ethical review. This study was conducted in full compliance with the GATHER reporting guidelines.

Results

Sharp Decline in MMR and Elimination of the Urban-Rural Gap in China from 1990 to 2023

China experienced a remarkable decline in MMR from 1990 to 2023, which was consistently confirmed by both GBD 2023 estimates and NMMSS data (Figure 1). According to GBD 2023, China's MMR declined from 121.9 (100.6 to 149.4) per 100,000 live births in 1990 to 10.7 (8.8 to 12.6) per 100,000 live births in 2023. From 1990 to 2023, China's decline in MMR (EAPC = −9.1% [−9.8 to −8.3]) far exceeded the global average (EAPC = −2.0 [−2.2 to −2.0]) (Table S3). While NMMSS surveillance data showed a congruent downward trend, China lowered the MMR from 88.9 to 15.1 per 100,000 live births between 1990 and 2023. There were inconsistencies between the estimates from the GBD 2023 and the surveillance data reported by NMMSS (Table S4). The divergence was particularly pronounced in the early years (1990–2000), with GBD estimates exceeding NMMSS by up to 37% in some years, before narrowing in recent decades.

The critical contributor to this national achievement was the significant reduction in the urban-rural health disparity. In 1990, the MMR in rural areas (112.5 per 100,000 live births) was 2.45 times the urban rate (45.9 per 100,000 live births). By 2023, this gap had been virtually eliminated, with the rural MMR at 17.0 and the urban MMR at 12.5 per 100,000 (Figure 1).

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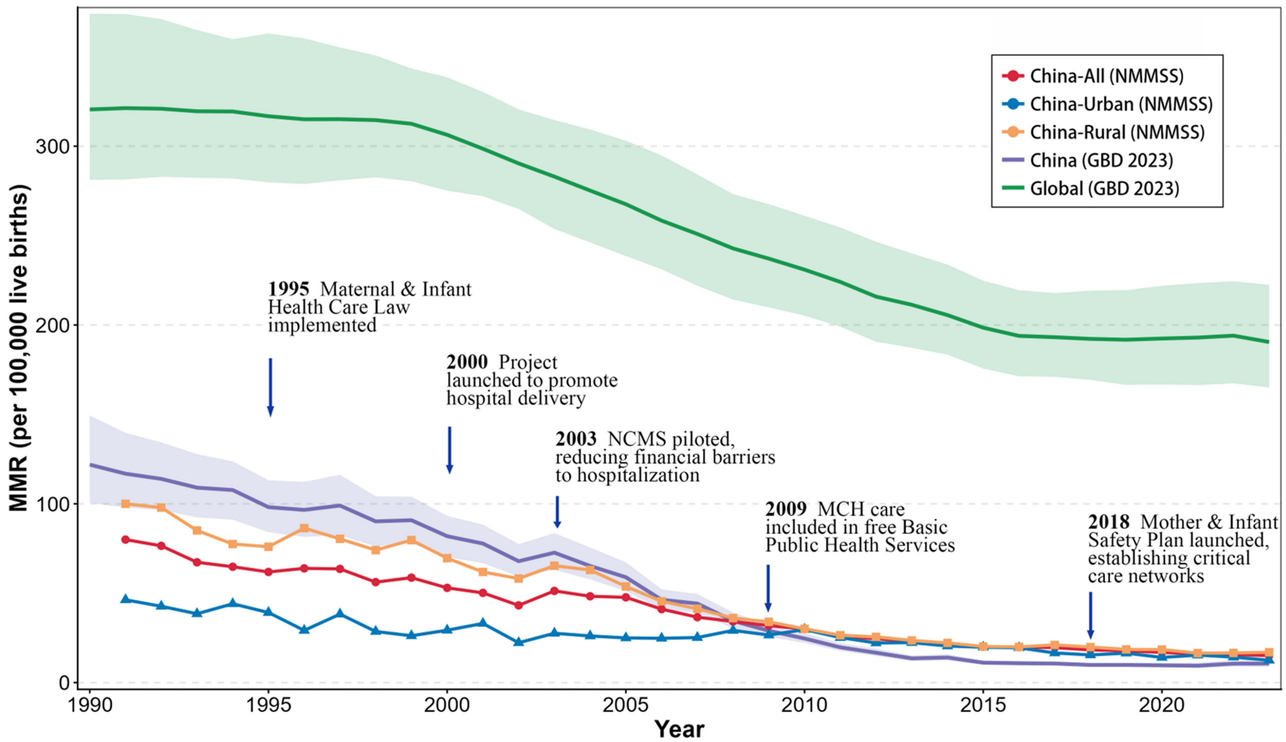

Figure 1 Temporal Trends in Maternal Mortality Ratio (MMR) in China, 1990–2023. Trends in MMR (deaths per 100,000 live births) from GBD 2023 study and NMMSS. NMMSS data are further stratified by urban and rural areas. Key national policies and public health initiatives are annotated on the timeline.
Abbreviations: GBD, Global Burden of Disease; NMMSS, National Maternal Mortality Surveillance System; MCH, Maternal and Child Health; NCMS, New Cooperative Medical Scheme.

Epidemiological Transition in the Burden of Maternal Disorders

Based on GBD 2023, Table 1 summarized the DALYs, mortality, and incidence trends of various maternal disorders in China and globally between 1990 and 2023. Overall, the maternal disorders burden had markedly reduced. The age-standardized DALY rate (ASDR) in China experienced a significant decline from 256.4 (210.5 to 309.9) in 1990 to 14.9 (12.3 to 18.1) in 2023, with an EAPC of −9.1 (−9.5 to −8.6). In comparison, the decline in China's maternal disorders burden far exceeded the global average (EAPC = −2.8[−2.9 to −2.8]).

The Joinpoint regression analysis for the period 1990–2023 in China revealed distinct temporal phases (Table 2). The MMR experienced its most rapid decline during 2004–2015 (APC = −15.45, $p<0.001$), subsequently transitioning to a plateau phase during 2015–2023 (APC = −1.10, $p = 0.211$). Analysis of DALYs identified 2007–2011 as the period of most accelerated reduction (APC = −18.92, $p<0.001$), while maternal disorder incidence showed a transient increase during 2010–2014 (APC = 6.62%, $p<0.001$) before resuming its downward trajectory.

While China's burden declined, distinct trends were observed across different disorders (Table 1 and Figure 2). Specifically, direct mortality causes such as maternal sepsis and other maternal infections (EAPC = −16.0 [−16.9 to −15.2]) and maternal hemorrhage (EAPC = −12.1 [−12.9 to −11.3]) exhibited the fastest rates of decline in MMR. Regarding DALYs, the most significant progress was also found in controlling maternal sepsis and other maternal infections (EAPC = −15.6[−16.3 to −14.8]) and maternal hemorrhage (EAPC = −12.8 [−13.3 to −12.3]). In contrast, the burden from other direct maternal disorders (EAPC = −4.1[−4.4 to −3.9]) and late maternal deaths (EAPC = −5.2[−5.6 to −4.8]) declined at a slower pace. Besides, the incidence of other direct maternal disorders was the only disease that remained stable (EAPC = 0.2 [−0.2 to 0.6]).

This reduction was accompanied by a profound epidemiological transition in the underlying etiology of maternal death and morbidity (Figure 3). In 1990, maternal mortality was primarily attributable to maternal hypertensive disorders and maternal hemorrhage, and also ranked the highest types for DALYs and incidence (Figure 3A). Regarding incidence rates, other direct maternal disorders became the highest-ranked disease, while maternal hypertensive disorders dropped

Table 1 The DALYs, Incidence and Mortality of Maternal Disorders with Their EAPC from 1990 to 2023 in China and Global

	China					Global				
	Number of Cases, Thousand, 1990	**ASR per 100,000 Population, 1990**	**Number of Cases, Thousand, 2023**	**ASR per 100,000 Population, 2023**	**EAPC, 1990–2023, 95% CI**	**Number of Cases, Thousand, 1990**	**ASR per 100,000 Population, 1990**	**Number of Cases, Thousand, 2023**	**ASR per 100,000 Population, 2023**	**EAPC, 1990–2023, 95% CI**
DALYs										
Maternal disorders	1798.4(1475.7–2181.0)	256.4(210.5–309.9)	86.8(71.4–105.8)	14.9(12.3–18.1)	−9.1(−9.5--8.6)	27,163.3 (24,004.7–31,700.1)	958.5(846.1–1117.2)	15,559.0 (13,478.3–17,959.5)	396.5(343.3–457.2)	−2.8(−2.9--2.8)
Ectopic pregnancy	27.7(17.9–41.4)	4.0(2.5–5.9)	1.8(1.1–2.6)	0.3(0.2–0.4)	−8.3(−8.9--7.7)	553.0(363.7–805.3)	19.4(12.7–28.2)	778.9(523.2–1083.1)	19.9(13.3–27.6)	0.1(0.0–0.1)
Indirect maternal deaths	242.9(150.7–358.9)	34.2(21.1–50.6)	18.5(13.0–24.7)	3.2(2.3–4.2)	−8.1(−8.7--7.5)	2341.4(1533.9–3513.0)	81.0(53.0–121.7)	1409.4(1002.3–2002.6)	36.0(25.6–51.1)	−2.2(−2.7--2.2)
Late maternal deaths	30.1(20.4–42.7)	4.3(2.9–5.9)	4.9(3.7–6.6)	0.8(0.6–1.2)	−5.2(−5.6--4.8)	439.8(354.9–565.4)	15.5(12.6–19.7)	484.1(404.2–596.5)	12.3(10.2–15.2)	−0.7(−0.8--0.7)
Maternal abortion and miscarriage	17.5(10.1–28.7)	2.5(1.4–4.0)	0.8(0.5–1.1)	0.1(0.1–0.2)	−9.2(−10.0--8.4)	2815.6(1832.2–4141.5)	100.0(65.4–146.7)	1261.9(810.3–1940.5)	32.2(20.7–49.5)	−3.9(−4.1--3.9)
Maternal deaths aggravated by HIV/AIDS	0.0(0.0–0.1)	0.0(0.0–0.0)	0.0(0.0–0.0)	0.0(0.0–0.0)	−5.0(−6.3--3.8)	78.2(47.5–106.4)	2.7(1.6–3.7)	96.1(60.2–134.9)	2.4(1.5–3.4)	−1.7(−2.3--1.7)
Maternal hemorrhage	793.4(585.0–1023.6)	114.2(85.0–146.6)	10.8(7.5–14.4)	1.8(1.3–2.4)	−12.8(−13.3--12.3)	9486.0(6797.0–12,286.5)	335.7(241.3–434.8)	3183.7(2214.7–4250.0)	80.9(56.3–107.9)	−4.5(−4.6--4.5)
Maternal hypertensive disorders	291.9(215.7–378.6)	41.2(30.5–53.3)	13.6(9.5–18.6)	2.4(1.7–3.3)	−9.0(−9.4--8.5)	4552.9(3531.6–5660.4)	159.5(123.6–198.4)	3084.7(2428.6–3799.2)	78.8(62.0–96.9)	−2.2(−2.3--2.2)
Maternal obstructed labor and uterine rupture	118.3(67.5–192.1)	16.9(9.7–27.4)	2.2(1.3–3.5)	0.4(0.2–0.6)	−12.5(−13.3--11.7)	2098.3(1340.7–3194.6)	76.4(49.3–114.9)	1110.5(772.7–1562.3)	28.4(19.8–39.9)	−3.1(−3.2--3.1)
Maternal sepsis and other maternal infections	127.5(84.2–183.1)	18.1(11.9–25.9)	0.8(0.5–1.0)	0.1(0.1–0.2)	−15.6(−16.3--14.8)	2679.4(1802.2–3623.4)	93.5(62.8–127.0)	1670.8(1192.5–2302.6)	42.6(30.4–58.7)	−2.5(−2.7--2.5)
Other direct maternal disorders	148.9(90.1–215.4)	21.1(12.8–30.7)	33.4(23.9–45.5)	5.7(4.1–7.9)	−4.1(−4.4--3.9)	2118.7(1364.7–3183.5)	74.7(48.2–112.0)	2479.0(1784.3–3479.2)	63.0(45.3–88.5)	−0.7(−0.8--0.7)
Incidence										
Maternal disorders	8606.8(7459.4–10,181.2)	1199.3(1045.5–1403.7)	3096.3(2852.5–3421.2)	531.0(487.1–582.2)	−2.0(−2.4--1.6)	121,700.3 (111,559.7–134,159.8)	4246.6(3896.5–4678.7)	124,434.1 (112,400.9–138,728.2)	3171.2(2866.4–3539.3)	−0.7(−0.8--0.7)
Ectopic pregnancy	85.4(56.3–123.7)	11.7(7.9–16.4)	25.5(18.9–33.3)	4.5(3.3–5.9)	−2.5(−2.8--2.1)	2426.4(1803.1–3100.8)	85.3(64.1–108.7)	2351.0(1824.2–2977.2)	59.7(46.1–75.5)	−1.0(−1.0--1.0)
Maternal abortion and miscarriage	868.4(629.4–1171.2)	132.3(97.2–176.9)	587.5(432.5–777.1)	88.7(65.6–117.6)	−0.4(−0.8--0.1)	58,764.7 (49,215.6–68,905.6)	2046.1(1726.7–2402.7)	63,776.0 (52,462.7–76,957.3)	1628.5(1340.0–1965.0)	−0.5(−0.6--0.5)
Maternal hemorrhage	2145.0(1584.8–2932.3)	291.8(213.6–401.1)	378.2(291.4–502.6)	70.4(53.3–93.3)	−3.1(−3.5--2.7)	14,402.1 (11,513.4–18,091.4)	501.1(400.9–629.2)	9926.5(7947.2–12,424.0)	252.8(201.7–317.5)	−2.0(−2.1--2.0)
Maternal hypertensive disorders	3333.5(2350.4–4638.1)	459.0(328.6–630.2)	675.8(528.9–870.1)	118.8(91.7–152.7)	−4.1(−4.7--3.6)	16,070.3 (12,582.5–19,891.4)	559.9(443.1–691.7)	15,237.4 (12,457.4–18,120.3)	388.0(316.6–463.2)	−1.1(−1.2--1.1)
Maternal obstructed labor and uterine rupture	128.9(69.9–223.8)	17.4(9.7–29.3)	49.1(28.3–80.1)	9.2(5.2–15.3)	−3.5(−4.1--2.9)	9866.7(6537.5–13,853.5)	342.8(229.4–475.4)	9477.2(6438.7–13,214.6)	242.1(164.7–339.6)	−0.9(−1.0--0.9)
Maternal sepsis and other maternal infections	151.6(113.1–206.0)	21.0(15.9–27.6)	67.1(51.2–85.2)	11.5(8.9–14.9)	−0.8(−1.3--0.4)	9070.0(7296.4–10,760.5)	315.4(255.6–373.4)	9935.4(8145.3–11,753.0)	253.0(207.5–299.9)	−0.5(−0.6--0.5)
Other direct maternal disorders	1894.0(1807.0–1986.2)	266.2(254.0–279.1)	1313.1(1258.8–1380.7)	227.8(218.4–239.5)	0.2(−0.2–0.6)	11,100.0 (10,594.4–11,626.4)	396.0(378.0–414.8)	13,730.6 (13,127.4–14,340.3)	347.1(331.8–362.5)	−0.2(−0.3--0.2)

(*Continued*)

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Table 1 (Continued).

	China					Global				
	Number of Cases, Thousand, 1990	**ASR per 100,000 Population, 1990**	**Number of Cases, Thousand, 2023**	**ASR per 100,000 Population, 2023**	**EAPC, 1990–2023, 95% CI**	**Number of Cases, Thousand, 1990**	**ASR per 100,000 Population, 1990**	**Number of Cases, Thousand, 2023**	**ASR per 100,000 Population, 2023**	**EAPC, 1990–2023, 95% CI**
Mortality										
Maternal disorders	27.6(22.8–33.8)	4.0(3.3–4.9)	1.0(0.8–1.1)	0.2(0.1–0.2)	−10.2(−10.7--9.8)	422.9(370.8–493.4)	15.1(13.2–17.7)	239.9(207.8–280.3)	6.1(5.3–7.1)	−2.9(−3.0--2.9)
Ectopic pregnancy	0.4(0.3–0.7)	0.1(0.0–0.1)	0.0(0.0–0.0)	0.0(0.0–0.0)	−8.2(−8.8--7.6)	8.8(5.8–12.8)	0.3(0.2–0.5)	12.7(8.5–17.8)	0.3(0.2–0.5)	0.1(0.0–0.1)
Indirect maternal deaths	3.9(2.4–5.7)	0.6(0.3–0.8)	0.3(0.2–0.4)	0.1(0.0–0.1)	−8.0(−8.6--7.4)	36.9(24.2–55.6)	1.3(0.8–2.0)	23.0(16.3–32.7)	0.6(0.4–0.8)	−2.1(−2.6--2.1)
Late maternal deaths	0.5(0.3–0.7)	0.1(0.0–0.1)	0.1(0.1–0.1)	0.0(0.0–0.0)	−5.1(−5.5--4.8)	7.1(5.7–9.0)	0.3(0.2–0.3)	8.0(6.8–9.9)	0.2(0.2–0.2)	−0.6(−0.8--0.6)
Maternal abortion and miscarriage	0.3(0.1–0.4)	0.0(0.0–0.1)	0.0(0.0–0.0)	0.0(0.0–0.0)	−12.3(−13.2--11.4)	44.9(29.0–66.4)	1.6(1.1–2.4)	19.6(12.2–30.8)	0.5(0.3–0.8)	−4.0(−4.3--4.0)
Maternal deaths aggravated by HIV/AIDS	0.0(0.0–0.0)	0.0(0.0–0.0)	0.0(0.0–0.0)	0.0(0.0–0.0)	−4.9(−6.2--3.7)	1.2(0.7–1.7)	0.0(0.0–0.1)	1.7(1.0–2.3)	0.0(0.0–0.1)	−1.4(−2.0--1.4)
Maternal hemorrhage	12.7(9.4–16.4)	1.9(1.4–2.4)	0.2(0.1–0.2)	0.0(0.0–0.0)	−13.3(−13.9--12.8)	152.7(109.9–197.7)	5.5(4.0–7.1)	52.0(35.8–70.0)	1.3(0.9–1.8)	−4.5(−4.6--4.5)
Maternal hypertensive disorders	4.1(2.9–5.5)	0.6(0.4–0.8)	0.1(0.1–0.1)	0.0(0.0–0.0)	−10.7(−11.1--10.3)	70.4(54.4–87.9)	2.5(1.9–3.1)	48.2(37.3–59.9)	1.2(0.9–1.5)	−2.2(−2.3--2.2)
Maternal obstructed labor and uterine rupture	1.9(1.1–3.1)	0.3(0.2–0.5)	0.0(0.0–0.1)	0.0(0.0–0.0)	−12.7(−13.4--11.9)	28.2(17.1–43.4)	1.0(0.6–1.6)	12.2(7.5–18.4)	0.3(0.2–0.5)	−3.8(−4.0--3.8)
Maternal sepsis and other maternal infections	2.0(1.3–2.9)	0.3(0.2–0.4)	0.0(0.0–0.0)	0.0(0.0–0.0)	−17.1(−17.8--16.4)	42.0(28.0–57.1)	1.5(1.0–2.0)	26.7(19.0–37.1)	0.7(0.5–0.9)	−2.5(−2.7--2.5)
Other direct maternal disorders	1.9(1.0–2.9)	0.3(0.1–0.4)	0.2(0.1–0.3)	0.0(0.0–0.1)	−6.5(−7.0--6.0)	30.7(18.7–47.2)	1.1(0.7–1.7)	35.7(25.2–51.8)	0.9(0.6–1.3)	−0.8(−0.9--0.8)

Note: 95% Uncertainty Intervals (UIs) for estimates and 95% Confidence Intervals (CIs) for EAPCs are shown in parentheses. Data are sourced from the Global Burden of Disease (GBD) 2023 study.
Abbreviations: ASR, age-standardized rates; DALYs, Disability-Adjusted Life Years; MMR, Maternal Mortality Ratio; EAPC, Estimated Annual Percentage Change.

Table 2 Joinpoint Regression Analysis of the DALYs, Incidence and Maternal Mortality Ratio for Maternal Disorders in China, 1990–2023

SDI region	Year	APC, 95% CI	P-value
DALYs	1990-2007	−9.07(−9.48–8.66)	<0.001
	2007-2011	−18.92(−22.84–14.79)	<0.001
	2011-2016	−3.08(−7.04–1.05)	0.135
	2016-2023	−7.59(−9.57–5.57)	<0.001
Incidence	1990-2001	−5.94(−6.42–5.46)	<0.001
	2001-2005	−2.18(−4.82–0.54)	0.108
	2005-2010	−4.65(−5.95–3.34)	<0.001
	2010-2014	6.62(4.42–8.87)	<0.001
	2014-2017	−1.12(−5.37–3.32)	0.594
	2017-2023	−5.27(−6.00–4.53)	<0.001
Maternal mortality ratio	1990-2004	−4.36(−5.20–3.51)	<0.001
	2004-2015	−15.45(−16.43–14.47)	<0.001
	2015-2023	−1.10(−2.84–0.67)	0.211

Note: Data are sourced from the GBD 2023. Data are sourced from the Global Burden of Disease (GBD) 2023 study.
Abbreviations: DALYs, Disability-Adjusted Life Years; CIs, Confidence Intervals; APC, Annual Percent Change.

to second place (Figure 3B). While other direct maternal disorders and indirect maternal deaths became the primary MMR causes and the highest DALYs type by 2023 (Figure 3C). The NMMSS results, however, diverged from GBD 2023, showing that the ranking of maternal mortality causes remained constant from 1990 to 2023, as obstetric hemorrhage, pregnancy hypertension, heart disease, amniotic fluid embolism, puerperal infection, and liver disease (Figure S1).

Evolving Age-Specific Risk Profile of Maternal Disorders

The distribution of maternal disorder burden demonstrates marked variation according to maternal age. In 2023, a U-shaped pattern of MMR was observed, with the highest rates observed in the youngest (10–15 years) and oldest (50–54 years) age groups, while the 25–29 age group showed the lowest MMR (Figure S2A). In contrast, incidence and DALYs exhibit a typical inverted U-shaped trend. While there are slight variations in the peak age groups for different types of maternal diseases, they are generally concentrated among women aged 25–34 (Figure S2B and C).

From 1990 to 2023, the maternal disorders burden declined across all age groups, yet the relative risk patterns remained generally consistent (Figure 4). The ASR for DALYs and MMR have shown a consistent and regular annual decline across all age groups (Figure 4A and B), whereas incidence exhibited a lesser decrease and even rebounded in some years (Figure 4C). A notable transition in the peak burden of maternal disorders was observed, with the highest ASDR shifting from the 20–24 age group in 1990 to the 25–29 age cohort by 2023 (Figure 4B).

Persistent Subnational Disparities in Maternal Health Resources and Service Coverage

Despite achieving high national averages in maternal healthcare utilization, significant provincial-level disparities persist (Figure 5). NMMSS data indicated that in 2023, maternal healthcare coverage was visibly lower in western and remote inland provinces compared to the more developed eastern coastal regions. Particularly in Tibet, the antenatal attendance rate, postnatal care visit rate, hospital delivery rate, and systematic management rate all ranked among the lowest nationwide.

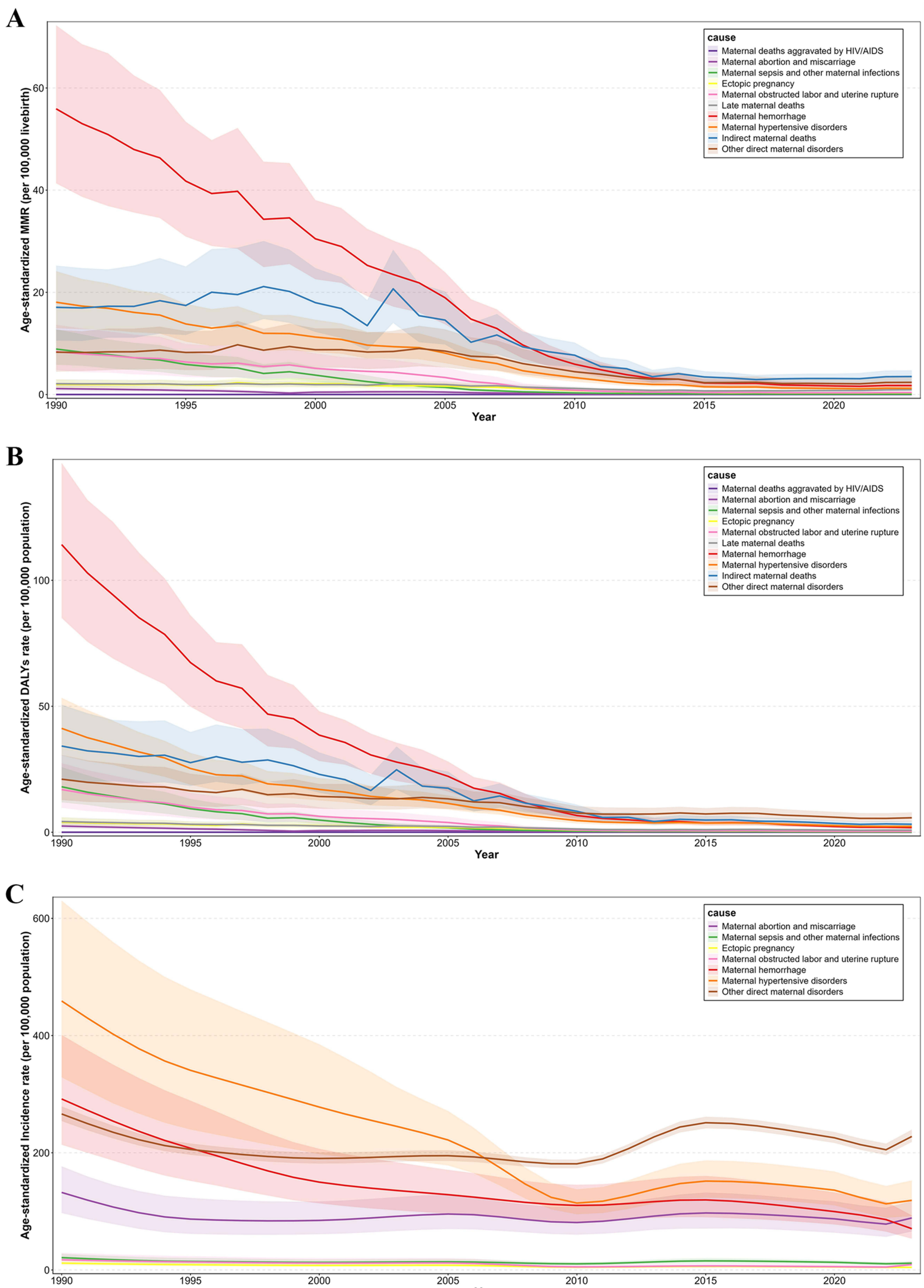

Figure 2 Trends in the burden of maternal disorders in China from 1990 to 2023. (**A**) Temporal trends in age-standardized MMR per 100,000 live births. **(B)** Temporal trends in age-standardized DALYs rate per 100,000 population. **(C)** Temporal trends in age-standardized incidence rate per 100,000 population. All estimates are from the GBD 2023 study, with shaded areas representing 95% uncertainty intervals.

Abbreviations: DALYs, Disability-Adjusted Life Years; MMR, Maternal Mortality Ratio.

A

Rank, 1990	Maternal disorder	Maternal disorder	Rank, 2023	Change in DALYs rate, 1990-2023, %	EAPC for DALYs, 1990-2023, 95%CI
1	Maternal hemorrhage	Other direct maternal disorders	1	-72.71	-4.1(-4.4--3.9)
2	Maternal hypertensive disorders	Indirect maternal deaths	2	-90.70	-8.1(-8.7--7.5)
3	Indirect maternal deaths	Maternal hypertensive disorders	3	-94.29	-9.0(-9.4--8.5)
4	Other direct maternal disorders	Maternal hemorrhage	4	-98.40	-12.8(-13.3--12.3)
5	Maternal sepsis and other maternal infections	Late maternal deaths	5	-80.12	-5.2(-5.6--4.8)
6	Maternal obstructed labor and uterine rupture	Maternal obstructed labor and uterine rupture	6	-97.83	-12.5(-13.3--11.7)
7	Late maternal deaths	Ectopic pregnancy	7	-92.42	-8.3(-8.9--7.7)
8	Ectopic pregnancy	Maternal sepsis and other maternal infections	8	-99.30	-15.6(-16.3--14.8)
9	Maternal abortion and miscarriage	Maternal abortion and miscarriage	9	-95.17	-9.2(-10.0--8.4)
10	Maternal deaths aggravated by HIV/AIDS	Maternal deaths aggravated by HIV/AIDS	10	-70.05	-5.0(-6.3--3.8)

B

Rank, 1990	Maternal disorder	Maternal disorder	Rank, 2023	Change in Incidence rate, 1990-2023, %	EAPC for Incidence 1990-2023, 95%CI
1	Maternal hypertensive disorders	Other direct maternal disorders	1	-14.43	0.2(-0.2-0.6)
2	Maternal hemorrhage	Maternal hypertensive disorders	2	-74.11	-4.1(-4.7--3.6)
3	Other direct maternal disorders	Maternal abortion and miscarriage	3	-32.94	-0.4(-0.8--0.1)
4	Maternal abortion and miscarriage	Maternal hemorrhage	4	-75.86	-3.1(-3.5--2.7)
5	Maternal sepsis and other maternal infections	Maternal sepsis and other maternal infections	5	-45.12	-0.8(-1.3--0.4)
6	Maternal obstructed labor and uterine rupture	Maternal obstructed labor and uterine rupture	6	-47.15	-3.5(-4.1--2.9)
7	Ectopic pregnancy	Ectopic pregnancy	7	-61.73	-2.5(-2.8--2.1)

C

Rank,1990	Maternal disorder	Maternal disorder	Rank, 2023	Change in MMR, 1990-2023, %	EAPC for MMR, 1990-2023, 95%CI
1	Maternal hemorrhage	Indirect maternal deaths	1	-79.36	-6.8(-7.8--5.9)
2	Maternal hypertensive disorders	Other direct maternal disorders	2	-71.24	-5.3(-6.1--4.5)
3	Indirect maternal deaths	Maternal hemorrhage	3	-96.85	-12.1(-12.9--11.3)
4	Maternal sepsis and other maternal infections	Maternal hypertensive disorders	4	-93.30	-9.5(-10.2--8.8)
5	Maternal obstructed labor and uterine rupture	Late maternal deaths	5	-55.61	-3.9(-4.5--3.3)
6	Other direct maternal disorders	Maternal obstructed labor and uterine rupture	6	-95.38	-11.4(-12.4--10.4)
7	Late maternal deaths	Ectopic pregnancy	7	-82.53	-7.0(-7.9--6.1)
8	Ectopic pregnancy	Maternal sepsis and other maternal infections	8	-99.15	-16.0(-16.9--15.2)
9	Maternal abortion and miscarriage	Maternal abortion and miscarriage	9	-96.60	-11.2(-12.2--10.2)
10	Maternal deaths aggravated by HIV/AIDS	Maternal deaths aggravated by HIV/AIDS	10	-29.83	-3.6(-5.2--2.0)

Rank increased | Rank decreased | Rank no change

Figure 3 Changes in the ranking of major maternal disorders burdens in China from 1990 to 2023. **(A–C)** represent the age-standardized rates of DALYs, incidence rates, and MMR rankings for maternal disorders, respectively, along with percentage change rates and the EAPC from 1990–2023, by GBD 2023.
Abbreviations: DALYs, Disability-Adjusted Life Years; MMR, Maternal Mortality Ratio.

Similarly, substantial disparities in maternal health resource allocation were observed across Chinese provinces (Table S5). Eastern provinces maintained relatively adequate specialist coverage, with obstetrician densities ranging from 23.48 to 33.45 per 100,000 women in 2023, while western regions demonstrated pronounced workforce shortages despite improvements in the number of maternal healthcare institution infrastructure. Specifically, Tibet reported an obstetrician density of only 15.29 per 100,000 women, while Xinjiang recorded the nation's lowest density at 12.27 per 100,000 women (Figure S3).

Projections of Maternal Mortality to 2030

To evaluate the feasibility of achieving the "Healthy China 2030" target of an MMR below 12.0 per 100,000 live births by 2030, we constructed a scenario-based projections model based on NMMSS data, and projected future trends under four distinct scenarios (Figure S4). Under the reference scenario, which assumes the ARR will continue the recent 2015–2023 trend, the national MMR is projected to decrease to 11.8 per 100,000 live births in 2030, just meeting the Healthy China 2030 goal. The optimistic scenario, based on the accelerated ARR of the 2004–2015 period, projects a more substantial decline to 9.6 per 100,000 live births. Conversely, the pessimistic scenario, modeling a stagnation in progress, projects that the MMR would only fall to 13.3 per 100,000 live births, failing to achieve the target. As the benchmark, the target achievement scenario demonstrates that a constant ARR of 3.23% is required to reach the goal, a rate slightly lower than the recently observed trend, reinforcing that the target is attainable if current momentum is sustained.

Furthermore, we constructed a BAPC prediction model to forecast other relevant metrics of the maternal disorder burden in China, and validated the model by comparing it with the actual values in GBD 2023. Our results indicated that by 2030, China's incidence, DALYs, and death for maternal disorders—both in numbers and age-standardized rates—

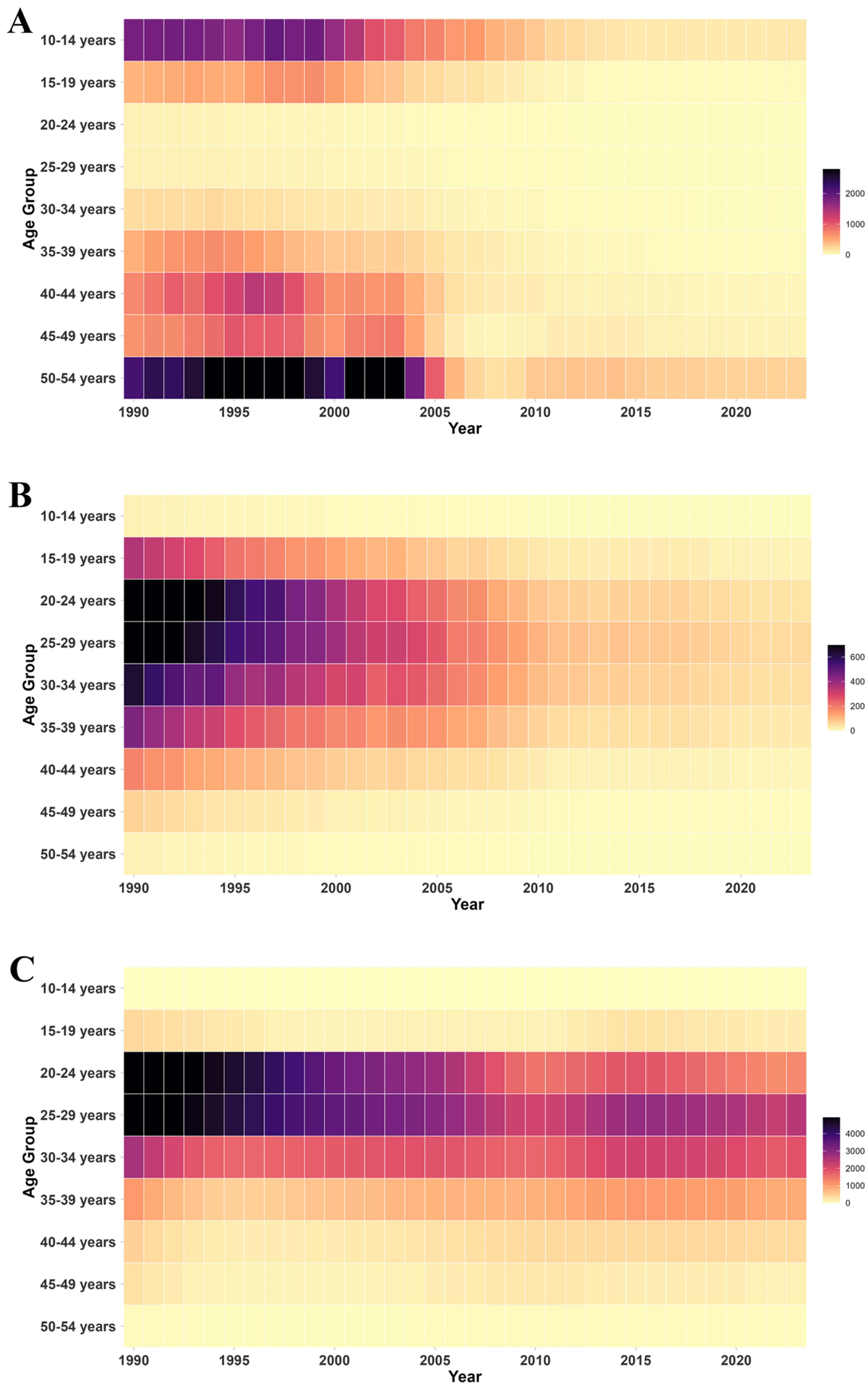

Figure 4 Age-Specific Temporal Trends of Maternal Disorder Burden in China, 1990–2023. The color intensity in heat maps corresponds to the magnitude of the age-standardized rate per 100,000 population/live births for **(A)** MMR, **(B)** Incidence, and **(C)** DALYs. Data are sourced from the GBD 2023 study.

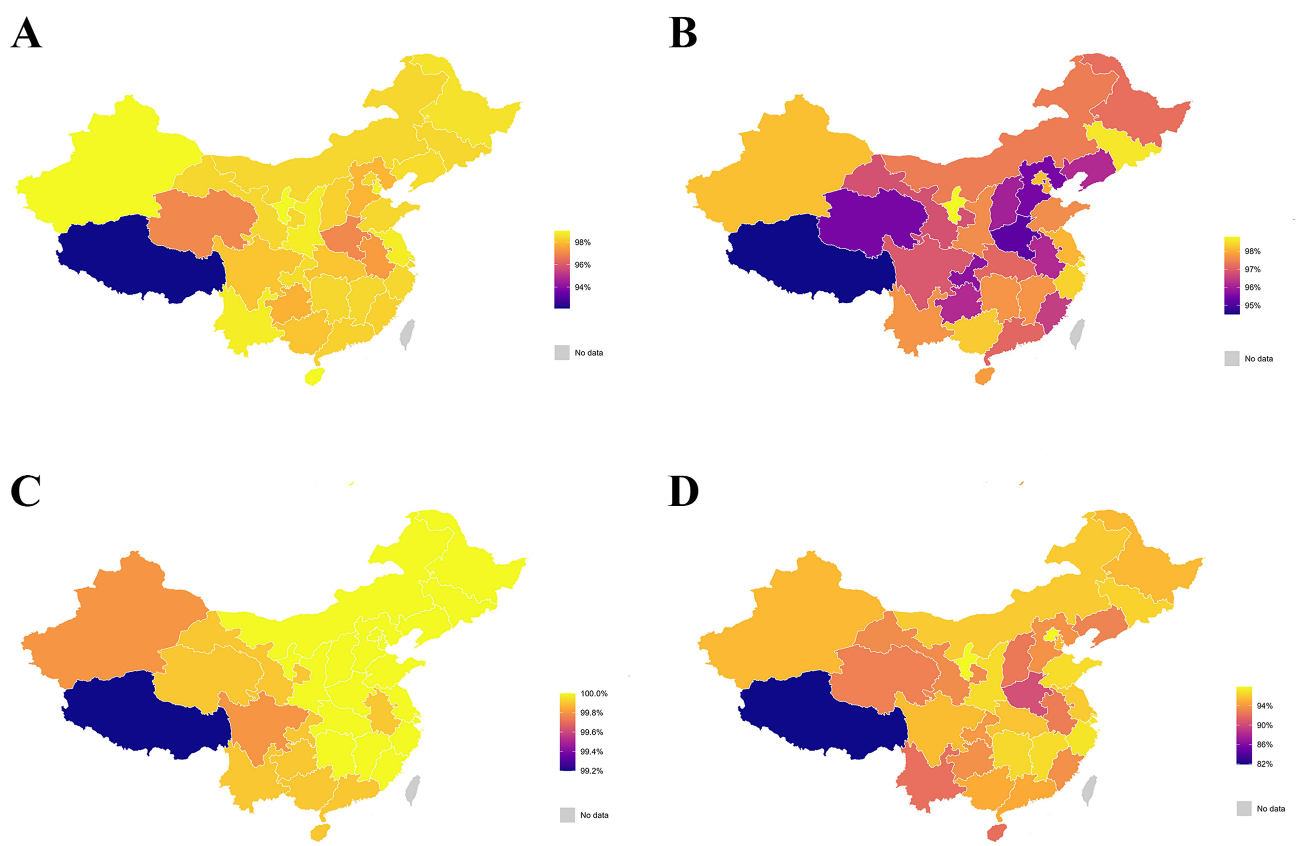

Figure 5 Provincial Disparities in Key Maternal Healthcare Service Indicators in China, **2023.** **(A)** Antenatal attendance rate; **(B)** Postnatal care visits rate; **(C)** Hospital delivery; **(D)** Systematic management rate. Higher color intensity indicates a higher coverage rate.

will continue to decline (Figure 6). Furthermore, we evaluated the performance of the BAPC prediction model. The overall MAPE values were 0.04% for incidence, 4.06% for deaths, and 0.23% for DALYs, indicating strong historical agreement, particularly for incidence and DALYs (Table S6).

Discussion

This study provides a comprehensive, dual-data source analysis of China's maternal health transformation over 33-year period. Our findings quantify a historic reduction in China's maternal mortality that far exceeds the global progress, and the near-complete elimination of the urban-rural health disparity, while GBD 2023 and NMMSS differed in both absolute MMR levels and the ranking of leading causes of maternal mortality. GBD 2023 identified a profound epidemiological transition in the underlying causes of maternal disorders burden, and the Joinpoint analysis indicated that the pace of improvement slowed after 2015. The NMMSS data revealed persistent subnational inequalities, and forecast future scenarios, confirming that the "Healthy China 2030" target is attainable but requires sustained efforts.

China's marked reduction in maternal mortality reflects the success of a synergistic, multi-tiered policy system. The key to this achievement has been the improvement in healthcare accessibility and the strengthening of the maternal health service network, particularly through the establishment of a robust three-tiered maternal and child healthcare system, which has effectively narrowed the urban-rural gap.[26,27] Recognizing financial barriers as a major obstacle, China implemented targeted interventions, including the "Reducing Maternal Mortality and Eliminating Neonatal Tetanus" program launched in 2000[28] and the nationwide "Rural Maternal Hospital Childbirth Subsidy" in 2009,[29] which significantly eliminated out-of-pocket expenses for institutional delivery among millions of rural women. These findings demonstrate how well-designed and precisely implemented health policies make it possible to achieve health outcomes beyond the constraints of socioeconomic factors. Nevertheless, our analysis confirms that significant geographical and socioeconomic gradients persist in China. Access to adequate, high-quality maternal services remains a critical challenge

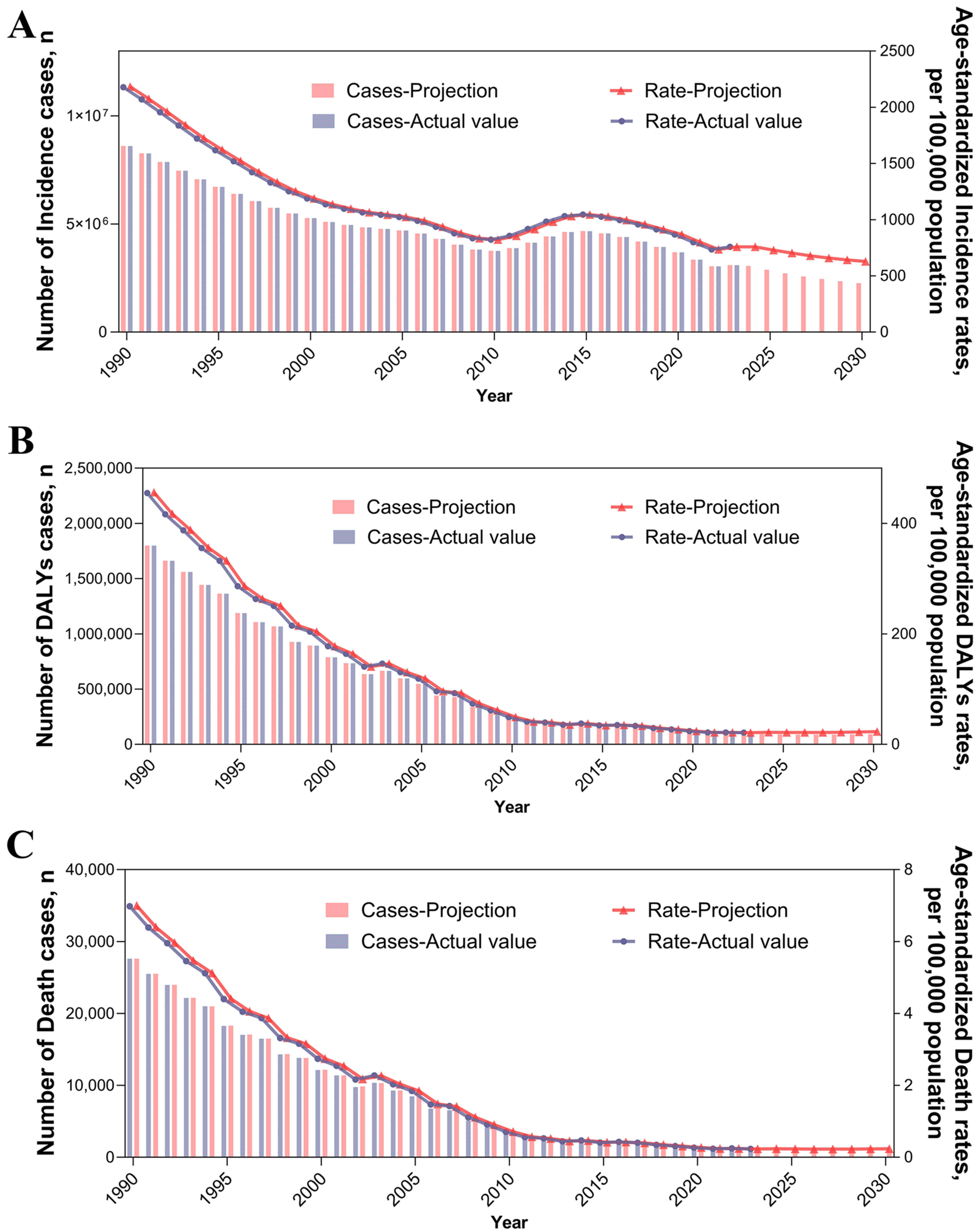

Figure 6 The BAPC projections model of maternal disorders burden in China to 2030. **(A–C)** represent the incidence, DALYs, and death for maternal disorders, respectively. The blue lines/bars indicate GBD-estimated historical values (1990–2023), and red lines/bars indicate BAPC-predicted values (1990–2030). The bar chart and left Y-axis represent the number, and the line chart and right Y-axis represent the age-standardized rate. Data are sourced from the GBD 2023 study.

in less developed provinces such as Tibet.[30] The entrenched inequities in these regions extend beyond imbalances in financial and medical resource allocation, they are further compounded by disparities in maternal education and underlying cultural practices, which influence healthcare-seeking behaviors and perinatal care adherence.[31,32] Hence, in provinces such as Tibet and Xinjiang, where maternal service coverage and obstetrician density remain comparatively low, priority should be given to workforce deployment, referral strengthening, and telemedicine-supported access to higher-level care.

From 1990 to 2023, the progress in MMR and associated disease burden, which far exceeds the global average, has positioned China as a key driver in achieving the MDGs and continues to be instrumental in the pursuit of SDGs.[8] However, our Joinpoint regression analysis indicates a notable deceleration in the MMR decline during the past decade, suggesting the emergence of a plateau. This pattern of stagnation as MMR reaches very low levels is not unique to China and has been similarly identified in several high-income countries, such as the United Kingdom, the United States, and Japan.[33–35] This phenomenon aligns with the characteristics of the fourth stage of obstetric transition, which is defined by a very low MMR (under 50 per 100,000 live births) and where the principal challenge shifts from addressing direct causes to confronting the growing burden of indirect causes of maternal mortality.[36,37]

A core finding of this study pertains to the fundamental, policy-relevant discrepancies between the GBD 2023 modeled estimates and the NMMSS national surveillance data. First, there is a substantial disparity in absolute MMR values. The NMMSS reported China's 2023 MMR as 15.1 per 100,000 live births, and GBD 2023 estimated it at 10.7 per 100,000 live births in 2023, suggest that China had already surpassed the "Healthy China 2030" target ahead of schedule, but clearly contradicts official reports.[38] Second, different conclusions regarding the primary causes of maternal mortality appeared. While GBD 2023 revealed a profound shift in maternal mortality causes toward indirect factors, the NMMSS presents a contrasting reality, consistently identifying obstetric hemorrhage as the primary cause throughout the three-decade study period.

Such discrepancies between modelled estimates and real-world data have been described in other disease contexts,[39,40] often resulting from differences in data collection, case ascertainment, modeling algorithms, and cause-attribution frameworks. The GBD 2023 synthesizes data from numerous and varied data sources, and utilizes uniform modeling approaches such as DisMod-MR 2.1 to generate standardized burden estimates, adjusting for potential under-reporting and misclassification.[41] Despite continuous improvements in each GBD version, these modelled estimates may still deviate from the reality captured by surveillance. In contrast, data from the NMMSS were systematically summarized, verified, and reported by medical institutions nationwide, are officially considered reliable real-world data. When evaluating national policy targets, the Chinese government officially designates NMMSS data as the "gold standard" indicator.[38,42] Although some underreporting may have occurred in the system's early stages, particularly in remote areas with limited diagnostic capacity.[43] These discrepancies should not be interpreted as a simple contradiction between a "correct" and an "incorrect" dataset, but as evidence that different data systems answer different policy questions. For international benchmarking and standardized burden comparisons, GBD remains highly informative. For evaluating national target attainment and guiding domestic maternal health planning, however, surveillance-based NMMSS estimates may be more directly actionable. The converging trends between these two data sources in recent years underscore a positive advance in both the comprehensiveness of data collection and the authenticity of real-world maternal health reports.

Therefore, China's efforts to reduce preventable maternal mortality in the next phase should adopt a dual focus: continuing to strengthen obstetric emergency care capabilities to overcome persistent obstetric hemorrhage issues, and addressing the increasingly complex challenges posed by indirect causes. The U-shaped maternal mortality curve indicates elevated risks at both the youngest and oldest extremes of maternal age. Adolescent pregnancies are often associated with biological immaturity and adverse socioeconomic factors,[44] whereas AMA is strongly correlated with a higher obstetrical complications and pre-existing chronic conditions.[45,46] These findings underscore the critical need for age-stratified risk assessment and tailored perinatal care, particularly with the relaxation of China's birth policies. Societal trends toward delayed childbearing, amplified by the implementation of the three-child policy, are raising the proportion of AMA pregnancies.[47,48] Another factor of concern is China's rapidly rising cesarean section rate,[49] which may impose an additional, long-term iatrogenic burden on maternal health. The slight rebound in MMR observed from

2021 to 2023 may indicate an early warning signal of growing pressure on the healthcare system, potentially exacerbated by the COVID-19.[50]

To achieve the higher-level "Healthy China 2030" targets, the national strategy should pivot from widespread public health programs toward precise, clinically focused interventions. Despite the significant decline in the burden from direct obstetric causes, NMMSS continued to identify obstetric hemorrhage as the leading cause of maternal mortality. This highlighted the urgent requirement for sustained strengthening of obstetric emergency care capabilities, particularly in managing postpartum hemorrhage. Furthermore, indirect maternal mortality was emerging as a prominent issue, especially in eastern provinces where epidemiological transition has progressed further. This type of mortality often demands coordinated expertise across obstetrics, internal medicine, anesthesiology, and critical care. To address this, it is necessary to incorporate routine screening for cardiovascular disease, pre-existing diabetes, and other chronic conditions into antenatal care protocols, particularly for older pregnant women, supported by standardized referral pathways and multidisciplinary team (MDT) protocols for high-risk pregnancies.[51] Meanwhile, as basic access to maternal healthcare has been largely achieved nationwide, the next priority is to bridge the quality gap across regions. This requires ensuring equitable access to high-quality care through continuous professional development and the strategic deployment of telemedicine, particularly in remote western regions, where enhancing local capacity to manage obstetric complications and chronic conditions is paramount.[52] Finally, establishing a more comprehensive and specialized information collection system would support clinical practice and health system reform. Effective strategies include enhancing the capabilities of information collectors, comprehensively gathering data on complications, social determinants, and non-fatal outcomes, and expanding the NMMSS to systematically track and evaluate severe maternal morbidity (SMM) and near-miss events.[7,53,54]

The main strength of this study is its innovative integration and comparison of two complementary, high-quality data sources, GBD 2023 and NMMSS, enabling a more detailed interpretation of long-term trends spanning 33 years (1990–2023), the most up-to-date period available. Beyond MMR, our analysis included multiple burden-of-disease metrics, including DALYs and incidence, thereby offering a uniquely comprehensive evaluation of maternal health in China. More importantly, it provides the first systematic comparison between global model estimates and nationally reported surveillance data, revealing significant discrepancies in both overall MMR levels and cause-specific rankings. This methodological distinction serves as a critical warning for other countries that rely on GBD models to formulate national policies. Furthermore, our study extends beyond prior China-focused GBD analyses by incorporating a comprehensive subnational inequity analysis across 31 provinces and scenario-based projections to assess progress toward the Healthy China 2030 target.

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However, several limitations warrant consideration when interpreting our findings. First, discrepancies in case definitions and cause attribution between GBD and NMMSS complicate one-to-one interpretation of cause-specific trends. Second, aggregated yearbook data do not permit individual-level validation or subgroup modeling beyond the reported strata. Third, scenario-based projections are assumption-dependent and should not be interpreted as deterministic forecasts. Finally, some surveillance under-reporting or differential diagnostic capacity may still affect historical comparisons, especially in less-resourced areas. Therefore, enhancing the comprehensiveness and accuracy of data collection is not merely a technical exercise, but a prerequisite for evidence-based policymaking that genuinely reflects the on-the-ground realities of maternal health.

Conclusion

In conclusion, China has made remarkable progress in reducing maternal mortality and narrowing the urban-rural gap, but the country has entered a more complex stage of maternal health improvement in which continued gains are harder to achieve. The discrepancy between GBD 2023 and NMMSS is substantial that in 2023 GBD estimates were approximately 29% lower than NMMSS data. This magnitude of divergence is sufficient to alter conclusions about current target attainment and cause priorities, underscoring the need for improved reconciliation between modeled and surveillance evidence. China appears close to achieving the Healthy China 2030 target under the recent-trend scenario derived from NMMSS, but this inference assumes continuation of the 2015–2023 rate of reduction, and it remains sensitive to the choice of reference period and to future fertility-policy shifts, post-COVID service disruption, or changes in referral quality and case mix. Further progress will require sustained strengthening of hemorrhage rescue systems and more specific responses to the rise of indirect causes. For example, in provinces where indirect maternal causes are becoming more prominent, cardiovascular and multisystem risk screening should be integrated into routine antenatal care, together with multidisciplinary referral pathways for high-risk pregnancies. More equitable access to high-quality maternal care in underserved and remote provinces remains essential.

Abbreviations

AAPC, average annual percent change; AMA, advanced maternal age; APC, annual percent change; ARR, annual rate of reduction; ASR, age-standardized rate; BAPC, Bayesian age-period-cohort; DALY, disability-adjusted life year; EAPC, estimated annual percentage change; GBD, Global Burden of Disease; GHDx, Global Health Data Exchange; INLA, Integrated Nested Laplace Approximation; MDG, Millennium Development Goal; MMR, maternal mortality ratio; NMMSS, National Maternal Mortality Surveillance System; SDG, Sustainable Development Goal; SMM, severe maternal morbidity; UI, uncertainty interval; WHO, World Health Organization.

Data Sharing Statement

All raw data in this study are derived from GBD 2023 and China Health Statistics Yearbook, which are both publicly available, accessible via the GBD tool (https://vizhub.healthdata.org/gbd-results/) and National Bureau of Statistics of China (https://www.stats.gov.cn/english/Statisticaldata/yearbook/), respectively.

Ethics Statement

This study is a secondary analysis of publicly available, anonymized, aggregate-level estimates from the Global Burden of Disease Study 2023 (GBD 2023) and the China Health Statistics Yearbook. No individual-level data, personal identifiers, or patient contact information were accessed; therefore, informed consent was not applicable. According to Article 32 (Items 1 and 2) of the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects issued by the National Health Commission of the People's Republic of China (February 18, 2023), research that uses legally obtained public data without involving identifiable personal information is exempt from institutional ethical review. Therefore, ethics committee approval from our institution was not required for this study. This study was conducted in full accordance with the GATHER reporting guidelines.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest in this work.

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