Research paper

Burden of maternal disorders in China from 1990 to 2019: Analysis of the Global Burden of Disease Study 2019

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ABSTRACT

Background: Efforts to quantify the burden of maternal disorders at the national and provincial levels are valuable for resource allocation and for development and adoption of public health policies.

Methods: Following the methods of the Global Burden of Diseases, Injuries, and Risk Factors Study 2019, the prevalence of maternal disorders and the resulting disability-adjusted life years (DALYs), years lived with disability(YLD), deaths, and years of life lost (YLL) at the national and provincial levels in China were examined for the 1990–2019 period. Estimated annual percentage changes (EAPCs) were calculated to estimate the trends of age-standardized rate (ASR) of prevalence, DALYs, death, and YLD due to maternal disorders and its main subcategories from 1990 to 2019.

Findings: In 2019, China had an estimated 0.85 million cases of maternal disorders (95% uncertainty interval: 0.65–1.08 million), with a 73% decline in absolute numbers from 1990 to 2019. The ASR of prevalence, DALYs and death for overall maternal disorders showed decreasing trends in China from 1990 to 2019 with the EAPCs being -3.25(95% confidence interval [CI] $= -3.86$ to -2.64), -8.07 (95% CI$= -9.14$ to -6.98), and -7.04 (95% CI$= -7.99$ to -6.07), respectively. The most pronounced decreases in trends in ASR of prevalence, DALYs and death were observed for maternal hemorrhage. Shandong, Hong Kong, Macao showed no significant trends in ASR of prevalence. Notably, the trends in ASR of prevalence due to maternal hypertensive disorders had been stable in China and most provinces. The trends in ASR of DALYs and death decreased the most in Jiangxi province.

Interpretation: The disease burden of prevalence, DALYs and death for overall maternal disorders decreased significantly in China from 1990 to 2019, however, the trends in ASR of prevalence due to maternal hypertensive disorders had been stable in China and most provinces.

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Research in context

Evidence before this study

We searched PubMed for ("Maternal hemorrhage" OR "Maternal sepsis" OR "Maternal infections" OR "Maternal hypertension" OR "Maternal hypertensive disorders" OR "Maternal obstructed labor and uterine rupture" OR "Maternal abortion and miscarriage" OR "Ectopic pregnancy" OR "Indirect maternal deaths" OR "Maternal deaths aggravated by HIV/AIDS" OR "Late maternal deaths" OR "maternal disorders") AND ("burden" OR "estimates" OR "model") with no language or publication date restrictions. To the best of our knowledge, no consistent and comparable assessments of the temporal trends in the burden of maternal disorders have been conducted at the national and provincial levels in China; thus, little is understood about their spatial patterns and temporal trends.

Added value of this study

This study provides the most comprehensive assessment of the prevalence of maternal disorders and the associated DALYs, YLDs, deaths, and YLLs at both the national and provincial levels in China using the unified GBD Study 2019 framework. This study expands on previous research by including the prevalence and DALYs of maternal disorders instead of focusing only on maternal deaths. The study reveals that the disease burden of prevalence, DALYs and death for overall maternal disorders decreased significantly in China from 1990 to 2019 at both the national and provincial levels. However, the trends in ASR of prevalence due to maternal hypertensive disorders had been stable in China and most provinces. The patterns and trends were heterogeneous across provinces, which illustrate the necessity of spatial resource allocation and priority setting across China.

Implications of all the available evidence

The increased prevalence of maternal disorders and the variation in their burden at the provincial level has important implications. Spatial resource allocation and priority setting across China are essential to establish local health policies.

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1. Introduction

In 2016, the mortality rate of pregnant women in China decreased to 19.9 per 100,000 live births, which marked the accomplishment of one of China's sustainable development goals for 2030 [target level of 70 per 100,000] [1,2]. Despite this remarkable achievement, the mortality rate in 191 counties (6.7%) remained above the sustainable development goal's target level of 70 per 100,000 [3], illustrating the regional disparities across China.

In 2019, China launched the "Healthy China" action plan, a maternal and child health promotion initiative to reduce the maternal mortality ratio to less than 12 per 100,000 live births by 2030 [4]. In this context, reliable information on the burden of maternal disorders at the provincial level in China is needed to identify the areas of success and remaining challenges and to assist in policy formulation as the country continues to prioritize maternal and reproductive health. This objective is also consistent with WHO's recommendation to examine maternal morbidity to identify intervention priorities in high-income countries with low MMRs.

Here, we present comprehensive estimates of the burden of maternal disorders at both national and provincial levels in China for 1990–2019 from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 (GBD 2019). In addition to estimates of the mortality rate, we also present estimates of four health-gap metrics of maternal disorders: prevalence, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life years (DALYs).

2. Methods

2.1. GBD 2019 framework

GBD 2019 estimated incidence, mortality, and disability-adjusted life-years (DALYs) due to 369 diseases and injuries, for two sexes, and for 204 countries and territories that were grouped into 21 regions and seven super-regions [5] Annual data on age-standardized rate (ASR) of prevalence, DALYs, death, and YLD of maternal disorders and its main subcategories were derived from the Global Health Data Exchange (GHDx) query tool. A detailed description of the metrics, data sources, and statistical modeling used in the GBD 2017 was reported elsewhere [5].

The National Center for Chronic and Noncommunicable Disease Control and Prevention, reviewed and approved this study. Informed consent was waived because no identifiable information was included in the analyses. The GBD 2019 was in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting statement [6].

2.2. Data sources

The original data estimated by the GBD for maternal disorders in China were obtained mainly from the Cause-of-Death Reporting System of the Chinese CDC, the Disease Surveillance Points system, and the Maternal and Child Surveillance System. The data on the causes of death for provinces were derived primarily from the surveillance systems, including the Disease Surveillance Points system and the Maternal and Child Surveillance System, and from surveys, the China Cancer Registry, and the Cause-of-Death Reporting System of the Chinese CDC.

Maternal disorders were identified from the 10th revision of the International Classification of Diseases and Injuries (ICD-10) discharge diagnosis codes (eTable 1), and included maternal hemorrhage, maternal sepsis and other maternal infections, maternal hypertensive disorders, maternal obstructed labor and uterine rupture, maternal abortion and miscarriage, ectopic pregnancy, indirect maternal death, maternal death aggravated by HIV/AIDS, late maternal death, and other maternal disorders.

2.3. Measures

The main outcome measures of our study were the prevalence, deaths, YLLs, YLDs, and DALYs associated with maternal disorders. The prevalence of a condition refers to the proportion of the population that has that condition at a specific time. YLDs refer to years of life lived with any sort of health-related disability over time and are calculated as the product of the disability weight and the prevalence number. (The disability weight is a value between 0 and 1 that represents the health loss severity related to a particular disease.) The details of the disability weights used in the GBD 2019 were reported elsewhere [5].

The YLLs were computed by multiplying the number of deaths from each cause in each age group by the reference life expectancy at the average age of death among those who died in the age group [7]. DALYs are commonly used to measure the overall disease burden and are expressed as the sum of YLLs due to premature death and YLDs [8].

For our metrics, we extracted YLD data in terms of the prevalence (YLD counts), rate (per 100,000 people), and percentage (proportion of YLDs due to the selected conditions relative to the total YLDs). For age, we extracted YLD data for all ages and as age-standardized rates. The estimates are reported with 95% uncertainty intervals (UIs) [9]. Thirty-three provinces/regions of China, including 31 mainland provinces, municipalities, and autonomous

Table 1

All-Age Prevalence, Deaths, YLDs, DALYs, YLLs numbers and Age-Standardized Rates(ASR) for Maternal disorders (including Subcategories) and Their temporal trends in China, 1990–2019.

	1990		2019		1990–2019	
	cases No. × 10³ (95% UI)	ASR (per 100,000) No. (95% UI)	cases No. × 10³ (95% UI)	ASR (per 100,000) No. (95% UI)	Change in Number No.(%)	EAPC No. (95% CI)
Maternal disorders						
Prevalence	3,217,197.72(2,488,297.09,4,127,806.71)	441.05(343.48,562.91)	854,682.07(655,864.93,1,086,142.07)	122.96(94.42,156.97)	−0.73(−0.79,−0.68)	−3.25(−3.86,−2.64)
Deaths	17,399.76(13,723.65,21,673.65)	2.59(2.05,3.21)	1537.31(1169.12,1960.42)	0.22(0.17,0.28)	−0.91(−0.94,−0.88)	−8.07(−9.14,−6.98)
YLDs	143,328.18(87,853.07,213,945.37)	19.65(12.13,29.02)	45,987.41(28,483.87,68,265.52)	6.67(4.12,9.79)	−0.68(−0.74,−0.62)	−2.71(−3.38,−2.04)
DALYs	1,181,743.72(952,920.04,1,449,047.22)	171.88(138.98,210.31)	134,061.12(106,104.12,162,483.40)	19.62(15.59,23.76)	−0.89(−0.91,−0.85)	−7.04(−7.99,−6.07)
YLLs	1,038,415.54(818,244.63,1,295,914.95)	152.22(120.31,189.42)	88,073.71(67,167.54,111,971.72)	12.95(9.93,16.35)	−0.92(−0.94,−0.88)	−7.92(−9.17,−6.65)
Maternal hemorrhage						
Prevalence	2,597,747.58(1,934,929.90,3,440,226.72)	357.06(266.38,470.19)	608,495.50(442,084.34,820,272.19)	86.31(62.83,115.34)	−0.77(−0.82,−0.70)	−3.69(−4.25,−3.13)
Deaths	7024.48(5529.75,8740.36)	1.07(0.84,1.32)	243.02(183.14,315.11)	0.03(0.03,0.04)	−0.97(−0.98,−0.95)	−11.28(−12.75,−9.78)
YLDs	83,290.19(48,562.15,128,689.04)	11.42(6.78,17.47)	16,443.35(9677.25,25,761.00)	2.33(1.37,3.64)	−0.80(−0.86,−0.73)	−4.23(−5.05,−3.39)
DALYs	495,416.80(399,494.49,609,518.57)	72.89(58.88,90.00)	30,105.29(22,564.63,40,153.02)	4.30(3.23,5.70)	−0.94(−0.95,−0.92)	−9.17(−10.43,−7.90)
YLLs	412,126.62(324,149.36,513,951.03)	61.47(48.38,76.44)	13,661.94(10,321.66,17,694.54)	1.97(1.50,2.53)	−0.97(−0.98,−0.95)	−11.07(−12.79,−9.32)
Maternal sepsis and other maternal infections						
Prevalence	325,882.80(163,609.62,545,880.49)	44.18(22.66,73.96)	145,622.42(79,473.61,238,657.44)	21.78(11.70,35.68)	−0.55(−0.61,−0.47)	−1.47(−1.90,−1.03)
Deaths	1841.17(1435.50,2318.91)	0.27(0.21,0.34)	19.53(14.74,25.07)	0.00(0.00,0.00)	−0.99(−0.99,−0.99)	−14.47(−16.11,−12.81)
YLDs	15,477.20(6683.34,29,501.38)	2.07(0.91,3.92)	6580.64(2937.58,12,371.77)	1.01(0.44,1.86)	−0.57(−0.63,−0.50)	−1.43(−1.90,−0.96)
DALYs	127,359.41(99,679.38,159,590.41)	18.18(14.33,22.78)	7692.26(3982.65,13,594.93)	1.17(0.61,2.04)	−0.94(−0.97,−0.90)	−8.65(−9.89,−7.38)
YLLs	111,882.21(87,432.97,140,696.25)	16.10(12.55,20.24)	1111.62(840.26,1423.97)	0.16(0.12,0.21)	−0.99(−0.99,−0.99)	−14.20(−16.24,−12.12)
Maternal hypertensive disorders						
Prevalence	248,652.56(152,693.35,380,177.21)	35.46(21.81,54.04)	131,466.30(82,707.93,195,408.30)	17.99(11.39,26.66)	−0.47(−0.57,−0.36)	−1.07(−2.42,0.30)
Deaths	2285.15(1800.36,2840.66)	0.33(0.26,0.41)	161.48(122.77,206.97)	0.02(0.02,0.03)	−0.93(−0.95,−0.90)	−8.75(−9.95,−7.53)
YLDs	12,687.76(6577.44,21,665.99)	1.81(0.92,3.04)	6755.36(3597.04,11,079.45)	0.93(0.49,1.50)	−0.47(−0.56,−0.35)	−1.19(−2.43,0.07)
DALYs	151,669.63(121,991.83,186,327.82)	21.79(17.50,26.77)	16,058.27(12,157.51,20,936.68)	2.31(1.76,2.97)	−0.89(−0.92,−0.86)	−7.41(−8.46,−6.36)
YLLs	138,981.87(109,359.00,172,505.13)	19.98(15.74,24.80)	9302.91(7084.59,11,897.39)	1.38(1.06,1.75)	−0.93(−0.95,−0.91)	−8.57(−10.01,−7.10)
Maternal obstructed labor and uterine rupture						
Prevalence	24,767.88(14,186.65,39,556.73)	3.43(1.97,5.46)	10,715.72(6326.74,16,468.81)	1.54(0.92,2.36)	−0.57(−0.63,−0.50)	−1.75(−2.17,−1.33)
Deaths	501.11(394.07,631.29)	0.07(0.06,0.09)	133.27(101.12,170.80)	0.02(0.01,0.02)	−0.73(−0.82,−0.62)	−4.60(−5.58,−3.60)
YLDs	7707.85(3785.32,13,288.57)	1.07(0.53,1.83)	3447.68(1710.38,5749.29)	0.50(0.25,0.83)	−0.55(−0.64,−0.45)	−1.60(−2.04,−1.16)
DALYs	37,452.62(29,547.31,46,555.35)	5.45(4.30,6.70)	10,968.76(8341.97,14,029.74)	1.58(1.20,2.02)	−0.71(−0.78,−0.62)	−3.99(−4.79,−3.19)
YLLs	29,744.77(23,433.05,37,579.32)	4.39(3.45,5.51)	7521.08(5728.92,9658.68)	1.08(0.83,1.38)	−0.75(−0.82,−0.64)	−4.51(−5.60,−3.40)
Maternal abortion and miscarriage						
Prevalence	97,668.13(58,918.65,147,139.15)	12.98(7.88,19.44)	42,381.08(27,278.50,60,679.01)	6.77(4.39,9.78)	−0.57(−0.62,−0.49)	−2.29(−2.74,−1.85)
Deaths	977.42(769.57,1222.68)	0.15(0.11,0.18)	16.25(12.25,21.01)	0.00(0.00,0.00)	−0.98(−0.99,−0.98)	−12.61(−14.03,−11.16)
YLDs	10,776.28(5414.22,17,785.16)	1.43(0.72,2.35)	4705.14(2529.33,7524.11)	0.75(0.40,1.21)	−0.56(−0.64,−0.46)	−2.17(−2.68,−1.67)
DALYs	69,122.53(55,295.17,85,089.28)	9.99(8.00,12.28)	5600.30(3463.26,8376.97)	0.88(0.54,1.32)	−0.92(−0.95,−0.88)	−7.62(−8.80,−6.43)
YLLs	58,346.25(45,995.48,73,039.76)	8.56(6.74,10.69)	895.16(673.22,1153.72)	0.13(0.10,0.17)	−0.98(−0.99,−0.98)	−12.70(−14.19,−11.18)
Ectopic pregnancy						
Prevalence	20,336.87(12,632.38,29,720.73)	2.93(1.82,4.28)	11,628.05(7280.84,16,746.54)	1.58(1.00,2.26)	−0.43(−0.51,−0.34)	−0.82(−1.34,−0.30)
Deaths	386.53(303.51,481.13)	0.06(0.04,0.07)	61.34(46.12,78.35)	0.01(0.01,0.01)	−0.84(−0.89,−0.78)	−6.38(−6.94,−5.81)
YLDs	2265.01(1163.75,3673.80)	0.33(0.17,0.53)	1321.93(681.40,2164.23)	0.18(0.09,0.30)	−0.42(−0.52,−0.27)	−0.78(−1.29,−0.27)
DALYs	25,471.78(20,384.01,31,418.87)	3.71(2.97,4.58)	4818.85(3730.47,5989.77)	0.69(0.54,0.86)	−0.81(−0.86,−0.74)	−5.65(−6.13,−5.17)
YLLs	23,206.77(18,234.10,29,038.91)	3.38(2.66,4.20)	3496.92(2623.07,4455.07)	0.51(0.38,0.65)	−0.85(−0.89,−0.79)	−6.43(−7.01,−5.85)

Table 1 (*continued*)

	1990		2019		1990–2019	
	cases No. × 103 (95% UI)	ASR (per 100,000) No. (95% UI)	cases No. × 103 (95% UI)	ASR (per 100,000) No. (95% UI)	Change in Number No.(%)	EAPC No. (95% CI)
Indirect maternal deaths						
Prevalence	–	–	–	–	–	–
Deaths	2517.44(1983.01,3131.57)	0.37(0.29,0.46)	556.85(423.26,707.48)	0.08(0.06,0.10)	−0.78(−0.84,−0.69)	−5.11(−6.18,−4.04)
YLDs	–	–	–	–	–	–
DALYs	152,422.91(119,982.68,189,800.18)	22.02(17.33,27.32)	32,340.07(24,642.42,40,968.69)	4.85(3.70,6.09)	−0.79(−0.85,−0.70)	−5.13(−6.21,−4.04)
YLLs	152,422.91(119,982.68,189,800.18)	22.02(17.33,27.32)	32,340.07(24,642.42,40,968.69)	4.85(3.70,6.09)	−0.79(−0.85,−0.70)	−4.98(−6.15,−3.79)
Maternal deaths aggravated by HIV/AIDS						
Prevalence	–	–	–	–	–	–
Deaths	0.20(0.09,0.33)	0.00(0.00,0.00)	0.11(0.05,0.20)	0.00(0.00,0.00)	–	−1.76(−3.28,−0.22)
YLDs	–	–	–	–	–	–
DALYs	11.89(5.58,19.43)	0.00(0.00,0.00)	5.98(2.58,11.15)	0.00(0.00,0.00)	−0.50(−0.70,−0.13)	−2.08(−3.57,−0.56)
YLLs	11.89(5.58,19.43)	0.00(0.00,0.00)	5.98(2.58,11.15)	0.00(0.00,0.00)	–	−1.92(−3.44,−0.37)
Late maternal deaths						
Prevalence	–	–	–	–	–	–
Deaths	113.82(86.26,153.12)	0.02(0.01,0.02)	17.04(12.07,23.62)	0.00(0.00,0.00)	−0.85(−0.90,−0.79)	−6.38(−7.24,−5.51)
YLDs	–	–	–	–	–	–
DALYs	6808.62(5142.56,9235.90)	1.00(0.76,1.34)	980.34(697.19,1354.30)	0.15(0.11,0.21)	−0.86(−0.90,−0.80)	−6.31(−7.24,−5.38)
YLLs	6808.62(5142.56,9235.90)	1.00(0.76,1.34)	980.34(697.19,1354.30)	0.15(0.11,0.21)	−0.86(−0.90,−0.80)	−6.20(−7.23,−5.15)
Other maternal disorders						
Prevalence	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)	0.00(0.00,0.00)
Deaths	1752.43(1380.89,2186.61)	0.26(0.21,0.32)	328.43(247.65,419.59)	0.05(0.04,0.06)	−0.81(−0.87,−0.74)	−5.44(−6.26,−4.63)
YLDs	11,123.88(6812.56,16,614.10)	1.52(0.94,2.25)	6733.32(4168.60,9987.80)	0.98(0.60,1.43)	−0.39(−0.50,−0.28)	−0.54(−1.01,−0.07)
DALYs	116,007.52(93,048.39,141,734.82)	16.84(13.54,20.67)	25,490.99(20,324.17,31,054.34)	3.69(2.93,4.48)	−0.78(−0.84,−0.70)	−4.72(−5.45,−3.99)
YLLs	104,883.64(82,752.83,130,984.90)	15.32(12.11,19.14)	18,757.67(14,171.70,23,943.64)	2.72(2.06,3.43)	−0.82(−0.88,−0.75)	−5.35(−6.30,−4.38)

Abbreviation: UI, uncertainty interval.

regions and the Hong Kong and Macao Special Administrative Regions, were analyzed.

2.4. Statistical analysis

The prevalence in this study were modelled using DisMod-MR 2.1, a meta-analysis tool that used a compartmental model structure with a series of differential equations that synthesised sparse and heterogeneous epidemiological data [5]. Causes of death due to maternal disorders are modelled with the Cause of Death Ensemble model (CODEm), which is designed to create a wide variety of models using a covariate selection algorithm and then to weight these models on the basis of their out-of-sample predictive validity [5]. All estimates were reported in terms of counts, age-standardised rates per 100 000 population. Population estimates independently produced by GBD 2019 were used as references for calculating age-standardised death rates and age-standardised DALY. We used the GBD world population to calculate the age-standardized rates. The data were reported as estimates with 95% uncertainty intervals (UIs)."

The annual ASR of prevalence, DALYs, death, and YLD, and the corresponding estimated annual percentage changes (EAPCs) were calculated. We calculated estimated annual percentage change (EAPCs) of age-standardized rates (ASRs). The EAPC describes the ASRs trends within a specified time interval. EAPCs were calculated by using the following regression model: $Y = \alpha + \beta X + \varepsilon$, where Y refers to ln (ASR), X the calendar year, and ε the error term. Based on this formula, β represents the positive or negative ASR trends. The natural logarithm of ASR is assumed to be linear along with time; that is, The EAPC was calculated as EAPC = $100 \times (\exp(\beta)-1)$. Its 95% confidence intervals (CI) could be obtained from the linear model [10]. If the EAPC value and its lower limit of 95% CI are both positive, the ASR shows an upward trend. Conversely, if the EAPC value and its upper limit of 95% CI are both negative, the ASR shows a descending trend. Otherwise, ASR is considered to be stable. If the EAPC is statistically significant but the uncertainty intervals of the GBD estimates overlap, ASR is still considered to be stable.

2.5. Role of the funding source

The funder had no role in the study design, data collection, data analysis, data interpretation, or preparation of the manuscript. All authors have full access to the study data, and the corresponding author has the final responsibility of the decision to submit the manuscript for publication.

3. Results

3.1. Prevalence counts and trends in age-standardized prevalence rate for all maternal disorders and the main subcategories

An estimated 0.85 million cases of maternal disorders (95% UI: 0.65–1.08 million) were recorded in China in 2019, which represents a decline of 73% from 3.21 million cases (2.48–4.12 million) in 1990 (Table 1). eFig. 1A shows the all-age prevalence data for maternal disorders in the 33 provinces in 2019.

In 2019, maternal hemorrhage had the highest age-standardized prevalence rate (86.31 per 100,000), followed by maternal sepsis and other maternal infections (21.78 per 100,000), and maternal hypertensive disorders (17.99 per 100,000) (Table 1). The age-standardized prevalence rate of maternal disorders had a decreasing trend from 1990 to 2019, with an EAPC of −3.25 (95% CI, from −3.86 to −2.64) (Table 1). The trends in age-standardized prevalence rates were decreased significantly in all subcategories of maternal disorders from 1990 to 2019, except for maternal hyperten-

sive disorders (EAPC =−1.07; 95% CI=−2.42 to 0.30) (Table 1). The most pronounced decreases were observed for maternal hemorrhage (EAPC= −3.69; 95% CI=−4.25 to −3.13), followed by maternal abortion and miscarriage (EAPC= −2.29; 95% CI=−2.74 to −1.85), maternal obstructed labor and uterine rupture (EAPC =−1.75; 95% CI=−2.17 to −1.33), maternal sepsis and other maternal infections (EAPC =−1.47; 95% CI=−1.90 to −1.03) (Table 1).

Fig. 1 and eTables 2–8 in the Supplement present the geographic distribution of the trends in the age-standardized prevalence rates of overall maternal disorders and the main subcategories during 1990–2019. With regard to overall maternal disorders, maternal hemorrhage, the most pronounced decrease was concentrated in Beijing, however, no significant trends in ASR of prevalence were observed in Shandong, Hong Kong, and Macao (Fig. 1A, 1B and eTables 2, 3). Notably, the trends in ASR of prevalence due to maternal hypertensive disorders had been stable in China and in most provinces (Fig. 1D and eTable 5).

3.2. DALY counts and trends in age-standardized DALY rate for all maternal disorders and the main subcategories

An estimated 0.13 million DALY numbers of maternal disorders (95% UI: 0.10–0.16 million) were recorded in China in 2019, which represents a decline of 89% from 1.18 million cases (0.95–1.44 million) in 1990 (Table 1). eFig. 1B shows the all-age DALY numbers for maternal disorders in the 33 provinces in 2019.

In 2019, maternal hemorrhage had the highest age-standardized DALY rate (4.30 per 100,000), followed by maternal hypertensive disorders (2.31 per 100,000), and maternal sepsis and other maternal infections (1.58 per 100,000) (Table 1). The age-standardized DALY rate of maternal disorders had a decreasing trend from 1990 to 2019, with an EAPC of −7.04 (95% CI, from −7.99 to −6.07) (Table 1). The trends of age-standardized DALY rates were decreased significantly in all subcategories of maternal disorders from 1990 to 2019 (Table 1). The most pronounced decreases were observed for maternal hemorrhage (EAPC=−9.17, 95%CI=−10.43 to −7.90), followed by maternal sepsis and other maternal infections (EAPC=−8.65, 95%CI=−9.89 to −7.38), maternal abortion and miscarriage (EAPC=−7.62, 95%CI=−8.80 to −6.43), and maternal hypertensive disorders (EAPC=−7.41, 95%CI=−8.46 to −6.36) (Table 1).

Fig. 2 and eTables 9–19 in the Supplement present the geographic distribution of the trends in the age-standardized DALY rates of overall maternal disorders and the main subcategories for 1990–2019. Declines in trends in the age-standardized DALY rates for overall maternal disorders and for the main subcategories were observed in almost every province of China from 1990 to 2019 (eTables 9–19). For 1990–2019, the largest decreases in trends in the age-standardized DALY rate for overall maternal disorders, maternal hemorrhage were observed in the Jiangxi provinces (Fig. 2A, Fig. 2B, eTables 9–10). In contrast, Hong Kong, and Shandong showed significantly smaller declines for the same category and subcategories (Fig. 2A,2B,2D; eTables 9,10,12). Tibet showed no significant trend in Maternal obstructed labor and uterine rupture (eTable 13).

3.3. Trends in age-standardized YLD rate for all maternal disorders and its main subcategories

The age-standardized YLD rate of maternal disorders had a decreasing trend from 1990 to 2019, with an EAPC of −2.71(95% CI, from −3.38 to −2.04) (Table 1). The trends of age-standardized YLD rates were decreased significantly in all subcategories of maternal disorders from 1990 to 2019 (Table 1). The most pronounced decreases were observed for maternal hemorrhage (EAPC=−4.23,
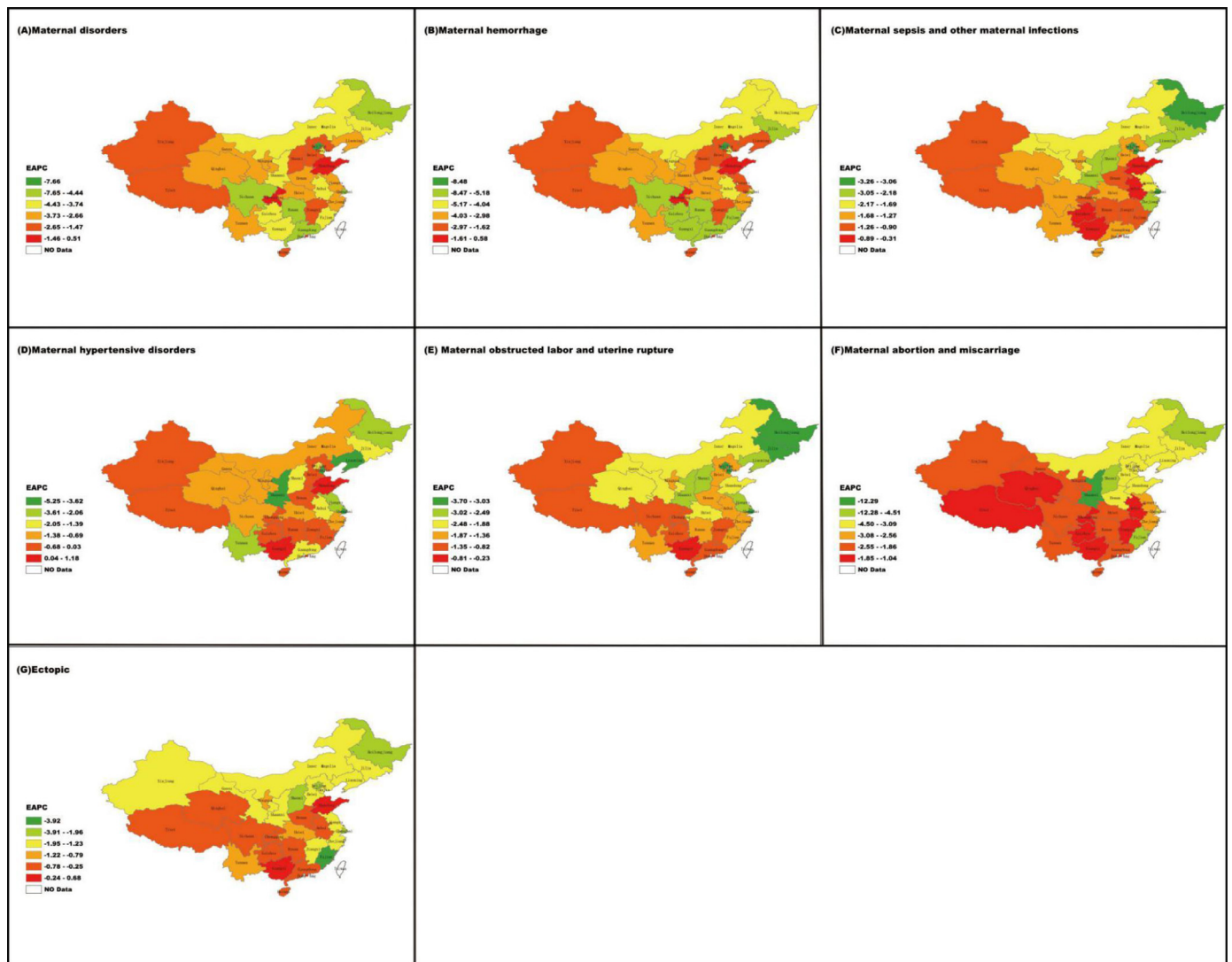
Fig. 1. Map of the EAPC in age-standardized prevalence rate for maternal disorders (A), maternal hemorrhage (B), maternal sepsis and other maternal infections (C), maternal hypertensive disorders (D), maternal obstructed labor and uterine rupture (E), maternal abortion and miscarriage (F) and ectopic (G) in China,1990–2019.

95%CI=−5.05 to −3.39), followed by maternal abortion and miscarriage (EAPC=−2.17, 95%CI=−2.68 to −1.67) (Table 1). For 1990–2019, the largest decreases in the trends in age-standardized YLD rate for overall maternal disorders were concentrated in Beijing (eTable 20).

3.4. Deaths and YLL counts and trends in age-standardized deaths and YLL rates for all maternal disorders and its main subcategories

The number of deaths due to maternal disorders decreased by 91% from 17,399.76(13,723.65–21,673.65) in 1990 to 1537.31(1169.12–1960.42) in 2019 (Table 1). Significant reductions in the number of deaths were seen in all provinces (eTables 22–32). eFig. 1C shows the numbers of all-age deaths for maternal disorders in the 33 provinces in 2019.

The age-standardized death rate of maternal disorders had a decreasing trend from 1990 to 2019, with an EAPC of −8.07 (95% CI, from −9.14 to −6.98) (Table 1). Fig. 3 present the geographic distribution of the EPAC in the age-standardized mortality rates of overall maternal disorders 1990–2019. The trends of age-standardized death rates were decreased significantly in all subcategories of maternal disorders from 1990 to 2019 (Table 1).

The most pronounced decreases were observed for maternal sepsis and other maternal infections (EAPC=−14.47, 95%CI=−16.11 to −12.81), maternal abortion and miscarriage (EAPC=−12.61, 95%CI=−14.03 to −11.16), maternal hemorrhage (−11.28, 95%CI=−12.75 to −9.78), and maternal hypertensive disorders (EAPC=−8.75, 95%CI=−9.95 to −7.53) (Table 1).

With regard to overall maternal disorders, the most pronounced decreases were during 1990–2019 were concentrated in the Jiangxi and Hunan provinces(Fig. 3 and eTable 22). Notably, in Hong Kong, the trends in age-standardized mortality rate during 1990–2019 showed the lowest decrease for maternal disorders, maternal hemorrhage, maternal sepsis and other maternal infections, maternal hypertensive disorders, and maternal abortion and miscarriage (eTable 22-25, 27).

4. Discussion

We performed a well-rounded evaluation of the burden of maternal disorders in China and at both national and provincial levels; the disease burden of prevalence, DALYs and death for overall maternal disorders decreased significantly in China from 1990 to 2019. However, the patterns and trends were heterogeneous across
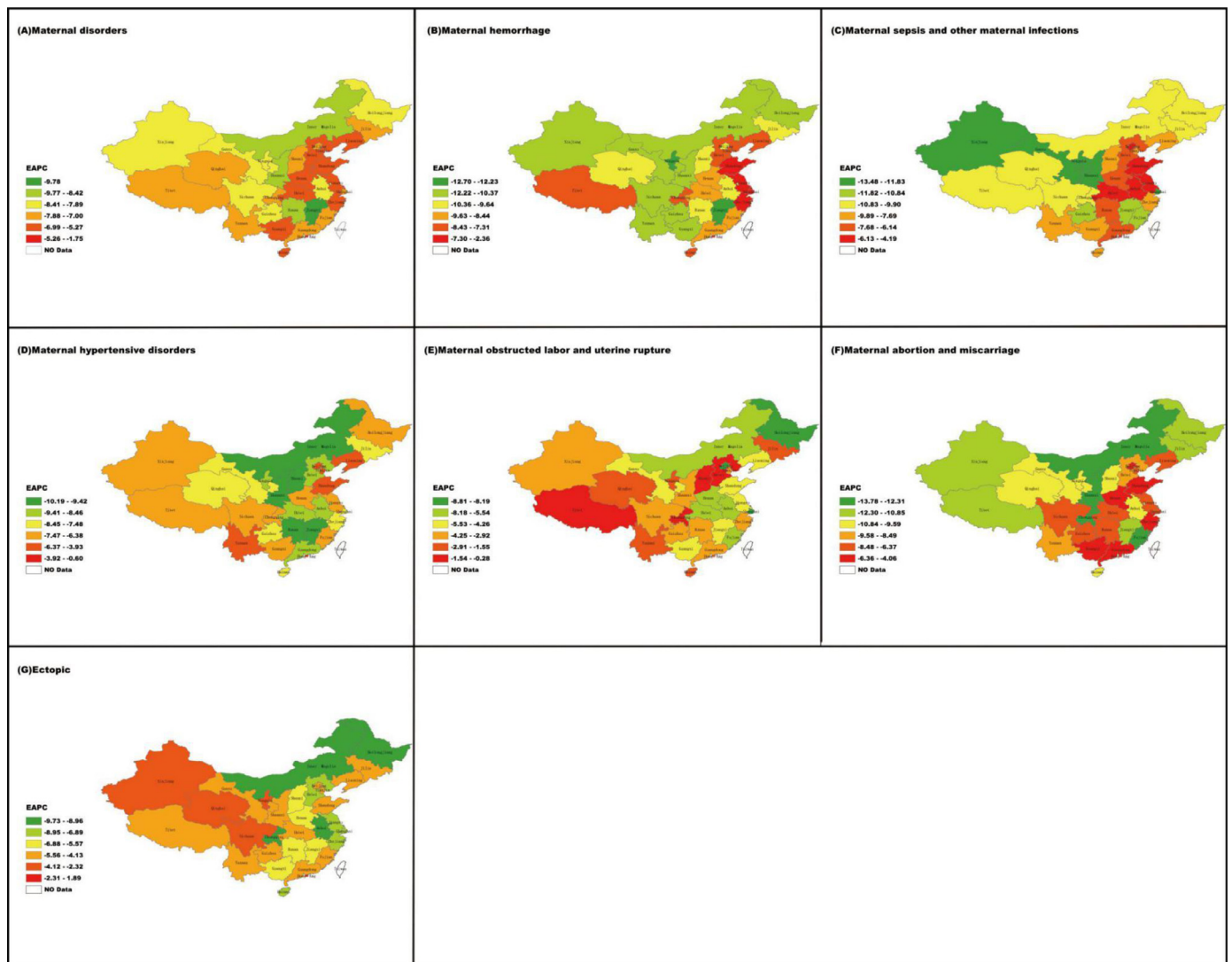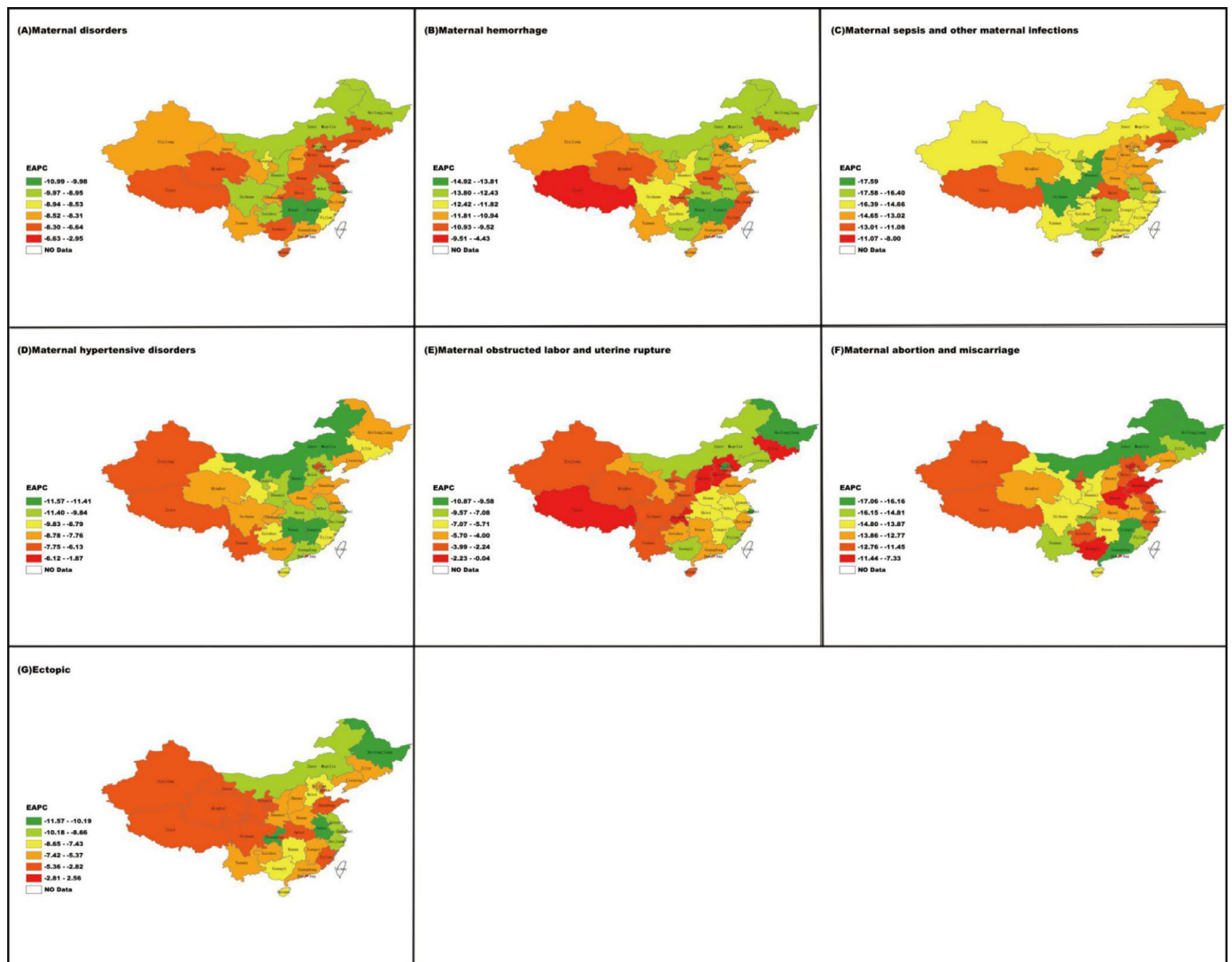
Fig. 2. Map of the EAPC in age-standardized DALYs rate for maternal disorders (A), maternal hemorrhage (B), maternal sepsis and other maternal infections (C), maternal hypertensive disorders (D), maternal obstructed labor and uterine rupture (E), maternal abortion and miscarriage (F) and ectopic (G) in China,1990–2019.

provinces, which illustrate the necessity of spatial resource allocation and priority setting across China.

Large decreases in trends in the ASR of death and DALYs for overall maternal disorders and subcategories were observed in every province of China from 1990 to 2019. China's success in lowering the maternal mortality ratio can be attributed mainly to a specific program—"Reducing Maternal Mortality and Eliminating Neonatal Tetanus"—rather than to general economic growth or a reduced fertility rate [11]. Both in-hospital birth and the percentage of pregnancies managed by systematic care have increased greatly since the initiation of universal basic coverage in 2007, which provides free maternal health care and management at community health centers [12]. Due to the promotion of institutional birth and implementation of public maternal and child health (MCH) programs [13], China's MCH services have seen high levels of use [14] Over the past decade, the proportion of mothers who have had five or more antenatal visits during pregnancy has increased greatly, as have institutional birth rates. Timely diagnosis, higher-quality standard care, and more accurate judgment by medical professionals have also contributed to the decline in the rate of DALYs [15].

The ASR of prevalence, DALYs and death for overall maternal disorders showed decreasing trends in China from 1990 to 2019, respectively. The most pronounced decreases in trends in ASR of prevalence, DALYs and death were observed for maternal hemorrhage. The declined trends might be due to the general economic growth, a reduced fertility rate [3], and the Free Pre-pregnancy Health Check (FPHC) surveillance program initiated by the Health Ministry of China in 2010 [16]. Besides, for reducing the maternal mortality, China initiated the national Five Strategies for Maternal and Newborn Safety (FSMNS), which is composed of five parts: (1) pregnancy risk screening and assessment strategy, (2) case- by-case management strategy for high- risk pregnancies, (3) referral and treatment strategy for critically ill pregnant women and newborns, (4) reporting strategy for maternal deaths (and 5) accountability strategy [17]. China has developed a unified pregnancy risk screening table to strengthen the implementation of FSMNs. After risk assessment and classification, all pregnant women's medical records are labeled green (low risk), yellow (medium risk), orange (high risk), red (highest risk), or purple (infectious disease) respectively, and they will be transferred to different medical facilities according to their risk levels. Since the establishment of FSMNS,

Fig. 3. Map of the EAPC in age-standardized deaths rate for maternal disorders (A), maternal hemorrhage (B), maternal sepsis and other maternal infections (C), maternal hypertensive disorders (D), maternal obstructed labor and uterine rupture (E), maternal abortion and miscarriage (F) and ectopic (G) in China,1990–2019.

the MMR in China has declined to 18.3 per 100 000 live births in 2018 [18].

Notably, In 2019, the age-standardized prevalences of overall maternal disorders and maternal hemorrhage were particularly high in the central provinces, such as Hubei, Henan, and Hunan. According to a national survey, the proportion of women who received at least five antenatal check-ups was the lowest in central China among the three studied regions (i.e., western, central, and eastern). In addition, the number of MCH employees per 10,000 population and the proportion of MCH employees with a high education level were lowest in the central region [19]. With the implementation of China's strategy for vigorous development of the western region, the health status of pregnant women there has improved rapidly and surpassed that in the central region [20]. Thus, it is now as important to address maternal health challenges in central China as in western China.

Notably, the trends in ASR of prevalence due to maternal hypertensive disorders had been stable in China and most provinces. Hypertensive disorders are the most common pregnancy complications and represent significant causes of maternal and perinatal morbidity and mortality [21]. Since the implementation of the two-child policy in 2015, more women are conceiving and giving

birth at an advanced maternal age, defined as at least 35 years [22]. Among the 90 million women of reproductive age (who had already borne one child) targeted by this policy, an estimated 60% were older than 35 years, and 50% were older than 40 years [21]. Consequently, women giving birth at a more advanced age are more likely to have hypertension during the pregnancy [23]. The significant increase in the proportion of high-risk pregnant women and high-risk pregnancy will be the challenge.

However, Tibet showed no significant trend in maternal obstructed labor and uterine rupture. Because of its unique geography, cultural history, and other factors, the development of maternal and child health in the Tibet Autonomous Region still lags far behind the mainland and national average levels. The MMR in the Tibet Autonomous Region remains five times higher than the national average [24]. Notably, the total numbers of health workers, qualified medical doctors, and registered nurses per 1000 people are much lower than the national average [24]. Because improving the coverage of maternal health services is the main strategy to reduce MMR [25], a robust health system with access to medical facilities is needed, together with universal coverage of maternal and neonatal intensive care in rural and remote areas [26].

4.1. Strengths and limitations

To date, this nationwide study provides the most integrated estimates of the burden of maternal disorders in China at the national and provincial levels for 1990–2019. According to the general analysis strategy used in 2019 GBD, we collect data from three sources to comprehensively estimate the temporal trends and geographic patterns along with age-standardized prevalence, DALYs, YLDs, deaths, and YLLs. The GBD 2019 remains the most standardized and accurate system available for comprehensive assessment of these indicators for 369 diseases and injuries across 204 countries and territories for 1990–2019. Its unified and standardized approach involves the latest progress in data analytical techniques, so these estimates are highly comparable both globally and at the provincial level in China.

As part of the GBD, this study is susceptible to each of the preceding described restrictions of the GBD methods [9,21,27–31]. Although greatest efforts were made to gather all published and unpublished data, the quantity and quality of the existing data remain restricted, which could have affected the precision of the estimated burden. Some of the variations in the age-standardized rates may be due to detection biases and to changes in screening protocols, for example, it is unclear whether the observed trends in our study reflect the actual epidemiological changes or whether they are the result of changes in coding.

In conclusion, the disease burden of prevalence, DALYs and death for overall maternal disorders decreased significantly in China from 1990 to 2019, the most pronounced decreases were observed for maternal hemorrhage.

Contributors

L-YH is the first author, contributed to the statistical analyses, and had primary responsibility for writing the manuscript. L-YH and M-GZ directed the study. L-YH, TC, J-JL, YP and M-GZ contributed to the analysis or interpretation of the data. TC (caiting12316@126.com) and M-GZ (meigengzhou@126.com) considered corresponding author. All authors critically reviewed the manuscript for important intellectual content. The corresponding authors (TC and M-GZ) attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Declaration of Competing Interest

No declare.

Acknowledgments

Data sharing

Data is publically available at Global Health Data Exchange (GHDx) online website (http://ghdx.healthdata.org/gbd-results-tool).

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lanwpc.2021.100141.

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