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Burden and trend of maternal sepsis and other maternal infections in BRICS countries from 1990 to 2021

Jiao Long[1*], Qi Zhang[1] and Chao Ma[1]

Abstract

Background Maternal septicemia and other maternal infections (MSMIs) continue to pose considerable challenges to public health on a global scale. However, comprehensive data on their impacts and trends are limited, particularly in BRICS countries, which include Brazil, Russian Federation, India, China, and South Africa. This study aims to compare the global epidemiological trends of MSMIs from 1990 to 2021 to MSMIs trends in BRICS countries and examine the relationship of disease burden with age and social development.

Methods Using data from the Global Burden of Disease database, this study analyzed the prevalence, incidence, death, and disability-adjusted life years (DALYs) of MSMIs from 1990 to 2021 globally and in BRICS countries. Temporal trends were assessed through estimated annual percentage change (EAPC) and percentage change. Joinpoint regression analysis was employed to rigorously evaluate time trends, allowing for the calculation of annual percentage change (APC) and average annual percentage change (AAPC), with corresponding 95% confidence intervals (CI).

Results In 2021, South Africa showed the highest prevalence of MSMIs (156.54 per 100,000), while the Russian Federation exhibited the highest incidence (1,001.51 per 100,000). Deaths and DALYs of MSMIs were lowered in BRICS countries compared to global averages. Between 1990 and 2019, India experienced the greatest decline in both incidence (EAPC = -2.68%) and prevalence (EAPC = -2.65%). Despite the global decline, regional variations in incidence were observed. In China, the incidence increased significantly between 2010 and 2014 (APC = 4.15%; 95% CI: 3.59–4.71%; $P < 0.001$). Similarly, in the Russian Federation, the incidence rose during three distinct periods: 2000–2004 (APC = 2.52%; 95% CI: 2.0–3.05%; $P < 0.001$), 2004–2010 (APC = 5.2%; 95% CI: 4.95–5.44%; $P < 0.001$), and 2010–2015 (APC = 1.79%; 95% CI: 1.46–2.12%; $P < 0.001$).

Conclusion MSMIs remain prevalent globally, imposing a substantial disability burden, particularly in BRICS countries. While China exhibits relatively low disease burdens, South Africa faces high prevalence, and global deaths and DALYs from MSMIs remain elevated.

Keywords Maternal septicemia and other maternal infections, Global burden of disease, Prevalence, MSMIs, GBD

*Correspondence:
Jiao Long
longj26@mail.sysu.edu.cn
[1]Department of Anesthesiology, The Seventh Affiliated Hospital of Sun Yat-sen University, Shenzhen, Guangdong 518107, China

Background

Maternal sepsis and other maternal infections (MSMIs) are defined by severe organ dysfunction resulting from infections during pregnancy, childbirth, or the postpartum period, and represent a major global health challenge. Clinically, it manifests as systemic inflammation, fever, tachycardia, and signs of organ failure, often leading to rapid deterioration if left untreated [1, 2]. This condition significantly increases maternal morbidity and mortality, accounting for nearly 10% of global maternal deaths [3, 4]. The burden is particularly pronounced in low- and middle-income countries, owing to delayed diagnosis, inadequate access to healthcare, and insufficient infection control [5–7].

The BRICS countries—Brazil, Russia, India, China, and South Africa—account for nearly half of the global population and about 40% of the global burden of disease [8–10]. Despite significant improvements in healthcare infrastructure, gaps remain in access to and quality of healthcare, leaving many patients vulnerable to preventable health problems [6]. Prior studies have highlighted the overburden of infectious diseases in these countries due to high birth rates, non-standardized antibiotic management, and socio-economic inequalities [11, 12]. However, few studies have focused on comparative analyses of disease trends and outcomes in these countries [13–14].

Current literature has outlined trends in maternal mortality but often lacks detailed data on maternal sepsis-specific outcomes [3]. Furthermore, discrepancies in data collection and classification systems complicate the assessment of the true burden [13, 14]. These gaps underscore the urgent need for dedicated research on maternal sepsis in BRICS countries to inform effective policy interventions. The disease burden and trends of MSMIs in BRICS countries have evolved significantly from 1990 to 2021 and have greatly been influenced by economic growth, healthcare investments, and policy changes [1]. By addressing data gaps and exploring regional differences, this research aims to provide actionable insights for reducing maternal mortality and improving healthcare delivery.

Methods

Data source and disease definition

Data on MSMIs from BRICS countries analyzed in this study were derived from the Global Burden of Disease (GBD) 2021 dataset. This dataset, freely available through the Global Health Data Exchange (https://ghdx.healthdata.org/gbd-2021/sources) [15], provides the most up-to-date epidemiological estimates for 371 diseases and injuries across 21 GBD regions and 204 countries and territories from 1990 to 2021. Detailed descriptions of data sources, methodologies, and statistical models can be found in prior reports [16]. In this study, the estimated number, rate, and 95% uncertainty interval (UI) of prevalence, incidence, mortality, and DALYs related to MSMIs came from GBD 2021 data. The dataset used in this study is anonymized and approved under the guidelines of the Institutional Review Board at the University of Washington with informed consent.

MSMIs encompass two components: maternal sepsis and other maternal infections. Maternal sepsis is clinically defined by body temperature deviations (< 36℃ or > 38℃) and signs of shock, including systolic blood pressure < 90 mmHg and tachycardia > 120 bpm. Other maternal infections do not include HIV, sexually transmitted infections, or infections without an epidemiological relationship with pregnancy [7].

Socio-demographic index (SDI)

The SDI, a composite indicator developed by the Institute for Health Metrics and Evaluation in 2015, reflects the development level of a country or region and emphasizes the interplay between social development and population health. SDI (from 0 to 1) was calculated as the geometric mean of three factors: the total fertility rates in individuals under age 25, mean education level among individuals aged ≥ 15, and the lag-distributed income per capita. For GBD 2021, SDI scores were multiplied by 100, resulting in a scale ranging from 0 to 100, where 0 indicated the lowest levels of income and education with the highest fertility rates, and 100 signified the opposite. Countries and regions were classified into five SDI levels: low, low-middle, middle, high-middle, and high [15].

Disability-adjusted life years (DALYs)

DALYs were quantified by summing the years of life lost (YLLs) due to premature death and the years lived with disability (YLDs). The calculation was as follows:

$$DALYs = YLLs + YLDs$$

To estimate uncertainty, each process was recalculated 500 times to produce an estimate with a 95% UI. Simulation testing confirmed that half of iterations did not affect the final estimates or their UIs [15]. Final values are represented as the mean of 500 drawings, and the 95% UI was defined by the 2nd and 97th percentiles [15].

Estimated annual percentage change (EAPC) and percentage change

EAPC is a robust and widely utilized metric for monitoring temporal trends in epidemiological indicators (e.g. prevalence and incidence) over defined periods [17]. This study estimated the dynamic trends in the prevalence, incidence, DALYs, and death of MSMIs in BRICS countries from 1990 to 2021. EAPC was calculated based on fitting a regression model to the natural logarithm of the rate of interest. With time as the independent variable, the natural logarithm of each observed value is plotted against time to produce a straight-line fit, with the slope of this line serving as the basis for EAPC estimation [18]. EAPC is expressed as:

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

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

where (y) represents the natural logarithm of the rate (e.g., prevalence or incidence), (x) is time in years, (α) is the intercept, (β) is the slope, and (ε) is the random error term. The 95% confidence interval (CI) for EAPC was derived from this model. Trends were delineated as 95% CI: a lower limit > 0 indicated an upward trend, whereas an upper limit < 0 reflected a downward trend. When the 95% CI included 0, it implied no statistically significant trend [19]. In addition to EAPC, percentage changes were calculated in prevalence, incidence, DALYs, and deaths between 1990 and 2021.

$$Percentage\ change = (2021\ cases - 1990\ cases) / 1990\ cases$$

Joinpoint regression analysis

To further evaluate temporal trends, this study employed the Joinpoint regression analysis model, a statistical method frequently applied in epidemiological research [20]. This model identified and quantified significant change points (joinpoints) over time for MSMI prevalence across BRICS countries and the world. It facilitated the calculation of annual percentage change (APC) along with its 95% CI and described the prevalence trend in detail over the study period. To summarize broader trends, the AAPC was computed, which reflected the overall trend from 1990 to 2021. APC or AAPC was delineated based on their associated 95% CI: A lower limit > 0 indicated an increasing trend. An upper limit < 0 suggested a decreasing trend. A 95% CI that included 0 denoted stability in the trend. The Joinpoint regression model is particularly useful for capturing subtle changes over time, offering insights into both gradual and abrupt shifts. The statistical methods and equations used in Joinpoint regression analysis are detailed in the supplementary materials to ensure reproducibility and transparency of the results.

Statistical analysis

Epidemiological metrics (prevalence, incidence, mortality, and DALYs) were analyzed through two distinct measures: population-adjusted rates and absolute counts. The rates were calculated as age-standardized estimates per 100,000 population, while the numbers reflected the total raw cases in the population. Both measures are presented as 95% uncertainty intervals (UI) to quantify statistical precision. All statistical analyses and visualizations were conducted using R statistical software (version 4.4.1) and the World Health Organization's Health Equity Assessment Toolkit. Statistical significance was set at $p < 0.05$.

Findings

Global and regional trends

By 2021, the global burden of MSMIs decline, with the incidence decreasing by 0.83% (Table 1). Although this reduction was not statistically significant, the EAPC was – 1.11 (95% CI: -1.17 to -1.04), indicating a sustained downward trend worldwide. However, when compared to BRICS countries, the global DALYs (Fig. 1A) and death rates (Fig. 1B) associated with MSMIs remained high. In 2021, there were 17664.87 cases of deaths globally (Table 1). Among BRICS countries, South Africa exhibited the highest prevalence of MSMIs, with 30,344.41 cases in 2021 (Table 1), increasing by 19.36% since 1990. The EAPC was – 0.61 (95% CI: -0.74 to -0.48), indicating a gradually declining trend over the decades. In contrast, China reported the lowest prevalence, incidence, death, and DALYs among BRICS countries (Supplementary Fig. 1). By 2021, the total number of MSMIs in China had dropped to 152,655.75, reflecting a substantial decrease by 55.69% since 1990 (Table 1). In India, MSMI prevalence (Fig. 1C) significantly reduced by 16.72% from 610,302.93 cases in 1990 to 508,281.04 in 2021. The EAPC of prevalence for India was – 2.65 (95% CI: -2.8 to -2.5), underscoring a marked reduction in the burden of MSMIs. In the Russian Federation, the prevalence decreased moderately by 21.91% during the same period. However, since 2000, a consistent year-on-year increase in prevalence was observed, with an EAPC of 1.02 (95% CI: 0.5 to 1.54). The total number of MSMIs in Russia was 429,934.68 in 2021, marking the highest incidence among BRICS countries (Fig. 1D). The EAPC of incidence was 1.03 (95% CI: 0.5 to 1.56). Compared with Brazil, India, and South Africa, the Russian Federation recorded the lowest death rates at 0.01% (95% CI: 0.01 to 0.02) in 2021.

Age distribution trends

Figure 2 illustrates the temporal trends in the prevalence of MSMIs across 5-year age groups from 10 to 54 years old. Globally, most cases of MSMIs occurred in young women aged 15–44 years (Fig. 2A), with similar patterns observed in Brazil (Fig. 2B) and the Russian Federation (Fig. 2C). In China, however, most cases were reported in women aged 20–44 years. Between 1990 and 2021, the burden of MSMIs shifted from middle-aged and older individuals (25–54 years) to younger age groups (20–29 years) (Fig. 2D). In India (Fig. 2E) and South Africa

Table 1 Prevalence, incidence, dalys, and deaths of MSMIs between 1990 and 2019 across the BRICS

Location	Number in 1990 (95% UI)	Number in 2021 (95% UI)	Percentage change,% (95% CI)	Rate in 1990 per 100 000 (95% UI)	Rate in 2021 per 100 000 (95% UI)	EAPC (95% CI)
Prevalence						
Global	2396696.12 (1554876.87,3637746.39)	2376876.42 (1678867.79,3421376.7)	-0.83 (-53.85,120.04)	140.68 (91.26,213.52)	95.28 (67.3,137.14)	-1.11 (-1.17,-1.04)
Low SDI	353651.36 (239740.5,520932.47)	597803.29 (423735.74,852979.5)	69.04 (-18.66,255.79)	237.22 (160.81,349.43)	166 (117.67,236.86)	-1.23 (-1.29,-1.18)
Low-middle SDI	778548.67 (527810.97,1140844.16)	829751.4 (615733.04,1147387.59)	6.58 (-46.03,117.39)	217.11 (147.19,318.14)	129.15 (95.84,178.59)	-1.66 (-1.71,-1.62)
Middle SDI	754093.71 (476441.32,1158468.92)	605737.87 (426289.36,876183.66)	-19.67 (-63.2,83.9)	133.17 (84.14,204.59)	76.67 (53.96,110.9)	-1.42 (-1.57,-1.27)
High-middle SDI	309592.76 (176816.32,492558.5)	197348.2 (123974.08,306631.65)	-36.26 (-74.83,73.42)	88.91 (50.78,141.46)	50.47 (31.71,78.42)	-1.18 (-1.47,-0.89)
High SDI	198900.85 (121454.17,308238.33)	144489.46 (92564.54,218709.36)	-27.36 (-69.97,80.08)	71.04 (43.38,110.09)	46.74 (29.94,70.75)	-1.54 (-1.63,-1.46)
China	344551.76 (190362.69,565515.06)	152655.75 (94045.74,240105.45)	-55.69 (-83.37,26.13)	87.41 (48.3,143.47)	36.47 (22.47,57.36)	-1.99 (-2.52,-1.45)
Brazil	82489.52 (52612.1,124444.62)	81679.24 (56425.76,115914.47)	-0.98 (-54.66,120.32)	164.27 (104.77,247.82)	111.79 (77.23,158.64)	-0.52 (-0.73,-0.31)
India	610302.93 (438598.37,857949.71)	508281.04 (381490.32,696265.64)	-16.72 (-55.53,58.75)	232.98 (167.43,327.52)	107.06 (80.35,146.65)	-2.65 (-2.8,-2.5)
South Africa	25423.21 (19958.38,33658.39)	30344.41 (24925.66,38127.51)	19.36 (-25.95,91.04)	204.89 (160.85,271.26)	156.54 (128.59,196.69)	-0.61 (-0.74,-0.48)
Russian Federation	46862.01 (26418.73,75482.32)	36592.46 (20676.53,58455.73)	-21.91 (-72.61,121.27)	97.42 (54.92,156.92)	85.24 (48.16,136.17)	1.02 (0.5,1.54)
Incidence						
Global	22450868.39 (16778828.21,28812948.6)	19047404.04 (14608562.99,24086485.61)	-15.16 (-49.3,43.55)	1317.76 (984.84,1691.19)	763.51 (585.58,965.5)	-1.47 (-1.57,-1.37)
Low SDI	3061688.63 (2301567.1,4006663.24)	4711029.91 (3557613.28,6151574.22)	53.87 (-11.21,167.28)	2053.69 (1543.82,2687.55)	1308.19 (987.9,1708.22)	-1.5 (-1.61,-1.4)
Low-middle SDI	6572867.16 (4886463.06,8549073.39)	5878471.83 (4402324.75,7500138.89)	-10.56 (-48.51,53.49)	1832.94 (1362.66,2384.04)	914.96 (685.2,1167.36)	-2.09 (-2.17,-2.01)
Middle SDI	7230603.65 (5277420.19,9435629.02)	4951603.65 (3759509.66,6269843.81)	-31.52 (-60.16,18.81)	1276.93 (932,1666.34)	626.74 (475.85,793.59)	-1.75 (-1.97,-1.53)
High-middle SDI	3464319.25 (2544071.08,4324952.13)	2035758.62 (1607901.62,2543159.09)	-41.24 (-62.82,-0.04)	994.91 (730.62,1242.07)	520.67 (411.24,650.44)	-1.37 (-1.68,-1.05)
High SDI	2101372.53 (1632186.92,2563347.86)	1454515.89 (1210068.27,1754445.32)	-30.78 (-52.79,7.49)	750.51 (582.94,915.5)	470.51 (391.43,567.53)	-1.64 (-1.72,-1.56)
China	3859571.06 (2657329.31,5264533.86)	1556590.68 (1160257.14,2046691.22)	-59.67 (-77.96,-22.98)	979.19 (674.18,1335.64)	371.84 (277.17,488.92)	-2.2 (-2.78,-1.61)
Brazil	811970.92 (619204.18,997416.57)	694892.36 (575371.45,825295.42)	-14.42 (-42.31,33.28)	1616.97 (1233.09,1986.27)	951.05 (787.47,1129.53)	-0.84 (-1.09,-0.59)
India	4389093.36 (3203409.56,5765476.99)	3361207.1 (2439721.39,4430900.34)	-23.42 (-57.68,38.32)	1675.52 (1222.89,2200.95)	707.96 (513.87,933.27)	-2.68 (-2.81,-2.55)
South Africa	141299.24 (106648.18,187148.89)	131242.35 (100131.96,170311.07)	-7.12 (-46.5,59.69)	1138.76 (859.5,1508.27)	677.05 (516.56,878.59)	-1.34 (-1.47,-1.2)
Russian Federation	554601.34 (412965.88,688543.8)	429934.68 (327757.79,533937.91)	-22.48 (-52.4,29.29)	1152.97 (858.52,1431.42)	1001.51 (763.5,1243.78)	1.03 (0.5,1.56)
DALYs						
Global	1680166.92 (1452194.98,1894883.62)	1144233.29 (956987.95,1352033.85)	-31.9 (-49.5,-6.9)	98.62 (85.24,111.22)	45.87 (38.36,54.2)	-2.63 (-3.06,-2.2)
Low SDI	782851.24 (659736.8,908463.74)	746867.05 (609519.12,920320.16)	-4.6 (-32.91,39.5)	525.11 (442.53,609.37)	207.4 (169.26,255.56)	-3.17 (-3.62,-2.71)
Low-middle SDI	567548.54 (488411.11,642938.35)	267608.49 (224432.1,317539.63)	-52.85 (-65.09,-34.99)	158.27 (136.2,179.29)	41.65 (34.93,49.42)	-4.49 (-5.13,-3.84)
Middle SDI	261080.83 (220380.81,305556.85)	108236.12 (87814.54,131652.22)	-58.54 (-71.26,-40.26)	46.11 (38.92,53.96)	13.7 (11.11,16.66)	-3.95 (-4.29,-3.62)

Table 1 (continued)

Location	Number in 1990 (95% UI)	Number in 2021 (95% UI)	Percentage change,% (95% CI)	Rate in 1990 per 100 000 (95% UI)	Rate in 2021 per 100 000 (95% UI)	EAPC (95% CI)
High-middle SDI	53369.88 (41603.54,68290.95)	13382.08 (8957.28,19789.34)	-74.93 (-86.88,-52.43)	15.33 (11.95,19.61)	3.42 (2.29,5.06)	-4.28 (-4.51,-4.04)
High SDI	14,117 (9409.73,20805.98)	7089.47 (3977.81,11384.11)	-49.78 (-80.88,20.98)	5.04 (3.36,7.43)	2.29 (1.29,3.68)	-2.28 (-2.47,-2.09)
China	61161.36 (43807.37,85415.69)	7998.44 (4461.29,13485.96)	-86.92 (-94.78,-69.22)	15.52 (11.11,21.67)	1.91 (1.07,3.22)	-6.18 (-6.72,-5.64)
Brazil	25445.36 (21620.2,29840.08)	10261.5 (8154.09,12826.62)	-59.67 (-72.67,-40.67)	50.67 (43.05,59.42)	14.04 (11.16,17.55)	-3.26 (-3.59,-2.93)
India	304441.45 (239052.78,380297.97)	202596.81 (160771.78,255605.15)	-33.45 (-57.72,6.92)	116.22 (91.26,145.18)	42.67 (33.86,53.84)	-3.85 (-5,-2.68)
South Africa	20220.73 (13815.78,28339.39)	3508.56 (2603.77,4619.4)	-82.65 (-90.81,-66.56)	162.96 (111.34,228.39)	18.1 (13.43,23.83)	-6.12 (-7.51,-4.7)
Russian Federation	5730.31 (4216.23,7469.39)	2019.45 (1086.13,3345.38)	-64.76 (-85.46,-20.65)	11.91 (8.77,15.53)	4.7 (2.53,7.79)	-2.17 (-2.5,-1.83)
Deaths						
Global	25704.85 (22432.05,29069.47)	17664.87 (14627.84,21190.58)	-31.28 (-49.68,-5.53)	1.51 (1.32,1.71)	0.71 (0.59,0.85)	-1.11 (-1.17,-1.04)
Low SDI	12718.79 (10745.76,14802.97)	12062.31 (9734.93,14937.46)	-5.16 (-34.24,39.01)	8.53 (7.21,9.93)	3.35 (2.7,4.15)	-1.23 (-1.29,-1.18)
Low-middle SDI	8555.55 (7290.11,9694.34)	4027.51 (3321.48,4829.24)	-52.93 (-65.74,-33.76)	2.39 (2.03,2.7)	0.63 (0.52,0.75)	-1.66 (-1.71,-1.62)
Middle SDI	3678.03 (3152.49,4191.03)	1451.63 (1214.34,1728.05)	-60.53 (-71.03,-45.18)	0.65 (0.56,0.74)	0.18 (0.15,0.22)	-1.42 (-1.57,-1.27)
High-middle SDI	641.21 (519.83,776.29)	85.99 (72,106.33)	-86.59 (-90.73,-79.55)	0.18 (0.15,0.22)	0.02 (0.02,0.03)	-1.18 (-1.47,-0.89)
High SDI	92.68 (76.48,111.42)	20.33 (16.96,24.38)	-78.06 (-84.78,-68.12)	0.03 (0.03,0.04)	0.01 (0.01,0.01)	-1.54 (-1.63,-1.46)
China	733.7 (505.06,1001.81)	27.03 (19.04,37.35)	-96.32 (-98.1,-92.6)	0.19 (0.13,0.25)	0.01 (0,0.01)	-1.99 (-2.52,-1.45)
Brazil	360.28 (306.57,418.14)	118.28 (96.54,142.2)	-67.17 (-76.91,-53.62)	0.72 (0.61,0.83)	0.16 (0.13,0.19)	-0.52 (-0.73,-0.31)
India	4248.71 (3310.25,5385.29)	3103.59 (2447.24,3938.25)	-26.95 (-54.56,18.97)	1.62 (1.26,2.06)	0.65 (0.52,0.83)	-2.65 (-2.8,-2.5)
South Africa	318.66 (216.6,449.66)	49.42 (36.1,66.53)	-84.49 (-91.97,-69.28)	2.57 (1.75,3.62)	0.25 (0.19,0.34)	-0.61 (-0.74,-0.48)
Russian Federation	56.56 (45.11,70.22)	4.99 (3.85,6.46)	-91.18 (-94.52,-85.68)	0.12 (0.09,0.15)	0.01 (0.01,0.02)	1.02 (0.5,1.54)

Abbreviations: EAPC: estimated annual percentage change; CI: confidence interval; UI: uncertainty interval; SDI: socio-demographic index; BRICS: Brazil, Russia, India, China, and South Africa; DALYs: disability-adjusted life years; MSMIs: maternal sepsis and other maternal infections

(Fig. 2F), MSMIs predominantly affected individuals aged 15–54 years, with relatively stable age distribution over time. However, significant changes were observed in the Russian Federation and China, where the age group most affected shifted from younger individuals (15–19 years) in 1990 to middle-aged and older individuals (20–54 years) by 2021. The incidence had the same age trend (Supplementary Fig. 2).

Similarly, trends in MSMI-related deaths from 1990 to 2021 varied across regions (Supplementary Fig. 4). In China and the Russian Federation, the age distribution of deaths remained relatively stable. However, in India, the age distribution of deaths shifted from younger individuals (15–19 years) to middle-aged and older populations (20–49 years). In Brazil, this trend was reversed, with the primary age group of deaths shifting from middle-aged and older individuals (25–54 years) to younger individuals (15–24 years). Regarding DALYs, age distribution remained relatively stable in China and across the world from 1990 to 2021 (Supplementary Fig. 3). In contrast, India experienced a shift from younger individuals (15–19 years) to middle-aged and older populations (20–49 years) (Supplementary Fig. 3). In Brazil, the burden of DALYs transitioned from middle-aged and older individuals (25–54 years) to younger populations (15–24 years). Notably, in the Russian Federation, the age distribution shifted from younger children (10–14 years) to middle-aged and older individuals (15–34 years).

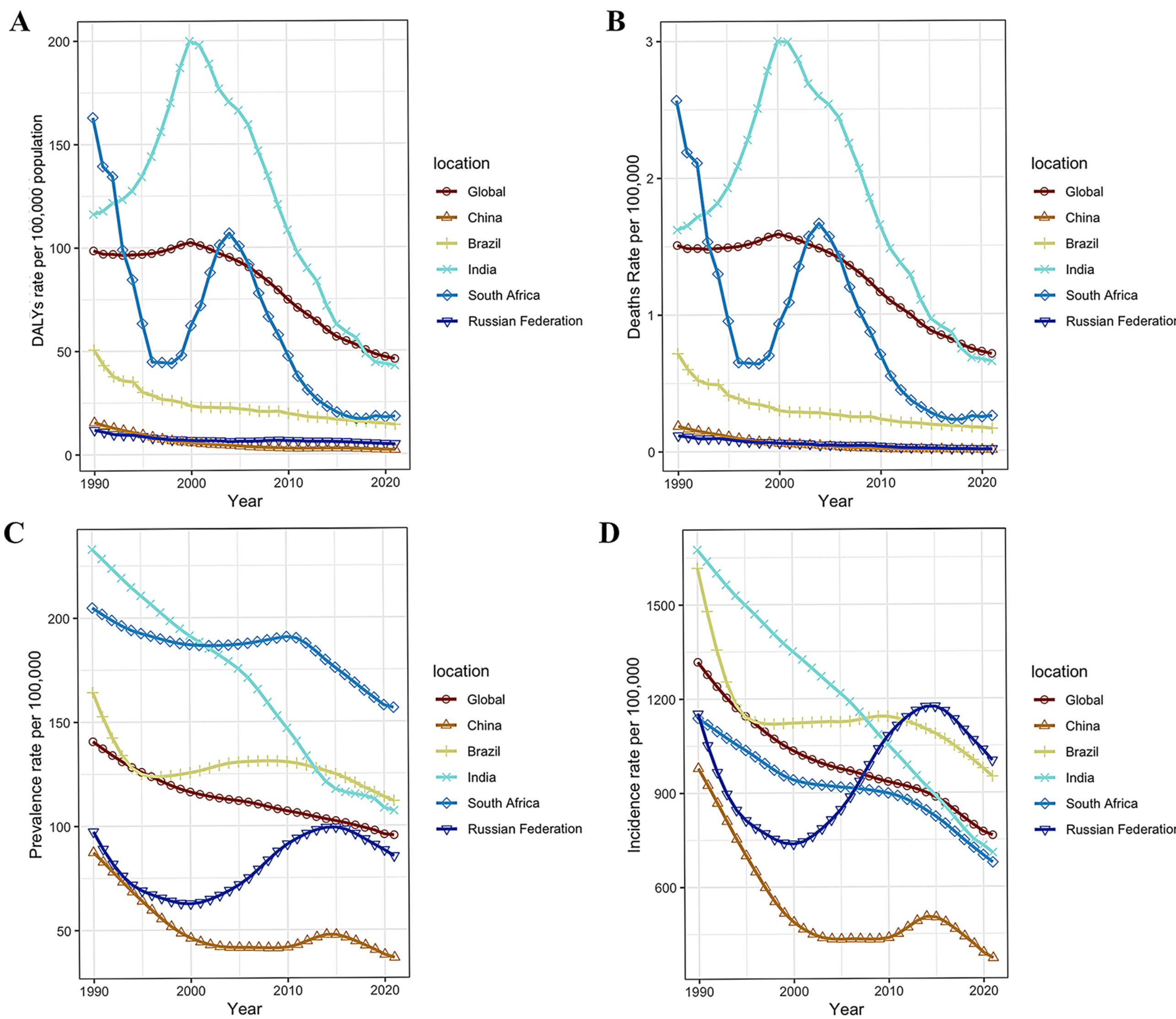

Fig. 1 Temporal trend of the burden of MSMIs over the world and in BRICS countries. The rates of DALYs (**A**), and Deaths (**B**), prevalence (**C**), incidence (**D**) from 1990 to 2021. BRICS = Brazil, Russia, India, China, and South Africa, DALYs: disability-adjusted life years, MSMIs: maternal sepsis and other maternal infections

Association with SDI

In 2021, the prevalence, morbidity, death, and DALY rates of MSMIs demonstrated negative correlations with the SDI across BRICS countries ($R < 0$, $P < 0.05$) (Fig. 3). With the development of the economy, the overall disease burden declined. Globally, the burden of MSMIs was slightly higher than expected, particularly in the Russian Federation (Fig. 3D). In contrast, China exhibited a lower-than-expected burden, while South Africa reported a significantly higher-than-expected burden. In India, regions with low and low-middle SDI levels were overburdened by MSMIs. However, Brazil showed a complex pattern: while the overall incidence of MSMIs was higher than expected, DALYs and deaths were lower than expected (Fig. 3A-B). Additionally, the prevalence was notably reduced in areas with high-middle and high SDI levels (Fig. 3C). These findings highlight that the burden patterns of MSMIs vary across countries with different economic and socio-demographic contexts, emphasizing the importance of targeted interventions for different countries and regions.

Temporal trends and policy implications

Joinpoint regression analysis reveals that the overall trend of MSMIs declined globally between 1990 and 2021 (Fig. 4). However, regional variations were evident. In China, the incidence of MSMIs significantly increased from 2010 to 2014 (APC = 4.15%; 95% CI: 3.59–4.71%; $P < 0.001$), so as the prevalence (Supplementary Table 1) (Fig. 4C). In the Russian Federation, the incidence of

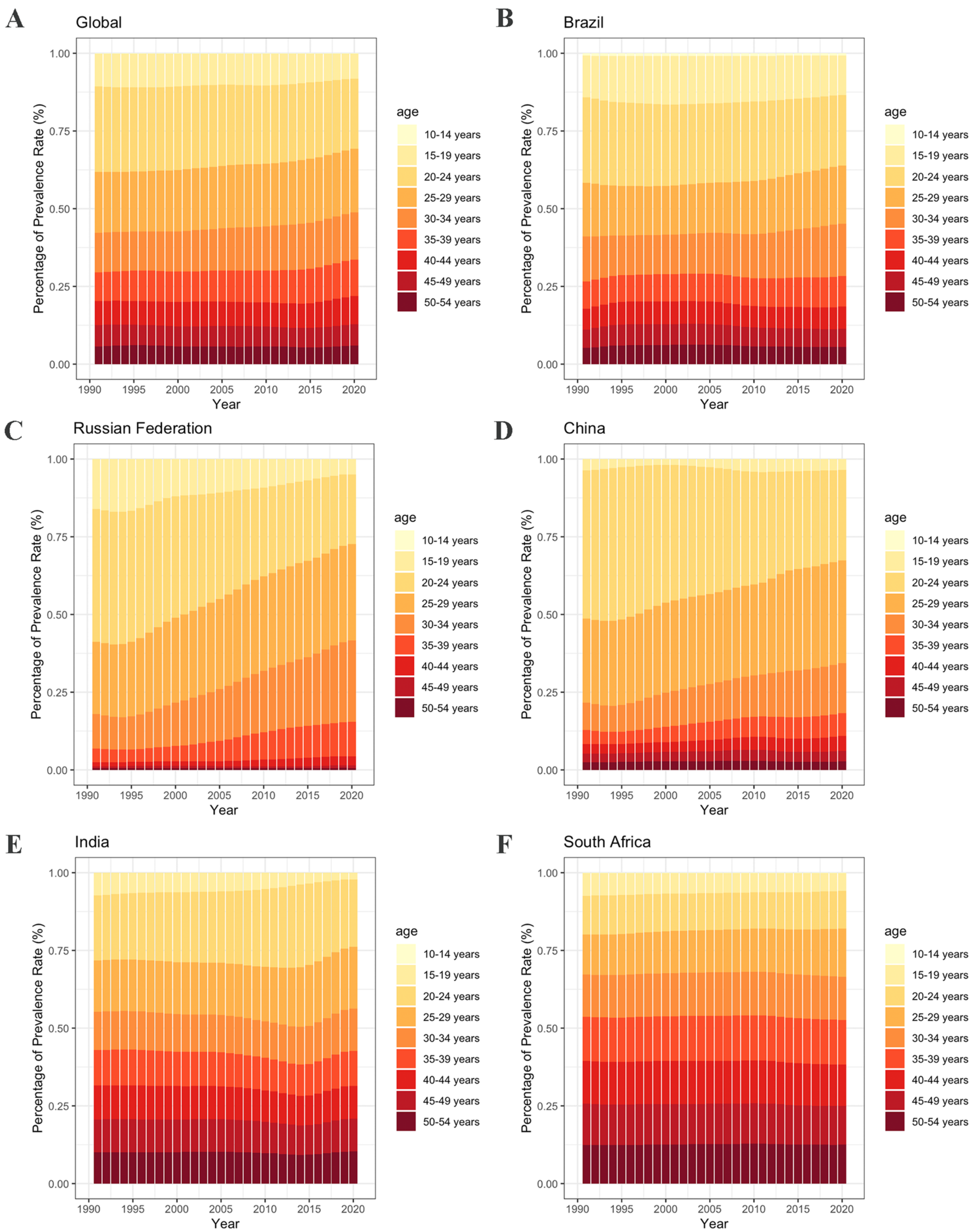

Fig. 2 Temporal change in the relative proportion of MSMIs in BRICS countries [Global (**A**), Brazil (**B**), Russia Federation (**C**), China (**D**), India (**E**), and South Africa (**F**)] and, prevalence rates across age groups, 1990–2021. BRICS: Brazil, Russia, India, China, and South Africa, MSMIs: maternal sepsis and other maternal infections

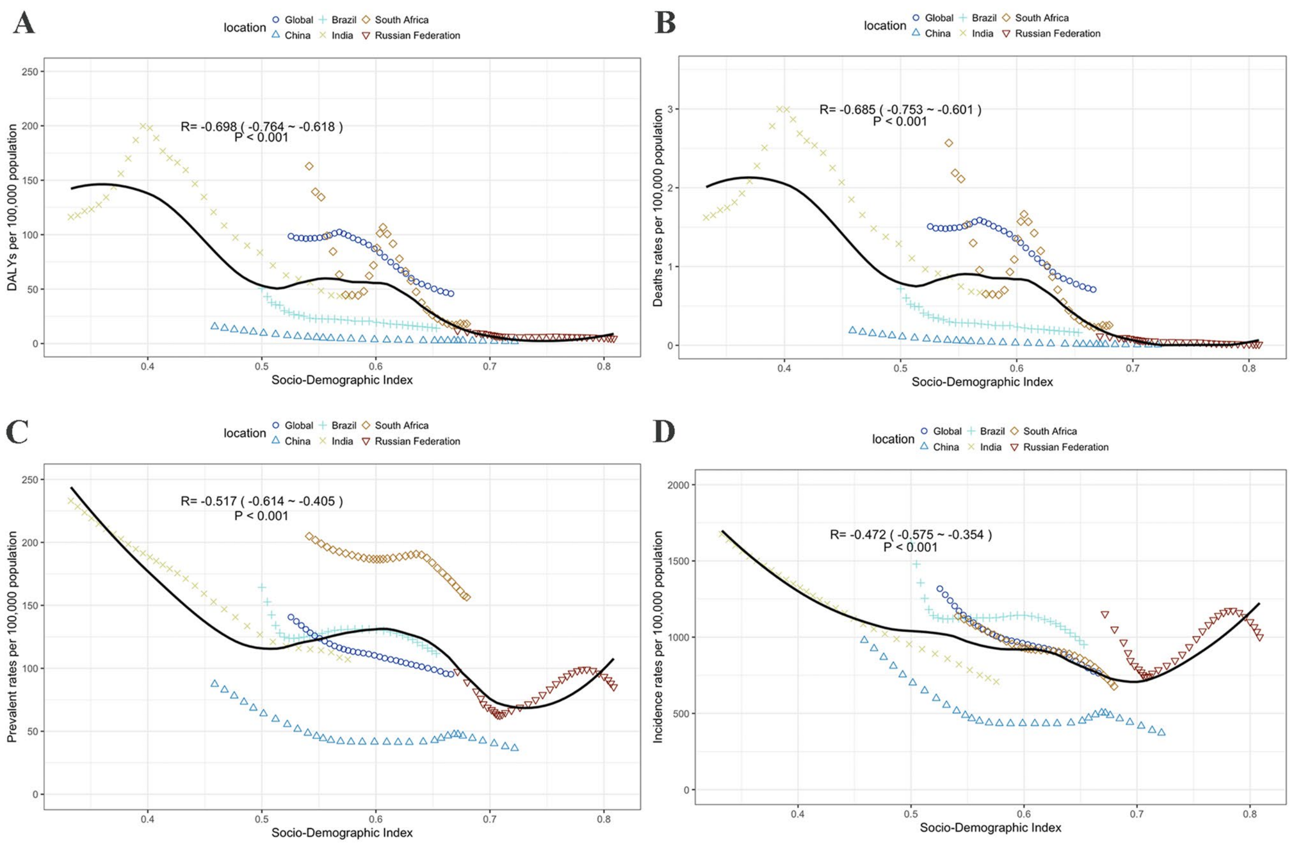

Fig. 3 Associations of the SDI with (**A**) DALYs rates, (**B**) deaths rates, (**C**) prevalence rates, and (**D**) incidence rates of MSMIs in BRICS countries (Brazil, Russia, India, China, and South Africa), 1990–2021. SDI: socio-demographic index

MSMIs increased during three distinct periods: from 2000 to 2004 (APC = 2.52%; 95% CI: 2.0–3.05%; $P < 0.001$), 2004 to 2010 (APC = 5.2%; 95% CI: 4.95–5.44%; $P < 0.001$), and 2010 to 2015 (APC = 1.79%; 95% CI: 1.46–2.12%; $P < 0.001$) (Supplementary Table 2) (Fig. 4D), with prevalence following a similar pattern. In India, the death rates of MSMIs surged from 1990 to 1995 (APC = 3.40%; 95% CI: 1.51–5.34%; $P = 0.001$) and from 1995 to 2000 (APC = 9.87%; 95% CI: 7.45–12.35%; $P < 0.001$) (Supplementary Table 3) (Fig. 4B). In South Africa, the death rate of MSMIs was elevated between 1997 and 2004 (APC = 17.32%; 95% CI: 13.82–20.92%; $P < 0.001$), and DALYs showed a parallel upward trend during the same period (Supplementary Table 4) (Fig. 4A).

Discussion

Our research found that by 2021, the global burden of MSMIs had a general downward trend. However, high death rates and DALYs persisted in BRICS countries, particularly in South Africa, which had the highest MSMI prevalence among them. In contrast, China showed the greatest reduction in MSMI burden, while Russia experienced a consistent increase in the prevalence and incidence of MSMI from 2000 to 2015. The age distribution of MSMIs shifted from middle-aged individuals to younger populations in some regions. In India, deaths and DALYs transitioned to older age groups, whereas in Brazil and Russia, the age distribution of deaths remained relatively stable. The burden of MSMIs showed negative correlations with SDI across BRICS countries, with the disease burden being higher in regions with lower SDI levels. The overall decline in MSMIs globally was accompanied by significant regional variations, with notable increases in China, Russia Federation, and India during specific periods.

MSMIs remain global public health concerns that significantly affect women in low- and middle-income countries. Despite decades of progress in reducing maternal morbidity and mortality, comprehensive data on the burden and temporal trends of MSMIs remain scarce, particularly in BRICS countries. This study leveraged data from the GBD 2021 to quantify the incidence, prevalence, DALYs, and death rates of MSMIs over the world and in BRICS countries. Through Joinpoint regression analysis, temporal trends, associations between MSMI burden and the SDI, and age distribution trends were examined.

Analysis of global data reveals that the prevalence and deaths of MSMIs are expected to decline by 2021,

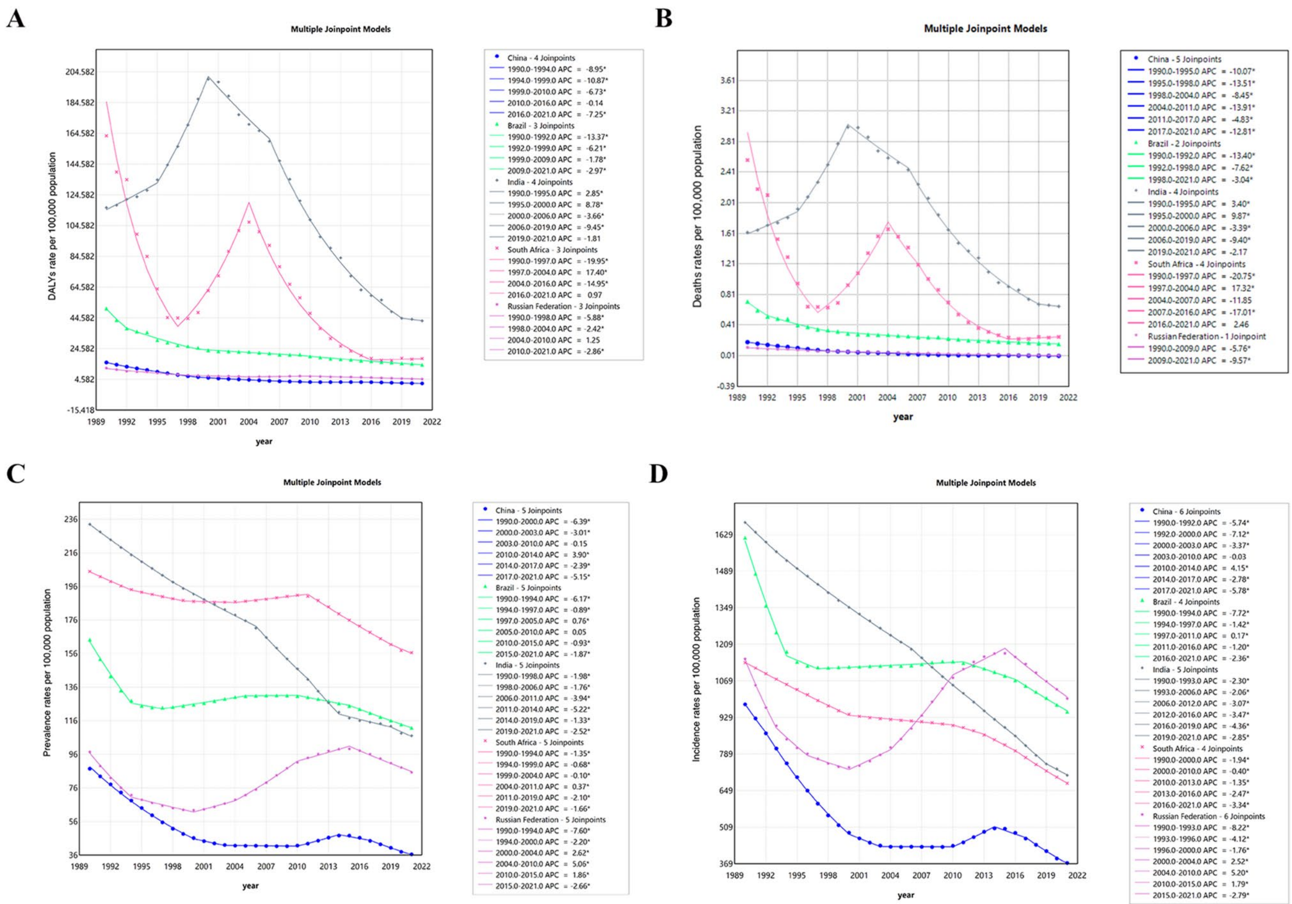

Fig. 4 Joinpoint regression analysis of the temporal trend of MSMI burden between 1990–2021. (**A**) DALYs rates, (**B**) death rates, (**C**) prevalence rates, and (**D**) incidence rates of MSMIs in BRICS countries (Brazil, Russia, India, China, and South Africa)

reflecting advances in disease prevention and medical interventions [21–23]. However, substantial disparities persist across countries [24, 25]. For instance, South Africa exhibited the highest prevalence of MSMIs, with an increase by 19.36% in total cases since 1990, despite a negative EAPC, indicating a sustained high disease burden. In contrast, the burden of MSMI in China was remarkably reduced, with total cases decreasing by 55.69% since 1990, underscoring its success in implementing robust public health measures and effective antibiotic use [26]. India similarly demonstrated significant declines in prevalence, whereas the Russian Federation exhibited an upward trend in total cases after 2000, despite a slight decrease in prevalence. This rebound suggests that disease control measures have failed during specific periods. The disintegration of the Union of Soviet Socialist Republics in 1991 had a great impact on economy, society, and public health, but the situation stabilized in the mid-2000s [27]. Changes in the health system during the transition period may influence maternal health services, thus affecting the incidence and prevalence of maternal infections. In addition, the coronavirus disease (COVID-19) broke out in 2019, and the environmental and socio-economic factors caused by the epidemic may also have an impact on maternal infections [28]. Notably, while Russia reported the highest incidence, its death rates remained relatively low, reflecting the mitigating effects of improved medical care.

The age distribution of MSMIs exhibited distinct regional characteristics and dynamic shifts over time. Globally, most affected cases were in young women aged 15–44 years, with Brazil and the Russian Federation showing the highest proportion of cases in this age group. In China, however, MSMIs predominantly affected women aged 20–44 years, possibly due to a heightened risk of infections during peak childbearing years and a decline in immune function. In contrast, in India and South Africa, the burden shifted to younger populations aged 20–29 years, due to changes in socioeconomic conditions and lifestyle factors. Similarly, a case-control study in Scotland reported that compared with women over 34 years old, women under 25 years old were five times more likely to suffer from uncomplicated sepsis and ten times more likely to suffer from severe sepsis [14]. The signs of systemic infections (hypotension, tachycardia, fever, oliguria, and hypoxemia) in young mothers may be masked by other compensatory mechanisms, leading to delays in timely detection and antibiotic treatment [29].

Age distributions of deaths and DALYs exhibited similar regional disparities. In India, the burden shifted from younger individuals (15–19 years) to middle-aged and older adults (20–49 years), reflecting an increased risk in older pregnant women and those with comorbidities [30, 31]. Meanwhile, Brazil presented an inverse trend, with the peak period of deaths and DALYs transitioning from middle age (25–54 years) to younger age (15–24 years), suggesting emerging health challenges among the younger population.

In 2021, the burden of MSMIs demonstrated a negative correlation with SDI levels [7]. Countries with higher SDI levels generally experienced lower disease burdens, reflecting the benefits of economic development. However, deviations from this trend highlight regional disparities. China showed significantly lower-than-expected burdens of MSMIs, implying the effectiveness of its policies regarding public health; while South Africa showed higher-than-expected burdens, implying persistent limitations in health resources and challenges in disease control [32–34]. India and other low- and lower-middle SDI regions exhibited higher-than-expected burdens, emphasizing the need for strengthened strategies for disease prevention. Notably, despite a higher-than-expected incidence in Brazil, its deaths and DALYs remained relatively low, likely reflecting its strong healthcare infrastructure.

Joinpoint regression analysis illustrated the complex burden trends of MSMIs. Although the overall burden declined from 1990 to 2021, certain regions and periods experienced significant increases. For example, the incidence and prevalence in China were elevated between 2010 and 2014 (APC = 4.15%), while Russia experienced a pronounced increase from 2000 to 2015 (APC range: 1.79–5.2%), potentially owing to policy changes or economic fluctuations. In China, in 2007, the government introduced basic medical insurance for urban residents, which significantly improved the medical consultation rate and hospitalization rate [35]. However, the disintegration of the Soviet Union led to significant social changes, and the health status and health system of Russians deteriorated rapidly [36]. Death trends in India and South Africa were particularly striking. India reported rapid increases from 1990 to 2000 (APC = 9.87%) likely due to insufficient resources for public health at the time. Similarly, deaths in South Africa surged from 1997 to 2004 (APC = 17.32%), reflecting the severe health crisis during this period.

This study has several limitations. First, the burden of MSMIs may be underestimated or overestimated due to underdiagnosis and misdiagnosis in underdeveloped regions. Second, despite rigorous cleaning and statistical modeling of GBD data, relying on modeling data may introduce biases and potential inaccuracies. Third, the GBD dataset has a limited range of MSMI subtypes, which further constrains comprehensive analysis. Finally, due to the inherent time lag in GBD data, the latest datasets are necessary to refine findings and inform policy interventions.

Conclusions

This study reveals the overall downward trend of the burden of MSMIs in BRICS countries and its regional differences. The achievements and challenges of disease control in different countries provide an important basis for future policymaking. Notably, high-burden countries such as South Africa and India should further optimize resource allocation and improve health interventions. Countries with a rebound or increase in the burden of MSMIs, such as Russia, should pay attention to potential influencing factors and formulate targeted prevention and control strategies. Future research should focus on the socio-economic drivers of disease burden change and explore multi-sectoral cooperation to further reduce the global burden of MSMIs and promote healthy, fair, and sustainable development.

Abbreviations

MSMIs	Maternal Septicemia and other Maternal Infections
BRICS	Brazil, Russia, India, China, South Africa
DALYs	Disability-Adjusted Life Years
UI	Uncertainty Intervals
EAPC	Estimated Annual Percentage Change
APC	Annual Percentage Change
AAPC	Average Annual Percentage Change
CI	Confidence Interval
GBD	Global Burden of Disease
SDI	Socio-Demographic Index
YLLs	Years of Life Lost
YLDs	Years Lived with Disability

Supplementary Information

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Supplementary Material 1

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Not applicable.

Author contributions

Conceptualization: Jiao Long; Methodology: Jiao Long; Formal analysis and investigation: Jiao Long, Qi Zhang, Chao Ma; Writing - original draft preparation: Jiao Long; Writing - review and editing: Qi Zhang, Chao Ma; Resources: Jiao Long, Qi Zhang, Chao Ma; Supervision: Jiao Long, Qi Zhang, Chao Ma, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability

Data on MSMIs from BRICS countries analyzed in this study were derived from the Global Burden of Disease (GBD) 2021 dataset. This dataset, freely available through the Global Health Data Exchange (https://ghdx.healthdata.org/gbd-2021/sources).

Declarations

Ethics approval and consent to participate

The dataset used in this study is anonymized and approved under the guidelines of the Institutional Review Board at the University of Washington with informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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