

# Global, Regional, and National Burden and Trends of Maternal Hypertensive Disorders from 1990 to 2021: A Population-Based Study

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**Objective:** This study aimed to comprehensively assess the global, regional, and national burden and trends of maternal hypertensive disorders (MHD) from 1990 to 2021.

**Methods:** By analyzing MHD data from 1999 to 2021, age-standardized incidence rate (ASIR), age-standardized mortality rate (ASMR) and age-standardized disability-adjusted life years (ASDR) were screened, and estimated annual percentage change (EAPC) was calculated. This study used joinpoint regression analysis to examine trends during the period. This study investigated the differences in the burden of MHD among different Socio-demographic Index (SDI) regions through health inequalities analysis. Finally, we used the Bayesian age-period-cohort (BAPC) model to predict the trend in incidence, mortality, and DALYs rates of MHD over the next 25 years.

**Results:** The results showed that in 2021, the global ASIR, ASMR and ASDR were 461.94, 0.97 and 63.47, respectively (per 100000 population). From 1990 to 2021, the EAPC results showed a decreasing trend in the global ASIR, ASMR, and ASDR of MHD. The joinpoint regression results showed that the global ASIR, ASMR, and ASDR of MHD showed an overall downward trend from 1990 to 2021. Countries with lower SDI levels bore a higher burden. The predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend.

**Conclusion:** The global ASIR, ASMR, and ASDR of MHD were all showing a downward trend from 1990 to 2021. However, this study found that Africa and low SDI regions bore a significant burden. The disparity in economic development could lead to an exacerbation of health inequalities. Therefore, it was emphasized that relevant public health policies should be formulated for African and low SDI regions. Medical staff should raise awareness of the risks of MHD and actively handle emergencies caused by MHD to reduce mortality, and DALYs rates and alleviate social burden.

**Keywords:** maternal hypertensive disorders, GBD 2021, disability-adjusted life years, health inequality, epidemiology

## Introduction

Maternal hypertensive disorders include gestational hypertension (onset after 20 weeks gestation), pre-eclampsia, severe preeclampsia, and eclampsia, but exclude chronic hypertension (onset prior to pregnancy or prior to 20 weeks gestation) unless superimposed preeclampsia or eclampsia develop.<sup>1</sup> A 15.87% increase in global MHD cases, alongside a 13.40% decrease in age-standardized incidence rates from 1992 to 2021.<sup>2</sup> From 1990 to 2019, the rates of Disability-adjusted life years (DALYs), mortality and incidence among women's health in Mexico caused by maternal disorders all decreased significantly, reaching 59.5%, 63.8% and 46.5%, respectively.<sup>3</sup> The overall trend of MHD was positive, but the complications and burden it brought could not be ignored. Pre-eclampsia or eclampsia pregnant women in Nigeria might experience acute kidney injury, stroke, sepsis during the postpartum period and aspiration pneumonia, etc.<sup>4</sup> Newborns often experience premature birth, low birth weight, and even admission to neonatal intensive care units.<sup>5</sup> Women with a history of preeclampsia were more likely to suffer from chronic hypertension, cardiovascular disease, kidney disease, diabetes and mental illness.<sup>5</sup> In 2012, the cost for pregnant

women with preeclampsia within 12 months before delivery in the United States was \$1.03 billion.<sup>6</sup> A cohort study in California showed that hospitalization costs for patients with gestational hypertension were higher than those without gestational hypertension.<sup>7</sup> Globally, preeclampsia and eclampsia were the leading causes of maternal mortality, with the majority occurring in underdeveloped countries.<sup>8</sup> A study showed that the prevalence of hypertensive disorders of pregnancy (HDP) in Africa often increased with the increase of national income levels.<sup>9</sup>

SDI is an abbreviation for Socio-demographic Index, a summary measure that identifies where countries or other geographic areas sit on the spectrum of development.<sup>10</sup> It is expressed on a scale of 0 to 100, with 0 being the lowest SDI value and 100 being the highest.<sup>10</sup> GBD 2021 divided global, 204 countries and regions into five SDI regions: Low SDI, Low-middle SDI, Middle SDI, High-middle SDI, and High SDI.

Currently, there is a lack of comprehensive research and reports on the MHD burden in different SDI regions. This study analyzed the burden, trends, and health inequalities of MHD in global, 204 countries and regions from 1990 to 2021, and predicted the incidence, mortality, and DALYs rates of MHD in the next 25 years. It could better understand the impact of MHD on people's health, help different regions formulate corresponding public health policies, strengthen prenatal intervention and obstetric care, and alleviate the health problems and economic burden caused by MHD.

## Materials and Methods

### Data Sources

Examining trends from 1990 to 2021, the Global Burden of Disease (GBD) study assessed mortality and disability from hundreds of diseases, injuries, and risk factors around the world.<sup>11</sup> Through the GBD Results tool, we could download mortality and morbidity 288 causes of death, 371 diseases and injuries, and 88 risk factors in 204 countries and territories.<sup>11</sup> The critical milestones for ongoing estimation included regular updates to the GBD estimates, referred to as the “GBD cycle”.<sup>10</sup> We conducted a secondary analysis of the GBD 2021. In this cross-sectional study, we selected relevant data based on the following criteria. Estimate selected “Cause of death or injury”. Disease selected “maternal hypertensive disorders”. Measure selected “Deaths, Incidence, and DALYs (Disability-Adjusted Life Years)”. Metric selected “Number, Percent, and Rate”. Location selected “Global, 204 countries and 5 SDI regions”. Year selected “1990–2021”. Gender selected “Female”. Age selected “All ages, Age-standardized, and All other age groups”.

### Socio-Demographic Index (SDI)

Socio-demographic Index (SDI) is a summary measure that identifies where countries or other geographic areas sit on the spectrum of development.<sup>10</sup> SDI was constructed based on three measures: i) lag-distributed income per capita; ii) average years of schooling in ages 15 and older; and iii) total fertility rate (TFR) for females under age 25.<sup>10</sup> For example, a low SDI value will be assigned to a country with lower income per capita, fewer average years of schooling, and higher TFR relative to other countries.<sup>10</sup> 0 is the lowest SDI value, and 100 is the highest.<sup>10</sup> GBD 2021 divided global, 204 countries and regions into five SDI regions: Low SDI, Low-middle SDI, Middle SDI, High-middle SDI, and High SDI.

### Estimated Annual Percentage Change

Estimated annual percentage change (EAPC) is a linear regression model used to quantify the change trend of disease burden (such as incidence, mortality, DALYs rate, etc.) over a period of time. We extracted the data of incidence, mortality, DALYs rate and its age-standardized rate (ASR, per 100000 population) caused by MHD of GBD 2021, and calculated age-standardized incidence rate (ASIR), age-standardized mortality rate (ASMR), age-standardized DALYs rate (ASDR) and their respective EAPC values and 95% confidence interval (CI) to assess the trend of MHD incidence, mortality and DALYs rate. The specific formula is as follows:  $y = \alpha + \beta x + \epsilon$ , where  $y = \ln(\text{ASR})$ ,  $\alpha$  = the intercept,  $x$  = year, and  $\epsilon$  = error term.<sup>12</sup>  $\text{EAPC} = 100 \times (\exp(\beta) - 1)$ .<sup>12</sup> If both the EAPC value and the 95% CI (lower limit) are greater than 0, it is considered that the age standardized indicator is showing an upward trend.<sup>12</sup> If both the EAPC value and the 95% CI (upper limit) are less than 0, it is considered that the age standardized indicator is showing a downward trend.<sup>12</sup> If the 95% CI of EAPC includes 0, it is a constant trend.<sup>12</sup>

## Joinpoint Regression

Joinpoint regression is a statistical method used to analyze the trend change in time series data. It is suitable for public health and epidemiological research and can be used to detect the trend of disease incidence rate or mortality over time. We used Joinpoint Regression Program (5.2.0.0 version) to calculate the average annual percentage change (AAPC) and 95% confidence interval (CI) to describe the disease burden trend from 1990 to 2021.

## Analysis of Health Inequalities

This study used two indicators, the slope index of inequality (SII) and the concentration index (CI), to evaluate absolute and relative—income related inequality between countries. SII is an absolute indicator for measuring the degree of health inequalities, which reflects the linear relationship between health indicators and socioeconomic status distribution. The higher the SII value, the more severe the inequality. A value of zero indicates no inequality. The concentration index (CI) is a relative measure of the degree of health inequalities. It reflects the distribution of health indicators in socioeconomic status. CI can take values from -1 to 1, with values closer to zero indicating lower inequality.

This study used the bayesian age-period-cohort (BAPC) model to predict the trend in incidence, mortality, and DALYs rates of MHD over the next 25 years. This study used R software (4.3.1 version) and Joinpoint Regression Program (5.2.0.0 version) for data analysis.

## Results

### Global Burden and Temporal Trend in Maternal Hypertensive Disorders

Globally, the age-standardized incidence rate (ASIR) of MHD was 554.35 (per 100000 population) in 1990 and 461.94 (per 100000 population) in 2021. The percentage change in age-standardized incidence rate from 1990 to 2021 was 0.17 (-0.21, -0.14), and the EAPC was -0.51 (-0.56, -0.45) (Table 1 and Figure 1). In 2021, there was a significant difference of ASIR in the SDI and GBD regions. The ASIR of Low SDI was the highest, at 1202.32 (per 100000

**Table 1** The Age-Standardized Incidence Rate for Maternal Hypertensive Disorders in 1990 and 2021 and Their Temporal Trends from 1990 to 2021

Location	Incidence			
	Age-Standardised Rate per 100,000 Population, 1990	Age-Standardised Rate per 100,000 Population, 2021	Percentage Change in Age-Standardised Rate per 100,000 1990–2021	EAPC (95% CI)
Global	554.35(461.38,675.43)	461.94(392.73,551.65)	-0.17(-0.21,-0.14)	-0.51(-0.56,-0.45)
<b>GBD region</b>				
Andean Latin America	307.22(271.68,349.51)	288.22(270.01,309.68)	-0.06(-0.13,0.01)	-0.16(-0.37,0.05)
Australasia	320.59(269.02,387.38)	224.57(173.84,281.37)	-0.3(-0.4,-0.18)	-1.03(-1.24,-0.83)
Caribbean	468.3(373.93,596.89)	345.1(278.18,433.02)	-0.26(-0.3,-0.22)	-0.95(-1.03,-0.87)
Central Asia	196.58(156.98,248.24)	180.35(144.84,228.23)	-0.08(-0.15,-0.01)	0.4(0.1,0.71)
Central Europe	192.52(140.98,264.48)	169.62(138.88,210.94)	-0.12(-0.27,0.04)	-0.29(-0.65,0.07)
Central Latin America	758.62(643.3,897.84)	455(399.42,524.36)	-0.4(-0.43,-0.36)	-0.99(-1.34,-0.64)
Central Sub-Saharan Africa	2206.02(1861.35,2593.78)	1323.57(1098.63,1609.63)	-0.4(-0.44,-0.36)	-1.51(-1.64,-1.38)
East Asia	171.41(127.45,239.11)	108.74(84.21,140.96)	-0.37(-0.45,-0.28)	-0.57(-1.75,0.63)
Eastern Europe	405.04(296.85,555.96)	417.91(323.56,535.96)	0.03(-0.12,0.22)	1.12(0.63,1.61)
Eastern Sub-Saharan Africa	2217.74(1859.57,2576.39)	1408.09(1198.03,1626.08)	-0.37(-0.38,-0.35)	-1.39(-1.53,-1.25)
High-income Asia Pacific	206.53(162.41,269.35)	154.28(132.33,182.35)	-0.25(-0.37,-0.13)	-1.52(-2.01,-1.03)
High-income North America	392.14(300.76,522.67)	369.83(318.7,434.19)	-0.06(-0.26,0.16)	-0.48(-0.72,-0.24)
North Africa and Middle East	687.79(550.29,868.7)	370.18(291.85,474.07)	-0.46(-0.49,-0.44)	-1.49(-1.67,-1.32)
Oceania	568.38(449.38,708.83)	471.69(376.23,599.7)	-0.17(-0.23,-0.1)	-0.72(-0.76,-0.67)
South Asia	740.13(616.22,900.44)	338.92(280.67,416.78)	-0.54(-0.56,-0.52)	-2.8(-3.18,-2.42)

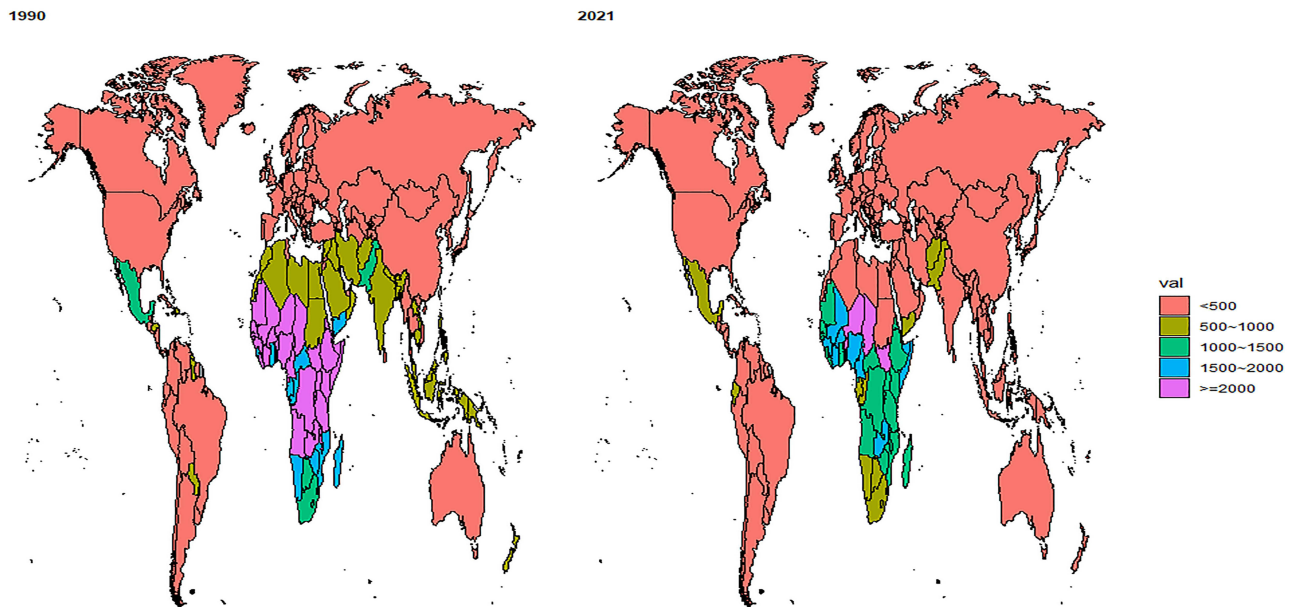
(Continued)

**Table 1** (Continued).

Location	Incidence			
	Age-Standardised Rate per 100,000 Population, 1990	Age-Standardised Rate per 100,000 Population, 2021	Percentage Change in Age-Standardised Rate per 100,000 1990–2021	EAPC (95% CI)
Southeast Asia	477.34(380.83,599.77)	309.44(248.43,383.27)	-0.35(-0.39,-0.32)	-1.33(-1.4,-1.26)
Southern Latin America	426.44(324.55,552.22)	384.74(323.35,465.73)	-0.1(-0.19,0.02)	-0.1(-0.2,0.01)
Southern Sub-Saharan Africa	1204.18(1012.69,1409.85)	813.53(681.66,958.35)	-0.32(-0.35,-0.3)	-1.09(-1.15,-1.03)
Tropical Latin America	479.5(385.21,613)	316.27(270.82,377.16)	-0.34(-0.41,-0.28)	-1.22(-1.49,-0.94)
Western Europe	190.81(146.7,250.2)	208.89(164.79,263.71)	0.09(-0.03,0.21)	0.41(0.27,0.55)
Western Sub-Saharan Africa	2256.21(1933.87,2588.36)	1678.15(1447.02,1911.36)	-0.26(-0.27,-0.24)	-0.84(-1.03,-0.65)
<b>SDI quintile</b>				
High SDI	269.6(211.65,353.21)	250.31(208.38,304.89)	-0.07(-0.2,0.07)	-0.49(-0.67,-0.31)
High-middle SDI	251.01(195.55,331.19)	207.21(166.86,257.15)	-0.17(-0.27,-0.07)	0.05(-0.32,0.42)
Middle SDI	422.36(348.93,524.25)	300.8(252.74,364.43)	-0.29(-0.33,-0.25)	-0.72(-0.88,-0.57)
Low-middle SDI	823.86(699.94,989.06)	487.24(411.49,575.58)	-0.41(-0.43,-0.39)	-1.83(-2,-1.67)
Low SDI	1792.92(1531.06,2095.17)	1202.32(1025.84,1408.89)	-0.33(-0.34,-0.32)	-1.28(-1.4,-1.15)

population), followed by Low-middle SDI (487.24 per 100000 population), Middle SDI (300.8 per 100000 population), High SDI (250.31 per 100000 population), and High-middle SDI (207.21 per 100000 population) (Table 1). The regions with high ASIR in 2021 were Western Sub-Saharan Africa (1678.15 per 100000 population), Eastern Sub-Saharan Africa (1408.09 per 100000 population), Central Sub-Saharan Africa (1323.57 per 100000 population), and Southern Sub-Saharan Africa (813.53 per 100000 population). In contrast, regions with lower ASIR were Western Europe (208.89 per 100000 population), Central Europe (169.62 per 100000 population), High-income Asia Pacific (154.28 per 100000 population), and East Asia (108.74 per 100000 population) (Table 1).

Globally, the age-standardized mortality rate (ASMR) for MHD was 1.94 (per 100000 population) in 1990 and 0.97 (per 100000 population) in 2021. The percentage change in age-standardized mortality rate from 1990 to 2021 was -0.5 (-0.59, -0.38), and the EAPC was -2.16 (-2.21, -2.1) (Table 2 and Figure 2). In 2021, there was a significant difference



**Figure 1** The age-standardized incidence rate for maternal hypertensive disorders in 204 countries and regions in 1990 and 2021.

**Table 2** The Age-Standardized Mortality Rate for Maternal Hypertensive Disorders in 1990 and 2021 and Their Temporal Trends from 1990 to 2021

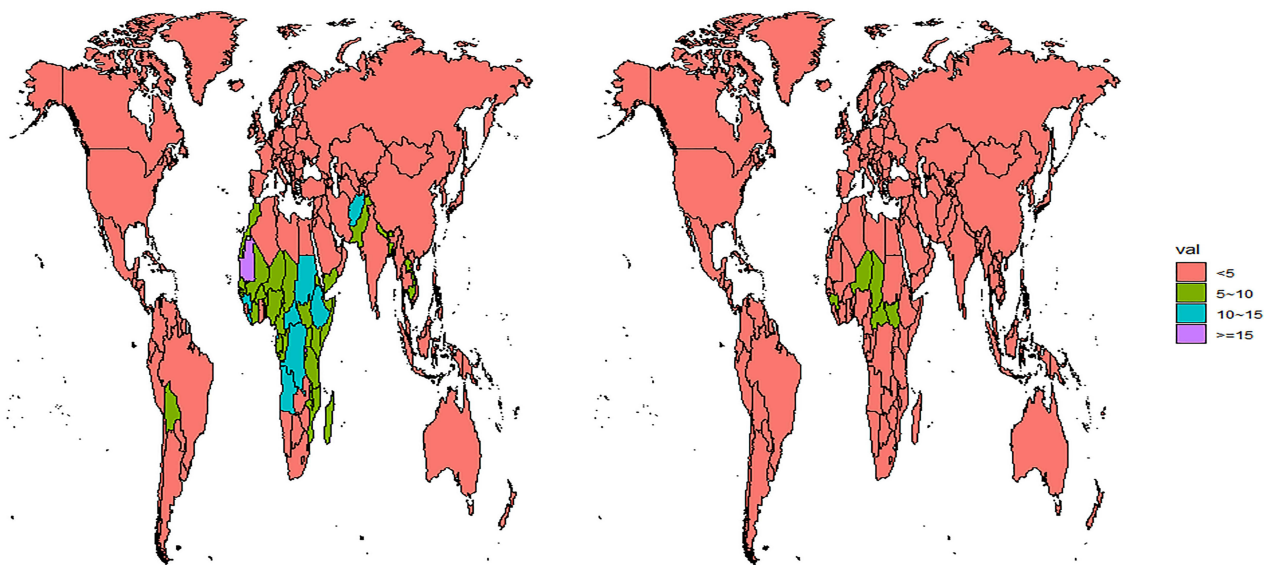
Location	Deaths			
	Age-Standardised Rate per 100,000 Population, 1990	Age-Standardised Rate per 100,000 Population, 2021	Percentage Change in Age-Standardised Rate per 100,000 1990–2021	EAPC (95% CI)
Global	1.94(1.71,2.15)	0.97(0.81,1.18)	-0.5(-0.59,-0.38)	-2.16(-2.21,-2.1)
GBD region				
Andean Latin America	3.32(2.83,3.87)	0.95(0.7,1.25)	-0.71(-0.8,-0.61)	-4.29(-4.54,-4.03)
Australasia	0.04(0.03,0.05)	0.01(0.01,0.01)	-0.76(-0.82,-0.67)	-3.88(-4.54,-3.22)
Caribbean	2.03(1.62,2.57)	2.09(1.34,3.07)	0.03(-0.32,0.53)	0.8(0.57,1.03)
Central Asia	0.7(0.62,0.78)	0.16(0.13,0.19)	-0.77(-0.81,-0.72)	-4.53(-4.86,-4.2)
Central Europe	0.09(0.07,0.1)	0.01(0.01,0.02)	-0.83(-0.87,-0.8)	-4.88(-5.32,-4.43)
Central Latin America	1.28(1.17,1.4)	0.36(0.29,0.44)	-0.72(-0.78,-0.65)	-3.92(-4.16,-3.68)
Central Sub-Saharan Africa	10.17(7.24,13.36)	4.17(2.93,5.75)	-0.59(-0.74,-0.34)	-2.08(-2.41,-1.75)
East Asia	0.26(0.18,0.35)	0.03(0.02,0.04)	-0.88(-0.92,-0.81)	-6.52(-6.79,-6.25)
Eastern Europe	0.17(0.14,0.19)	0.02(0.02,0.02)	-0.89(-0.91,-0.86)	-6.67(-7.04,-6.29)
Eastern Sub-Saharan Africa	9.01(7.69,10.39)	3.11(2.47,3.82)	-0.66(-0.73,-0.56)	-3.24(-3.38,-3.09)
High-income Asia Pacific	0.06(0.05,0.07)	0.01(0.01,0.01)	-0.84(-0.88,-0.79)	-5.65(-6,-5.29)
High-income North America	0.06(0.05,0.07)	0.05(0.04,0.06)	-0.18(-0.36,0.06)	0.12(-0.18,0.41)
North Africa and Middle East	2.83(2.24,3.37)	0.51(0.37,0.68)	-0.82(-0.87,-0.76)	-5.12(-5.31,-4.92)
Oceania	1.36(0.77,2.02)	1.1(0.75,1.54)	-0.19(-0.49,0.48)	-0.57(-0.77,-0.37)
South Asia	3.78(3.19,4.3)	1.19(0.88,1.57)	-0.69(-0.77,-0.57)	-3.92(-4.12,-3.73)
Southeast Asia	2.57(2.15,3)	0.84(0.67,1.05)	-0.67(-0.75,-0.57)	-3.44(-3.53,-3.36)
Southern Latin America	0.45(0.39,0.54)	0.11(0.08,0.13)	-0.77(-0.83,-0.69)	-3.65(-3.97,-3.32)
Southern Sub-Saharan Africa	2.32(1.76,3.07)	1.07(0.82,1.38)	-0.54(-0.68,-0.31)	-0.98(-2.13,0.18)
Tropical Latin America	1.51(1.34,1.69)	0.29(0.25,0.33)	-0.81(-0.84,-0.78)	-4.44(-4.9,-3.98)
Western Europe	0.04(0.04,0.05)	0.01(0.01,0.01)	-0.76(-0.79,-0.71)	-3.99(-4.29,-3.68)
Western Sub-Saharan Africa	6.48(5.784)	3.95(3.5,15)	-0.39(-0.56,-0.12)	-1.51(-1.6,-1.43)
SDI quintile				
High SDI	0.07(0.06,0.09)	0.03(0.02,0.03)	-0.63(-0.7,-0.53)	-2.71(-2.88,-2.54)
High-middle SDI	0.35(0.28,0.42)	0.06(0.05,0.08)	-0.82(-0.86,-0.77)	-5.33(-5.45,-5.21)
Middle SDI	1.13(1,1.27)	0.4(0.34,0.48)	-0.65(-0.71,-0.57)	-3.22(-3.29,-3.15)
Low-middle SDI	4.04(3.49,4.54)	1.37(1.1,1.71)	-0.66(-0.74,-0.57)	-3.46(-3.55,-3.37)
Low SDI	7.88(6.72,8.98)	3.38(2.77,4.15)	-0.57(-0.66,-0.46)	-2.6(-2.7,-2.5)

of ASMR in the SDI and GBD regions. The ASMR of Low SDI was the highest, at 3.38 per 100000 population, followed by Low-middle SDI (1.37 per 100000 population), Middle SDI (0.4 per 100000 population), High-middle SDI (0.06 per 100000 population), and High SDI (0.03 per 100000 population) (Table 2). The regions with high ASMR in 2021 were Western Sub-Saharan Africa (3.95 per 100000 population), Eastern Sub-Saharan Africa (3.11 per 100000 population), and Central Sub-Saharan Africa (4.17 per 100000 population). In contrast, regions with lower ASMR were Australasia (0.01 per 100000 population), Central Europe (0.01 per 100000 population), High-income Asia Pacific (0.01 per 100000 population), and Western Europe (0.01 per 100000 population) (Table 2).

Globally, the age-standardized DALYs rate (ASDR) for MHD was 123.15 (per 100000 population) in 1990 and 63.47 (per 100000 population) in 2021. The percentage change in age-standardized DALYs rate from 1990 to 2021 was -0.48 (-0.57, -0.38), and the EAPC was -2.1 (-2.16, -2.04) (Table 3 and Figure 3). In 2021, there was a significant difference of ASDR in the SDI and GBD regions. The ASDR of Low SDI was the highest, at 210.89 per 100000 population, followed by Low-middle SDI (85.54 per 100000 population), Middle SDI (26.84 per 100000 population), High-middle SDI (5.97 per 100000 population), and High SDI (4.18 per 100000 population) (Table 3). The regions with high ASDR in 2021 were Western Sub-Saharan Africa (251.68 per 100000 population), Central Sub-Saharan Africa (255.22 per 100000 population),

1990

2021



**Figure 2** The age-standardized deaths rate for maternal hypertensive disorders in 204 countries and regions in 1990 and 2021.

and Eastern Sub-Saharan Africa (191.51 per 100000 population). In contrast, regions with lower ASDR were Australasia (2.97 per 100000 population), East Asia (2.97 per 100000 population), Western Europe (2.88 per 100000 population), Central Europe (2.72 per 100000 population), and High-income Asia Pacific (1.9 per 100000 population) (Table 3).

**Table 3** The Age-Standardized DALYs Rate for Maternal Hypertensive Disorders in 1990 and 2021 and Their Temporal Trends from 1990 to 2021

Location	DALYs			
	Age-Standardised Rate per 100,000 Population, 1990	Age-Standardised Rate per 100,000 Population, 2021	Percentage Change in Age-Standardised Rate per 100,000 1990-2021	EAPC (95% CI)
Global	123.15(109.2,137.37)	63.47(53.55,76.02)	-0.48(-0.57,-0.38)	-2.1(-2.16,-2.04)
<b>GBD region</b>				
Andean Latin America	200.7(171.36,233.29)	58.68(44,76.4)	-0.71(-0.79,-0.61)	-4.19(-4.42,-3.95)
Australasia	6.01(4.32,8.44)	2.97(1.82,4.7)	-0.51(-0.62,-0.38)	-2.08(-2.33,-1.83)
Caribbean	124.67(100.3,154.48)	126.37(81.88,183.6)	0.01(-0.32,0.47)	0.75(0.52,0.97)
Central Asia	43.8(38.88,49.13)	11.46(9.48,13.84)	-0.74(-0.78,-0.69)	-4.09(-4.42,-3.77)
Central Europe	7.46(6.14,9.27)	2.72(1.87,3.95)	-0.63(-0.72,-0.54)	-2.81(-3.26,-2.35)
Central Latin America	84.5(76.19,92.66)	25.67(21.19,30.95)	-0.7(-0.75,-0.63)	-3.61(-3.83,-3.39)
Central Sub-Saharan Africa	611.23(436.47,800.29)	255.22(182.06,348.26)	-0.58(-0.72,-0.34)	-2.06(-2.38,-1.74)
East Asia	17.5(12.54,23.22)	2.97(2.18,4.01)	-0.83(-0.88,-0.74)	-5.36(-5.62,-5.1)
Eastern Europe	15.34(12.57,19.32)	5.93(3.63,9.3)	-0.61(-0.73,-0.49)	-2.62(-2.98,-2.25)
Eastern Sub-Saharan Africa	540.94(467.39,619.53)	191.51(155.03,233.27)	-0.65(-0.72,-0.56)	-3.17(-3.32,-3.01)
High-income Asia Pacific	5.47(4.33,6.91)	1.9(1.3,2.74)	-0.65(-0.73,-0.57)	-3.66(-4.11,-3.21)
High-income North America	7.71(5.68,10.78)	6.57(4.7,8.81)	-0.15(-0.29,0.02)	-0.32(-0.51,-0.12)
North Africa and Middle East	172.25(138.43,204.4)	34.77(26.2,45.35)	-0.8(-0.85,-0.74)	-4.78(-4.97,-4.58)
Oceania	87.07(51.57,128.05)	71.19(49.91,97.87)	-0.18(-0.47,0.41)	-0.55(-0.74,-0.35)
South Asia	239.29(203.52,272.23)	73.56(55.16,96.28)	-0.69(-0.77,-0.58)	-4(-4.2,-3.81)
Southeast Asia	158.33(132.51,184.49)	52.81(42.93,66.17)	-0.67(-0.74,-0.56)	-3.37(-3.44,-3.29)

(Continued)

**Table 3** (Continued).

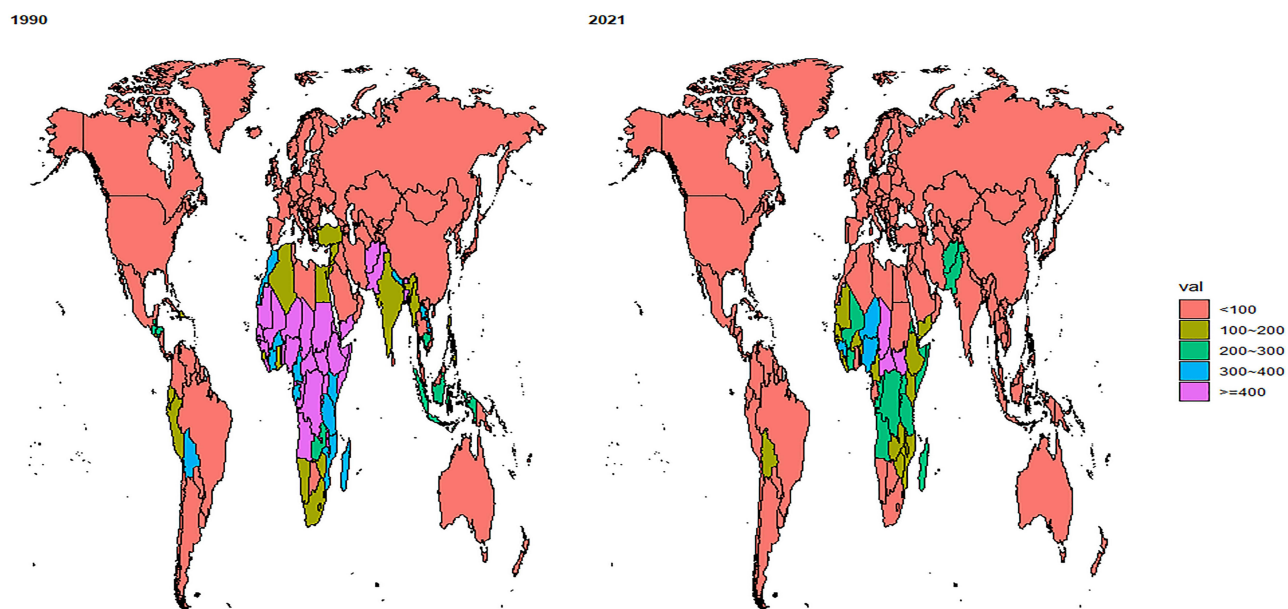
Location	DALYs			
	Age-Standardised Rate per 100,000 Population, 1990	Age-Standardised Rate per 100,000 Population, 2021	Percentage Change in Age-Standardised Rate per 100,000 1990-2021	EAPC (95% CI)
Southern Latin America	32.27(27.4,38.18)	10.74(8.1,14.07)	-0.67(-0.74,-0.58)	-2.79(-3.03,-2.55)
Southern Sub-Saharan Africa	149.51(115.62,196.21)	70.87(55.31,89.65)	-0.53(-0.66,-0.32)	-1.05(-2.09,0)
Tropical Latin America	93.61(84.17,104.29)	20.42(17.45,23.48)	-0.78(-0.81,-0.75)	-4.06(-4.5,-3.62)
Western Europe	4.73(3.72,6.3)	2.88(1.82,4.46)	-0.39(-0.53,-0.26)	-1.36(-1.52,-1.2)
Western Sub-Saharan Africa	419.31(329.99,508.31)	251.68(196.22,325.42)	-0.4(-0.56,-0.15)	-1.57(-1.66,-1.48)
<b>SDI quintile</b>				
High SDI	7.25(5.69,9.32)	4.18(2.91,5.92)	-0.42(-0.52,-0.32)	-1.7(-1.81,-1.6)
High-middle SDI	23.84(19.22,28.91)	5.97(4.66,7.62)	-0.75(-0.81,-0.68)	-4.19(-4.28,-4.1)
Middle SDI	72.63(63.89,81.83)	26.84(23.07,31.91)	-0.63(-0.69,-0.55)	-3.05(-3.12,-2.99)
Low-middle SDI	253.59(221.4,282.92)	85.54(69.11,106.12)	-0.66(-0.73,-0.58)	-3.49(-3.58,-3.39)
Low SDI	484.86(412.55,553.38)	210.89(173.87,255.87)	-0.57(-0.65,-0.45)	-2.57(-2.68,-2.46)

### Joinpoint Regression Analysis of Global Burden in Maternal Hypertensive Disorders

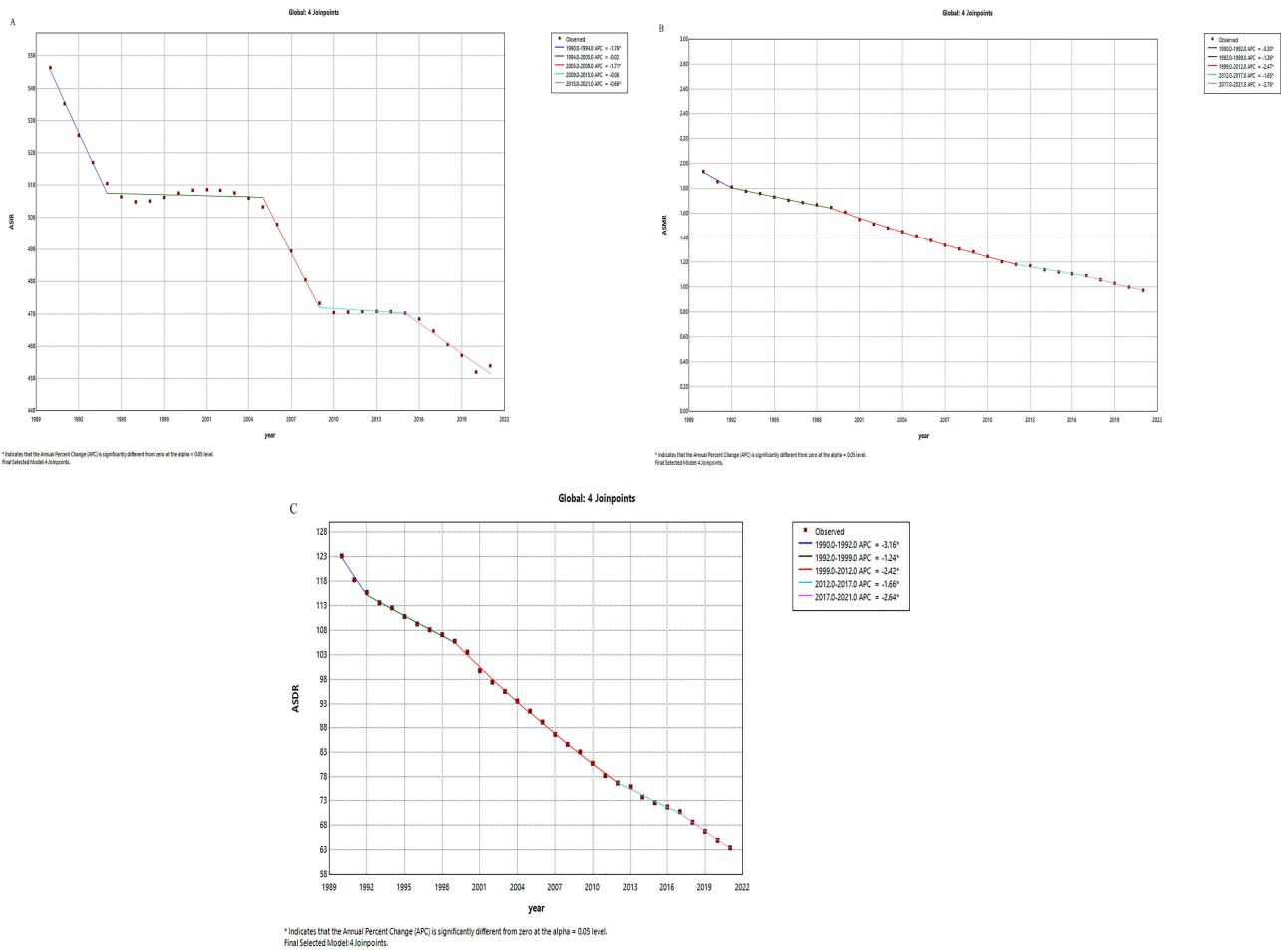
Globally, the ASIR (AAPC=-0.5982, 95% CI: -0.6652, -0.5310, p<0.05), ASMR (AAPC=-2.1812, 95% CI: -2.3257, -2.0364, p<0.05), and ASDR (AAPC=-2.116, 95% CI: -2.2442, -1.9789, p<0.05) of MHD showed an overall downward trend from 1990 to 2021 (Figure 4). The most significant decline in ASIR globally occurred from 1990 to 1994 (APC=-1.76, 95% CI: -2.02, -1.50, p<0.05) (Figure 4A) and remained stable from 1994 to 2005 and from 2009 to 2015. Globally, the most significant decline in ASMR occurred from 1990 to 1992 (APC=-3.30, 95% CI: -4.58, -2.01, p<0.05) (Figure 4B). The most significant decline in ASDR globally occurred from 1990 to 1994 (APC=-3.16, 95% CI: -4.33, -1.98, p<0.05) (Figure 4C).

### Analysis of Health Inequalities in MHD

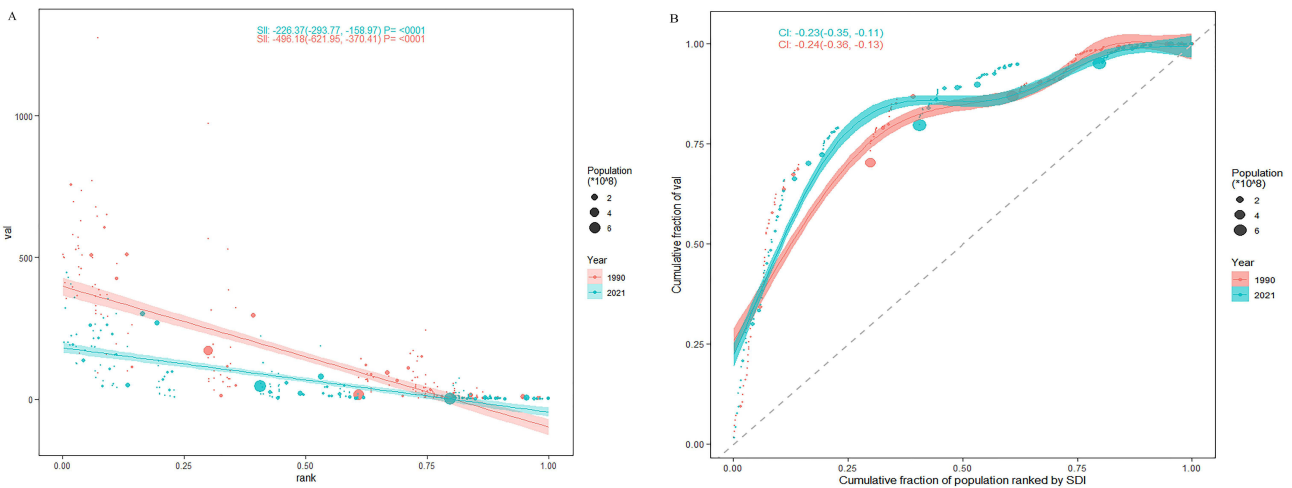
This study indicated significant absolute and relative inequality in MHD burden across different SDI regions. In global, 204 countries and regions, countries with lower SDI levels bore a higher burden. As shown in Figure 5, the SII of ASDR



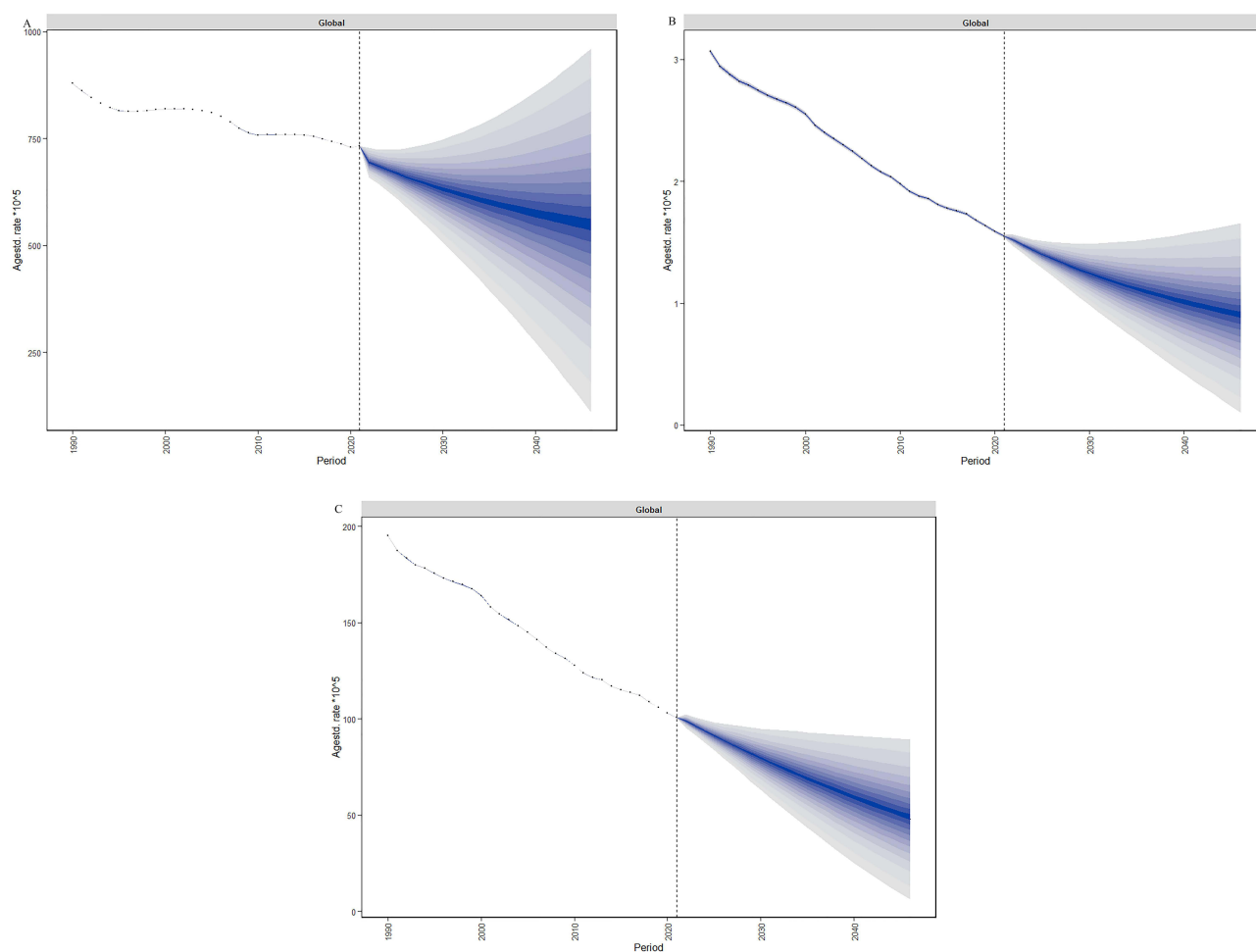
**Figure 3** The age-standardized DALYs rate for maternal hypertensive disorders in 204 countries and regions in 1990 and 2021.



**Figure 4** Joinpoint regression analysis of ASIR (A), ASMR (B), and ASDR (C) for global MHD from 1990 to 2021.



**Figure 5** The health inequality regression curve (A) and concentration curve (B) of DALYs for MHD in 1990 and 2021.



**Figure 6** The predicted incidence (A), mortality (B), DALYs (C) rates of MHD for the next 25 years.

was  $-496.18$  ( $-621.95$ ,  $-370.41$ ) in 1990, and it was  $-226.37$  ( $-293.77$ ,  $-158.97$ ) in 2021 (Figure 5A). The concentration index of the health inequality was  $-0.24$  ( $-0.36$ ,  $-0.13$ ) in 1990 and  $-0.23$  ( $-0.35$ ,  $-0.11$ ) in 2021 (Figure 5B).

## Predicted Trends

The predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend (Figure 6A–C).

## Discussion

Preeclampsia and eclampsia in maternal hypertensive disorders were the main causes of maternal mortality, often occurring in underdeveloped countries. The medical burden of preeclampsia was significant. The hospitalization cost for premature infants born to women with severe preeclampsia was twice that of newborns born to women with no hypertension in pregnancy. This study used GBD 2021 data to comprehensively evaluate the burden of MHD in global, 204 countries and regions, as well as the global burden trend over the next 25 years.

The most significant decline in ASIR globally occurred from 1990 to 1994 and remained stable from 1994 to 2005 and from 2009 to 2015. The most significant decline in ASMR globally occurred from 1990 to 1992. The most significant decline in ASDR globally occurred from 1990 to 1994. In 2021, the distribution of the ASIR, ASMR, and ASDR in the five SDI regions and GBD regions was roughly consistent. The ASIR, ASMR, ASDR for Low SDI and African regions were relatively high, while the ASIR, ASMR, ASDR of high-income Europe regions were low. The analysis of health

inequalities of MHD showed that regions with lower SDI levels bore a higher burden. The predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend.

This study indicated that the global ASIR, ASMR and ASDR of MHD were both showing a downward trend, and the predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend. However, the ASIR, ASMR and ASDR of MHD in underdeveloped countries such as African regions were relatively high, and low-income countries bore a higher burden. In 2019, hypertension in Mexican pregnant women was highly lethal (58 deaths per 100000 cases).<sup>3</sup> The mortality rate of all maternal diseases was higher among women over 35 years old.<sup>3</sup> From 1999 to 2021, the incidence rate of MHD in Brazil, India and South Africa in the BRICS countries was declining in all age groups, but the majority of age groups in China and Russian Federation showed an upward trend.<sup>2</sup> The burden of HDP in Africa was high from 1997 to 2017.<sup>9</sup> The prevalence of HDP in Africa was the highest in the world.<sup>9</sup> The prevalence of HDP in Africa increased with the improvement of national income levels, possibly due to advanced health systems, professional healthcare providers, and higher education levels, which strengthened the emphasis on prenatal checkups.<sup>9</sup> Our study showed that low SDI and African regions had higher ASIR, while high-income countries such as European regions had lower ASIR. Some studies were consistent with our research, which suggested that differences between women with African or European ancestry were due to factors such as low socio-economic status, lower income and education levels, lack of medical insurance, underutilization of pre-pregnancy and antenatal services, stress, discrimination, and more.<sup>13,14</sup>

MHD posed many hazards to women and their offspring. Patients with a history of HDP might be at risk of stroke, early CAD, aortic dissection, and offspring strabismus.<sup>15–18</sup> In addition, the offspring of pregnant women with pre-eclampsia were at increased risk of psychological, respiratory, behavioral, learning difficulties, and infection.<sup>5</sup> A meta-analysis showed that the overall prevalence of preeclampsia and eclampsia in Nigerian pregnant women was 4.51% and 1.39%, respectively.<sup>4</sup> The maternal mortality rate associated with preeclampsia or eclampsia was 6.04%, and the fetal mortality rate was 16.73%.<sup>4</sup> The risk factors of preeclampsia or eclampsia included family history of diabetes or hypertension, young or older age, high BMI, low education level, low economic ability, anemia during pregnancy and irregular prenatal examination.<sup>5,13,19</sup> From 2000 to 2021, the maternal mortality rate caused entirely by eclampsia in Brazil showed a decreasing trend, with eclampsia mainly occurring in those over 50 years old, widowed, with low education levels, and black women.<sup>20</sup>

Although our research suggests that the predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend. However, the serious complications and mortality rates of MHD suggest that we should develop better public health policies. Firstly, strengthen the identification, prevention, and management of MHD among medical staff. Secondly, regularly conduct lectures to learn about relevant guidelines, understand the correct measurement methods of blood pressure and commonly used therapeutic drugs, and provide training on obstetric emergency skills. Strengthen education for pregnant women and improve their management of blood pressure, blood sugar, body weight, and diet. Include screening for preeclampsia in pregnant women in the scope of medical insurance. For women with low economic levels, free examinations can be conducted, and corresponding iron supplements or calcium tablets can be provided according to the pregnant woman's condition. Strengthen the popularization of eugenics and child rearing, and reduce the occurrence of premature or advanced pregnancy. Establish a nursing clinic specifically for high-risk pregnancies, providing nutrition and MHD education to pregnant women to alleviate their anxiety. If the pregnant woman's condition is severe, she should be transferred to a tertiary healthcare institution for further management as soon as possible. For pregnant women with poor compliance, the community provides on-site prenatal care visits and consultations.

This study analyzed in detail the burden of MHD in global, 204 countries and regions through the GBD database and predicted future development trends. This study had the advantages of wide coverage, long observation period, and large data volume. However, this study still had some limitations. Firstly, the data in this study came from different countries and regions, which might result in delayed diagnosis and omissions of diseases, as well as errors in data collection and registration. Secondly, populations in different SDI regions might refuse medical treatment due to low economic capacity, lack of medical insurance, and might affect the integrity of the data. Besides, the methods were limited due to the parameters used. Furthermore, this study did not take into account the impact of factors such as conflict areas, natural

disasters and famine on the burden of MHD. Also, this study could only reflect the average level of the group and could not determine the relationship between individual exposure and disease. Finally, GBD data had lag.

## Conclusion

This study analyzed the burden of MHD in global, 204 countries and regions from 1999 to 2021 and its trends over the next 25 years. Although ASIR, ASMR, and ASDR of MHD were all showing a downward trend globally across global, different SDI zones and GBD regions. The predicted incidence, mortality, and DALYs rates of MHD for the next 25 years are both showing a downward trend. However, this study found that Africa and low SDI regions bore a significant burden. The disparity in economic development could lead to an exacerbation of health inequalities. Therefore, it was emphasized that relevant public health policies should be formulated for African and low SDI regions. Medical staff should raise awareness of the risks of MHD and actively handle emergencies caused by MHD to reduce mortality, and DALYs rates and alleviate social burden.

## Data Sharing Statement

All original data is available at <https://vizhub.healthdata.org/gbd-results/>.

## Ethics Declarations

The study received ethical approval from the Ethics Committee of Zhangjiagang TCM Hospital Affiliated to Nanjing University of Chinese Medicine (approval number: KY2024SZK0123).

## 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.

## Funding

This study was supported by the Gusu Health Talent Plan Research Project (No.GSWS2023016); the Science and Technology Development Plan of Suzhou (No.SLT2022012, SKYD2022010); School-Land Collaborative Innovation Research Project of Jiangsu Pharmaceutical Vocational College (No.20239602); and the Science and Technology Research Program of Suzhou (No.SYWD2025370).

## Disclosure

The authors declare no competing interests. We clarify that there are no funding sources or affiliations that may influence the design, analysis, or interpretation of the research.

## References

1. Maternal hypertensive disorders - Level 4 cause. Available from: <https://www.healthdata.org/research-analysis/diseases-injuries-risks/factsheets/2021-maternal-hypertensive-disorders-level-4>. Accessed January 27, 2025.
2. Wang X, et al. Time trends in maternal hypertensive disorder incidence in Brazil, Russian Federation, India, China, and South Africa (BRICS): an age-period-cohort analysis for the GBD 2021. *BMC Pregnancy Childbirth*. 2024;24:731. doi:10.1186/s12884-024-06931-z
3. Montoya A, Lozano R, Sanchez-Dominguez M, Fritz J, Burden L-FH. Incidence, mortality and lethality of maternal disorders in Mexico 1990-2019: an analysis for the global burden of disease study 2019. *Arch Med Res*. 2023;54:152-159. doi:10.1016/j.arcmed.2022.12.013
4. Kokori E, Aderinto N, Olatunji G, et al. Prevalence and materno-fetal outcomes of preeclampsia/eclampsia among pregnant women in Nigeria: a systematic review and meta-analysis. *Eur J Med Res*. 2024;29:482. doi:10.1186/s40001-024-02086-x
5. Socol FG, Bernad E, Craina M, et al. Health impacts of pre-eclampsia: a comprehensive analysis of maternal and neonatal outcomes. *Medicina*. 2024;60:1486. doi:10.3390/medicina60091486
6. Li R, Tsigas EZ, Callaghan WM. Health and economic burden of preeclampsia: no time for complacency. *Am J Obstet Gynecol*. 2017;217:235-236. doi:10.1016/j.ajog.2017.06.011
7. Hersh AR, Mischkot BF, Greiner KS, Garg B, Caughey AB. Maternal and infant hospitalization costs associated with hypertensive disorders of pregnancy in a California cohort. *J Matern Fetal Neonatal Med*. 2022;35:4208-4220.
8. Khowaja AR, Qureshi RN, Sawchuck D, et al. The feasibility of community level interventions for pre-eclampsia in South Asia and Sub-Saharan Africa: a mixed-methods design. *Reprod Health*. 2016;Suppl 13(S1):56. doi:10.1186/s12978-016-0133-0

9. Noubiap JJ, Bigna JJ, Nyaga UF, Noubiap JJ, et al. The burden of hypertensive disorders of pregnancy in Africa: a systematic review and meta-analysis. *J Clin Hypertens*. 2019;21:479–488. doi:10.1111/jch.13514
10. GBD. Available from: <https://www.healthdata.org/research-analysis/about-gbd>. Accessed January 27, 2025.
11. GBD Results tool updates. Available from: <https://vizhub.healthdata.org/gbd-results/>. Accessed Jan 27, 2025.
12. Zhang D, Liu S, Li Z, Wang R. Global, regional and national burden of gastroesophageal reflux disease, 1990–2019: update from the GBD 2019 study. *Ann Med*. 2022;54:1372–1384. doi:10.1080/07853890.2022.2074535
13. Nakimuli A, Chazara O, Byamugisha J, et al. Pregnancy, parturition and preeclampsia in women of African ancestry. *Am J Obstet Gynecol*. 2014;210:510–520.e1. doi:10.1016/j.ajog.2013.10.879
14. Ngene NC, Moodley J. Preventing maternal morbidity and mortality from preeclampsia and eclampsia particularly in low- and middle-income countries. *Best Pract Res Clin Obstet Gynaecol*. 2024;94:102473. doi:10.1016/j.bpobgyn.2024.102473
15. Qu K, Li M, Yu P, Jiang W, Dong M. Hypertensive disorders of pregnancy and stroke: a univariate and multivariate Mendelian randomization study. *Front Endocrinol*. 2024;15:1366023. doi:10.3389/fendo.2024.1366023
16. Vaughan LE, Kanaji Y, Suvakov S, et al. Hypertensive disorders of pregnancy increase the risk for myocardial infarction: a population-based study. *J Am Coll Cardiol*. 2024;84:2264–2274. doi:10.1016/j.jacc.2024.06.049
17. Eghan P, Folsom AA, Donkor A, Kokuro C, Amo Wiafe Y. Relationship between hypertensive disorders of pregnancy (HDP) and cardiac remodeling during pregnancy: systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. 2024;298:108–115. doi:10.1016/j.ejogrb.2024.05.003
18. Zhu H, You X, Jing Y, et al. Maternal hypertensive disorder in pregnancy and childhood strabismus in offspring. *JAMA Netw Open*. 2024;7:e2423946. doi:10.1001/jamanetworkopen.2024.23946
19. Meazaw MW, Chojenta C, Muluneh MD, Loxton D. Systematic and meta-analysis of factors associated with preeclampsia and eclampsia in sub-Saharan Africa. *PLoS One*. 2020;15:e0237600. doi:10.1371/journal.pone.0237600
20. Flávio-Reis VHP, Pessoa-Gonçalves YM, Barbosa AD, et al. Maternal deaths caused by eclampsia in Brazil: a descriptive study from 2000 to 2021. *Rev Bras Ginecol Obstet*. 2024;46:e-rbgo65. doi:10.61622/rbgo/2024rbgo65

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