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Original Article

Maternal mortality trends and profile in Baixada Maranhense, 2013-2022: time series analysis

Tendência e perfil da mortalidade materna na Baixada Maranhense, 2013-2022: análise de série temporal

Tendencias y perfil de la mortalidad materna en la Baixada Maranhense, 2013-2022: análisis de series temporales

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ABSTRACT

Background and Objectives: Reducing maternal mortality remains an unsolved global challenge and is part of the 2030 Agenda, established by the United Nations through the Sustainable Development Goals. This study aimed to analyze the temporal trend of the Maternal Mortality Ratio (MMR) and the epidemiological profile of maternal deaths in *Baixada Maranhense*, Brazil. **Methods:** Time-series analysis study, which included all maternal deaths reported in *Baixada Maranhense*, from 2013 to 2022, obtained from the Mortality Information System made available by the Department of Information and Informatics of the Unified Health System (DATASUS). Statistical analysis employed Prais-Winsten generalized linear regression modeling. **Results:** During the analyzed period, 90 maternal deaths were reported. The average MMR was 98.6 maternal deaths per 100,000 live births (standard deviation ± 23.83). A statistically significant increasing trend in the MMR was identified, with an average annual increase of 6.18% (95% CI: 3.12−9.32; p<0.0001). Brown women (62.2%), aged 20 to 29 years (40.0%), single (43.3%) and with 8 to 11 years of education (58.9%) constituted the main group of victims. Hypertensive syndromes (30.0%) and postpartum hemorrhage (13.3%) were the main causes of death. The majority of deaths occurred during pregnancy, childbirth or puerperium (36.7%), being classified as direct obstetric (88.9%), occurred in hospitals (88.9%) and investigated (66.7%). **Conclusion:** The MMR remains high in *Baixada Maranhense*, still far from achieving national and international targets, making its reduction a challenge.

Keywords: *Maternal death. Health profile. Public policy. Health information systems. Time series analysis.*

RESUMO

Justificativa e Objetivos: A redução da mortalidade materna permanece como um desafio não resolvido mundialmente e integra a Agenda 2030, estabelecida pela Organização das Nações Unidas por meio dos Objetivos de Desenvolvimento Sustentável. Objetivou-se analisar a tendência temporal da Razão de Mortalidade Materna (RMM) e o perfil epidemiológico dos óbitos maternos na Baixada Maranhense, Brasil. **Métodos:** Estudo de análise de série temporal, que incluiu todos os óbitos maternos notificados na Baixada Maranhense, no período de 2013 a 2022, obtidos a partir do Sistema de Informação de Mortalidade disponibilizados pelo Departamento de Informação e Informática do SUS (DATASUS). A análise estatística empregou modelagem por regressão linear generalizada de Prais-Winsten. **Resultados:** No período analisado notificaram-se 90 óbitos maternos. A RMM média foi de 98,6 óbitos maternos por 100.000 nascidos vivos (desvio padrão±23,83). Identificou-se tendência crescente estatisticamente significativa na RMM, com aumento médio anual de 6,18% (IC95%: 3,12−9,32; p<0,0001). Mulheres pardas (62,2%), na faixa etária de 20 e 29 anos (40,0%), solteiras (43,3%) e com 8 a 11 anos de estudos (58,9%), constituíram o principal grupo de vítimas. As síndromes hipertensivas (30,0%) e hemorragia pós-parto (13,3%) foram as principais causas de óbito. A maioria dos óbitos ocorreu durante a gravidez, parto ou puerpério (36,7%), sendo classificada como obstétrica direta (88,9%), ocorrida em hospitais (88,9%) e investigada (66,7%). **Conclusão:** A RMM permanece alta na Baixada Maranhense ainda distante do alcance das metas nacionais e internacionais, sendo sua redução um desafio.

Descritores: *Morte materna. Perfil epidemiológico. Políticas públicas. Sistema de informação em saúde. Análise de série temporal.*

RESUMEN

Justificación y Objetivos: Reducir la mortalidad materna sigue siendo un desafío global sin resolver y forma parte de la Agenda 2030, establecida por las Naciones Unidas a través de los Objetivos de Desarrollo Sostenible. Este estudio tuvo como objetivo analizar la tendencia temporal de la Razón de Mortalidad Materna (RMM) y el perfil epidemiológico de las muertes maternas en *Baixada Maranhense*, Brasil. **Método:** Estudio de análisis de series temporales, que incluyó todas las muertes maternas reportadas en *Baixada Maranhense*, de 2013 a 2022, obtenidas del Sistema de Información de Mortalidad puesto a disposición por el Departamento de Información e Informática del Sistema Único de Salud (DATASUS). El análisis estadístico empleó el modelo de regresión lineal generalizada de Prais-Winsten. **Resultados:** Durante el período analizado, se reportaron 90 muertes maternas. La tasa de mortalidad materna (TMM) promedio fue de 98,6 muertes maternas por cada 100.000 nacidos vivos (desviación estándar ± 23,83). Se identificó una tendencia creciente estadísticamente significativa en la TMM, con un incremento anual promedio de 6,18% (IC del 95%: 3,12−9,32; p<0,0001). Las mujeres de piel morena (62,2%), de 20 a 29 años (40,0%), solteras (43,3%) y con 8 a 11 años de escolaridad (58,9%) constituyeron el principal grupo de víctimas. Los síndromes hipertensivos (30,0%) y la hemorragia posparto (13,3%) fueron las principales causas de muerte. La mayoría de las muertes ocurrieron durante el embarazo, parto o puerperio (36,7%), siendo clasificadas como obstétricas directas (88,9%), ocurridas en hospitales (88,9%) e investigadas (66,7%). **Conclusión:** La tasa de mortalidad materna (RMM) se mantiene alta en *Baixada Maranhense*, lejos aún de alcanzar las metas nacionales e internacionales, lo que dificulta su reducción.

Palabras Clave: *Muerte materna. Perfil de salud. Política pública. Sistemas de información en salud. Análisis de Series de Tiempo.*

INTRODUCTION

Maternal death represents a serious violation of women's human, sexual and reproductive rights, as it is a premature and preventable tragedy in 92% of cases, affecting mostly developing countries.[1] The reduction in one of the main challenges faced by health systems at a global level.[1-2] This commitment is incorporated in the 2030 Agenda, proposed by the United Nations (UN), through the Sustainable Development Goals (SDGs).[2]

Specifically, SDG Target 3.1 sets the goal of reducing global MMR to less than 70 maternal deaths per 100,000 live births (LBs) by 2030. In order to adapt this goal to national contexts and challenges, the Federal Government, in partnership with the Institute of Applied Economic Research (IPEA), carried out an adaptation of the SDGs to the Brazilian reality. As a result, the nationalized SDG Target 3.1 was redefined to: by 2030, reduce the MMR in Brazil to a maximum of 30/100,000 LB.[1-2]

The MMR is an important indicator of women's health, reflecting not only biological aspects, but also socioeconomic factors, gender inequalities, quality of obstetric care and political commitment to the promotion of public therefore, the best management tool for production and systematization of new resources to reduce the morbidity and mortality numbers of women of childbearing age.[3]

In 2022, Brazil recorded an RMM of 57.7/100,000 LB, still far from the agreed reduction target of a maximum of 30/100,000 NV by 2030.[1] The Northeast region presented one of the highest MMR indices in the country with 73.1/100,000 LB. Maranhão had a MMR of 91.9/100,000 LB, being the 5th state in Brazil and the 3rd in the Northeast region with the highest number of maternal deaths, behind only Piauí and Sergipe.[5] It is noteworthy that regions with lower per capita income are the most affected by maternal mortality, which is evidenced by the low socioeconomic and health conditions that impact this indicator.[1,5]

In Brazil, direct obstetric maternal death continues to be responsible for maintaining high levels of MMR. Pregnancy-specific hypertensive syndromes (PSHS), hemorrhages, puerperal infection and complications of unsafe abortion are the four main causes of maternal death. All these causes are treatable and could be avoided through timely and equitable access to adequate and high-quality health services, including follow-up during the pregnancy-puerperium period, performed by properly trained health professionals, especially in the first weeks after delivery, a critical period for maternal health.[3,5]

Given this, the reduction of MMR in Brazil is still a challenge for both health services and society in general. The high maternal mortality rates reflect the disarticulation, disorganization and low quality of health offered to women during pregnancy, childbirth and puerperium, reflecting weaknesses in the care line and in the maternal-child health care network.[1]

Therefore, considering the growing MMR in recent years, it was highlighted the need to conduct an investigation into maternal deaths occurred in *Baixada Maranhense* in the last decade, since to reach its reduction, it is necessary to know its magnitude. It should be noted that Maranhão remains one of the states with one of the worst human development indices (HDI) and lowest per capita income in the country, with direct repercussions on social assistance and women's health.[6] what is the MMR and epidemiological characteristics of maternal deaths occurred in *Baixada Maranhense*? The objective of this study was to analyze the temporal trend of MMR and the epidemiological profile of maternal deaths in *Baixada Maranhense*, Brazil.

METHODS

Design

This is an analytical, cross-sectional and quantitative study that analyzed all maternal deaths of women of childbearing age (10-49 years) living in the Baixada Maranhense region, reported from 2013 to 2022. The study followed the recommendations of the STROBE checklist for observational studies in epidemiology.[7]

Context

The geographical area of interest was the Baixada Maranhense, composed by 21 municipalities, namely: Anajatuba, Arari, Bela Vista do Maranhão, Cajari, Conceição do Lago Açu, Igarapé do Meio, Matinha, Monção, Olinda Nova do Maranhão, Palmeirândia, Pedro do Rosário, Penalva, Peri-mirim, Pinheiro, President Sarney, Saint Helena, São Bento, São João Batista, São Vicente Ferrer, Viana and Vitória do Mearim. *Baixada Maranhense* is a region of approximately 20,000 km 2, has a population of approximately 639,553 inhabitants, with predominantly rural population, except for the municipalities of Pinheiro, Arari, São Bento, Santa Helena and Viana that present a more expressive urban population predominance.[8]

It is evident that *Baixada Maranhense* presents specific structural challenges in maternal and childcare. Aspects such as limited access to health services and marked socioeconomic inequalities are determinants that directly affect the health indicators of this population. In addition, the region is characterized by a peculiar geography, composed of extensive flooded areas and island chains, which makes land access limited and often dependent on waterway transport. This geographical condition historically contributes to difficulties in inter-municipal transport, causing delays

and restrictions in timely access to health services, especially those of medium and high complexity.[8-9]

Data source and selection criteria

Anonymized data were used for all cases of maternal deaths, obtained from death certificates, reported in the Mortality Information System (SIM - *Sistema de Informação sobre Mortalidade* in Portuguese) in *Baixada Maranhense*, from 2013 to 2022, provided by the Department of Informatics of the Unified Health System (DATASUS) of the Ministry of Health, accessible at: http://www.datasus.gov.br. Data collection was carried out in November 2024. The period from 2013 to 2022 was chosen because it corresponds to the last decade with updated final data available in SIM at the time of data collection. The inclusion criteria were all deaths of women of childbearing age, aged 10 to 49 years, that occurred during pregnancy, childbirth or puerperium up to one year after these events in the period from 2013 to 2022 from any cause. Maternal deaths from non-obstetric causes were excluded, as they result from incidental or accidental causes and are not directly related to pregnancy, childbirth or puerperium and their management, in addition to not being included in the calculation of MMR.

Variables

The variables investigated were: year of notification, age group, race/color, schooling, marital status, cause of maternal death, time of maternal death in the gestational-puerperal cycle, type of maternal death, place of occurrence of death, investigation of death and MMR.

Maternal death is defined as the death of a woman during pregnancy or up to 42 days after the end of pregnancy, regardless of the duration or location of the pregnancy, due to any cause related to or aggravated by the pregnancy or measures taken in relation to it, but not due to accidental or incidental causes. It is classified as direct obstetric, indirect obstetric and non-obstetric. Direct obstetric maternal death is the one that occurs due to obstetric complications, during pregnancy, childbirth or puerperium, related to interventions, omissions, incorrect treatment or a chain of events resulting from any of these causes. Indirect obstetric maternal death is the result of pre-existing diseases before pregnancy or those that developed in the gestational period, aggravated by the physiological effects of pregnancy.[10]

The analysis of the basic causes of death was carried out from the 10th Revision of the International Classification of Diseases (ICD-10) with emphasis on chapter XV - Pregnancy, childbirth and puerperium (exceptions: O96 and O97), and by conditions classified in other chapters, such as: obstetric tetanus (A34), postpartum mental and behavioral disorders (F53), puerperal osteomalacia (M83.0), disease caused by HIV (B20 to B24, recently updated to O98.7), malignant or invasive hydatidiform mole (D39.2) and postpartum hypophyseal necrosis (E23.0).[10]

Data analysis

After collection, all collected data were entered into a database of the Microsoft Excel® 2021 program. Soon after, they were exported and analyzed using descriptive statistics resources, using the R software (version 4.5.1), in the R Studio® environment. Absolute and relative frequencies of the study variables were calculated and presented in tables and figures.

For the description of maternal deaths, measures of central tendency, dispersion, MMR, average MMR and variation (□) of MMR were calculated. For the calculation of the MMR indicator, data on the number of maternal deaths per 100,000 LB of mothers resident in *Baixada Maranhense* were used, in the years 2013-2022, according to the following formula:

$$\text{MMR} = \frac{\begin{array}{c}\textit{n.}\text{ of deaths of the women,}\\ \text{from causes and conditions considered maternal death}\end{array}}{\text{n. of live births of the women}} x100.000$$

The parameters of the World Health Organization (WHO) were used to classify the indicator MMR: low - up to 20/100,000 LB; average - from 20 to 49/100,000 LB; high - from 50 to 149/100,000 LB and very high - < that 150/100,000 LB.[1] The data regarding the number of live births of mothers living in *Baixada Maranhense* were collected from the Information System on Live Births (SINASC), made available by DATASUS.

To estimate the average MMR, the simple arithmetic mean of the annual MMR values for the period 2013-2022 was calculated according to the following formula:

$$Average\ MMR = \frac{\sum annual\ MMR}{n}$$

The variation (□) of the MMR in the period 2013-2022 was calculated in order to identify relative (or proportional) changes between the base year (initial) and the years belonging to the time series. The calculation of the total change in MMR was obtained by dividing the value of the MMR of the last (current) year for the year 2022 by the value of the base (initial) MMR equivalent to the year 2013, subtracting the reference value (-1) and multiplying it by 100, to obtain the variation in percentage terms, according to formula:

$$\Delta MMR \left[\frac{(current\ MMR)}{(initial\ MMR)} - 1\right] x100$$

To analyze the evolution of MMR, we estimated the trend over time from generalized linear regression of Prais-Winsten, by the analysis of regression coefficient (β), coefficient of determination (R 2), annual variation of rates and confidence intervals (95%CI), considering a significance level $p < 0.05$. The regression results were interpreted as: increasing trend when p-value was less than 0.05 and regression coefficient was positive; decreasing trend when p-value was less than 0.05 and

regression coefficient was negative; or stationary trend when the p value was greater than 0.05.11 In addition, a MMR equal to 70/100,000 LB was used as reference value for the UN SDG Target 3.1.

Ethical Aspects

Because it is the use of anonymized secondary data from public domain databases, as recommended by the General Law on the Protection of Personal Data no 13.709/2018, the study did not need to be submitted to the according to Resolutions no 510/2016 and no 466/2012 of the National Health Council.

RESULTS

In the period from 2013 to 2022, in *Baixada Maranhense*, 90 maternal deaths were reported in the age group of 10-49 years. The mean was 9 maternal deaths per year (SD 2.05), median 8.5 (minimum of 6 and maximum of 8 maternal deaths). The years of 2016 and 2021, stood out with the highest number of records, 12 deaths (13.3%), respectively. In 2014, the lowest number was 6 maternal deaths (6.7%).

The average MMR of *Baixada Maranhense* in the period from 2013 to 2022 was 98.63/100,000 NV (SD 23.83). There was average growth of MMR over the period investigated, with an average rate of increase of 2.34% per year, even with years of punctual fall. Mortality peaks were identified in 2016 (130.2/100,000 LB) and 2021 (134.3/100,000 LB), when compared to previous years. In the last year of the historical series, after the Covid-19 pandemic, 2022 had a decrease of 21.4% of RMM, compared to 2012 (85.7/100,000 LB). The MMR in 2021 was 134.3/100,000 NV, with an increase of 28.5% compared to the pre-pandemic period (Figure 1).

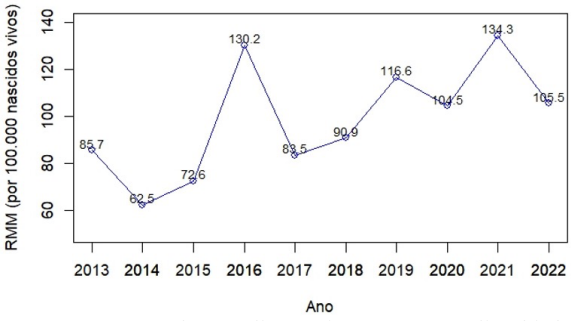

Figure 1. Maternal Mortality Ratio per 100,000 live births in the age group 10-49 years, *Baixada Maranhense*, Brazil, 2013 to 2022.
Abbreviation: MMR (per 100,000 live births).

The MMR trend analysis indicated a significant average annual growth of 6.18% (95%CI: 3.12% - 9.32%; p < 0.0001) in the period 2013-2022, represented graphically by the blue line that corresponds to the average growth trend over time. There is a positive slope, confirming the progressive increase of MMR during the analyzed period. After model adjustment, 96% of the MMR variation was explained by time (R2=96%). About the baseline of the Goal 3.1 ODS (MMR = 70/100,000 LB), it was observed that the target was exceeded only in 2014 (MMR = 62.5/100,000 LB), with no consistent approximation until 2022 and still far from the national target (RMM < 30/100,000 NV) (Figure 2).

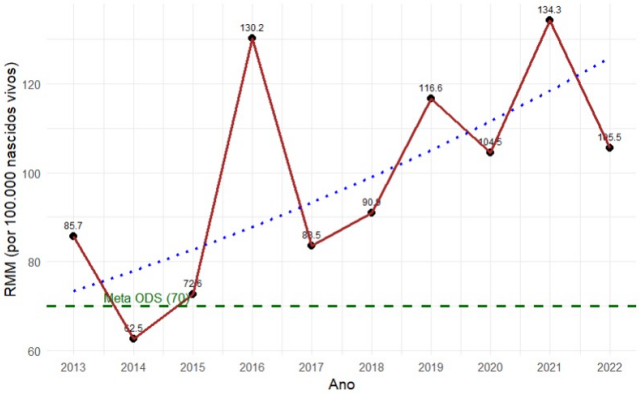

Figure 2. Evolution of the Maternal Mortality Ratio per 100,000 live births in the age group 10-49 years, *Baixada Maranhense*, Brazil, 2013 to 2022.
Abbreviation: MMR (per 100,000 live births). Year.

As for the socioeconomic profile of women who evolved to maternal death recorded in the SIM, in *Baixada Maranhense*, between 2013 and 2022, most women were aged between 20 and 29 years (40%), brown race/color (62.2%), single (43.3%) and with 8 to 11 years of education (58.9%) (Table 1).

Table 1. Socioeconomic characterization of women with maternal death in *Baixada Maranhense*, Brazil, 2013 to 2022.

Variables	N (%)
Age group (years)	
10 - 19	21 (23.3)
20 - 29	36 (40.0)
30 - 39	28 (31.1)
40 - 49	5 (5.6)
Race/Color	
White	14 (15.6)
Black	18 (20.0)
Brown	56 (62.2)
Ignored	2 (2.2)
Marital Status	
Single	39 (43.3)
Married	17 (18.9)
Stable union	29 (32.2)
Ignored	5 (5.6)
Education (years of study)	
None	2 (2.2)
1 - 3	5 (5.6)
4 - 7	18 (20.0)
8 - 11	53 (58.9)
≥12	3 (3.3)
Ignored	9 (10.0)

The main direct obstetric causes of maternal death identified were: 1) PSHS with 27 cases (30.0%), highlighting 15 deaths due to eclampsia (16.7%) and 7 deaths due to gestational hypertension with significant proteinuria and; 2) postpartum hemorrhage, 12 deaths (13.3%). Among the indirect obstetric causes are 8 deaths from pre-existing diabetes mellitus (8.9%). The majority of deaths occurred during pregnancy, childbirth or puerperium (36.7%), classified as direct obstetric (88.9%), occurring in hospitals (88.9%) and investigated (66.7%) (Table 2).

Table 2. Epidemiological characterization of maternal deaths in *Baixada Maranhense*, Brazil, 2013 to 2022.

Variables	N (%)
ICD-10 Category	
Gestational Specific Hypertensive Syndromes	
O15 Eclampsia	15 (16.7)
O14 Gestational hypertension with significant proteinuria	7 (7.8)
O16 Maternal hypertension not specified	3 (3.3)
O10 Pre-existing hypertension complicating pregnancy, childbirth and puerperium	1 (1.1)
O13 Gestational hypertension without significant proteinuria	1 (1.1)
Hemorrhages	
O72 Postpartum hemorrhage	12 (13.3)
Other Causes	
O75 Other complications of labor and delivery not classified elsewhere	9 (10.0)
O99 Other diseases of the mother, classified elsewhere, but that complicate pregnancy, childbirth and puerperium	6 (6.8)
O03 Spontaneous abortion	3 (3.3)
O05 Other types of abortion	2 (2.2)
O07 Failure to attempt abortion	1 (1.1)
O08 Complications due to miscarriage, ectopic or molar pregnancy	1 (1.1)
O85 Puerperal infection	2 (2.2)
Others[1]	27 (30.0)
Maternal Death in the Pregnancy-Puerperal Cycle	
During pregnancy, childbirth or abortion	33 (36.7)
During puerperium under 1 year	21 (23.3)
Unspecified	11 (12.2)
Ignored	25 (27.8)
Classification of Maternal Death	
Direct obstetric	80 (88.9)
Obstetric indirect	8 (8.9)
Unspecified	2 (2.2)
Place of the Fact	
Hospital	80 (88.9)
Other health care facility	2 (2.2)
House	4 (4.4)
Public road	2 (2.2)
Others	2 (2.2)
Death Investigated	
Yes	60 (66.7)
No	30 (33.3)

Abbreviation: The category "Other" corresponds to the following causes: O00 Ectopic pregnancy (n=5), O01 Hydatidiform mole (n=1), O42 Premature rupture of membranes (n=2), O43 Placenta disorder (n=1), O44 Placenta previa (n=1), O45 Premature detachment of the placenta (n=5), O62 Uterine contraction abnormality (n=4), O88 Obstetric embolism (n=3), O90 Postpartum complications not classified elsewhere (n=5).

DISCUSSION

In the period from 2013 to 2022, 90 maternal deaths were reported in *Baixada Maranhense*, highlighting, over the time series, the years 2016 and 2021 with the highest number of registered deaths. The mean MMR in *Baixada Maranhense* was 98.6 maternal deaths per 100,000 live births. In descriptive terms, an average annual growth of 2.34% of the MMR was observed. The inferential analysis showed a statistically significant increasing trend of MMR, with an average annual increase of 6.18% ($p<0.0001$). Increase peaks, such as those of 2016 and 2021 may reflect external events, such as failure or low quality of obstetric care during the pregnancy-puerperal cycle and the Covid-19 pandemic.

There was a growing increase in maternal mortality from 2019 to 2021, which coincides directly with the Covid-19 pandemic. These data are consistent with the national scenario, which in turn registered an increase in the number of maternal deaths from Covid-19 in Brazil, recording 462 deaths in 2020 and 1,518 in 2021.12if the country presented its highest mortality peak in the historical series of MMR in the second quarter of 2021 reaching 197.75/100,000 NV.13 The lack of knowledge about Covid-19, lack of timely assistance, delay in the inclusion of pregnant women in the priority group for vaccination, in addition to the existing precariousness and unequal access to adequate prenatal care and obstetric assistance were associated with this outcome.[14]

It is noteworthy that, in 2016, Maranhão recorded the 2nd largest MMR in the country, behind only Amapá. The average MMR in the state reached 122/100,000 NV, in line with the data observed in this study. The shortage of obstetric beds in the public health system was identified as one of the main factors associated with this scenario. In response, the State Department for Health of Maranhão adopted several strategies, such as the institution of the State Health Force of Maranhão (Fesma) in municipalities with lower HDI, investments in the restructuring of health units and qualification of professionals.[15]

In the context of *Baixada Maranhense*, this study assumes a pioneering character by analyzing the trend and profile of MMR in the last decade, considering the lack of updated data on this subject in the region of Maranhão. Study carried out in the Regional Health Unit of Pinheiro, which includes 17 municipalities of *Baixada Maranhense*, identified an average MMR of 82/100,000 LBs in the period from 2008 to 2017 and attributed the high maternal death rate to the low quality of life and health care offered to women in this region.[16] In fact, *Baixada Maranhense* concentrates municipalities with socioeconomic needs, gaps in the quality of obstetric care, scarcity of obstetric reference centers of medium and high complexity, besides its geographical particularity characterized by waterway transport via ferryboat with travel time variability, which makes intermunicipal obstetric transfers and referrals to the capital São Luís operationally challenging.[8-9,16]

The MMR of *Baixada Maranhense* remained high in all historical series analyzed, according to the WHO parameters (high MMR = 50 to 149/100,000 NV), with an average MMR equivalent to 98.63/100,000 LB. In 2014 alone, the UN SDG Target 3.1 was achieved with an MMR of 62.5/100,000 LB. In the analyzed period, the nationalized SDG Goal 3.1 (MMR 30.0/100,000 LB) was not reached and is far from being met based on current data.[2]

Brown women, aged 20 and 29 years old, single and with 8 to 11 years of studies, constituted the main group that evolved to maternal death. Eclampsia and postpartum hemorrhage were the main causes of death. Most maternal deaths occurred during pregnancy, delivery or abortion were classified as direct obstetric maternal death, occurred in hospital and investigated.

Concerning age, the maternal deaths recorded occurred mostly in young women aged 20 to 29 years. This age group concentrates the majority of pregnancies, which naturally increases exposure to obstetric risks. Results of national and international studies reinforce these findings and indicate that maternal deaths occurred more frequently among young women, especially during the period of greatest reproductive potential.[3,17]

Regarding the color/race variable, there was a predominance of brown women, corroborating with other findings in international and national literature.[14,18-19] It is known that brown/black women tend to have greater predisposition to diseases that can affect pregnancy, such as hypertensive syndromes (such as pre-eclampsia and eclampsia), gestational diabetes, sickle cell anemia, obesity and metabolic syndrome, in addition to experiencing conditions of greater social, structural and health vulnerability, such as low socioeconomic level, obstetric violence and even institutionalized racism, that directly influence the unequal access to quality health services, early management of complications, culminating in adverse maternal and perinatal outcomes.[19]

Single women were those who in the greatest proportion evolved to maternal death in the period analyzed. A national survey that analyzed data on maternal deaths between 2020 and 2023 identified that the majority of maternal deaths occurred among single women, especially in the Southeast and Northeast.[20] Social support reduced by the absence of the partner associated with stigmatization and prejudice that single pregnant women may face during pregnancy, represent risk factors related to illness and death, since this group tends to have greater vulnerability and neglect of care during pregnancy.[18]

Low education is also a factor associated with maternal death.14 Studies show that the lower the level of schooling, the higher the maternal mortality rate, because generally, women with low education face barriers that increase the risk of complications during pregnancy, labor and childbirth, such as limited access to health care, insufficient understanding of the recommended guidelines during prenatal and postpartum care, low level of information and empowerment, poor socioeconomic conditions, discrimination, among others.[14,18,20]

Regarding the causes of maternal death, this research showed that the main cause of maternal death was eclampsia. It is known that the four main causes of maternal death in Brazil are: hypertensive syndromes, hemorrhages, puerperal infections and abortion complications.[20-21] continue to be the main causes of maternal death in Brazil and worldwide.[18,19-22]

The predominance of eclampsia in the pregnancy-puerperal period is associated with factors such as the presence of severe or uncontrolled arterial hypertension, preeclampsia and vascular alterations that directly affect the brain and may cause fatal complications, such as tonic-clonic seizures for the mother, when not diagnosed and treated in a correct and fast way, can generate serious consequences maternal, fetal or both. The effectiveness of prenatal care in primary health care is highlighted as the main form of prevention and treatment of gestational hypertension and its complications.[20-22]

Maternal deaths occurred with greater prevalence during pregnancy, childbirth or puerperium, being classified as direct obstetric maternal deaths, corresponding to 88.9% of the cases. Direct obstetric causes are still responsible for at least 66% of maternal deaths in Brazil, this finding is extremely worrying because such causes are largely preventable and treatable with access to adequate and respectful health care during pregnancy, childbirth and puerperium.[18,22] Thus, such deaths are consequences of failures in the assistance of obstetric services, since they are related to unnecessary interventions, omissions, incorrect treatment or the succession of events resulting from any of these situations.[18,23]

Regarding the place of occurrence and investigation of maternal deaths, there was a high number of deaths in hospital with more than half of the investigated deaths. The predominance of maternal deaths in hospitals reflects the fact that approximately 98% of births in Brazil take place in a hospital environment, either in units of usual risk, reference for high-risk pregnancy or in general hospitals.[18,19] Most were investigated and had an informed summary sheet, this is due to the fact that they occurred in a hospital environment, being mandatory their investigation. Results of a systematic review with meta-analysis and observational studies indicate that the investigation of maternal deaths is fundamental to accurately determine the cause of maternal death, identify failures in the health system and implement corrective measures.[1,24-25]

Regarding the limitations, the use of secondary data does not allow to control under notifications, inconsistency in filling variables and delays in updating information.[23-24] It is worth highlighting the presence of ignored/blank data, which can sometimes compromise the accuracy of the analysis and limit the characterization and identification of specific risk factors for maternal mortality. However, since these are official data of the Ministry of Health and are mandatory registration throughout the national territory, the proposed objective may have been achieved. The integration between databases, standardization of information and public access to updated and complete data are crucial strategies for subsidizing effective public policies and ensuring quality production and scientific knowledge.

It is emphasized that for the achievement of the SDG 3.1 goal of the 2030 Agenda in *Baixada Maranhense*, that is to achieve a MMR below 70 maternal deaths per 100,000 LB by the year 2030, it is necessary to implement effective intersectoral public policies and improvement of existing policies emphasizing actions for the strengthening of prenatal care for early detection of risks during pregnancy, continuing education and training of health teams to ensure quality care, and better surveillance of maternal deaths for the identification of possible failures and/ or underreporting.

Moreover, the worsening of MMR rates during the years of the Covid-19 pandemic reinforces the vulnerability profile of this population and local health services, considering that changes in access to health care during the pandemic may have influenced the routine of prenatal follow-ups and the patterns of diagnosis and treatment of diseases or complications during the pregnancy-puerperal period. Therefore, it is important to carry out epidemiological studies to identify and broaden the understanding about the social, institutional and regional determinants that contribute to maternal deaths, since the MMR remains high in *Baixada Maranhense* and its reduction is still a challenge.

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AUTHORS' CONTRIBUTIONS

Leila Camila Reis Pereira contributed to the bibliographical research, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, preparation of tables and conclusions, review. **Kezia Cristina Batista dos Santos** contributed to the administration of projects, bibliographic research, ethics committee release, abstract writing, introduction, methodology, discussion, interpretation and description of results, conclusions, review and statistics.

All authors approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.

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