Maternal mortality in Pernambuco: spatial and temporal analysis before and during the COVID-19 pandemic

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Abstract

Objectives: to analyze the spatial distribution and temporal trend of the maternal mortality ratio in Pernambuco, before and during the COVID-19 pandemic.

Methods: mixed ecological study, based on the maternal mortality ratio. The spatial units were the resident municipalities and health regions in the pre-pandemic (2017-2019) and pandemic (2020-2022) periods. The risk ratio was calculated using the pre-pandemic period as a reference. The temporal units were semesters, analyzed using the Joinpoint regression model.

Results: the maternal mortality ratio increased by 14.5%, from 55.9 to 64.0 per 100,000 live births; an increase was observed in five health regions and in 63 (50.8%) of the 124 municipalities with registered deaths. In the time series, a decreasing trend in the ratio was observed between the first half of 2021 and the second half of 2022.

Conclusion: maternal mortality increased in some health regions and in most municipalities, highlighting the need to prioritize pregnant and postpartum women during health crises. The temporal analysis shows a decreasing trend, suggesting effective actions by health services. The implementation of policies that ensure the continuity of care is crucial to reduce preventable maternal deaths.

Key words *COVID-19, Maternal mortality, Time series studies, Spatial analysis, Ecological studies*

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Introduction

Maternal death, defined as the death of women during the pregnancy-puerperal cycle, is an undesirable event that is mostly preventable and requires mandatory notification to international health authorities.[1] According estimates from the World Health Organization (WHO), in 2020, about 800 women died every day from preventable maternal causes, and nearly 95% of these deaths occurred in developing countries.[2]

The distribution of maternal mortality reflects social vulnerabilities in geographic spaces, producing patterns that show a concentration of risk in the poorest areas.[3] Events that cause crises in health services, such as the COVID-19 pandemic, reinforce existing vulnerabilities, exacerbating flaws in access and care, which in turn leads to an increase in maternal mortality.[4]

In the period from December 2019 to June 2020, six countries reported 160 maternal deaths due to COVID-19 worldwide; of these, 124 occurred in Brazil.[5] For the year 2021, according to *Observatório COVID-19 Fiocruz* (COVID-19 Fiocruz Observatory), the number of maternal deaths due to COVID-19 was 1,519, which represented 3.3 times the number of deaths recorded in 2020.[6] Similarly to national data, the state of Pernambuco had a number of deaths due to COVID-19 in 2021 that was 1.9 times higher than the previous year.[7]

The COVID-19 pandemic, associated with the precarization of health services, led Brazil to revert to the maternal mortality rates of the 1990s, when over 100 maternal deaths per 100,000 live births occurred.[8] Accordingly, collaborative efforts are necessary across all government, public and private sectors to mitigate deaths during pregnancy, childbirth and the puerperium.

Spatiotemporal ecological studies allow for the identification of inequalities in the distribution of maternal mortality risk, in addition to assessing the provision, access, and quality of health services, thus informing rapid-response actions and the enhancement of obstetric care in priority areas.[11-13] In this context, epidemiological analyses that encompass spatial and temporal dimensions are essential to identify vulnerable territories and guide public policies. The present study aims to analyze the spatial distribution and temporal trend of the maternal mortality ratio in Pernambuco, before and during the COVID-19 pandemic.

Methods

This is a mixed ecological study with a temporal and spatial approach, comprising all maternal deaths of residents in Pernambuco, as recorded in the Mortality Information System (SIM – Portuguese acronym), from 2017 to 2022. This period corresponds to both the pre-pandemic triennium (2017-2019) and the pandemic triennium (2020-2022).

The state of Pernambuco comprises 184 municipalities and the administrative district of Fernando de Noronha, organized into 12 regional health authorities. The state is home to approximately 3,034,239 women between ten to 49 years.

The units for spatial analysis were the municipalities of the state of Pernambuco. Fernando de Noronha was excluded due to its lack of contiguity with the mainland, which prevents any spatial correlation analysis. The 12 semesters from 2017 to 2022 constituted the temporal analysis units.

Deaths of women aged ten to 49 years were analyzed, specifically those in the pregnancy-puerperal cycle up to 42 days after the end of pregnancy. The underlying cause of death was any code of the Chapter XV of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), as well as the other maternal causes classified in other chapters: Obstetric Tetanus (A34); Mental and behavioral disorders associated with the puerperium, not-elsewhere classified (F53); Puerperal Osteomalacia (M83.0); Neoplasm of uncertain or unknown behavior of placenta (D39.2); Hypopituitarism (E23.0); and HIV/AIDS (B20-B24).

Deaths from external causes were excluded (O93), in addition to deaths from any obstetric cause that occurred more than 42 days but less than one year after childbirth (O96), and deaths from sequelae of direct obstetric causes occurring more than one year after childbirth (O97).

Data were obtained from the Mortality Information System and the Live Birth Information System using the Tabnet platform, available on DataSUS. The data were accessed on April 10, 2025. In the spatial analysis, we used cartographic meshes obtained from the Brazilian Institute of Geography and Statistics, accessed on April 10, 2025.

The indicator used was the Maternal Mortality Ratio (MMR), which is calculated by dividing the number of maternal deaths by the number of livebirths given geographic area and time period, multiplied by 100,000.

Variables related to the date of death were analyzed and used for the temporal analysis of the MMR, by year and by semester. In this study, the MMR was calculated dividing the number of maternal deaths by the number of live births by semester. In the distribution of the MMR and spatial analysis, municipalities of residence were used. The MMRs were classified into: low (MMR<20

by 100,000 Live Births – LB); medium (MMR 20-50 by 100,000 LB); high (MMR 50-150 by 100,000 LB) or very high (>150 by 100,000 LB). We also calculated the risk ratio of municipalities and health regions within the periods, according to the expression bellow:

$$\text{Risk Ratio} = \frac{CV}{RV}$$

Where: CV is the current value and RV is the reference value. We used the pre-pandemic datum as the reference value.

The risk ratio compares the probability of an outcome between the exposed and unexposed groups to a specific factor. Values greater than one indicate an increase in risk; values less than one, a decrease.[14]

In order to assess the temporal impact of COVID-19, we analyzed the MMR trend in Pernambuco from 2017 to 2022, with a semester-based disaggregation (12 observations). We applied the Joinpoint regression model, which identifies significant changes in trends and estimates the Semestral percent change (SPC), with 95% confidence intervals and 5% significance level.[15,16] The best model was selected with Schwarz's Bayesian Information Criterion (BIC). The analyses were performed using Joinpoint software, version 4.9.0.1.

The study was developed in accordance with Resolutions 466/2012 and 674/2022 of the *Conselho Nacional de Saúde* (National Health Council). Since it uses public data with aggregated information that prevents the identification of participants, it was exempted from review by the Research Ethics Committee on Human Beings.

Results

In the study period, 466 maternal deaths were recorded in Pernambuco. In the triennium preceding the pandemic, the MMR was 55.9. During the pandemic triennium, it was 64.0 per 100,000 LB, which represents a 14.5% increase (Table 1).

The distribution of the MMR by health region showed that, of the 12 health regions, five (I, III, IV, VIII, X) experienced an increase in the MMR during the three pandemic years. We highlight health region III, which experienced the highest MMR in the pandemic period (73.3 per 100,000 LB) and health region VIII, which experienced the greatest risk ratio, 1.36 (Table 1).

In the spatial distribution of MMR by municipalities, 99 municipalities recorded maternal deaths during the pre-pandemic period. Of these, 46 (46.46%) had a high MMR and 33 (33.33%), had a very high MMR. Two (2.02%) municipalities showed a low MMR (Figure 1A). During the pandemic period, 80 municipalities recorded maternal deaths. Of these, 42 (52.50%) had a high MMR and 22 (27.50%) had a very high MMR (Figure 1B). In the comparative analysis between the periods, we observed that 124 municipalities recorded maternal deaths in at least one of the periods. Of these, 63 (50.81%) had an increased risk of maternal death during the pandemic period (Figure 1C).

Table 1

Maternal mortality ratio (per 100,000 LB) by health region and risk ratio between the pre-pandemic (2017-2019) and pandemic (2020 – 2022) periods in Pernambuco.

Health region	Pre-pandemic			Pandemic			
	Maternal deaths	Live-births	MMR	Maternal deaths	Live-births	MMR	Risk ratio
I	90	173,583	51.8	104	151,432	68.7	1.32
II	18	23,397	76.9	15	22,129	67.8	0.88
III	15	25,098	59.8	16	21,823	73.3	1.23
IV	31	59,424	52.2	34	56,650	60.0	1.15
V	13	24,580	52.9	11	23,129	47.6	0.90
VI	10	18,598	53.8	6	17,950	33.4	0.62
VII	6	6,797	88.3	6	6,560	54.7	0.62
VIII	13	26,407	49.2	17	25,317	67.1	1.36
IX	11	17,383	63.3	10	16,697	59.9	0.95
X	4	8,012	49.9	5	7,523	66.5	1.33
XI	7	11,234	62.3	6	10,962	54.7	0.88
XII	10	13,024	76.8	8	11,915	67.1	0.87
PE	228	407,537	55.9	238	372,087	64.0	1.14

Source: MS/SVS/CGIAE – Mortality Information System (SIM); Data collected on April 10, 2025; MMR= maternal mortality ratio.

The analysis of the time series using the Joinpoint regression model revealed three trends. The first two, (2017 to 2019) and (2020 to 2021) were stationary. The third trend was decreasing during the period of the second semester of 2021 and 2022, (SPC = -22.7; p=0.049) (Table 2 and Figure 2).

Figure 1

Spatial distribution of the maternal mortality ratio (per 100,000 live births) according to the pre-pandemic Triennium 2017-2019 (A); Pandemic triennium 2020-2022 (B); Risk ratio of maternal mortality between periods (C).

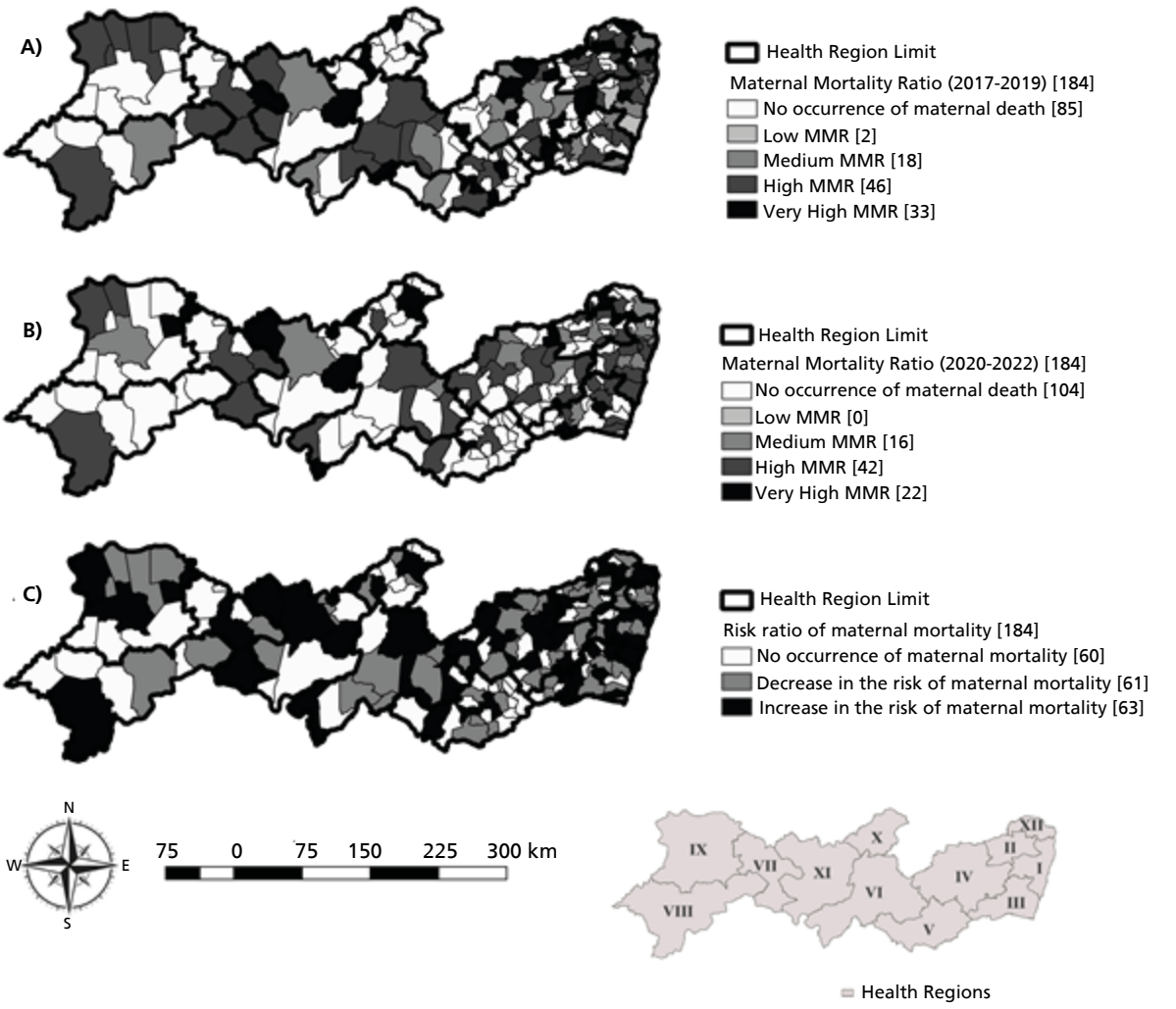


Table 2

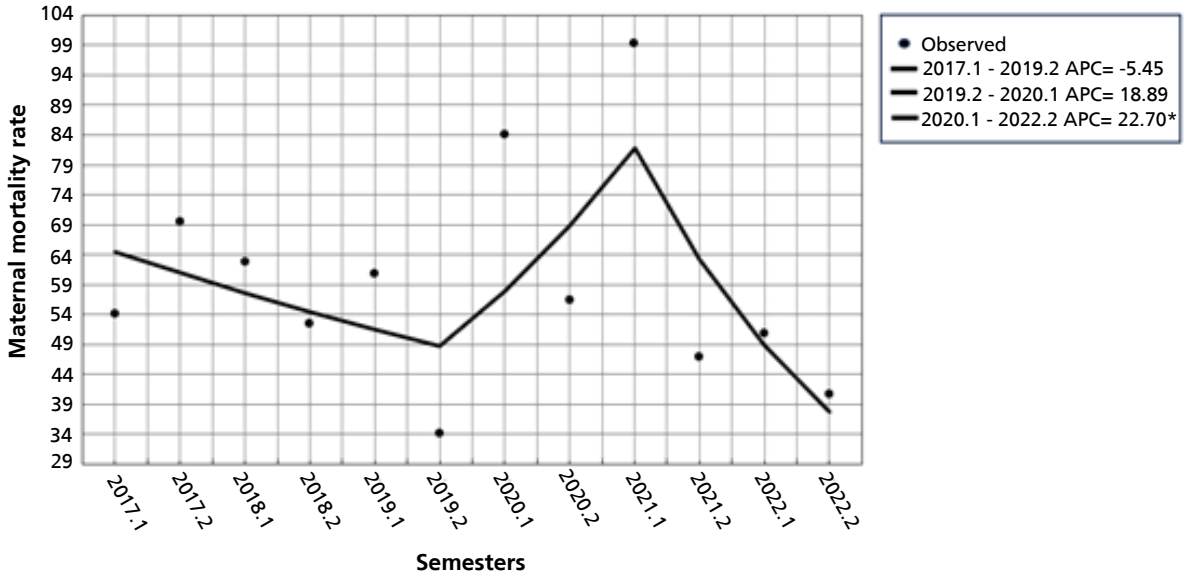
Temporal trend of maternal mortality in Pernambuco, 2017 to 2022.

	Trend	Period		SPC	Confidence interval		*p*
		Initial	Final		Minimum	Maximum	
SPC	1st	2017.1	2019.2	-5.4	-15.7	6.0	0.246
	2nd	2019.2	2021.1	18.9	-28.7	98.3	0.401
	3rd	2021.1	2022.2*	-22.7*	-40.2	-2.8	0.049

SPC = Semestral Percent Change.

Figure 2

Temporal Evolution of the maternal mortality ratio (per 100,000 LB) by semester in Pernambuco, 2017 to 2022.



Discussion

This study observed an increased risk of maternal death during the pandemic triennium in some of the municipalities and health regions of the state of Pernambuco that had recorded maternal deaths. The analysis of the time Semestral time series by semester demonstrated a decreasing trend in the maternal mortality ratio starting in the second semester of 2021 and continuing until the end of the study period.

The first years of the public health crisis were the period in which the majority of maternal deaths occurred, and consequently, an increase in the MMR. This finding aligns with a study conducted in Brazil on the temporal trend, which reported excess maternal mortality in the majority of months.[17] Initially, the scarcity of diagnostic resources and the lack of knowledge on the adequate management of pregnant and puerperal women with COVID-19 were factors that heightened the risk of maternal death.[18,19] Moreover, the unavailability of vaccines further weakened the healthcare network, especially in local communities where the availability of services is insufficient, and resources are limited.[18] This led to several flaws that include not only a decrease in prenatal consultations, but also impaired access to high-complexity services, such as intensive care units.[19]

Although the services provided to pregnant and puerperal women were not discontinued, the COVID-19 pandemic strained health services, which occasionally hindered access.[4,10,20] Besides the direct consequences of having COVID-19, the restrictions in displacement, combined to the insecurity in relation to contamination promoted a decrease in prenatal consultations.[21] Accordingly, diseases that should be diagnosed and treated during prenatal care evolved to unfavorable outcomes.[22,23] Thus, there was an increase in MMR,[24] which is consistent with the present study.

An ecological study conducted in Brazil from 2010 to 2020, aiming to assess the impact of COVID-19 on maternal mortality, evidenced a significant difference in the increase in the number of maternal deaths between women with low-risk pregnancies, that is, those who did not have an elevated risk of sepsis and hemorrhages.[25] Thus, in the year 2020, the straining of obstetric services during the pandemic may have had a greater impact on deaths from direct obstetric causes than either COVID-19 or preexisting comorbidities.[25]

It is widely known that the risk of maternal death is geographically uneven. Areas with lower economic development and impaired availability of access to actions and basic health services demonstrate higher risk.[18,19,26] Poverty, suboptimal referral conditions and delayed access to care may lead to unfavorable maternal outcomes.[26] Additionally, healthcare hubs tend to be concentrated in the metropolitan regions of the states. The health region I is the most populous one and concentrates 41.9% of obstetric beds and 70.9% of ICU beds in the state. This uneven distribution of health services leads to flaws in the timely access, since long-distance displacements is a reality.[12]

The time series analysis of MMR in Pernambuco demonstrated a stationary trend in the first pandemic years. In spite of stationarity as the result of the temporal analysis model adopted, it is important to observe that the ratio between 2020 and the first half of 2021 demonstrates higher numbers. This is a reflection of an excess in the number of maternal deaths and of the decrease of the number of live births during COVID-19 pandemic. An exploratory study aiming to assess the effects of COVID-19 pandemic on maternal mortality in Brazil in 2021, revealed that, compared to the trend of the five preceding years, 2021 had a 39% excess mortality.[27]

For 2022, the study observed a decreasing trend in MMR. This reduction may be related to the control of the pandemic, aligned with the normalization of prenatal consultations, the increase of bed availability, in addition to the mass testing. Another important factor was the availability of vaccines for pregnant and puerperal women.[28]

Despite the protective effect of vaccines, the rollout of vaccination campaign against COVID-19 for pregnant and puerperal women in Brazil was marked by delays in the procurement of immunizing agents, logistical shortcomings, and delayed issuance of specific guidelines from the Ministry of Health.[29] These barriers contributed to the increase in maternal mortality in 2021. The temporal analysis indicates that the reduction in the risk of maternal death observed at the end of the pandemic could have occurred earlier if governmental actions had been timelier.

For this study, it is important to clarify that the codes O96, pertaining to late maternal death, and O97, which describes deaths from sequelae of direct obstetric causes, are, by definition, not considered in the MMR calculation.[1] However, taking into account that late maternal deaths are avoidable and may reflect the increase in survival due to developments in health technology, studies that include these deaths in their analyses are necessary.

An important limitation of the study is that maternal death is a rare event, which impairs its analysis and interpretation in small populations. Moreover, since the analysis uses secondary data, the inadequate completion of death certificates, specifically regarding the cause and moment of death in the pregnancy-puerperal period, in addition to potential errors in coding or data entry, may cause underregistration of maternal deaths, negatively affecting MMR estimates. Nonetheless, the health information systems in Pernambuco have been showing satisfactory quality in relation to vital events, which reinforces their use as reliable tools for the analysis of the health situation.[30]

The study showed an increase in maternal mortality in the majority of health regions and municipalities of the state, which reinforces the need for prioritizing pregnant and puerperal women during public health crises. The decreasing trend observed in the temporal analysis reflects the effective action of health services. The implementation of strategic policies that ensure the continuity of prenatal care and other essential types of care, especially for vulnerable groups, improves access to healthcare and reduces avoidable deaths.

Authors' contribution

Oliveira HJP: conceptualization and design of the study, analysis and interpretation of results, writing and critical review of the manuscript. Bonfim CV: conceptualization and design of the study and critical review of the manuscript. Barbosa CC: critical review of the manuscript. Maciel MMSA: writing and critical review of the manuscript. Silva APSC: conceptualization and design of the study, analysis and interpretation of results and critical review of the manuscript. All authors approved the final version of the article and declared no conflicts of interest.

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Data availability

All datasets supporting the results of this study are included in the article.

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