ORIGINAL ARTICLE

Impact of COVID-19 on maternal mortality in the state of São Paulo between 2020 and 2022

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Abstract

Objectives: to identify the epidemiological characteristics of maternal deaths associated with COVID-19 in the state of São Paulo, Brazil, between 2020 and 2022.

Methods: a cross-sectional study was conducted using secondary data from the Mortality Information System. A total of 854 maternal deaths were analyzed and classified according to the presence (n=288) or absence (n=566) of COVID-19. Sociodemographic characteristics, timing of death and associated causes were compared. Prevalence ratios (PRs) and 95% confidence intervals (95% CI) were estimated using Poisson regression with robust variance.

Results: the maternal mortality ratio peaked at 65.7 per 100,000 live births in 2021, compared to approximately 43.5 during the pre-pandemic period. Among COVID-19–related maternal deaths, 82.2% occurred during the postpartum period (PR=2.14; 95%CI=1.64–2.80). Higher prevalence was observed among women with ≥12 years of formal education (PR=1.57; 95%CI=1.11–2.22) and those with a partner (PR=1.39; 95%CI=1.14–1.69). Most COVID-19–related deaths had no associated obstetric causes (PR=0.33; 95%CI=0.25–0.44); however, gestational diabetes was an aggravating factor (PR=1.51; 95%CI=1.06–2.10).

Conclusion: COVID-19 pandemic significantly increased maternal mortality, with greater impact during the postpartum period, underscoring the need for enhanced postpartum surveillance.

Key words *Maternal mortality, COVID-19, Women's health, Epidemiology, Health Information Systems*

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Introduction

The World Health Organization (WHO) defines maternal death as the death of women during pregnancy, delivery, or up to 42 days after the termination of pregnancy, regardless of the duration and site of pregnancy, and resulting from any cause related to or aggravated by pregnancy or its management, excluding accidental or incidental causes. According to this classification, deaths are subdivided into: direct obstetric deaths, resulting from complications of the pregnancy itself, delivery, and puerperium – including interventions, omissions or incorrect treatment – and indirect obstetric deaths, resulting from preexisting diseases or those that developed during pregnancy, but were aggravated by the physiological effects of pregnancy.[1]

In addition to reflecting the quality of care provided to women during the pregnancy and postpartum period and their adequate access to health services, maternal death reflects the socioeconomic development level of a given country.[2]

The COVID-19 pandemic, caused by SARS-CoV-2, had a significant impact on health indicators on a global scale. By 2021, over 116 million cases and 2.5 million deaths had been registered worldwide. In Brazil, this impact was particularly severe on maternal mortality, reversing previous gains in its reduction.[3]

The UN Sustainable Development Goals (SDG) global agenda established the target of reducing the maternal mortality ratio to less than 70 deaths per 100,000 live births by 2030; Brazil, in turn, committed to reducing this indicator to no more than 30 deaths per 100,000 live births.[4]

Although all population groups were affected by the pandemic, vulnerable populations – specifically pregnant and puerperal women with multiple comorbidities – were disproportionately impacted. The physiological changes associated with pregnancy induce immune, cardiovascular, and respiratory alterations that heighten vulnerability to complications from respiratory viral infections, as previously documented in other epidemics (H1N1, SARS).[5]

Clinical evidence indicates that pregnancy is associated with a higher rate of complications and death compared with non-pregnant women of the same age group.[6] Multicenter studies have observed a higher risk of ICU admission, maternal mortality, preeclampsia, preterm birth and neonatal morbidity among infected pregnant women. Furthermore, the overload of health services, the scarcity of ICU beds, interruptions to prenatal care, and late vaccination of pregnant women worsened the scenario, contributing to the increase in maternal mortality during the pandemic period.[7]

Therefore, maternal mortality remains a severe public health problem, and the pandemic has intensified this challenge, justifying this investigation to guide updated public policies. This study aims to describe the epidemiological characteristics of maternal deaths caused by COVID-19 in the state of São Paulo from 2020 to 2022.

Methods

This is a cross-sectional study based on secondary data from maternal deaths registered in the Mortality Information System (SIM – Portuguese acronym), a national platform established in 1979 that collects anonymized individual death records.[8] The platform is subdivided by state; accordingly, all maternal deaths that occurred in the state of São Paulo (SP) were selected based on from Chapter XV "Pregnancy, Childbirth, and the Puerperium", of the International Classification of Diseases, 10th Revision (ICD-10).

Data extraction was conducted in March 2024 using filters available in SIM: year of death, age of the pregnant/puerperal woman, color/race, marital status, municipality of residence and occurrence, timing of death, and causes reported on all lines of the Death Certificate (DO), according to ICD codes. Records with blank fields were excluded from the analysis.

Women aged 14 to 50 years with underlying, intervening, or contributing causes related to pregnancy or the puerperium within 42 after childbirth were included, according to ICD-10 codes O00-O99 (excepting O96 and O97 which correspond to late maternal deaths and are not included in the maternal mortality ratio calculation).

Based on these criteria, 854 maternal deaths among residents of SP were identified in the period between 2020 and 2022. Subsequently, the deaths were classified into two groups based on the presence or absence of the ICD-10 codes for COVID-19 (B34.2 and U07.1). Altogether, 288 records included the infection code, while 566 did not mention it on any line of the death certificate.

For the trend analysis, descriptive statistics were calculated using JoinPoint Trend Analysis Software, version 5.2.0, to evaluate annual variations in mean maternal mortality ratios (MMR – number of maternal deaths divided by the number of live births in the same period, multiplied by a 100,000) from 2012 to 2022 (n=2,982 deaths, also recorded and tabulated by the SIM). The software fits segmented linear regression models to identify statistically significant changes in trends. [9] And for the spatial analysis, TABWIN software (version 3.6b) was used to generate municipal choropleth maps of the state, specifically for COVID-19 deaths in the period between 2020 and 2022, expressed in absolute numbers and maternal mortality ratios per municipality.

The 645 municipalities were analyzed according to their populations, being classified as small-sized (up to 50,000 inhabitants), medium-sized (up to 100,000 inhabitants), or large-sized according to IBGE (Brazilian Institute of Geography and Statistics) criteria.[10] Variability of ratios was expressed using the interquartile range (IQR), defined as the difference between the third (Q3) and the first quartiles (Q1), representing the central 50% of the sample. Outliers were identified and excluded from the analysis according to Tukey's Rules, defining as outliers any values exceeding Q3 + 1.5 × IQR.[11] The TABNET platform was used to obtain the live birth data for MMR calculation; this system was implemented in 1994 by the Department of Informatics of the Unified Health System (DATASUS) which aggregates, among other epidemiological data, the Live Birth Information System (SINASC – Portuguese acronym) database.[12]

In the comparative analysis, maternal deaths were described by age group (≤19, 20-34, ≥35 years), race/skin color (White, Black, or Brown), educational attainment ((≤7, 8–11, ≥12 years of schooling), marital status (with partner – married/stable union and without partner – single and widowed/divorced), and timing of death (pregnancy, childbirth or the puerperium). The underlying contributing causes of death were also analyzed for both groups, classified by the ICD-10 of the same chapter regardless of whether they were listed as the underlying cause: gestational diabetes (O24), hypertensive syndromes (O10-O16), pregnancy with abortive outcome (O00-O08), hemorrhage (O20, O46 and O72), abnormalities of forces of labor (O62), HIV (B20-B24), labor and delivery complications (O63-O75), and obstetric embolism (O88). Maternal deaths associated with infectious disease that were not COVID-19 in the pandemic period were also identified (n=24).

Statistical analyses were performed using Stata (version 16.1), and OpenEpi. The associations between COVID-19 and the variables of interest were assessed by contingency tables and estimated as crude prevalence ratios (PR), with no multivariate analysis performed, and calculated using Poisson regression models with robust variance. This method is recommended for cross-sectional studies with binary outcomes, in which standard errors are adjusted for potential violations of variance assumptions, thereby preventing PR overestimation. Statistical significance was defined as a p-value < 0.05 and 95% confidence intervals (95% CI) excluding the null value (1.0).

In accordance with Resolution No. 510/2016 of the Brazilian National Health Council, this study was exempted from review by the Research Ethics Committee/ National Research Ethics Commission (CEP/CONEP) system, as it relies exclusively on anonymized public domain data, ensuring no possibility of individual identification.

Results

Figure 1 shows the variation of maternal mortality ratios between 2012 and 2022, totaling 2,982 deaths, with four statistically significant joinpoints.

The ratio showed a continuous increase until 2017, rising from 36.8 in 2012 to 52.3 in 2017. Subsequently, there was a slight decline until 2019 (40.1). In the following years, coinciding with the COVID-19 pandemic, a sharp increase was observed, reaching 51.6 in 2020 and 65.0 in 2021. By 2022, the indicator returned to levels similar to the pre-pandemic period, reaching 43.7.

Figure 2 illustrates that 121 (18.9%) of the 645 municipalities in the state of São Paulo recorded maternal deaths due to COVID-19. Of these, 56 (46.2%) had a higher number of deaths from the infection than for other causes, most notably Jundiaí (six additional cases), followed by Itapeva and Itapira (four cases each).

Among the 524 municipalities with no recorded maternal deaths from COVID-19, 467 (89.1%) are small, 35 (6.7%) are medium, and 22 (4.2%) are large, including Americana, Atibaia, Bauru, Botucatu, São Caetano do Sul, and Taubaté.[11]

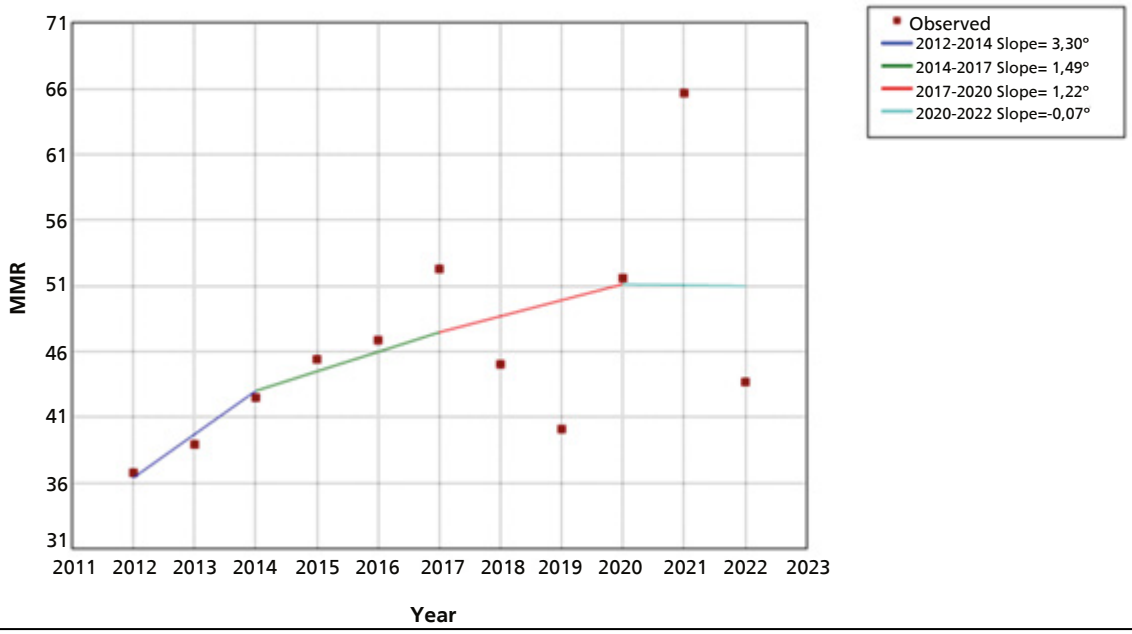
In absolute numbers (left-hand map), 73 municipalities recorded a single death, 33 had between two and three deaths each and 15 had four or more, concentrated primarily in the state's metropolitan areas. The municipality of São Paulo accounted for 57 deaths (19.8% of the total), followed by Guarulhos (14) and Sorocaba (12). Itapeva, Jundiaí and São Bernardo do Campo registered seven deaths each, while Campinas and Limeira recorded six. Seven other municipalities – Cubatão, Itapira, Marília, Osasco, Ribeirão Preto and Suzano – reported four deaths.

The classification based on maternal mortality ratios (right-hand map) was defined based on the interquartile range of municipalities with at least one death. The first group consists of the same 524 municipalities without recorded deaths, along with 13 outliers identified by Tukey's rule, including Macedônia, Manduri, Nhandeara, Redenção da Serra, Rifaina, Rio Claro, Rubiácea, Sandovalina, Santo Antônio do Jardim, São João de Iracema, São Luís de Paraitinga, Suzano, and Tabapuã.

The second group (up to the first quartile, Q1 = 20.43) comprised 27 municipalities, including Barueri, Campinas, Carapicuíba, Diadema, Franca, Guarujá, Itapevi, Itu, Mauá, Mogi das Cruzes (the lowest ratio: 5.87), Osasco, Ribeirão Preto, Santo André, São Carlos, São José dos Campos, São Paulo (the 14th lowest ratio: 13.70), and São Vicente. The statewide average MMR due to COVID-19 was 18.11, compared to 35.59 for other causes.

Figure 1

Trend of maternal mortality ratio in São Paulo State, 2012 to 2022.

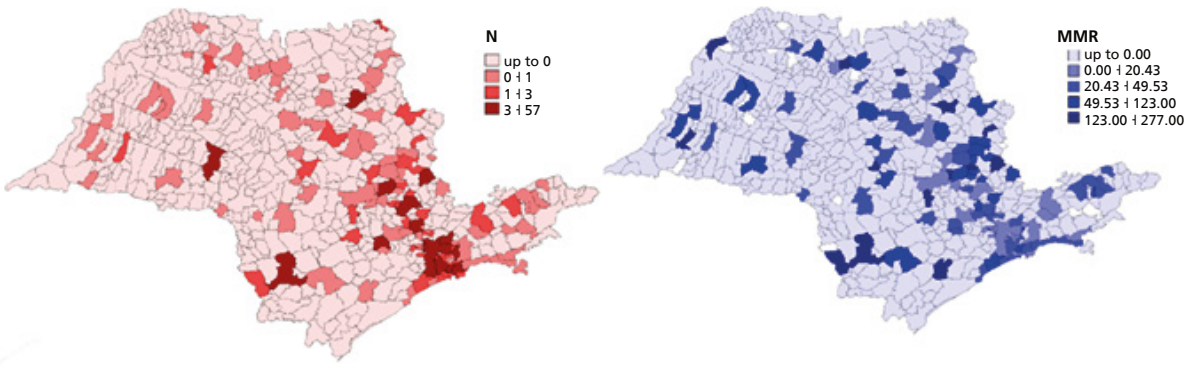


CMMR =maternal mortality ratio; *p<0.05.

Source: Developed by the authors from data from the Mortality Information System and the Live Birth Information System, Brazil, 2023.

Figure 2

Spatial distribution of maternal deaths from COVID-19, by municipalities in São Paulo State, 2020 to 2022.



Left: absolute number of maternal deaths from COVID-19; Right: maternal mortality ratio (MMR) by municipality.

Source: Developed by the authors from data from the Mortality Information System and the Live Birth Information System, Brazil, 2023.

The third group (up to the median of 49.53) included 39 municipalities, such as Araraquara, Araras, Bertioga, Catanduva, Franco da Rocha, Guarulhos (33rd position: 25.42), Jundiaí, Marília, Ourinhos, Peruíbe, Praia Grande, Santos (50th position: 34.12), São Bernardo do Campo, Sorocaba, Sumaré, and Votuporanga.

The fourth group (up to Q3 = 123.00) comprised 28 municipalities, notably Bairi, Cubatão, Dracena, Itanhaém, Itupeva, Limeira, Olímpia, and Socorro. Finally, the last group (up to 276.86 – values above which were considered outliers) included 14 municipalities, including Ilhabela (144.72), Itapeva (178.12), Itapira (193.89), and São Simão (the highest ratio: 271.44).

The interquartile range (Q3-Q1) of 102.57 revealed a high dispersion of ratios, reflecting significant regional heterogeneity.

Table 1 presents studied variables studied (age group, skin color, educational attainment, marital status, and timing of death), comparing to both groups: maternal deaths due to COVID-19 and maternal deaths from other causes.

Table 1

Sociodemographic characteristics and timing of maternal death by COVID-19 status in São Paulo State, 2020 to 2022.

Variables	with COVID-19		without COVID-19		PR (95%CI)
	n	%	n	%	
Age group (years)					
Up to 19	14	28.0	36	72.0	1.21 (0.76-1.96)
20-34	181	34.0	352	66.0	1.01 (0.82-1.23)
>35*	93	34.3	178	65.7	1.00
Total	288		566		
Color					
White	167	38.0	272	62.0	1.29 (1.06-1.56)
Black+Brown*	118	29.4	283	70.6	1.00
Total	285		555		
Education (years)					
Up to 7*	35	27.1	94	72.9	1.00
8-11	162	32.5	336	67.5	1.20 (0.87-1.63)
>12	56	42.8	75	57.2	1.57 (1.11-2.22)
Total	253		505		
Marital status					
With partner	162	39.1	252	60.9	1.39 (1.14-1.69)
Without partner*	116	28.2	296	71.8	1.00
Total	278		548		
Timing					
Pregnancy+Childbirth*	51	19.1	215	80.9	1.00
Up to 42 postpartum	237	41.0	341	59.0	2.14 (1.64-2.8)
Total	288		556		

*category of reference; PR= prevalence ratio; 95%CI= 95% confidence interval.
Source: Developed by the authors from data from the Mortality Information System and the Live Birth Information System, Brazil, 2023.

The median maternal age in both groups was 31.0 years, with a mean of 31.1 for women with COVID-19 (SD = 6.5), and 30.5 (SD = 6.9) for those without, showing no statistically significant difference. In both groups, more than 34% of pregnancies occurred after 35 years, defined as those occurring after 35 years old.

A higher prevalence of deaths due to COVID-19 was observed among white women, with a 30% increase in cases compared to Black and Brown women.

The analysis of educational attainment indicated that the portion of women with 12 or more years of schooling who died from COVID-19 showed a 57% higher prevalence ratio compared to those with up to seven years of study.

For marital status, having a partner (married or stable union) was associated with a 39% higher PR compared to those without a partner (single, widowed, or divorced).

The puerperium saw the highest occurrence of deaths due to COVID-19, representing a 114% increase relative to the gestational period and childbirth, which showed a 50% reduction.

Table 2 illustrates the conditions and comorbidities associated with deaths among women with and without COVID-19, relative to the group without the diagnosis.

Throughout the study period, 36.5% of deaths resulted from infectious diseases. Prior to 2019, the annual absolute number cases for this cause ranged between five and seven; in 2020, there was an increase to 68, in 2021 to 222 (74.3% of the total of deaths that year), followed by a decline to 22 in the following year. Consequently, infectious diseases became the leading cause of maternal death in the 2020–2022 period, surpassing hypertensive syndromes (11.1%) and hemorrhagic outcomes (4.6%).

Most maternal deaths from COVID-19 (82.9%) did not show associated obstetric causes, in contrast to women without the infection (17.0% vs. 49.2%). The exception was gestational diabetes, associated with a 51.0% increase in the prevalence ratio among COVID-19

Table 2

Conditions associated with maternal deaths by COVID-19 status in São Paulo State, 2020 to 2022.

Exposure	with COVID-19		without COVID-19		PR (95%CI)
	n	%	n	%	
Associated Cause					0.33 (0.25-0.44)
Yes	49	14.9	279	85.1	
No	239	44.6	287	55.4	
Gestational diabetes					1.51 (1.06-2.10)
Yes	16	50.0	16	50.0	
No	272	33.1	550	76.9	
Hypertensive syndrome					0.40 (0.25-0.60)
Yes	20	14.2	121	85.8	
No	252	36.2	445	63.8	
Abortion-related					0.27 (0.10-0.79)
Yes	3	9.3	29	90.7	
No	285	34.7	537	65.3	
Hemorrhagic complications					0.16 (0.06-0.41)
Yes	4	5.8	65	94.2	
No	284	36.2	501	63.8	
Uterine contraction abnormalities					0.30 (0.10-0.87)
Yes	3	10.3	26	89.7	
No	285	34.6	540	65.4	
HIV					
Yes	2	25.0	6	75	0.73 (0.22-2.46)
No	286	33.8	560	66.2	
Labor complications					0.20 (0.05-0.78)
Yes	2	7.1	26	92.9	
No	286	34.6	540	65.4	
Embolism					0.16 (0.04-0.64)
Yes	2	5.8	32	94.2	
No	286	34.9	534	65.1	
Total	288		566		

PR= prevalence ratio; 95%CI = 95% confidence interval.
Source: Developed by the authors from data from the Mortality Information System and the Live Birth Information System, Brazil, 2023.

deaths. Hypertensive syndromes, abortions, hemorrhages, and obstetric embolism, in turn, were more prevalent among women without infection.

Regarding the remaining 24 deaths from other infectious diseases, a predominance of opportunistic infections with the context of immunosuppression was observed, including five cases of tuberculosis, four of pneumonia, two of dengue, and four cases related to HIV.

Discussion

Maternal mortality, historically recognized as a severe public health problem in Brazil, intensified during the COVID-19 pandemic. In the state of São Paulo, the maternal mortality ratio, which remained at approximately 43.5 per 100,000 live births until 2019, rose to 56.3 between 2020 and 2022. A similar trend was observed at

the national level, with an increase from 57.1 to 79.9 over the same period.[12]

In the global context, it is estimated that 99% of maternal deaths occur in underdeveloped or developing countries, with 70% concentrated in sub-Saharan Africa. In 2020, the maternal mortality ratio in these countries was 430 per 100,000 live births, contrasting with 12 per 100,000 live births in high-income countries.[13] It is important to highlight that countries such as the US or the United Kingdom, unlike Brazil, have already incorporated late maternal deaths (between 43 days and one year of puerperium), in accordance with WHO guidelines, which expands the absolute number of records while maintaining ratios significantly lower than those observed in Brazil.[14]

This scenario reinforces that maternal mortality reflects the quality of primary healthcare. Locations with higher rates are generally characterized by marked social inequality, poverty, healthcare underfunding, low vaccination coverage, insufficient prenatal care, and delays in receiving timely medical care, factors that intensified during the pandemic and contributed to the deterioration of maternal outcomes.[15]

Municipal-level analysis demonstrates that diverse local factors influence the risk of maternal death. It was observed that most deaths occurred in large-sized municipalities, where high-complexity services and referral hospitals are concentrated, which in turn are frequently overwhelmed during pandemic peaks. On the other hand, smaller municipalities experience scarcity of qualified health professionals and impaired access to specialized care.[16] These findings reinforce that both overcrowding of large centers and healthcare vulnerabilities of smaller municipalities contribute to the risk of maternal deaths, evidencing territorial inequalities in access and quality of obstetric care.

Despite the absence of statistically significant differences among age groups, an increase in maternal mortality was observed with increasing maternal age. This finding may be explained by the higher prevalence of preexisting chronic diseases (obesity, diabetes, hypertension), obstetric complications (placenta previa, placental abruption, cesarean section) and reduced physiological adaptability to clinical complications. Accordingly, women of advanced maternal age (over 35 years) should receive high-risk prenatal care, with a higher number of consultations and more detailed evaluations, to ensure that potential conditions are promptly identified, monitored, and treated.[17]

The association between higher educational attainment and COVID-19 deaths appeared counterintuitive at first. Although educational attainment is a socioeconomic marker, the results indicate that women of higher educational attainment had a higher proportion of deaths due to COVID-19 compared to those without infection. Considering that the predominant causes of the group without COVID-19 cases (hypertensive syndromes, hemorrhages, abortion-related complications) are generally avoidable and more frequent in contexts of social vulnerability,[18] it is inferred that COVID-19 had a more widespread impact across social strata, including groups with higher income and education levels.

Similarly, the higher proportion of white and married women in COVID-19 deaths does not necessarily indicate a higher risk, but reflects the predominant demographic profile among pregnant women who died from the infection. During the quarantine and social isolation period, the prevalence of pregnancy among women with partners increased, which may explain the higher frequency of deaths in this group compared to women without partners. Furthermore, the distribution according to race/skin color follows the populational composition of infected pregnant women, which differs from the traditional pattern of maternal mortality due to avoidable obstetric causes, which tends to disproportionately impact Black and Brown women.[19]

From a pathophysiological standpoint, the increase in estrogen and progesterone reduces physiological reserve during hypoxia,[20] which, combined with the immune modulations characteristic of this period (decreased CD4 + CD8+ T lymphocyte counts, increase of inflammatory cytokines and higher expression of the receptor of angiotensin-converting enzyme 2 [ACE2] - the entry point for SARS-CoV-2 into the cell) contribute to increased COVID-19 severity.[19]

The higher frequency of deaths in the puerperium, particularly in the COVID-19 group, may be related to the combination of impaired access to healthcare services during the postpartum period and to the intensification of physiological hypercoagulability characteristic of this period, which substantially increases thrombotic risk.[22] In addition, common clinical signs in the puerperium, such as lower limb edema, may delay the recognition of thromboembolic events.[23]

The elevated rate of deaths from COVID-19 without associated obstetric causes may reflect inconsistencies in the completion of death certificates. In spite of the smaller number of cases, it was observed an association between gestational diabetes mellitus (GDM) and maternal mortality, a finding that warrants cautious interpretation. Regardless of that, the literature suggests that hyperglycemia, during pregnancy, may compromise the immune response and worsen COVID-19 progression, as it increases even further upregulating ACE receptors,[2]

contributing to a higher risk of severe outcomes for pregnant women with GDM,[2] as well as may also promote vascular lesions, which influence the clot formation and the previously described thromboembolism.[26]

The inclusion of pregnant and postpartum women in the priority groups for COVID-19 vaccination, since mid-2021,[27] associated with the expansion of vaccine coverage, the presence of antibodies circulating in subsequent waves and the improvements in clinical management, contributed to the reduction in maternal mortality. These factors, along with the reduced hospital strain and the return of prenatal and postnatal care, help explain the return of ratios to pre-pandemic levels in 2022.[28]

This study has limitations inherent to the use of secondary data from SIM, in which comparisons between deaths with and without COVID-19 preclude direct risk estimates for the population of pregnant and postpartum women. The dependence on the correct completion of death certificates may result in underreporting and misclassification, in addition to the absence of adjusted analyses for potential confounders and potential inaccuracies regarding place of residence and occurrence of death. A major strength is the use of nationwide population-based data and extensive temporal coverage, allowing the analysis of maternal mortality associated to COVID-19 across different pandemic stages in Brazil.

The analysis of maternal mortality due to COVID-19 in the state of São Paulo between 2020 and 2022 showed a substantial impact of the pandemic on this indicator, set against a backdrop of historically elevated maternal mortality, reflecting long-standing structural issue in Brazilian obstetric healthcare. The reduction of ratios in 2022 to pre-pandemic levels suggests the pivotal role of vaccination, the enhancement of clinical management, and the return of prenatal and postnatal care. These findings reinforce the importance of the continuous strengthening of healthcare services and maternal epidemiologic surveillance, with a special emphasis on the postpartum period, including the systematic incorporation of late maternal deaths to better estimate the magnitude of maternal mortality and inform more effective policies aiming its reduction.

Author's contribution

Carvalho AF: conceptualization, data curation, formal analysis, methodology, and manuscript writing.

Lima RB: supervision, validation, and manuscript writing.

França AP: data curation, project administration, supervision, and validation of the manuscript.

All authors approved the final version of the article and declared no conflicts of interest.

Data availability

All datasets supporting the study are included in the article.

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