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# Analysis of the implications of the COVID-19 pandemic on maternal mortality in Brazil in 2020-2021

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**Abstract** *This is a descriptive and ecological study that analyzed the behavior of maternal mortality during the covid-19 pandemic in Brazil in 2020 and 2021, based on data from both the mortality information system (sim) at datasus and the network portal national health data (rnds). from the historical series of maternal mortality ratios (mmr) from 1996 to 2021, it was identified an average of 56.79 maternal deaths per 100,000 live births, concentrated in the north, northeast, and midwest regions, during the pandemic an increase of mmr to 110.25/100,000 live births. of these deaths, 40.5% were related to covid-19 and 70% occurred during the postpartum period, affecting brown, and high-school level of education women. the south, midwest regions and the federal district increased the mmr related to the coronavirus by more than 400%. we identified a low adherence to vaccination against covid-19 was observed in the north, northeast and midwest regions. with noteworthy disparities between the state of são paulo there was a (268.14%) vaccination coverage of immunized pregnant and puerperal women, while in the state of roraima there was only a (4.57%). as a conclusion, the pandemic had tragic effects on maternal health, setting back the mmr in Brazil by about 20 years, which poses even greater challenges to achieving sdg target 3.1 for reducing maternal mortality in the country.*
**Keywords** *Maternal mortality, covid-19, Vaccination coverage, SDG, Brazil*

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## Introduction

Maternal mortality is one of the most serious violations of women's human rights and is preventable in 92% of the cases through adequate prenatal, childbirth, and postpartum care [1]. In 2019, before the beginning of the COVID-19 pandemic, and according to data from the World Health Organization (WHO), 830 women died in the world every day from complications related to pregnancy, childbirth, and the postpartum, mainly in developing countries [2].

Following the declaration of the Public Health Emergency of International Concern in February 2020, SARS-CoV-2 infection spread rapidly throughout the world, with high transmissibility and mortality in different population groups, requiring immediate government responses [3-4].

Mutations in the novel coronavirus and the emergence of new variants exacerbated the risks, especially in more vulnerable groups. Due to physiological changes in women's bodies during pregnancy and childbirth, pregnant women were considered a risk group with high potential to evolve to severe acute respiratory syndrome (SARS), requiring ventilatory support and intensive care, besides the risk of evolving with complications during delivery and the postpartum period [5-6].

Based on the magnitude of excess maternal mortality in Brazil during the COVID-19 pandemic, the current article's objective is to analyze the behavior of maternal mortality during the COVID-19 pandemic in Brazil in 2020 and 2021.

COVID-19 case fatality in pregnant and postpartum women in Brazil peaked in May 2021, when the moving average reached 47.9 deaths per week. By late 2021, more than 2,039 such deaths had been recorded[7]. Numerous factors were related to these deaths, such as vulnerabilities, social inequalities, weaknesses in women's healthcare, and problems in the Unified Health System (SUS) in various regions of the country, including fear and insecurity in accessing health services during the height of the pandemic [8-6].

COVID-19 vaccination was the only tool capable of containing the infection's spread, protecting the workforce and reducing collapses in health services during the crisis. The WHO led a global effort to produce an effective and safe vaccine to be made available with equity and equality to all countries, with governments responsible for initiatives, investments, and organization to deploy the largest vaccination campaign in world history[9].

In Brazil, vaccination began in January 2021 in the priority groups defined as healthcare workers, indigenous people, elderly, and individuals with comorbidities. Pregnant and postpartum women with comorbidities were included in the calendar in March 2021, but their vaccination was suspended in April 2021 pending investigation of adverse events and was resumed in July 2021 for all pregnant women according to the vaccination's campaign's calendar [10-11].

By mid-September 2021, Brazil accounted for 50% of all maternal deaths from COVID-19 in Latin America [12]. Various international agreements since the 1990s had converged in the Sustainable Development Goals (SDGs), adopted by 193 world leaders in September 2015. The targets included the reduction of maternal mortality to 30 maternal deaths per 100 thousand live births by 2030 [2].

Maternal mortality is a serious public health problem in Brazil and displays large regional differences that were further exacerbated by COVID-19 since 2020. The collapse of public and private healthcare systems throughout the world, high case fatality in different population groups, and excess maternal mortality led to a setback of some 20 years in the advances achieved in reducing maternal mortality ratios (MMRs).

## Methodology

This is a descriptive ecological study using as analytical units the maternal mortality ratios (MMRs), maternal deaths caused by or associated with COVID-19 infection in 2020 and 2021, and COVID-19 vaccination coverage in pregnant and postpartum women in Brazil in 2021. The context is analyzed according to regions and states of Brazil and public policy events expressed on a timeline.

A literature review was performed, by intentional selection, on maternal mortality and the relationship to SDG target 3.1 for reduction of overall MMR to fewer than 70 deaths per 100,000 live births by 2030, maternal mortality from COVID-19, and vaccination in Brazil. The search in databases in the Unified Health System (SUS) was conducted in the Mortality Information System (SIM) and the Information System on Live Births (SINASC) for analysis of

the historical series on overall maternal mortality. Information was obtained on the number of vaccine doses administered to pregnant, postpartum, and childbearing-age women in Brazil from the dashboard *Vacinômetro COVID-19*, available on the website of the Department of Monitoring, Evaluation, and Communication of Strategic Data and Information in Health (DEMAS) [13].

The main challenges for the data collection, organization, and analysis involved the fact that COVID-19 was a new event, besides fragmentation of these databases and lack of current information.

Data on maternal mortality were obtained from the Mortality Information System according to information on August 4, 2022, to construct historical series on maternal mortality in Brazil from 1996 to 2020, and on September 7, 2022, to analyze maternal mortality from COVID-19 in 2020 and 2021. These data refer to the maternal death certificates (Domat) from 2021 and were updated in July 2022. The outcome variable for this consultation was all deaths in which the death certificate contained COVID-19 as the immediate, underlying, or contributing cause of death and containing one or more emergency use ICD-10 codes published by the WHO on February 10, 2020[14].

The ICD-10 codes for the outcomes were: B34 – viral infection of unspecified site; B34.2 - coronavirus infection of unspecified site; B97.2 - coronavirus as the cause of diseases classified elsewhere; U04 – severe acute respiratory syndrome (SARS); U04.9 - severe acute respiratory syndrome (SARS), unspecified; U07.1 - COVID-19, virus identified; U07.2 - COVID-19, virus not identified; U08 – personal history of COVID-19; U08.9 – personal history of COVID-19, unspecified; U09 - post-COVID-19 condition; U09.9- post-COVID-19 condition, unspecified; U10 – multisystem inflammatory syndrome associated with COVID-19; U10.9- multisystem inflammatory syndrome associated with COVID-19, unspecified; U12 – adverse reaction to a COVID-19 vaccine; and U12.9 – adverse reaction to a COVID-19 vaccine, unspecified.

To calculate MMRs, we used data from the Information System on Live Births (SINASC) with the total number of live births obtained via Tabnet and multiplied by 100. Data for evaluation of vaccination coverage were based on the number of COVID-19 vaccine doses administered to pregnant, postpartum, and childbearing-age women in Brazil according to major geographic region and state.

Due to the absence of standards and protocols on criteria for calculating vaccination coverage in the population of pregnant and postpartum women in relation to COVID-19 vaccination, we performed a literature search on the criteria adopted by various vaccine manufacturers and regimens for immunobiological products authorized in Brazil.

Vaccination coverage is defined as the proportion of administered doses of an immunobiological recommended on the national calendar in a specific population during a certain period [15]. However, we found a wide variation in the criteria for calculating both the numerator, considering multidose vaccines, and the denominator in specific groups such as pregnant and postpartum women.

To calculate the numerator, for multidose vaccines the WHO recommends considering the last dose or attributed to each dose (D1, D2), that is, estimating vaccination coverage for each dose received, represented as percentages [15].

To calculate coverage of the triple bacterial vaccine (DTP) in pregnant women, the DataSUS base uses as the numerator the sum of the second dose plus the booster dose (D2 + booster) of the adult dual vaccine and the acellular-pertussis triple bacterial vaccine (DTaP) in pregnant women from 12 to 49 years of age. The denominator is the number of live births in the respective year [16].

To calculate DTaP coverage in pregnant women from 2018 to 2021, the Health Surveillance Secretariat of Brazil's Federal District (Brasilia) used as the numerator the total doses administered to childbearing-age women, considering the presence of under-recording of the field "pregnant woman" in the Information System of the National Immunization Program (SI-PNI). The denominator was total live births in the reference period, obtained from the SINASC base [17].

The Brazilian Ministry of Health defines complete immunization against COVID-19 as the administration of two doses (D1 and D2) of the Pfizer, AstraZeneca, or CoronaVac vaccines or a single dose of the Janssen vaccine for non-immunosuppressed individuals. The booster dose is the dose following the primary regimen in certain groups[10].

Based on the review and due to the absence of specific protocols and technical notes specifying vaccination coverage, an immunized

pregnant woman was defined as one that had received the second dose plus the booster dose (D2 + booster), and the denominator was total live births for the year 2020 according to SINASC data, since the data for 2021 were still not available.

To ensure methodological rigor and considering possible under-recording and failures in the identification of this priority group, we also assessed vaccination coverage in childbearing-age women from 12 to 49 years of age, considering the number of second doses plus the booster dose (D2 + booster) and the single doses. This is due to administration of the Janssen vaccine (single dose) in this group, where the denominator was the population estimated by the Brazilian Institute of Geography and Statistics (IBGE), available on the projected population spreadsheet by sex and age for 2010/2060.

We observed some limitations during the data collection, including age group incompatibility, since the Brazilian Ministry of Health defines childbearing-age women as women 10 to 49 years of age and adopts this type of aggregation in all its dashboards. However, the National Health Data Network dashboard aggregates the data by age groups, starting at 5 to 11 years and 12 to 17 years, which is incompatible with the DataSUS base. Thus, due to the unfeasibility of working with a unified vaccination databank for the overall population, we used information on immunization of women starting at 12 years of age.

We also identified 655 records of single-dose vaccination in pregnant and postpartum women, even though the single-dose Janssen vaccine is contraindicated in this group since it is a viral vector vaccine. These records were excluded from the calculation of vaccination coverage.

The databanks were organized by total vaccine doses administered in each geographic region and state according to two groups: (i) childbearing-age women from 12 to 49 years of age and (ii) pregnant and postpartum women, collected on August 29, 2022. Note that the vaccine doses in this source are not reported by year of administration. Thus, calculations of vaccination coverage include all the doses administered, from the start of the vaccination campaign (January 18, 2021) to the date of data collection.

Vaccination coverage was thus calculated as the total number of doses (D2 + booster) administered in pregnant and postpartum women divided by total live births, multiplied by 100. Coverage in childbearing-age women was calculated as total doses (D2 + booster + single dose) administered to childbearing-age women 12 to 49 years of age divided by the population of childbearing-age women 12 to 49 years of age multiplied by 100.

All the collected information was organized in Microsoft Excel® spreadsheets, aimed at describing the distribution of maternal death in the geographic regions and states, as the absolute numbers and percentages of deaths, using as variables age group, place of death, and percentage of principal causes of maternal deaths (COVID-19 or other causes, separated by ICD-10 and absolute number of pregnant, postpartum, and childbearing-age women that were immunized and COVID-19 vaccine doses administered.

After critique and validation of the collected data, the analysis was performed by descriptive statistics (means, medians, and standard deviations) using the R software (version 1.4.1106) and the R Commander package, presented as tables and charts.

**Political context of maternal mortality: 2030 agenda and the COVID-19 pandemic**

The 2030 Agenda that was adopted in 2015 consists of 17 Sustainable Development Goals (SDGs), 169 targets, and 232 economic, social, and environmental indicators. The goals and targets indicate the ambition of universal adoption and preservation of each country's individual realities and capacities according to the involvement of governments and the political, social, and economic context [18].

In Brazil, the target is to reduce MMR to a maximum of 30 deaths per 100 thousand live births by 2030. A recent study [19] showed that besides stagnant rates from 1996 to 2018, older maternal age was associated with greater the risk of maternal death from direct causes, mainly affecting black, brown, and single women and those with less schooling.

With the evolution of the coronavirus pandemic, we identified excess maternal mortality from COVID-19 in Brazil, with a 192% in MMR: from 10.1/100 thousand live births in 2020 to 30.1/100 thousand live births in 2021[7-12]

According to the WHO [20], vaccination is the main tool for prevention, protection, and health promotion and has an important cost-benefit ratio. In Brazil, vaccination began on January 18, 2021, following authorization of emergency

use of the CoronaVac (Sinovac/Butantan) and AstraZeneca (University of Oxford/Fiocruz) vaccines, which was only possible through the political initiative of Brazilian national institutes.

However, due to the denialist logic practiced by the Brazilian federal government administration at the time, which promoted the loosening of social isolation measures and encouraged the use of scientifically unproven drugs, the population was exposed to predatory antivax proselytism. This was promoted in the name of theories on purported individual safety and freedom of choice that clashed with collective safety during a pandemic with high case fatality [21].

All these conducts, alongside a lack of political and legal accountability in federal government spheres in conflict with scientific evidence mobilized to confront the grave health crisis, led various state and municipal governments to assume their own federative responsibility, resulting in uncoordinated actions with extensive fragmentation[21-22].

According to Maciel *et al.*[23], Brazil was slow to implement vaccination, which was preceded by numerous factors such as the federal government's pejorative discourses concerning the vaccines' reactions and risks, lack of support, and political interference, denying the leadership role of the National Immunization Program (PNI) in the vaccination campaign. This allowed state and local governments to take the lead, backed by the National Congress, through public policies and action by the Supreme Court in mediating federative impasses, thus opening a critical conjuncture in the country, marked by different conflicts in actions and reactions that characterized alternative institutional paths and political forces vis-à-vis the health crisis [24].

In this political context, vaccination was launched in Brazil approximately one month after European countries. According to experts, the conducts and behavior by the President of Brazil interfered directly in the timely introduction of vaccination in Brazil [6-23-24]

Late introduction of vaccination in pregnant and pregnant women and those with miscarriages up to 15 days as a risk group for COVID-19 only occurred on March 15, 2021, following the publication of Technical Note 1/2021 (DAPES/SAPS/MS)[7]. However, soon after this release, on May 14, 2021, COVID-19 vaccination in this group was suspended by the Ministry of Health after notification of a post-vaccination adverse event in a pregnant woman [11].

The World Health Organization (1) identifies vaccine hesitancy as one of the ten leading global health threats. Given all these aspects and insecurity, such hesitancy has been considered serious in pregnant and postpartum women according to various studies in the world. Factors associated with interference in adherence to vaccination include multiparity, low schooling (less than 12 years), and unemployment [25-26].

The timeline in Figure 1 summarizes the principal events expressed in federal documents in relation to the paths used to introduce COVID-19 vaccines in Brazil. When analyzing the decision-making milestones, we highlight various publications in a short space of time with diverse and contradictory orientations on the release of vaccination in the specific group of pregnant and postpartum women in Brazil. This may have interfered in vaccine adherence by these women.

## Results and Analyses

When analyzing the trend in maternal mortality affected by COVID-19 and how it jeopardizes SDG target 3.1, we observed that in Brazil, MMRs oscillated from 1996 to 2021, with major variation during the pandemic, from 71.97 (2020) to 110.25 maternal deaths per 100 thousand live births (2021). As shown in Chart 1, the widest variations were in the North and Northeast regions.

Other variations were identified in 1998 and 2009, with MMRs of 64.87 and 64.96 maternal deaths per 100 thousand live births, respectively. Evidence associates these increased MMRs with the H1N1, MERS-CoV, and SARS-CoV outbreaks in these years [5-27].

Comparing the major geographic regions and the Federal District, we found that the North and Northeast of Brazil showed the highest MMRs in the last 25 years, with medians of 62.62 and 64.63, respectively. Meanwhile, the Southeast showed the lowest MMRs, with a median of 51.97. Motta and Moreira (2021) also identified inequalities when they evaluated Brazil's 450 Health Regions (Regional Inter-Administrator Commissions) in 2019 and found that more than 50% of the regions with MMRs higher than the global target were located in the North and Northeast, while those with adequate MMRs were concentrated in the South and Southeast.

Data also suggest an increase in MMR in all regions of Brazil and the Federal District in 2020

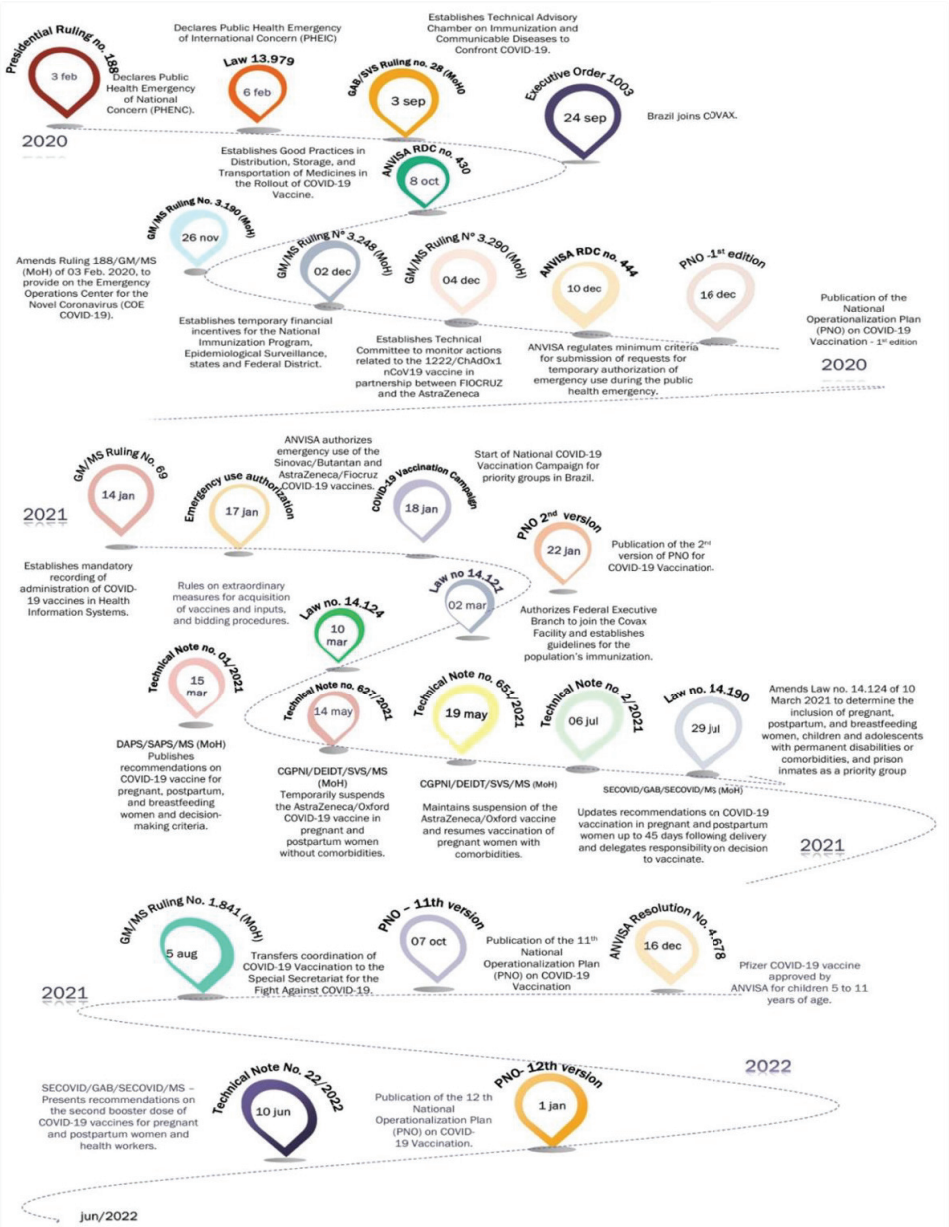


**Figure 1.** Timeline of decision-making milestones on COVID-19 vaccination in Brazil from January 2020 to August 2022.

Source: prepared by the author based on list of rulings (planalto.gov.br) and Technical Notes — Portuguese (Brazil) (www.gov.br).

and 2021, highlighting that the Central-West region (not including the Federal District) had higher MMRs than the Northeast. Such disparities indicate the degree to which these regions were affected by the pandemic, since 40.5% of maternal deaths were related to COVID-19, according to the criteria adopted in this article.

Chart 2 shows the volume of maternal death in Brazil's major geographic regions and the Federal District. In 2020, the South recorded 6.93 maternal deaths per 100 thousand live births, increasing to 62.38 in 2021, an increase equivalent to 900%. Likewise, the Central-West increased from 16.92 to 79.75 maternal deaths

**Table 1.** Maternal mortality ratios in major geographic regions and Federal District by reference year. Brazil (1996-2021)

| Year | Major Geographic Regions, Brazil | | | | | | |
|---|---|---|---|---|---|---|---|
| | North | Northeast | Southeast | South | Central-West | Federal District | Brazil |
| 1996 | 47.45 | 56.77 | 52.37 | 52.83 | 33.16 | 29.94 | 51.61 |
| 1997 | 53.10 | 54.90 | 64.67 | 71.51 | 55.36 | 44.82 | 61.16 |
| 1998 | 57.07 | 56.25 | 70.08 | 76.25 | 54.60 | 55.76 | 64.87 |
| 1999 | 63.11 | 56.25 | 55.28 | 62.08 | 61.14 | 42.55 | 57.36 |
| 2000 | 62.26 | 57.66 | 48.23 | 53.44 | 40.06 | 35.42 | 52.30 |
| 2001 | 49.77 | 57.42 | 44.29 | 52.65 | 60.35 | 29.86 | 50.62 |
| 2002 | 53.12 | 61.42 | 46.27 | 57.37 | 67.26 | 34.94 | 54.10 |
| 2003 | 57.17 | 63.00 | 42.16 | 51.58 | 61.71 | 21.69 | 52.14 |
| 2004 | 52.73 | 63.68 | 44.19 | 59.03 | 66.30 | 43.87 | 46.46 |
| 2005 | 57.49 | 67.03 | 40.71 | 55.09 | 57.72 | 41.38 | 53.38 |
| 2006 | 58.90 | 63.56 | 46.52 | 56.72 | 60.05 | 46.51 | 55.11 |
| 2007 | 64.78 | 63.62 | 48.09 | 52.91 | 46.74 | 38.55 | 54.99 |
| 2008 | 58.39 | 69.57 | 46.71 | 54.37 | 66.67 | 58.86 | 57.28 |
| 2009 | 67.26 | 72.94 | 62.10 | 54.86 | 63.55 | 54.63 | 64.96 |
| 2010 | 62.66 | 71.09 | 53.76 | 52.18 | 63.44 | 45.20 | 60.07 |
| 2011 | 62.47 | 68.98 | 47.21 | 44.43 | 54.61 | 43.71 | 55.27 |
| 2012 | 62.59 | 65.58 | 45.89 | 47.95 | 60.50 | 43.68 | 54.48 |
| 2013 | 74.06 | 75.11 | 49.58 | 34.89 | 57.32 | 53.90 | 58.06 |
| 2014 | 78.65 | 71.30 | 51.57 | 37.58 | 56.40 | 44.72 | 58.37 |
| 2015 | 66.68 | 68.53 | 52.75 | 40.83 | 65.02 | 34.69 | 57.59 |
| 2016 | 72.51 | 67.58 | 53.66 | 40.07 | 64.22 | 55.38 | 58.44 |
| 2017 | 76.76 | 65.83 | 58.17 | 35.97 | 53.12 | 47.12 | 58.76 |
| 2018 | 72.05 | 62.74 | 52.83 | 36.88 | 62.93 | 54.30 | 56.30 |
| 2019 | 74.28 | 59.36 | 52.77 | 38.07 | 63.93 | 21.22 | 55.31 |
| 2020 | 94.49 | 85.90 | 65.09 | 43.21 | 78.49 | 53.35 | 71.97 |
| 2021 | 141.12 | 107.39 | 100.55 | 105.15 | 134.85 | 100.06 | 110.25 |

Source: prepared by the author based on the number of reported maternal deaths per year in the Mortality Information System (SIM). In the calculation, the denominator is the number of live births, obtained from the Information System on Live Births (SINASC) by reference year. MMR –maternal mortality ratio/100 thousand live births.

Measures of central tendency of the MMR: Median: North (62,62), Northeast (64.63) Southeast (51.97), South (52.74), Central-West (60.82), Federal District (44.29), and Brazil (56.79). Standard deviation: North (18.01), Northeast (10.67) Southeast (11.82), South (14.69), Central-West (17.02), Federal District (14.82), and Brazil (11.43).

per 100 thousand live births, an increase of 471%. The Federal District (analyzed separately from the Central-West), showed MMR of 60.56 per 100 thousand live births in 2021, some 477% higher than in 2020, when the MMR was 12.70 maternal deaths per 100 thousand live births.

According to Souza and Amorim[5], these high mortality ratios are associated with problems in direct healthcare for women, such as lack of funding, low quality of prenatal care, barriers in access to public healthcare services, and obstetric violence.

Given the limited capacity of the Unified Health System (SUS), evidence indicates that some 90% of Brazilian municipalities lacked ICU beds at the start of the pandemic, and that most of these municipalities without ICU beds were concentrated in the North and Northeast regions [28]. According to Francisco *et al* [29], such conditions help explain why 25.5% of the deaths from March 1, 2020, to May 5, 2021, were in pregnant or postpartum women without ICU access and that 33.5% of these failed to receive invasive ventilatory support.

We further highlight the predominance of maternal deaths in postpartum women, accounting for 71.43% of the deaths in 2020 and 75.20% in 2021. These data reveal a change in the profile of maternal deaths. In May 2021, the case-fatality rate was 7.2% and consisted predominantly of pregnant women in the second and third trimesters[7]. Thus, vaccination in early

**Table 2.** Total reported maternal deaths and maternal mortality ratios related to COVID-19 by major geographic regions of Brazil in 2020 and 2021

| Region/ State | Total deaths related to COVID-19 | Total deaths in 2020 | Total deaths in 2021* | MMR / COVID-19 2020 | MMR / COVID-19 2021 |
|---|---|---|---|---|---|
| North | 309 | 83 | 226 | 27.52 | 73.32 |
| Northeast | 497 | 159 | 338 | 20.63 | 44.21 |
| Southeast | 710 | 171 | 539 | 16.25 | 53.45 |
| South | 252 | 26 | 226 | 6.93 | 62.38 |
| Central-West | 191 | 39 | 152 | 16.92 | 79.75 |
| Distrito Federal | 28 | 5 | 23 | 12.70 | 60.56 |
| Brazil | 1.987 | 483 | 1.504 | 17.69 | 56.29 |

Source: prepared by the author based on the Mortality Information System (SIM) using certificates of maternal deaths (Domat) in 2020 and 2021, available at: https://datasus.saude.gov.br/transferencia-de-arquivos/. MMR – maternal mortality ratio per 100 thousand live births. In the calculation, the denominator is the number of live births, obtained from the Information System on Live Births (SINASC) by reference year. * Preliminary data updated in 2022.

pregnancy could have prevented such complications. Chart 3 shows the vaccination coverage of childbearing-age women 12 to 49 years of age considering the number of COVID-19 vaccine doses administered.

Our analysis of the results revealed important vaccination coverage in Brazil's regions, although the coverage is not adequate, since the estimated population of childbearing-age Brazilian women is 61 million, and these women would need to have received at least two doses (D2 + booster). The total number of administered doses should have been 123 million rather than 85,433,078 (Chart 3). The high observed percentages may have resulted from aggregation of databanks that considered the total vaccine doses administered rather than the total number of women completely immunized in 2021 and 2022. This discrepancy requires more precise investigation of vaccination in childbearing-age women in Brazil.

Meanwhile, the specific group of pregnant and postpartum women showed low rates of vaccination coverage in most of Brazil's regions. Table 1 shows low vaccination coverage in the North (31.72%), Northeast (55.25%), and Central-West (49.58%). The states of Brazil with the lowest COVID-19 vaccine coverage in pregnant and postpartum women were Roraima (4.57%), Amapá (19.05%), Acre (24.42%), Amazonas (25.64%) Mato Grosso do Sul (26%), Tocantins (31.89), Ceará (33.09%), Alagoas (34.92%), Pará (35.40%) and Maranhão (39.15%).

When comparing regions and states, we found the highest rates of COVID-19 immunized pregnant and postpartum women in the South (70.12%) and Southeast (173.52%) and in the states of São Paulo (268.14%), Paraná (86.18%), Espírito Santo (80.84%), and Minas Gerais (79.56%).

Recent evidence points to an 80% reduction in the odds of deaths in pregnant women immunized with two doses of COVID-19 vaccine, compared to those who have not received any dose [30]. However, with the results, we observed low coverage rates in most of Brazil's regions and an enormous discrepancy, especially when comparing the state of São Paulo, with more than 268% of pregnant women immunized, to the state of Roraima, with slightly more than 4.5%, and the fact that the worst coverage rates were concentrated in the North and Northeast. All these rates, which increased the overall national vaccination coverage to 99.98%, clearly emphasize the huge heterogeneity between regions of Brazil and the country's persistent challenges.

**Table 3.** COVID-19 vaccination coverage in childbearing-age women 12 to 49 years of age according to major geographic region and state from January 2021 to August 2022. Brazil, 2022

| Region/State | Population of childbearing-age women | Total doses (D2 + booster + single dose *) administered to childbearing-age women | Vaccination coverage** (%) | Estimated total doses for complete immunization of childbearing-age women (D2+booster) |
|---|---|---|---|---|
| North | 5,804,057 | 5,380,183 | 92.70 | 11,608,114 |
| Northeast | 17,413,695 | 22,500,964 | 129.21 | 34,827,390 |
| Southeast | 25,146,672 | 39,658,703 | 157.71 | 50,293,344 |
| South | 8,331,790 | 11,864,700 | 142.40 | 16,663,580 |
| Central-West | 3,956,500 | 4,715,568 | 119.19 | 7,913,000 |
| Distrito Federal | 976,468 | 1,312,960 | 134.46 | 1,952,936 |
| Total Brazil | 61,629,182 | 85,433,078 | 138.62 | 123,258,364 |

Source: prepared by the author, based on the number of COVID-19 vaccine doses administered to childbearing-age women 12 to 49 years of age, from the population projection spreadsheet by sex and age, 2010/2060 by IBGE, referring to the year 2021. Available at https://www.ibge.gov.br/estatisticas/sociais/populacao/9109-projecao-da-populacao.html?=&t=resultados. Number of vaccine doses obtained from the RNDS. Available at: https://infoms.saude.gov.br/extensions/DEMAS_C19_Vacina_v2/DEMAS_C19_Vacina_v2.html. *Single dose: childbearing-age women (12 to 49 years of age) that received a single dose vaccine. **Vaccination coverage: sum of number of doses administered to childbearing-age women, divided by the population, multiplied by 100.

**Table 4.** COVID-19 vaccination coverage in pregnant and postpartum women according to major geographic region and state from January 2021 to August 2022. Brazil, 2022.

| Region/State | Target population (live births) | Total doses (D2 + booster) administered | Vaccination coverage (%) |
|---|---|---|---|
| **North** | **301,635** | **95,683** | **31.72** |
| Rondônia | 25,798 | 14,546 | 56.38 |
| Acre | 15,142 | 3,697 | 24.42 |
| Amazonas | 75,635 | 19,390 | 25.64 |
| Roraima | 13,760 | 629 | 4.57 |
| Pará | 132,938 | 47,066 | 35.40 |
| Amapá | 14,633 | 2,788 | 19.05 |
| Tocantins | 23,729 | 7,567 | 31.89 |
| **Northeast** | **770,688** | **425,775** | **55.25** |
| Maranhão | 106,079 | 41,527 | 39.15 |
| Piauí | 45,229 | 28,547 | 63.12 |
| Ceará | 121,904 | 40,341 | 33.09 |
| Rio Grande do Norte | 43,531 | 30,994 | 71.20 |
| Paraíba | 56,379 | 38,972 | 69.13 |
| Pernambuco | 128,481 | 110,226 | 85.79 |
| Alagoas | 48,341 | 16,882 | 34.92 |
| Sergipe | 31,784 | 17,118 | 53.86 |
| Bahia | 188,960 | 101,168 | 53.54 |
| **Southeast** | **1,052,399** | **1,826,130** | **173.52** |
| Minas Gerais | 247,198 | 196,663 | 79.56 |
| Espírito Santo | 53,767 | 43,466 | 80.84 |
| Rio de Janeiro | 199,124 | 105,043 | 52.75 |
| São Paulo | 552,310 | 1,480,958 | 268.14 |

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| Region/State | Target population (live births) | Total doses (D2 + booster) administered | Vaccination coverage (%) |
|---|---|---|---|
| South | 374,949 | 262,927 | 70.12 |
| Paraná | 146,291 | 126,076 | 86.18 |
| Santa Catarina | 97,916 | 50,941 | 52.03 |
| Rio Grande do Sul | 130,742 | 85,910 | 65.71 |
| Central-West | 191,113 | 94,748 | 49.58 |
| Mato Grosso do Sul | 41,308 | 10,739 | 26.00 |
| Mato Grosso | 57,037 | 31,241 | 54.77 |
| Goiás | 92,768 | 52,768 | 56.88 |
| **Federal District** | **39,361** | **24,406** | **62.01** |
| **Brazil** | **2,730,145** | **2,729,669** | **99.98** |

Source: prepared by the author, using as the numerator the number of second doses (D2 + booster) of COVID-19 vaccine in the priority group (pregnant and postpartum women), and as the denominator the number of live births obtained from the SINASC by state for the year 2020.

## Conclusion

We concluded that the pandemic took a tragic toll on maternal health in Brazil, producing a setback of some 20 years in MMRs, and that the delay in the prioritization and the release of vaccination in this group, as well as the policy aspects involved in government decisions, resulted in low vaccination coverage. This poses even greater challenges for meeting SDG target 3.1 for the reduction of maternal mortality in the country,

Thus, numerous actions and initiatives need to be prioritized by policy-makers at the national level, seeking to overcome regional inequalities, besides: 1) prioritizing social policies in health targeted to childbearing-age women, aimed at overcoming the complexity of maternal death, especially in the North, Northeast, and Central-West of Brazil; 2) investing in public healthcare services for allocation and training of health workers, seeking to upgrade women's healthcare during pregnancy, childbirth, and the postpartum; 3) strengthening actions in primary healthcare, aimed at offering measures for the prevention of chronic, emerging, and reemerging diseases, reinforcing existing programs in the Unified Health System; and 4) promoting adequate monitoring through health information systems and indicators that favor decision-making and allow immediate action in the face of maternal mortality risks, thereby guaranteeing women's reproductive rights independently of ethnicity, race/color, and/or social status.

## Contributions

As the main author, Souza VTF worked on the design of the methodological model, on the secondary database research and construction of the results, analysis and final review. As a co-author, Ribeiro JM participated in the design of the methodological model, analysis and final review of the text, and approved the manuscript and agreed to its submission to Ciência & Saúde Coletiva.

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