Final Technical Report

for

Research Project

Retrospective Assessment of the impact of COVID-19 on pregnancy and newborn outcomes : an explanatory sequential mixed method study

Principal Investigator: Edit Oktavia Manuama (WHO Indonesia)
Co-Investigator(s): Dr. Detty Siti Nurdiati (Center for Child Health - Pediatric Research Office, University of Gadjah Mada), Dr.Indah Kartika Murni (Center for Child Health - Pediatric Research Office, University of Gadjah Mada), Dr. Likke Prawidya Putri (Center for Child Health - Pediatric Research Office, University of Gadjah Mada), Bayu Satria Wiratama (Center for Child Health - Pediatric Research Office, University of Gadjah Mada), Dr. Vicka Oktaria (Center for Child Health - Pediatric Research Office, University of Gadjah Mada)

2023.4.MP

February 2024

Final Technical Report

Disclaimer

The final technical report is submitted by the research on completion of a research project funded and sponsored by WHO regional office for South-East Asia and the WHO country offices in the South-East Asia Region. The final technical report publishes preliminary and unpolished results and aim to provide a vehicle for early access to research finding to maximize their use for informing policies and programs. The reports have not been edited, proof-read or peer reviewed, and have been published as presented. The findings, interpretations, and conclusions expressed in the final technical report are entirely those of the author(s) and should not be attributed in any manner to the World Health Organization, or to its affiliated organizations. Citation and the use of material presented in the final technical report should take into account this provisional character. The sponsoring technical team and author(s) bear full responsibility for the quality of the technical contents and presentation of material in the series.

FINAL REPORT

Retrospective assessment of the impact of COVID-19 on pregnancy and newborn outcomes: an explanatory sequential mixed method study

Submitted to:

RMNCAH Unit

Department of Healthier Population and Non-Communicable Diseases

WHO Indonesia

Submitted by:

Center for Child Health – Pediatric Research Office (CCH-PRO)

Faculty of Medicine, Public Health, and Nursing

Universitas Gadjah Mada

22 December 2023

GENERAL INFORMATION

Title	Retrospective assessment of the impact of COVID-19 on pregnancy and newborn outcomes: an explanatory sequential mixed method study
Document Type	Technical Report
Date and Version	22 December 2023, Version 2.0
Principal Investigator	dr. R. Detty Siti Nurdiati Z, MPH., Ph.D., Sp.OG(K) Center for Child Health (CCH-PRO) Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia. Email: detty@ugm.ac.id
Co-Investigators	dr.Indah Kartika Murni, M.Kes., PhD, Sp.A(K) ● Co-Principal Investigator Bayu Satria Wiratama, S.Ked., MPH, PhD, FRSPH Epidemiologist/Biostatistician dr. Vicka Oktaria, MPH PhD FRSPH ● Epidemiologist in maternal and child health dr. Likke Prawidya Putri, MPH, PhD ● Public Health Policy Specialist Dr. dr. Tunjung Wibowo, MPH, PhD, Sp.A(K) ● Consultant Neonatologist dr. Ahmad Watsiq Maula, MPH ● Data Manager Specialist Rizka Dinari, S.Gz, MPH ● Project Manager dr. Rohmah Mufidah Ramadhani ● Research Assistant
Technical advisor	Ministry of Health: ● dr. Lovely Daisy, MKM ● dr. Laila Mahmudah, MPH WHO Indonesia: ● Edit Oktavia Manuama, S.Kep, Ns. MPH ● dr. Nurlely Bethesda Sinaga, MPH
Research Sites and Local Investigators	**East Java:** RSUD Dr. Soetomo, East Java ● dr. Manggala Pasca Wardhana, Sp.OG, Subsp.KFM ● Dr. dr. Risa Etika, Sp.A(K) RS Universitas Airlangga

	● dr. M. Ilham Aldika Akbar, Sp.OG ● dr. Muhammad Ardian C.L, SpOG. Subsp.Obginsos. M.Kes ● dr. Robby Nurhariansyah, Sp.A **Central Java:** RSUP Dr. Kariadi Semarang, Central Java ● dr. Julian Dewantiningrum, MSi.Med, SpOG, Subsp. KFM RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH) ● dr. Muhammad Irsam, Sp.OG **West Java:** RSUP Dr. Hasan Sadikin, West Java ● dr. Akhmad Yogi Pramatirta, SpOG(K) ● Dr. dr. Fiva Aprilia Kadi, Sp A(K)., M.Kes RSUD Al Ihsan Provinsi Jawa Barat ● dr. Nuniek Kharismawati, Sp.OG **Yogyakarta:** RSUP Dr Sardjito ● dr. R. Detty Siti Nurdiati Z, MPH., Ph.D., Sp.OG(K) ● Dr. dr. Tunjung Wibowo, MPH, PhD, Sp.A(K) ● dr. Indah Kartika Murni, M.Kes., PhD, Sp.A(K) UGM Academic Hospital (RS Akademik UGM) ● dr. Yosi Tamara, Sp.OG
Funder	WHO Indonesia 5th Floor, Gama Tower, Jl. H.R. Rasuna Said Kav. C-22, Jakarta 12940, Indonesia, Telephone: (021) 50387860
Conflict of interest	The investigators declare no potential conflicts of interest.

EXECUTIVE SUMMARY

Background: Declared by the World Health Organization on March 11, 2020, the COVID-19 pandemic has globally affected millions. Pregnant women, due to physiological changes and restricted lung expansion, are susceptible to severe COVID-19 and may experience adverse pregnancy outcomes linked to the virus. Challenges faced by hospitals during the pandemic underscored the unprecedented nature of the situation, emphasizing the crucial role of organizational structures in managing healthcare challenges. There have been limited studies from Indonesia that have investigated the impact of COVID-19 during pregnancy in hospital settings, exploring health services disruption and mitigation strategies implemented across multiple provinces during the pandemic

Objective: The study pregnancy and birth aims at revealing an elevated risk of maternal mortality during the COVID-19 pandemic and the maternal health service disruptions

Methods: We conducted an explanatory sequential mixed method study consisting of (1) a retrospective cohort analysis of pregnant women who got tested for COVID-19 with positive or negative test results and had completed their pregnancy (delivery or miscarriage) during hospitalization at selected hospitals between March 2020 and December 2022 across four provinces in Indonesia, and (2) a qualitative study based on the 4S framework (Staff, Stuffs, Structures and Systems) used to assess health service readiness in Indonesia using a semi structured interviews with individual and group respondents from eight hospitals in four provinces.

Key findings: We discovered that being positive for COVID-19 during pregnancy was linked to an elevated risk of maternal mortality among those who either tested positive for SARS-CoV-2 infections or contracted the virus during the Delta wave. However, this association was not observed with the risks of miscarriage, preeclampsia, neonatal mortality, and stillbirth. Experiencing moderate-to-severe symptoms of COVID-19 increased the risk of maternal and neonatal mortality, as well as stillbirth, but did not elevate the risk of miscarriage or preeclampsia. The ability of hospitals to adapt to fluctuating COVID-19 cases varied based on their structures. Disruptions to maternal-newborn health (MNH) services were attributed to the limited surge capacity of staff and medical devices in hospitals, as well as the restricted capacity of primary care in MNH treatment.

Recommendation: Future research should explore nuanced interactions between COVID-19 and maternal-neonatal outcomes, considering long-term impacts. The imperative to vaccinate pregnant women remains crucial, exploring the interplay between socio-economic factors, healthcare access, and outcomes is vital for mitigating disparities. Ongoing surveillance and collaborative efforts are essential to adapt healthcare strategies to the evolving pandemic landscape. Future directions include refining surge capacity strategies and fostering continued collaboration between entities to build sustained resilience within healthcare systems. Comprehensive research and collaborative efforts are critical for understanding, mitigating, and adapting to the multifaceted impact of COVID-19 on maternal and neonatal health in Indonesia.

Contents

List of Figures

List of Table

1. BACKGROUND

The World Health Organization (WHO) declared the Coronavirus disease 2019 (COVID-19) pandemic on March 11, 2020. (1) As of October 22, 2023, WHO has reported a global cumulative case count of more than 771 million cases of COVID-19 with 6.9 million deaths.(2) In 2021, Indonesia was one of the global epicenters of the COVID-19 pandemic during the Delta variant outbreak. During that period, the total number of Indonesian people infected with SARS-CoV-2 exceeded 4.2 million people (approximately 1.5% of the Indonesian population), and the death toll reached 144,227. (1) The case fatality rate (CFR) ranged from 0.8% to 12% with higher CFRs being reported in those with comorbidities, including pregnant women. (3,4)

During pregnancy, some physiological and immunological changes occur and cause pregnant women to be more susceptible to infections. (5) Further, the ability of the lungs to expand during pregnancy is limited by the growth of the fetus and fluid retention in the lungs. These changes complicate the compensatory mechanism of pregnant women with respiratory diseases, making them more likely to have hypoxia and an increase in cytokines and complements. (6)

A recent meta-analysis reported an association between SARS-CoV-2 infections and adverse pregnancy outcomes in mothers and newborns.(6) In pregnant women with COVID-19, the number of emergency cesarean sections was higher as well as the occurrence of poor fetal outcomes such as prematurity, miscarriage, and fetal deaths. (6) A living systematic review and meta-analysis reported that being infected with COVID-19 increases the risk of pregnant women having preterm birth (OR 1,57, 95% CI 1.36; 1.81) and stillbirth (OR: 1.81, 95% CI 1.38 to 2.37). (7) Pre-existing comorbidities (gestational diabetes and preeclampsia), advanced maternal age, and high body mass index are risk factors for having adverse COVID-19 and pregnancy outcomes. (7)

Although there have been a large number of studies on the impact of COVID-19 on pregnant women and newborns, Indonesia requires original research to understand the impact of COVID-19 on maternal and newborn health in the context of health facility preparedness and quality of care. An online survey published in 2021, investigated the impact of COVID-19 on pregnant women developing anxiety. The samples are pregnant women residing in Java, Bali, and Sulawesi found that most of the pregnant women experienced anxiety in finding a safe health facility for doing antenatal care and childbirth.(8) Although the finding is consistent with other similar studies, this survey only involved 20 pregnant women from three big islands in Indonesia leading to issues with generalizability.

Studies and reviews on COVID-19 and pregnancy outcomes were conducted on a small scale or sample size, in a single hospital, limited in one district, and mostly involved pregnant women with COVID-19 only and were designed as case reports.(9–11) Moreover, most of the studies are conducted exclusively at one level of referral hospital, for instance, type A only.(9–12) To our knowledge, based on our search from the WHO COVID-19 research database, there is only one study that compared the pregnancy outcome between pregnant women with and without COVID-19 infections.(12) The study published in January 2022, a hospital-based prospective cohort study performed in Surabaya (12), one of the most populated cities in Indonesia, reported no association between COVID-19 positive status and neonatal outcomes. However, the sample size was small (N=141 both in the exposed and non-exposed group). The odds of maternal mortality was reported to increase 7 times in those with COVID-19 than those in the non-COVID-19 group, but this difference was statistically not significant (OR: 6.91, 95% CI: 0.79-60.81).

Studies into COVID-19 and pregnancy topics in Indonesia mostly discuss service disruption and supply-side readiness during the pandemic in Indonesia, and most of them have highlighted significant health service disruptions related to fear of being infected, unclear regulations, and an increase in the burden of health workers and health facilities.(13–15) Another flaw of the existing studies into service disruptions is most of the studies include only specific profession/health staff. A qualitative study, conducted in Mataram and Surabaya, two cities in Indonesia, reported village midwives encountered fear of their well-being and that of her family, increased workload, insufficient personal protective equipment (PPE), difficulty in locating a referral hospital, discomfort in wearing PPE, and social and travel restrictions.(16) Another qualitative study involving nurse managers identified three important components should be in place for health service preparedness during pandemic, which are operational guidelines (including forming

budgeting and referral pathway), infrastructure arrangement, and health personnel management.(17) These two studies successfully identified issues related to maternal health service disruptions and key elements that should be prepared to face pandemic, but might overlooked professional relationships, decision-making processes, and organizational aspects that might affect the performance of health workers. For instance, health professionals feel excluded from decision-making processes and dissatisfied with institutional leadership or recommended procedures that are not implemented by health workers due to lack of feedback from authority.(18,19) Henceforth, a qualitative study conducted in hospital settings that involve multiple hospital stakeholders; obstetrician, neonatologists/pediatricians, chief of triage (emergency) and hospital managers with a focus in COVID-19 in pregnancy might allow wider perspectives and more comprehensive understanding around the service disruptions, operational barriers and enablers, and health system readiness.

We identified that there is a need for conducting a rigorous study to assess impact of COVID-19 in pregnancy outcomes and understand any disruptions and barriers to provision optimum care for pregnant women during pandemic. As a result, Center for Child Health (CCH-PRO) Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, in collaboration with the Ministry of Health (MoH), and WHO in Indonesia aimed to investigate the pregnancy-related and birth outcomes of pregnant women with COVID-19 infection. Further, our study was expected to gain lessons learned to prevent future adverse outcomes for pregnant women due to direct impact of COVID-19 infection or due the complexity of management and referral systems during COVID-19 pandemic to improve the preparedness of health service delivery and risk mitigation during pandemic situations. This study was conducted in multiple and different levels of referral hospitals in four provinces in Indonesia. Our data collection instruments adapted the variables from the WHO generic protocol: a prospective cohort study for investigating maternal infection and neonatal outcomes for women infected with SARS-CoV-2.(20)

2. STUDY OBJECTIVES

2.1. Primary Objective

To assess the impact of COVID-19 infection status in pregnancy on maternal complications, birth

outcomes and newborn status.

2.2. Secondary Objectives

1. To compare maternal characteristics, complications and birth outcomes among pregnant women with COVID-19 during pregnancy by COVID-19 severity (quantitative study).
2. To explore the extent of maternal service disruptions and readiness of healthcare facilities during COVID-19 pandemic (qualitative study).

3. METHODS

WHO and the Indonesian MoH , in collaboration with Center for Child Health (CCH-PRO) conducted an explanatory sequential mixed method study, consisting of (1) a retrospective cohort analysis of pregnant women who got tested for COVID-19 with positive or negative test results and had completed their pregnancy (delivery or miscarriage) during hospitalization at selected hospitals between March 2020 and December 2022 across four provinces in Indonesia, and (2) a qualitative study based on the 4S framework (Staff, Stuffs, Structures and Systems) used to assess health service readiness in Indonesia using a semi structured interviews with individual and group respondents from eight hospitals in four provinces.. UGM developed a new framework of multilayered determinants factors for maternal COVID-19 severity and deaths as illustrated in **Figure 1**. Based on this **Figure 1**, we explored individual factors, and social determinants of health in quantitative study, while health facility readiness was assessed in qualitative study.

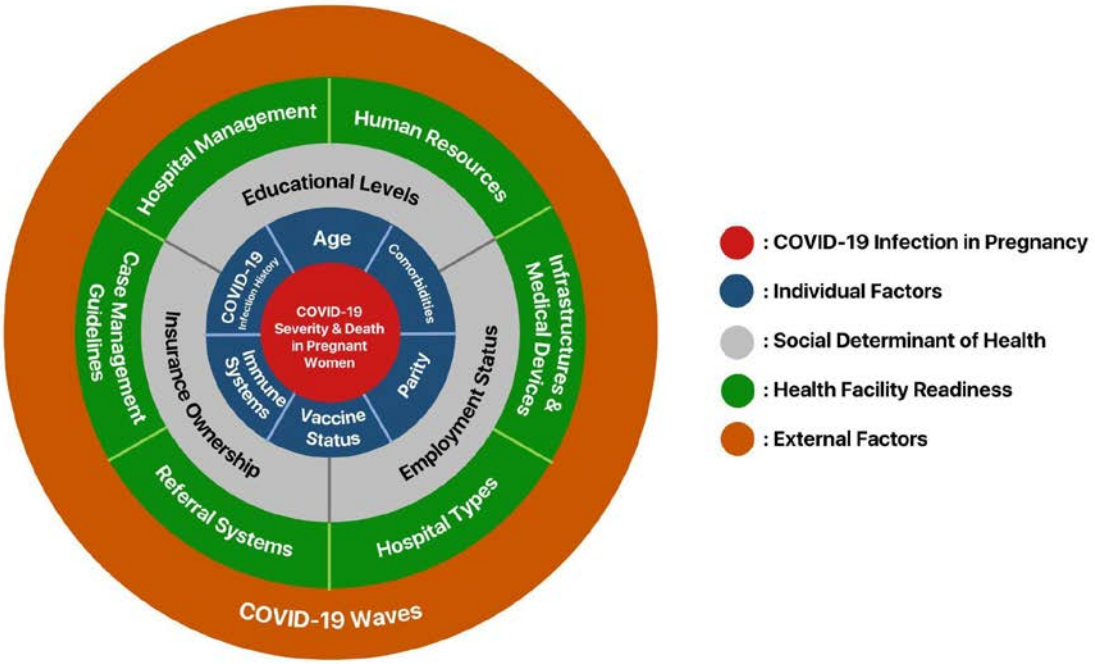

Figure 1. UGM framework of determinant factors of maternal COVID-19 infections examined in the study using quantitative and qualitative design

3.1. Quantitative Study

3.1.1. Study Design, Setting, and Population

The quantitative design was conducted as a retrospective cohort analysis of pregnant women who got tested for COVID-19 with positive or negative test results and had completed their pregnancy (delivery or miscarriage) during hospitalization at selected hospitals between March 2020 and December 2022 across four provinces in Indonesia (**Figure 2**). The selected provinces reported the highest number of maternal deaths associated with COVID-19 during 2021, based on a MoH report (Indonesia Health Profile 2021, **Table 1**).(21)

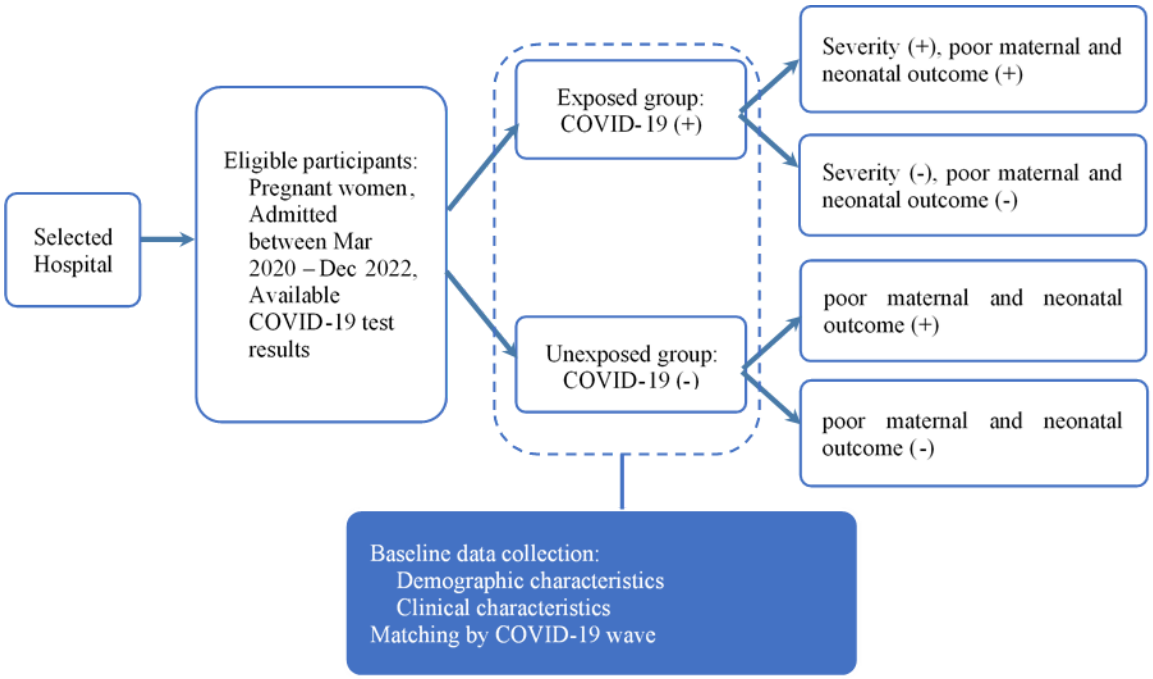

Figure 2. Study Design

Table 1. Maternal mortality related to COVID-19 in 2021 (21)

Province	Livebirth	Total maternal deaths	Maternal Mortality Rate	Total Maternal Deaths related to COVID 19	Maternal Mortality Rate related to COVID 19 (1)
East Java	539,691	1,279	237	799	148
Central Java	495,556	976	197	539	108
West Java	815,650	1,204	148	479	58
Yogyakarta	56,684	162	286	110	194

[1]per 100,000 livebirth

We included eight COVID-19 referral hospitals within the selected provinces, consisting of type A and B. According to Government Regulation 47/2021, type A hospitals (~tertiary hospital) are the highest subspecialist service with at least 250 beds, and type B hospitals (~secondary hospitals) with at least 200 beds. The distribution of the hospitals is presented in **Table 2**. Based on our preliminary survey in several primary health care centers (PHCs), we did not collect participants from PHCs due to incomplete information about COVID-19 test, and clinical data, and low number of pregnant women managed at PHCs during the study period.

Table 2. List of selected hospital

Province	Type A	Type B
East Java	RSUD Dr. Soetomo	RS Universitas Airlangga (UNAIR)
Central Java	RSUP Dr. Kariadi Semarang	RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH)
West Java	RSUP Dr. Hasan Sadikin	RSUD Al Ihsan Provinsi Jawa Barat
Yogyakarta	RSUP Dr. Sardjito	RS Akademik UGM

The data collection was planned to be conducted for a four-month period by doing medical record reviews at the selected hospitals.

Inclusion criteria:

- Pregnant women who are admitted to the hospital, regardless of cause, in participating hospitals during March, 2020 to December, 2022, **AND**
- Whose pregnancy completed or terminated in a participating hospital during hospitalization, **AND**

- Who has a positive or negative COVID-19 test result during hospitalization.

Exposure status:

- **COVID-19 test positive**: a positive test result for SARS-CoV-2 at any point during hospitalization based on results of laboratory confirmed reverse transcription polymerase chain reaction (RT-PCR) test or rapid diagnostic test antigen (RDT-Ag) test.
- **COVID-19 test negative:** a negative test result for SARS-CoV-2 during hospitalization.

3.1.2. Recruitment

A retrospective review of the mother-baby's medical record was performed in the participating hospitals in four provinces where screening and/or symptomatic testing of SARS-CoV-2 took place from March 2020 to December 2022. A list of eligible participants was provided by the hospitals. Eligible pregnant women with COVID-19 positive test results were matched (1:1) with pregnant women with COVID-19 negative test results based on COVID-19 waves. Timeline of the COVID-19 waves was defined following Mandala et al.(22) (**Table 3**). In addition, there were several changes in COVID-19 guidelines implemented during COVID-19 pandemic, which influenced COVID-19 case management in each hospital. Medical records of admitted pregnant women at participating hospitals were reviewed to explore the severity of COVID-19 symptoms, prognosis and complications of pregnancy and delivery as well as neonatal outcomes during hospitalization. For each province there was one study coordinator (consultants in obstetrics or neonatology) who helped to validate the medical record review process.

Table 3. Estimated timeline of COVID-19 waves (22)

Wave	Date onset	Date ended
Alpha	Unknown	Before January 1, 2021
Beta	January 1, 2021	April 30, 2021
Delta	June 1, 2021	October 31, 2021
Omicron	December 1, 2021	March 31, 2022

3.1.3. Sample Size calculation

The calculation of sample size was based on study by Papageorghiou et al. (23), with 5% type-1 error, 80% power, 6.68% incidence of preeclampsia in unexposed group and 12% in exposed group (RR preeclampsia 1.77). The minimum sample size of 4,024 mothers and 4,024 baby dyads for both exposed and non-exposed groups with 1:1 ratio.

3.1.4. Main Study Outcome

Table 4. List and operational definition of maternal and birth outcomes

Outcome variable	Definition
Maternal outcomes	
Maternal mortality	Death of a woman due to causes linked to pregnancy while pregnant or within 42 days after giving birth.
Pregnancy completion	
• Miscarriage	Termination of pregnancy before the fetus is able to survive, which occurs when the pregnancy is less than 20 weeks gestation or the fetal weight is <500 grams, either spontaneously or induced.(24)
• Spontaneous delivery	Delivery per vaginal with or without stimulation (e.g., oxytocin or misoprostol) during the second stage of labor.
• Induction delivery	Delivery per vaginal with the use of agents for labor induction and/or instrumentation (e.g., forceps or vacuum extraction) before cervical dilation and effacement.
• Cesarean section delivery	Delivery through an open abdominal incision and an incision in the uterus.
Preeclampsia	Preeclampsia was based on doctor's diagnosis written in the medical records or when hypertension (systolic>140 mmHg and/or diastolic>90 mmHg) and proteinuria (+1 protein or above = 30 mg/dL) occurred together.
Birth outcomes	
Neonatal mortality	Death of a live-born infant, regardless of gestational age at birth, within the first 28 completed days of life.(25)
Stillbirth	Death of an infant that occurs after 28 weeks of pregnancy, either before or during birth.(26)
Poor fetal outcome	
Respiratory distress	Downe's score is more than one or based on the doctor's diagnosis

Outcome variable	Definition
Premature	Infant born before 37 weeks of gestational weeks (Quinn, et al,, 2016 (32)
Low birth weight	Birthweight <2,500 grams (Cutland, et al., 2017(33)
Low Apgar score at 5 minutes	Apgar score measured at 5 minutes after birth which scored less than seven (Montgomery, 2000)
Neonatal infection	Any kind of infection, such as omphalitis, or pneumonia, except sepsis.

3.1.5. Study Variables

This study collected several types of variables, which were demographic characteristics, clinical characteristics, COVID-19 treatment, pregnancy and maternal outcomes, and neonatal outcomes, from the medical record. Clinical characteristics of COVID-19 symptom severity was assessed among COVID-19 positive mothers following the WHO progression scale: mild, moderate, severe, dead (**Table 5 ,** severity classified by oxygen therapy), except for cases without comorbidities but admitted to ICU due to laboratory indication which is considered as a severe case. Details of variables and definitions are presented in **Table A1 (available in the Annexure page)**.

Table 5. Modified WHO classification on COVID-19 severity level (27)

Patient State	**Descriptor**	**Original Score**	**Modified Descriptor**	**Modified Scor**
Uninfected	Uninfected; no viral RNA detected	0	Uninfected; no viral	0
Ambulatory mild diseases	Asymptomatic; Viral RNA detected Symptomatic; independent Symptomatic; assistance needed	1 2 3	Asymptomatic; Viral RNA detected Symptomatic; no specific COVID-19 therapy	1 2
Hospitalize: moderate disease	Hospitalized; no oxygen therapy	4	Hospitalized; no oxygen therapy	3
	Hospitalized; oxygen by mask or nasal prongs	5	Hospitalized; oxygen by mask or nasal prongs	4
Hospitalize: severe diseases	Hospitalized; oxygen by NIV or high flow	6	Hospitalized; oxygen by NIV or high flow	5
	Intubation and mechanical ventilation, pO2/FiO2>= 150 or SpO2/FiO2>=200	7	Intubation and mechanical ventilation or vasopressors	6
	Mechanical ventilation, pO2/FiO2<150 or SpO2/FiO2<200 or vasopressors	8		
	Mechanical ventilation, pO2/FiO2<150 and vasopressors, dialysis or ECMO	9	Mechanical ventilation, pO2/FiO2<150 and vasopressors	7
Dead	Dead	10	Dead	8

3.1.6. Data Collection, Storage, and Management

An electronic based data collection system was developed using Research Electronic Data Capture (REDCap). To assess the feasibility and reliability of data collection, we piloted the e-questionnaire in RSUP Dr. Sardjito by research assistants who had medical doctor and non-medical doctor backgrounds. We employed four enumerators for each province (a total of 16 enumerators). All of the enumerators were briefed on the study protocol and underwent two days training on how to use the e-questionnaire during the data collection process as part of data quality assurance. The data collectors and researchers was also equipped with ethical aspects of the study, such as Good Clinical Practice, Good Documentation Practice, and Ethic in Research. Data quality control was conducted daily by the data verifiers. If there is a query related to the data, the data verifiers will contact the respective enumerators. We conducted two types of data verification, including: 1) remote verification to inspect typological error, inconsistency data, and incomplete data, and 2) source data verification to inspect the validity of the 10% of data in each hospital. In brief, our mitigation strategies are as follows:

1. Utilization of real-time execution of data quality in REDCap (e.g., date of delivery < date of admission),
2. Inform common mistakes to enumerators and provide clarification,
3. Cross-check data validity to directly to medical record (10%), and
4. Data quality checking using R statistical software.

Missing data due to data not available in the medical record was checked to see whether the data is missing at random (MAR) or missing not at random (MNAR). We compared the characteristics of those with missing data with those without missing data by using a chi-square test, an independent t-test or other statistical methods. We used imputation methods to deal with missing data in this study. For numerical data, we use median imputation to fill the missing data. While for categorical data, we add an additional category which is unknown data to compensate missing data in the variable.

3.1.7. Data Analysis

Data analysis was performed using STATA 18, StataCorp LP, Texas. We presented the distribution of outcomes by all risk factors with absolute numerical values and percentages. For statistical analysis, we conducted bivariate and multivariate analyses for each of the outcome variables. In the bivariate

analysis, we used a simple logistic regression to examine the association between all risk factors and outcomes. In accordance with previous research, a p-value less than 0.2 was the cut-off point for including risk factors in the multivariate analysis.(28) We performed a multiple logistic regression analysis to calculate the adjusted odds ratios (aORs) for all of the outcomes. We also conducted a survival analysis approach using the difference between time of admission with occurrence of outcomes and performed a log-rank test to test any significant difference in survival probability based on outcomes. We also performed a multivariable analysis using a cox proportional hazard regression to calculate hazard ratios (HRs) and adjusted hazard ratio (aHRs). We calculated Cramer's V and used a chi square independent test to assess multicollinearity among risk factors. Multicollinearity is considered presence if the variance inflation factor (VIF) is more than 10. This study applied 95% CIs and α=0.05. Additional analysis was conducted by introducing interaction terms of vaccination status, a likelihood ratio test p-value less than 0.01 was considered as significant interaction.

3.2. Qualitative Study

3.2.1. Study Design, Setting, and Population

We developed the research questions based on the 4S framework used to assess health service readiness in Indonesia (29) and conducted semi structured interviews with individual and group respondents from eight hospitals in four provinces. Prior to the data collection, we employed a checklist adapted from the WHO Service Availability and Readiness Assessment (SARA) to explore factors contributing to availability of required facilities, infrastructure, and equipment in the hospitals.

The interviews were conducted offline or online by two qualitative researchers. The offline interviews were scheduled between the researchers and respondents. The respondents included, but not limited to: hospital managers, obstetricians, pediatrician/neonatologists, and chief of triage (emergency) among the hospitals used in the quantitative study in East Java, Central Java, West Java, and Yogyakarta. When the respondents were unable to meet at the scheduled time, online meetings were arranged. Online meetings were also arranged for the triangulation discussion with the medical record staff and staff in charge of the infectious prevention and control. All interviews were led by public health policy specialists, recorded and transcribed.

The following aspects of healthcare systems were investigated to understand barriers in providing optimum care for mothers with COVID-19 and the newborns, proposed in previous study as 4S: 1) staff (health worker availability, training, human resource management to cope with shortages), 2)

stuffs (availability medical equipment, medicines and consumables), 3) structures (building design, hospital beds, surge capacity), and; 4) systems (referral systems, information systems, guidelines and policies).(29) As COVID-19 pandemic experienced several waves, we also explored the changes of the given aspects during the first, delta, and omicron waves by collecting information in 2020, 2021, and 2022.

3.2.1. Data analysis

Analysis was done in a mixed approach: deductive and inductive. For the deductive approach, the four domains (staff, stuff, structures, and systems) were initially assigned as the main codes. Two new codes, financing and health information systems, were added to address the health systems building blocks. Sub-codes were developed by LP and YL, and consulted to other team members. The codes and sub-codes are shown in the **Table 6** below.

Table 6. Final codes and sub-codes

Codes	Sub-codes
Structure	Challenges in the hospital structures
	Flexibility of hospital structure
	Dedicated space for maternal and newborn cases
Staff	Challenges in the workforce
	Strategies / intervention from the national government
	Innovation within the hospital
	Task shifting / sharing / delegation
Stuff	Challenges in equipment, medicine, and supplies availability
	Strategies to cope with the challenges
Systems	Challenges on leadership and governance
	Guidelines / standard operational procedure (SOOP) development and adjustment

	Changes in SOPs for maternal and newborn care
	Hospital disaster plan
	External collaboration
Information systems	Challenges on information systems
	Strategies related to medical records
	The use of technologies to maintain service delivery
Financing	Challenges on financing
	Hospital financing arrangement capacity
	Strategies / intervention from the national government

Each interview was transcribed by trained transcribers that have minimum qualification of master degree related to public health and/or bachelor in health topic with experience in transcribing qualitative interviews. All verbatim transcript was checked by MR and RD, who attended the interviews, then read and coded independently by LP and YL, both with more than 5 years of experience in conducting qualitative study on public health topics. The coded transcripts were then arranged and consolidated using a combination of Dedoose and Microsoft Excel. The two researchers discussed the coding result, and differences are further discoursed with the research team to reach agreements.

The data collection and analyses were conducted iteratively (the coding was done as soon as the transcripts ready) to allow identification of interesting findings for triangulation in the following interview sessions. Triangulation was also completed by discussion with each hospital research coordinator to clarify the findings.

3.3. Ethics

Ethical approval for this study was obtained from:

1. Medical and Health Research Ethics Committee (MHREC), Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada and Dr. Sardjito General Hospital (reference number: KE/FK/0209/EC/2023)
2. SEARO Research Ethics Review Committee (reference number: 2023.04.MP)
3. Dr. Soetomo General Hospital (reference number: 0722/KEPK/VII/2023)

4. Universitas Airlangga Hospital (reference number: 060/KEP/2023)

4. OVERALL STUDY CONDUCT

The study was developed from July 2022 to April 2023, before formally commencing from April 3, 2023 to November 30, 2023. There are five main milestones, including preparation, quantitative data collection, qualitative data collection, data analysis, and dissemination.

4.1. Preparation

During the preparation period (April 2023 to June 2023), we obtained ethical approvals from MHREC, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, SEARO Research Ethics Review Committee, and ethical approvals or study permits from each hospital, as detailed in Table 7. In addition, we conducted several coordination meetings with the representatives of MoH, WHO, and site coordinators, including presentation to the ethics committee in the selected hospitals (Figure 3-6).

Table 7. Study permits from hospitals

Hospital name	Province	Type of permit	Date of granted
RSUD Dr. Soetomo Surabaya	East Java	Ethics approval Research Agreement	20 July 2023 13 September 2023
RS Universitas Airlangga (UNAIR), Surabaya	East Java	Ethics approval Research Agreement	18 April 2023 18 August 2023
RSUP Dr. Kariadi Semarang	Central Java	Permit	28 April 2023
RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH)	Central Java	Permit	5 June 2023
RSUP Dr. Hasan Sadikin	West Java	Permit	7 June 2023
RSUD Al Ihsan Provinsi Jawa Barat	West Java	Permit	28 April 2023
RSUP Dr. Sardjito	Yogyakarta	Permit	2 May 2023
RS Akademik UGM	Yogyakarta	Permit	4 May 2023

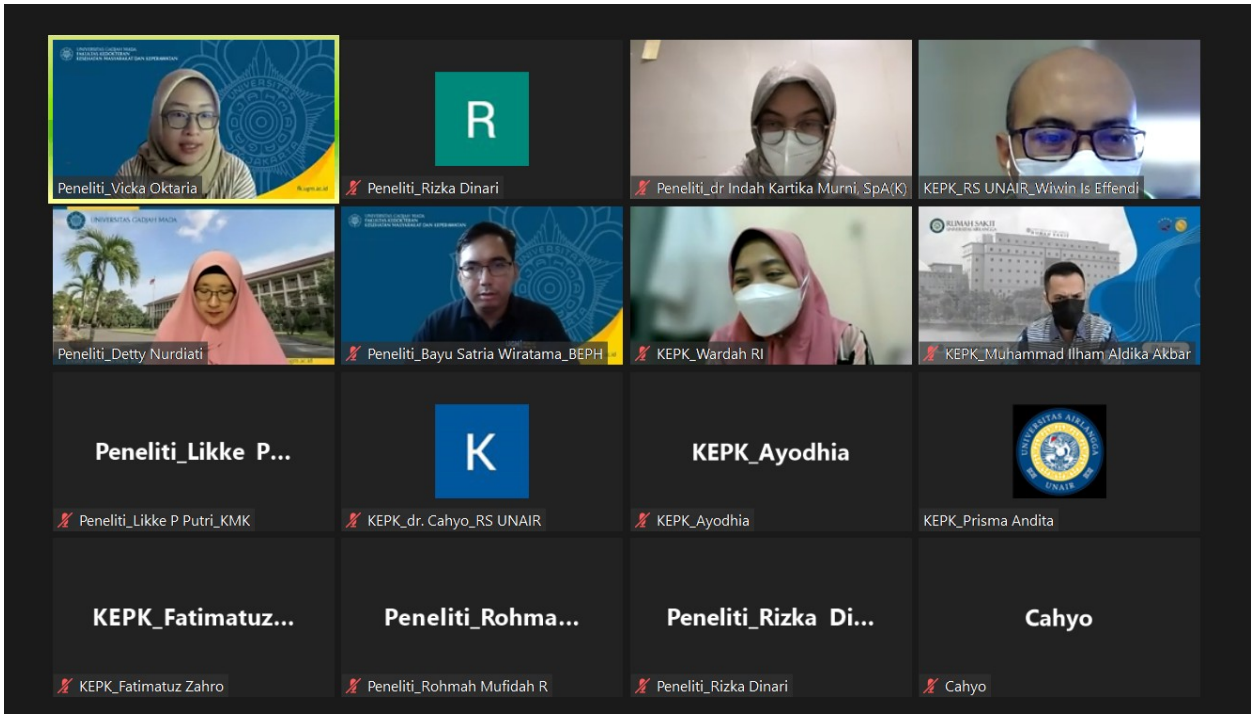

Figure 3. Presenting study protocol to Ethic Committee in RS Universitas Airlangga, Surabaya on 18 April 2023

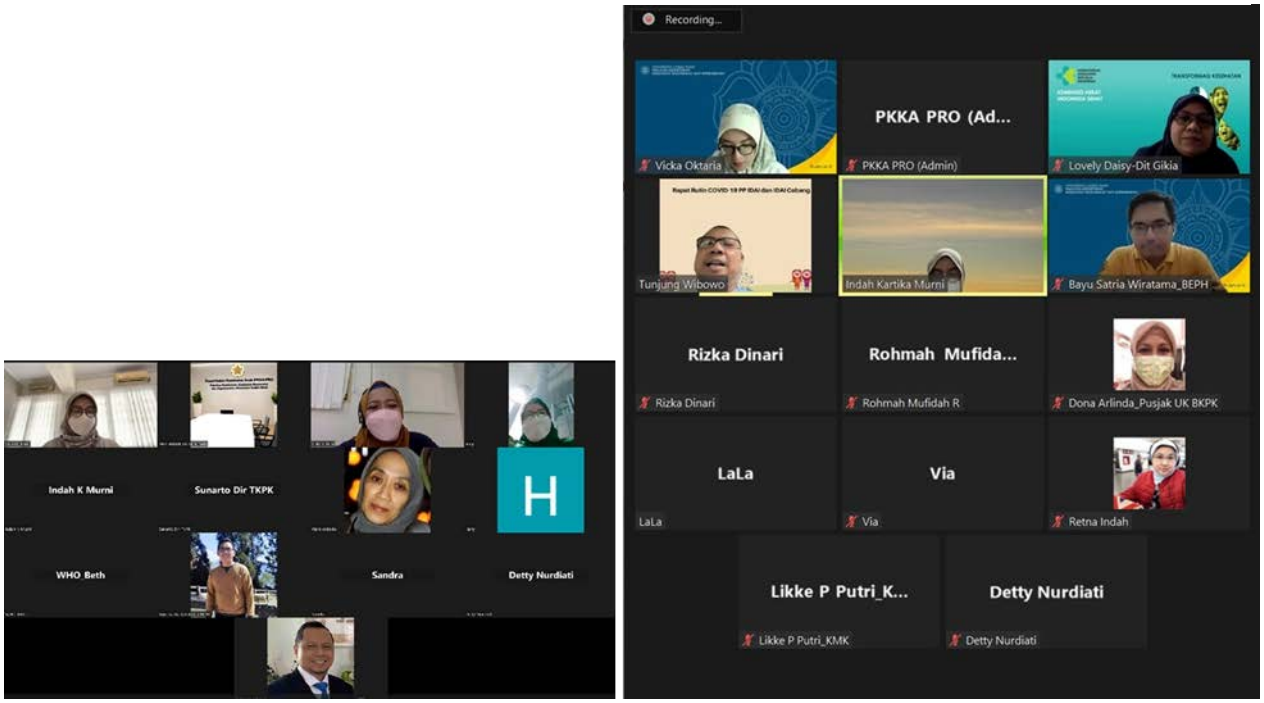

Figure 4. Meeting with MoH and WHO representatives on 23 December 2022 and 22 May 2023

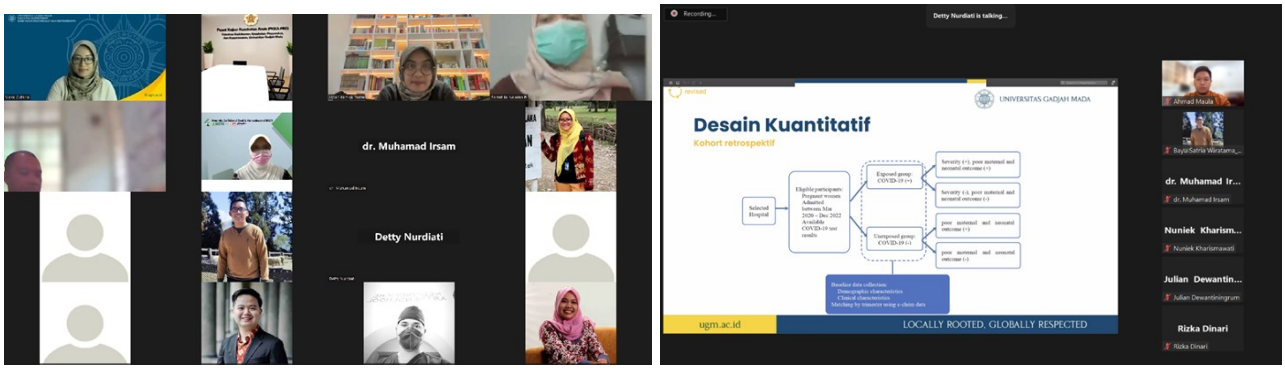

Figure 5. Coordination meeting with hospital representatives on 6 February 2023 and 29 March 2023

A total of 16 enumerators with qualifications of midwife or general practitioner, and several data verifiers with a qualification of general practitioners, were recruited for data collection and verifications. Interviews for selecting enumerators and data verifiers were conducted virtually by the investigators. The selected enumerators and data verifiers were trained in-person for two days (June 8-9, 2023), along with a kick-off meeting in Yogyakarta (**Figure 6**).

Figure 6 Kick-off meeting and enumerator training on 8 - 9 June 2023

4.2. Quantitative data collection

Quantitative data collection started from June 12 to October 31, 2023 (21 weeks), extended four weeks from the original study timeline (planned to be concluded on October 12, 2023). The commencement date of extracting data from medical records varied across hospitals, depending on the permit/ethical approval and daily medical-record-access limit (**Table 8**). Most of the sites started data collection in June, except RSUD Dr Soetomo, RSUP Dr Kariadi, and RSUP Dr. Hasan Sadikin. The longest delay in the data collection commencement was in RSUD Dr Soetomo as the ethical approval and research agreement were finalized in September 2023, leaving only seven weeks to extract the medical records (initial target was 1,668 medical records of mother-baby dyads). Our coping strategy was relocating several enumerators from Central Java to East Java. We successfully extracted 70% of the initial target (1,168/1,668). The decision to conclude this data collection (on October 31, 2023) was made by WHO and UGM due to time constraints. The recruitment rate in each hospital is summarized in **Figure 7,** while the total of extracted medical records is presented in the 'Result and Discussion' section.

Table 8 Start and end date of quantitative data collection in each hospital

Hospital name	**Province**	**Start date**	**End date**	**Total medical records**	
				Mother	**Newborn**
RSUD Dr. Soetomo Surabaya	East Java	7 September 2023	31 October 2023	1,168	1,187
RS Universitas Airlangga (UNAIR), Surabaya	East Java	26 June 2023	20 September 2023	737	729
RSUP Dr. Kariadi Semarang	Central Java	3 July 2023	9 September 2023	659	669
RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH)	Central Java	12 June 2023	4 July 2023	216	218
RSUP Dr. Hasan Sadikin	West Java	17 July 2023	11 September 2023	722	749
RSUD Al Ihsan Provinsi Jawa Barat	West Java	13 June 2023	9 September 2023	221	223
RSUP Dr. Sardjito	Yogyakarta	12 June 2023	19 October 2023	621	610
RS Akademik	Yogyakarta	23 June	4 September 2023	601	535

UGM		2023			

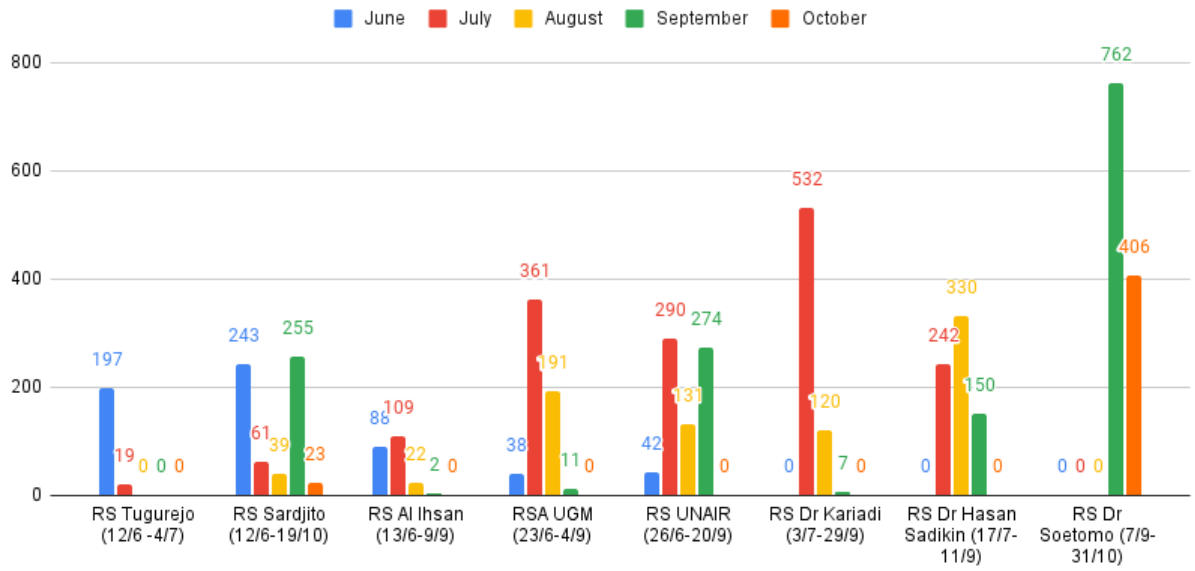

Figure 7. Monthly recruitment rate in each hospital from 12 June 2023 to 31 October 2023

As a part of site visit monitoring, we visited each site to monitor the progress and evaluate the data collection process from June to September 2023. The initial site visit monitoring was conducted on 22 June 2023, at Central Java and the last monitoring was on 1 September 2023, at East Java (**Figure 8**). During these visits, we discussed the challenges faced by the

enumerators, such as administrative problems related to ethical approval, strategies to complete missing data due to poor storage systems during the pandemic, etc.

Figure 8. Site monitoring visit in RSUD Tugurejo, Central Java (upper-left), RSUD Al Ihsan West Java (upper-right), RS Universitas Airlangga, East Java (bottom-left), RSUP Dr Soetomo, East Java (bottom-right).

Furthermore, we performed two stage data verification with daily remote monitoring and on-site source data verification by data verifiers (**Figure 9**). During the daily remote monitoring, to limit errors in data we performed a real time data validation using the data quality feature in REDCap and variables cross-validation using R Software. The numbers of medical records to be randomly verified during on-site verification are presented in **Table 9**. The most common errors were typological errors which were immediately corrected by the corresponding enumerators.

Figure 9. Source data verification in RSUP Sardjito Yogyakarta and RSUP Dr Hasan Sadikin, West Java

Table 9. Numbers of randomly checked medical records at the final stage data collection.

Hospital name	Province	Total mothers' medical	Total of 10% randomly
RSUD Dr. Soetomo Surabaya	East Java	1,187	105
RS Universitas Airlangga (UNAIR), Surabaya	East Java	729	75
RSUP Dr. Kariadi Semarang	Central Java	669	66
RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH)	Central Java	218	22
RSUP Dr. Hasan Sadikin	West Java	749	74
RSUD Al Ihsan Provinsi Jawa Barat	West Java	223	23
RSUP Dr. Sardjito	Yogyakarta	610	64
RS Akademik UGM	Yogyakarta	535	60

4.3. Qualitative data collection

Qualitative data collection started from July 27, 2023 to November 23, 2023 with the first individual/group interview session being held at Central Java (**Figure 10**). Due to time constraints, qualitative data collection was performed almost simultaneously with the quantitative data collection. The checklist to explore factors contributing to the availability of required facilities, infrastructure, and equipment in the hospitals was sent before the individual/group interview session. However, most of the hospital staff required a longer time to complete the checklist as they needed to compile data from different departments (Department of medical services, human resources, laboratory, etc), and submitted the checklist after interview sessions. We added extra interview sessions for collecting supporting data from the medical record divisions, and infection prevention and control divisions.

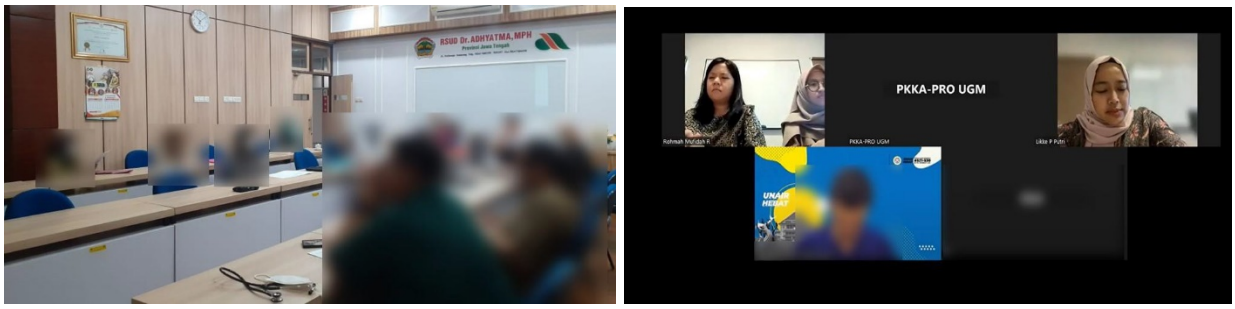

Figure 10. Qualitative data collection

4.4. Data analysis

Data analysis commenced after all data was collected and data cleaning process was completed (November 1-12, 2023). We conducted intensive and frequent workshops to analyze and pick up the main findings of both quantitative and qualitative data (**Figure 11**). Detailed methods of data collection, storage, and management are presented in **section 3.1.6**, and methods of data analysis are presented in **section 3.1.7**.

Figure 11. Workshop of data analysis and writing the manuscript

4.5. Dissemination

National dissemination was conducted hybrid (online and in-person) on November 13, 2023 through a half-day offline session in Jakarta. We invited representatives of MoH (Directorate of Nutrition and Mother and Child Health, Directorate of Health Care Quality, Directorate of Referral Health Care, Directorate of Primary Health Care, Agency for Health Policies Development), National Research and Innovation Agency, WHO, UNICEF, USAID Momentum, site coordinators, enumerators (online), data verifiers (online), participants of the focus group discussion/in-depth interviews (online). This dissemination was attended by 22 in-person

participants, and 26 online participants. During this dissemination, we presented the study overview, research variables, quantitative data verification and analysis, quantitative study results, qualitative study results, and recommendations (**Table 10**). During the discussion session, additional analysis were recruited, including to: 1) examine the case fatality rate for neonatal outcome, 2) average time needed by hospitals to adapt with the COVID-19 pandemic, 3) elaborate the qualitative analysis according to the six pillars of health systems, 4) identify whether case management during the pandemic in compliance to the national standardized operational procedure, and 5) to formulate in recommendations that should be achieved in short, medium, and long term.

This dissemination yielded an action plan in which the study findings are anticipated to be published in policy brief, and to serve as the empirical basis for formulating an operational guideline aimed at enhancing preparedness in addressing natural disasters, social conflicts, or pandemic scenarios in subsequent occurrences. Documentation of the offline session is presented in **Figure 12**.

Table 10. Dissemination agenda

Time	Activity	Speaker/ facilitator
08.30-09.00 WIB	Registration	
09.00-09.05 WIB	Opening	dr. Bertha
09.05-09.35 WIB	Welcoming remarks Principal investigator: dr. Detty Nurdiati Z, MPH., Ph.D.,Sp.OG(K) Director of Nutrition and Mother and Child Health: dr. Lovely Daisy, MKM WHO Indonesia: dr. Nurlely Bethesda Sinaga, MPH	dr. Bertha
09.35-09.50 WIB	Study overview	dr. Indah Kartika Murni, M.Kes, PhD, Sp.A(K)
09.50-10.00 WIB	Variable of interest	Dr. dr. Tunjung Wibowo, Sp.A(K)
10.00-10.10 WIB	Methods of data verification and analysis	dr. Ahmad Watsiq Maula, MPH
10.10-10.20 WIB	Coffee break	dr. Bertha
10.20-10.40 WIB	Study findings: quantitative data	dr. Vicka Oktaria, MPH, PhD, FRSPH
11.00-11.10 WIB	Study recommendation	dr. Detty Nurdiati Z,

		MPH., Ph.D.,Sp.OG(K)
11.10-11.40 WIB	Discussion	dr. Detty Nurdiati Z, MPH.,Ph.D.,Sp.OG(K)
11.40-11.55 WIB	Formulating action plan	dr. Nurlely Bethesda Sinaga, MPH
11.55-12.00 WIB	Closing	dr. Bertha
12.00-13.00 WIB	Lunch	dr. Bertha

Figure 12. National dissemination of study findings on 13 November 2023

5. RESULTS

5.1. Quantitative study

5.1.1. Maternal, demographic, and clinical characteristics

During the recruitment period (June 12 - October 31, 2023), we enrolled 4,945 pregnant women and 4,920 infants, above the minimum required sample size of 4,024 mother-baby dyads. Of all pregnant women, 2,525 of them were COVID-19 positive, while 2,420 were COVID-19 negative Details on recruitment per hospital are presented in **Table 11.** However, in most of the hospitals, the total recruitment numbers were lower than the expected target (reported by each hospital coordinator prior to the data collection), due to a lower number of available medical records (except for RS Akademik UGM and RSUP Dr. Kariadi) and challenges to access medical records, including limited quota of medical record access per day, delayed access to medical records in certain hospitals, and transition from paper-based to electronic medical record.. The number of babies included in the study was slightly lower than the mothers' number as some of the pregnancies were miscarriage cases.

Table 11. Distribution of enrolled pregnant women and babies

Hospitals	Preliminary estimated no of participants from hospital database		Eligible data of mothers from available medical records		Total	Eligible data of babies from available
	COVID-19	COVID-19	COVID-19	COVID-		
RSUP Dr	329	329	301 (91%)	320 (97%)	621 (94%)	610 (93%)
RS Akademik	236	178	326 (138%)	275	601	535 (129%)
RSUD Dr Soetomo	834	834	585 (70%)	583 (70%)	1,168 (70%)[1]	1,187 (71%)
RS UNAIR	441	441	370 (84%)	367 (83%)	737 (84%)	729 (83%)
RSUP Dr	286	286	330 (115%)	329	659	669 (117%)
RSUD	207	207	96 (46%)	120 (58%)	216 (52%)	218 (53%)
RSUP Dr Hasan	689	689	410 (60%)	312 (45%)	722 (52%)	749 (54%)
RSUD Al	280	280	107 (38%)	114 (41%)	221 (39%)	223 (40%)
Total	**3,302**	**3,244**	**2,525 (76%)**	**2,420**	**4,945**	**4,920 (75%)**

[1]Data collection was concluded due to time constraint (70%, 1,168/1,668)

[2]Some mothers had miscarriage

Maternal, demographic, and clinical characteristics are presented in **Table 12**. Of pregnant women included in this study, the mean age was 29.48 (SD 6.18) years, median parity was 2.25 (IQR 1.28), and mean body mass index (BMI) was 23.57 (SD 5.46) kg/m^2. Ninety-five percent of the COVID-19 positive participants were covered by COVID-19 insurance. The proportion of referral cases were higher in COVID-19 positive than COVID-19 negative (59.90% versus 40.10%, respectively). Only 11.3% (559/4,945) of pregnant women received at least one dose of COVID-19 vaccine, with a relatively similar distribution between COVID-19 positive (58.32%, 326/559) and negative groups (41.68%, 233/559). The proportion of COVID-19 re-infection was higher in COVID-19 positive group (80.57%, 228/283) compared to the negative group (19.43%, 55/283). In the group of pregnant women with COVID-19 negative, the presence of comorbidities was more pronounced, including chronic hypertension, gestational hypertension, preeclampsia, tuberculosis, cardiovascular disease, kidney disease, autoimmune disease, and cancer.

Table 12. Maternal, Demographic and Clinical Characteristics

Characteristics	Total (N=4,945)	COVID-19 positive (N=2,525)	COVID-19 negative (N=2,420)	P value
Maternal Characteristics				
Age, mean (SD), years	29.48 (6.18)	29.53 (6.08)	29.43 (6.27)	**0.001**
Parity, median (IQR)	2.25 (1.28)	2.23 (1.29)	2.27 (1.27)	0.203
BMI, mean (SD)	23.57 (5.46)	23.78 (5.25)	23.34 (5.67)	**0.004**
Demographic Characteristics				
Hospital type, No. (%)				
Type A	3,170 (64.11)	1,626 (51.29)	1,544 (48.71)	0.663
Type B	1,775 (35.89)	899 (50.65)	876 (49.35)	
Insurance status, No. (%)				
Out-of-pocket payment	377 (7.62)	111 (29.44)	266 (70.56)	**<0.001**
National health insurance[1]	2,652 (53.63)	618 (23.30)	2,034 (76.70)	
Private insurance	39 (0.79)	11 (28.21)	28 (71.79)	
COVID-19 Insurance	1,867 (37.76)	1,781 (95.39)	86 (4.61)	
Unknown	10 (0.20)	4 (40.00)	6 (60.00)	

Characteristics	Total (N=4,945)	COVID-19 positive (N=2,525)	COVID-19 negative (N=2,420)	P value
Occupational status, No.(%)				
Employed	4,251 (86.00)	2,165 (50.93)	2,086 (49.07)	**0.004**
Unemployed	172 (3.48)	108 (62.79)	64 (37.21)	
Unknown	520 (10.52)	252 (48.46)	268 (51.54)	
Referral status, No. (%)				
Yes	2,561 (51.79)	1,534 (59.90)	1,027 (40.10)	**<0.001**
No	2,291 (46.33)	940 (41.03)	1,351 (58.97)	
Unknown	93 (1.88)	51 (54.84)	42 (45.16)	
Vaccination Status, No. (%)				
Vaccinated at least once	559 (11.30)	326 (58.32)	233 (41.68)	**<0.001**
Cardiovascular Disease, No. (%)				
Yes	168 (3.40)	70 (41.67)	98 (58.33)	**0.014**
No	4,423 (89.44)	2,259 (51.07)	2,164 (48.93)	
Unknown	354 (7.16)	196 (55.37)	158 (44.63)	
Kidney Disease, No. (%)				
Yes	21 (0.42)	9 (42.86)	12 (57.14)	**<0.001**
No	4,115 (83.22)	2,035 (49.45)	2,080 (50.55)	
Unknown	809 (16.36)	481 (59.46)	328 (40.54)	
Autoimmune Disease, No. (%)				
Yes	31 (0.63)	12 (38.71)	19 (61.29)	**<0.001**
No	4,037 (81.65)	1,972 (48.85)	2,065 (51.15)	
Unknown	876 (17.72)	540 (61.64)	336 (38.36)	
Cancer, No. (%)				
Yes	19 (0.38)	5 (26.32)	14 (73.68)	**<0.001**
No	4,051 (81.92)	1,974 (48.73)	2,077 (51.27)	
Unknown	875 (17.69)	546 (62.40)	329 (37.60)	

1) National health insurance = Jaminan Kesehatan Nasional managed by Social Health Insurance Administration Body (Badan Penyelenggara Jaminan Sosial/BPJS)

In the group of pregnant women with COVID-19 positive (N=2,525), 826 of them (32.71%) were symptomatic with 33.54% (277/826) having one symptom, 32.57% (269/826) having two symptoms, 20.34% (168/826) having three symptoms, and 13.56% (112/826) having four or more symptoms. The most common symptoms presented were cough (73.85%, 610/826), fever (45.52%, 376/826), dyspnea (33.66%, 278/826), and runny nose (30.39%, 251/826).

Table 13. Distribution of symptoms among pregnant women with COVID-19 positive (N=826)

Symptom	Presence, No.	Absence, No.	Unknown, No. (%)
Fever	376 (45.52)	440 (53.27)	10 (1.21)
Cough	610 (73.85)	208 (25.18)	8 (0.97)
Anosmia	67 (8.11)	670 (81.11)	89 (10.77)
Myalgia	22 (2.66)	746 (90.31)	58 (7.02)
Diarrhea	14 (1.69)	754 (91.28)	58 (7.02)
Dyspnea	278 (33.66)	528 (63.92)	20 (2.42)
Fatigue	77 (9.32)	680 (82.32)	69 (8.35)
Stomach pain	25 (3.03)	728 (88.14)	73 (8.84)
Chest pain	16 (1.94)	728 (88.14)	82 (9.93)
Loss of	17 (2.06)	729 (88.26)	80 (9.69)
Delirium	5 (0.61)	788 (95.40)	33 (4.00)
Seizure	6 (0.73)	789 (95.52)	31 (3.75)
Runny nose	251 (30.39)	547 (66.22)	28 (3.39)
Sore throat	94 (11.08)	718 (84.67)	36 (4.25)

Clinical treatment given to pregnant women during hospitalization is summarized in **Table 14**. There was a significant difference in the different clinical treatments received between COVID-19 positive and COVID-19 negative pregnant women including ICU admission, mechanical ventilation, antiviral treatment, antibiotic treatment and immunotherapy treatment. However, the proportion of pregnant women receiving corticosteroid treatment did not differ much irrespective of the COVID status

Table 14. Clinical treatments given to pregnant women during hospitalization

Therapy	Total (N=4945)	COVID-19 positive (N=2,525)	COVID-19 negative (N=2,420)	P value
ICU admission, No.				
Yes	511 (10.34)	239 (46.77)	272 (53.23)	0.041
No	4,429 (89.66)	2,283 (51.55)	2,146 (48.45)	
Mechanical ventilator, No. (%)				
Yes	225 (4.55)	148 (65.78)	77 (34.22)	**<0.001**
No	4,720 (95.45)	2,377 (50.36)	2,343 (49.64)	
Radiology result, No. (%)				
Bilateral pneumonia	607 (12.28)	541 (89.13)	66 (10.87)	**<0.001**
Unilateral pneumonia	330 (6.67)	249 (75.45)	81 (24.55)	
Non-pneumonia	4,008 (81.05)	1,735 (43.29)	2,273 (56.71)	
Antiviral treatment, No. (%)				
Yes	1,071 (21.66)	1,051 (98.13)	20 (1.87)	**<0.001**
No	3,831 (77.47)	1,443 (37.67)	2,388 (62.33)	
Unknown	43 (0.87)	31 (72.09)	12 (27.91)	
Antibiotic treatment, No. (%)				
Yes	3,909 (79.05)	2,038 (52.14)	1,871 (47.86)	**0.005**
No	1,024 (20.71)	479 (46.78)	545 (53.22)	
Unknown	12 (0.24)	8 (66.67)	4 (33.33)	
Corticosteroid treatment, No. (%)				
Yes	1,148 (23.22)	604 (52.61)	544 (47.39)	0.074
No	3,755 (75.94)	1,906 (50.76)	1,849 (49.24)	
Unknown	42 (0.85)	15 (35.71)	27 (64.29)	
Immunotherapy treatment, No.				
Yes	33 (0.67)	33 (100.00)	0 (0.00)	**<0.001**
No	4,896 (99.01)	2,481 (50.67)	2,415 (49.33)	
Unknown	16 (0.32)	11 (68.75)	5 (31.25)	

As for laboratory findings, a significant difference between COVID-19 positive and negative pregnant women was observed in C-reactive protein, D-dimer, interleukin 6, and random blood glucose levels, but proportion of pregnant women with abnormal blood glucose were significantly higher (67.67%, 157/232) in COVID-19 positive group than in the COVID-19 negative group (**Table 15)**

Table 15. Laboratory findings among pregnant women during hospitalization

Laboratory Findings	**Total (N=4,945)**	**COVID-19 positive (N=2,525)**	**COVID-19 negative (N=2,420)**	**P value**
Neutrophil leukocyte ratio (NLR), mean	8.26 (10.71)	8.39 (7.54)	8.12 (12.23)	0.378
Procalcitonin, mean (SD)	1.98 (42.21)	2.97	0.95 (20.92)	0.093
C-Reactive protein, mean (SD), per 10	1.15 (2.03)	1.48 (2.64)	0.81 (0.96)	**<0.001**
D-Dimer, mean (SD), per 100 unit	22.43	26.01	18.69 (7.55)	**<0.001**
Interleukin 6, mean (SD), per 10 unit	3.78 (4.15)	3.95 (5.81)	3.60 (0.07)	**0.003**
Random Blood Glucose, No. (%)				
Abnormal blood glucose	232 (4.69)	157 (67.67)	75 (32.33)	**<0.001**
Normal blood glucose	4,713	2,368	2,345	

5.1.2. Pregnancy outcomes

Overall, the proportion of maternal deaths was significantly higher in pregnant women with COVID-19 (85.71%, 102/119) than those with COVID-19 negative (14.29%, 17/119, Table 16). However, miscarriage (32.79%, 60/183 vs. 67.21%, 123/183) and preeclampsia (44.02%, 342/775 vs. 55.98%, 435/775) were significantly lower in pregnant women with COVID-19 positive. As for the distribution of other pregnancy outcomes, including gestational hypertension, premature rupture of membrane (PROM), and placental abruption, the proportion were relatively similar between pregnant women with COVID-19 positive and negative.

Table 16. Distribution of pregnancy outcome by COVID-19 status

Outcomes	COVID-19 positive (N=2,425)		COVID-19 negative (N=2,420)		P Value
	N	%	N	%	
Maternal death	102	85.7	17	14.2	**<0.001**
Miscarriage	60	32.7	123	67.2	**<0.001**
Mode of delivery					
• Spontaneous labor	896	52.3	817	47.6	0.203
• Induction labor	133	46.6	152	53.3	
• Cesarean Section	1,43	51.9	1,32	48.0	
Preeclampsia	342	44.0	435	55.9	**<0.001**
Gestational hypertension	373	45.6	445	54.4	**0.001**
Premature rupture of membrane (PROM)	456	48.2	489	51.7	0.055
Placental abruption	9	36.0	16	64.0	0.131

5.1.2.1. Maternal mortality

Our study reported a markedly higher maternal mortality rate (**Table 17**) than the national report (**Table 1**) as our study was conducted in hospital-based settings, and the participating hospitals also had roles as a referral hospital for COVID-19, whereas the national report represented maternal mortality in the general community. In the participating hospitals, most of the maternal deaths were due to COVID-19, as shown in **Table 17**. The maternal mortality rates (either due to all causes or specifically due to COVID-19) from the highest to the lowest were in Yogyakarta, Central Java, East Java, and West Java, respectively. Differently, East Java ranked second in the national report (**Table 1**) which could possibly be due to the study recruitment for East Java only achieving 70% (1,1688/1,668) of the targeted pregnant women by the end of data collection.

Table 17. Maternal mortality rates in four provinces based on data from eight participating hospitals.

Province	**Live Birth**	**Maternal Deaths**	**Maternal Mortality Rate[1]**	**Maternal deaths due to COVID-19**	**Maternal mortality rate due to COVID-19[1]**	**ΔMaternal mortality rate**
East Java	1,916	48	2,505	40	2,088	418
Central Java	887	27	3,044	26	2,931	113
West Java	972	1	103	1	103	0
Yogyakarta	1,145	42	3,668	35	3,056	611

1per 100.000 live birth

We explored the incidence rate of mortality in pregnant women with different COVID-19 status using Kaplan-Meier curve (**Figure 13**), and found a higher incidence rate of mortality in pregnant women with COVID-19 positive (4.44 per 1,000 person-days) compared to those with COVID-19 negative (1.28 per 1,000 person-days). Among pregnant women with COVID-19 positive, those who had moderate-to-severe symptoms had an incidence rate of mortality of 11.58 per 1,000 person-days, 4-fold higher than those with asymptomatic-to-mild symptoms (2.86 per 1,000 person-days).

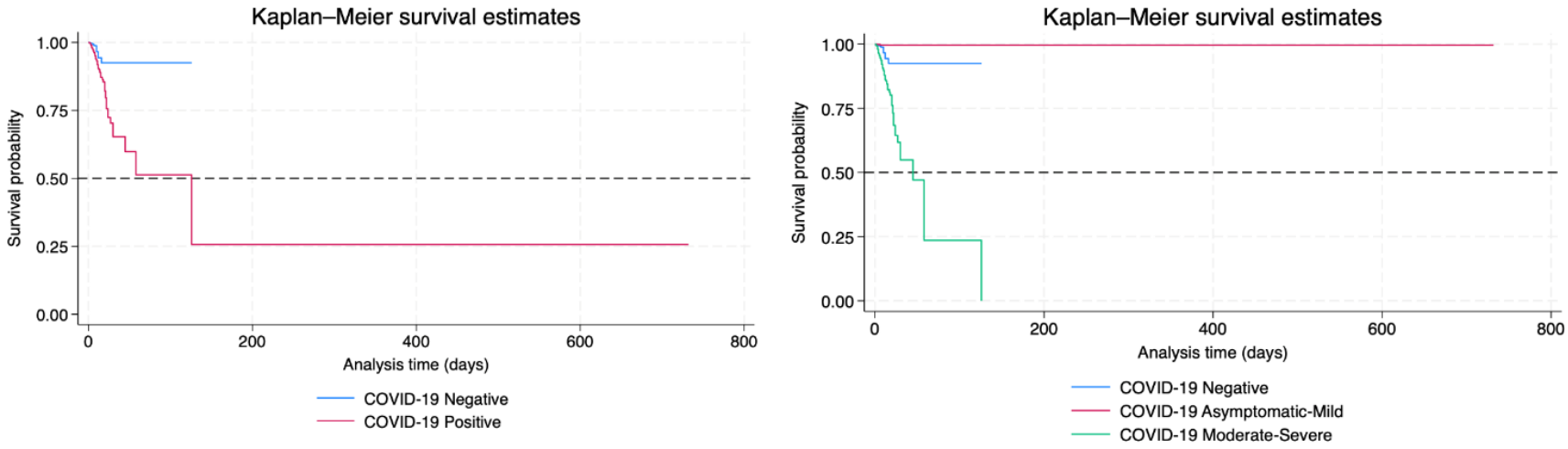

Figure 13. Incidence rate of mortality for pregnant women with different COVID-19 status and symptom severity

Of pregnant women with COVID-19 positive, the incidence rate of mortality with more invasive oxygen therapy was higher (**Figure 14**). Those who did not receive oxygen therapy had an incidence rate of mortality of 0.19 per 1000 person-days, while those who received mask/nasal cannula was 1.11 per 1000 person-days, non-invasive ventilator (NIV)/high flow was 18.32 per 1000 person-days, and ventilator/intubation was 39.21 per 1000 person-days.

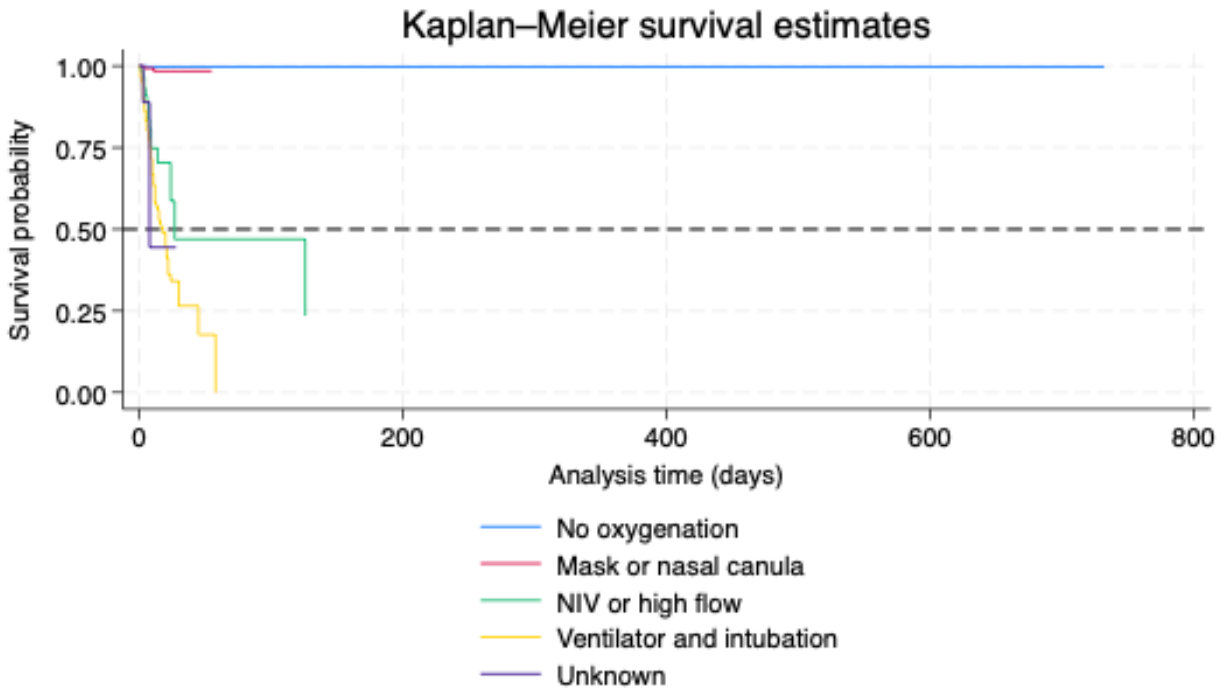

Figure 14. Incidence rate of mortality for pregnant women receiving different oxygen therapy.

Lower incidence rate of mortality was found in pregnant women who were vaccinated for COVID-19 at least once (0.74 per 1,000 person-days) compared to those who were not vaccinated (7.07 per 1,000 person-days, **Figure 15**), highlighting the importance of COVID-19 vaccination against COVID-19.

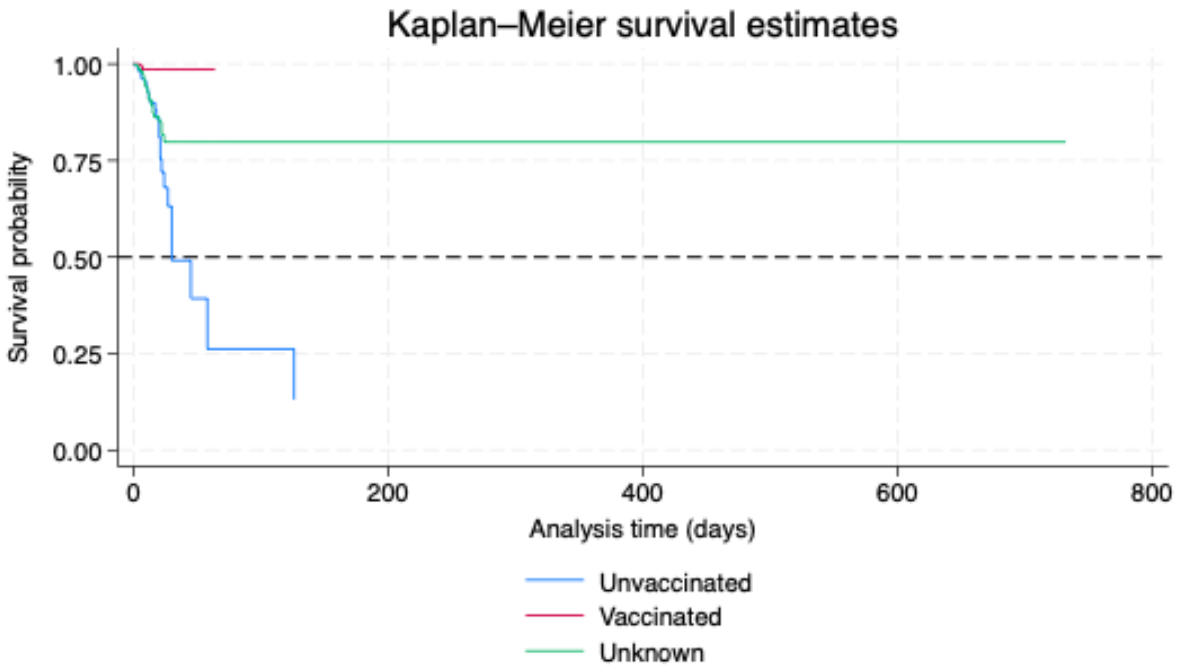

Figure 15. Incidence rate of mortality for pregnant women with different vaccination status.

5.1.2.2. Case Fatality Rate

Case fatality rate (CFR) for pregnant women with COVID-19 was 4.04% (102/2,525, **Figure 16**). We observed that pregnant women with a condition of COVID-19 positive and referred due to obstetric complication had almost three times higher in CFR (2.91%, 22/757) than those with COVID-19 negative who referred due to obstetric complication (1.19%, 11/928). Moreover, when COVID-19 positive co-existing with preeclampsia, the CFR increased to 6.30% (22/349) than the group of COVID-19 negative with preeclampsia (1.86%, 8/431). Hence, being COVID-19 positive during pregnancy exacerbated the fatality of health outcomes, particularly in pregnant women with obstetric complications, such as preeclampsia.

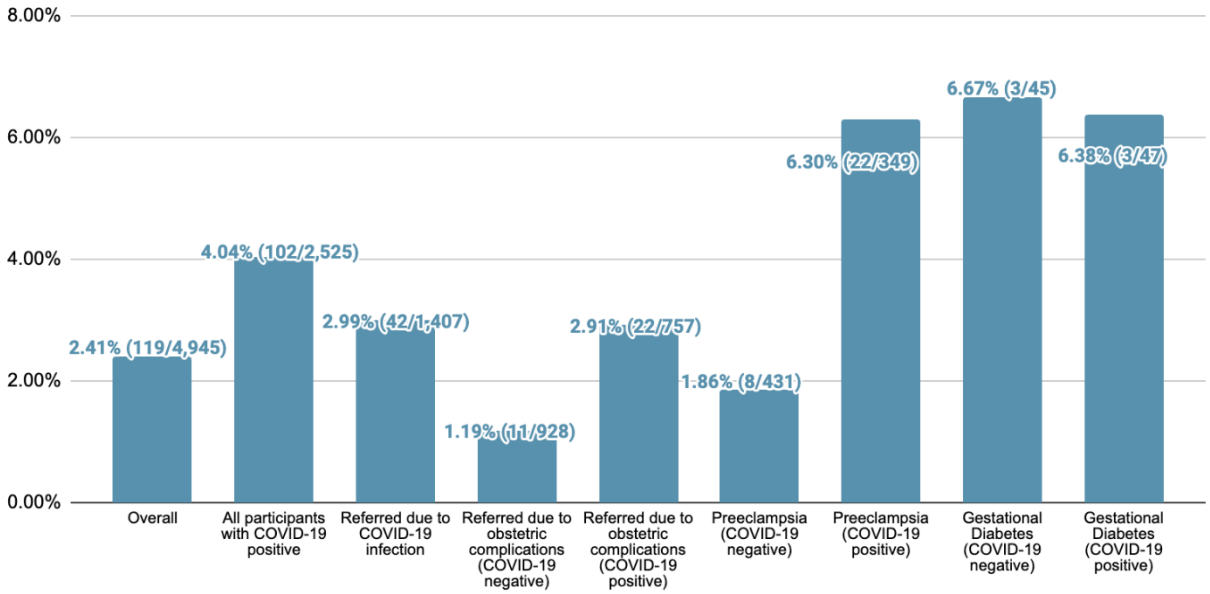

Figure 16. Case fatality rate of pregnant women with and without COVID-19 in different health conditions

5.1.2.3. Factors associated with maternal mortality

Contracting COVID-19 infection during pregnancy increased 6.12-fold (95% CI 2.37-15.82) the risk of maternal mortality compared to those with COVID-19 negative after adjusting for demographic and clinical factors (**Table 18**). Other risk factors for maternal mortality included being infected during Delta wave (aOR 2.95, 95%CI 1.39-6.24), being employed (aOR 40.76, 95%CI 2.91-571.02), having ICU admission (aOR 7.18, 95%CI 2.97-17.33), using mechanical ventilator (aOR 35.52, 95%CI 14.74-85.59), parity of 2-3 (aOR 2.11, 95%CI 1.07-4.19), a higher NLR (aOR 1.015, 95%CI 1.002-1.027), and an abnormal blood glucose (aOR 2.84, 95%CI 1.38-5.86), while the protective factor was being referral cases (aOR 0.27, 95%CI 0.08-0.92). As for COVID-19 vaccination, evidence of being a protective factor was shown only in crude analysis (OR 0.08, 95%CI 0.02-0.35).

Table 18. Association between COVID-19 infection and other risk factors for maternal mortality among all participants using multiple logistic regression.

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
COVID-19 status				
COVID-19 positive	**5.95 (3.55-9.97)**	**<0.001**	**6.12 (2.37-15.82)**	**<0.001**
COVID-19 negative	Ref		Ref	
Age group				
>35 years	2.67 (0.63-11.31)	0.181	0.51 (0.09-2.89)	0.446
20-35 years	2.01 (0.49-8.25)	0.331	0.38 (0.07-1.93)	0.241
<20 years	Ref		Ref	
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	1.45 (0.75-2.78)	0.266	1.24 (0.45-3.40)	0.673
Delta	**3.31 (2.07-5.28)**	**<0.001**	**2.95 (1.39-6.24)**	**0.005**
Omicron	0.36 (0.16-0.79)	0.012	0.65 (0.20-2.13)	0.476
Hospital type				
Type A	Ref		Ref	
Type B	0.25 (0.15-0.43)	<0.001	0.99 (0.42-2.31)	0.978
Educational level				
Not attending school	Ref		Ref	
Elementary school	1.23 (0.14-10.47)	0.851	1.70 (0.03-114.88)	0.804
Junior high school	1.58 (0.20-12.23)	0.663	2.49 (0.04-149.39)	0.662
High school	1.15 (0.16-8.46)	0.893	1.25 (0.02-71.01)	0.915
College education	1.17 (0.16-8.86)	0.877	0.82 (0.01-47.94)	0.926
Unknown	0.44 (0.05-3.53)	0.438	1.24 (0.02-77.30)	0.917
Occupational status				
Unemployed	Ref		Ref	
Employed	4.75 (0.66-34.24)	0.122	**40.76 (2.91-571.02)**	**0.006**

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Unknown	0.99 (0.10-9.60)	0.995	112.60 (0.66-239.71)	0.092
Insurance status				
Out-of-pocket payment	Ref		Ref	
National health insurance	1.57 (0.48-5.15)	0.456	0.78 (0.16-3.83)	0.762
Private insurance	3.28 (0.33-32.32)	0.309	3.40 (0.16-70.80)	0.430
COVID-19 insurance	**5.73 (1.80-18.22)**	**0.003**	0.78 (0.17-3.62)	0.750
Unknown	NA		NA	
Clinical characteristic				
Referral status				
Yes	0.80 (0.56-1.16)	0.242	**0.27 (0.08-0.92)**	**0.036**
No	Ref		Ref	
Unknown	0.39 (0.05-2.85)	0.354	0.22 (0.01-3.58)	0.285
Referral due to COVID-19				
Yes	1.38 (0.95-2.02)	0.095	2.13 (0.73-6.21)	0.164
No	Ref		Ref	
Referral due to obstetric condition				
Yes	0.74 (0.49-1.11)	0.141	1.19 (0.50-2.86)	0.692
No	Ref		Ref	
ICU admission				
Yes	**46.94 (29.23-75.37)**	**<0.001**	**7.18 (2.97-17.33)**	**<0.001**
No	Ref		Ref	
Use of mechanical ventilator				
Yes	**127.20 (79.66-203.10)**	**<0.001**	**35.52 (14.74-85.59)**	**<0.001**
No	Ref		Ref	

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Number of Pregnancy				
1	Ref		Ref	
2-3	1.44 (0.95-2.18)	0.088	**2.11 (1.07-4.19)**	**0.032**
4+	1.06 (0.57-1.97)	0.851	9.57 (0.21-1.51)	0.257
Gestational diabetes				
Yes	**2.88 (1.23-6.72)**	**0.015**	1.15 (0.23-5.74)	0.860
No	Ref		Ref	
Unknown	0.35 (0.05-2.50)	0.294	0.13 (0.01-7.39)	0.318
Chronic hypertension				
Yes	1.40 (0.74-2.62)	0.300	0.88 (0.31-2.55)	0.818
No	Ref		Ref	
Unknown	0.97 (0.24-3.99)	0.964	1.91 (0.05-66.63)	0.720
Gestational hypertension				
Yes	**1.88 (1.23-2.87)**	**0.003**	1.42 (0.48-4.21)	0.523
No	Ref		Ref	
Unknown	0.71 (0.10-5.13)	0.730	32.62 (0.05-234.20)	0.299
Preeclampsia				
Yes	**1.82 (1.19-2.77)**	**0.006**	0.70 (0.23-2.12)	0.530
No	Ref		Ref	
Unknown	0.56 (0.08-4.07)	0.567	1.12 (0.01-735.02)	0.972
BMI[1] before pregnancy				
Underweight	1.03 (0.54-1.96)	0.936	1.01 (0.40-2.50)	0.999
Normal weight	Ref		Ref	
Overweight	0.92 (0.54-1.55)	0.736	0.62 (0.28-1.38)	0.243
Obese	**1.62 (1.01-2.58)**	**0.034**	0.91 (0.45-1.85)	0.793
Asthma				
Yes	NA		NA	
No	Ref		Ref	

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Unknown	0.55 (0.20-1.50)	0.243	3.35 (0.38-29.74)	0.278
Tuberculosis				
Yes	NA		NA	
No	Ref		Ref	
Unknown	1.58 (1.02-2.44)	0.041	2.32 (0.35-15.27)	0.381
Cardiovascular disease				
Yes	**2.58 (1.32-5.02)**	**0.005**	0.98 (0.34-2.83)	0.966
No	Ref		Ref	
Unknown	0.35 (0.11-1.10)	0.073	0.07 (0.01-0.75)	0.027
Kidney disease				
Yes	**10.18 (3.36-30.83)**	**<0.001**	2.22 (0.27-17.90)	0.455
No	Ref		Ref	
Unknown	1.21 (0.75-1.94)	0.430	0.35 (0.05-2.36)	0.283
Autoimmune disease				
Yes	1.53 (0.21-11.36)	0.677	0.15 (0.01-102.720)	0.813
No	Ref		Ref	
Unknown	1.74 (1.15-2.63)	0.008	14.90 (1.27-174.84)	0.032
Cancer				
Yes	NA		NA	
No	Ref		Ref	
Unknown	1.73 (1.15-2.61)	0.009	0.11 (0.01-1.20)	0.070
COVID-19 history				
At least once	**2.07 (1.08-3.93)**	**0.027**	0.85 (0.32-2.30)	0.755
Never	Ref		Ref	
Unknown	0.88 (0.58-1.35)	0.567	0.43 (0.21-0.89)	0.025
Vaccination status				
Vaccinated	**0.08 (0.02-0.35)**	**0.001**	0.37 (0.06-2.42)	0.300
Unknown	0.52 (0.36-0.75)	0.001	0.80 (0.39-1.62)	0.537
Not vaccinated	Ref		Ref	

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Neutrophil leukocyte ratio (NLR)	**1.044 (1.030-1.060)**	**<0.001**	**1.015 (1.002-1.027)**	**0.019**
Random Blood Glucose				
Abnormal blood glucose	**9.79 (6.44-14.89)**	**<0.001**	**2.84 (1.38-5.86)**	**0.005**
Normal blood glucose	Ref		Ref	

[1]Underweight: <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25.0-30.0 kg/m^2; obese ≥30kg/m^2.

5.1.2.4. Factors associated with maternal mortality among COVID-19 positive pregnant women

Further analysis performed among pregnant women with COVID-19 positive to examine factors associated with maternal mortality, and results are presented in **Table 19**. We found that having moderate-to-severe COVID-19 symptoms increased the risk of mortality to 12.67 times (95%CI 1.79-89.76) compared to having asymptomatic-to-mild COVID-19 symptoms after adjusting for other relevant variables. Among pregnant women with COVID-19 positive, other risk factors for maternal mortality were being employed (aOR 37.72, 95%CI 1.66-854.56), ICU admission (aOR 6.53, 95%CI 2.26-18.91), using mechanical ventilator (aOR 9.6, 95%CI 3.23-28.55), bilateral pneumonia (aOR 2.95, 95%CI 1.1-7.96), higher level of C-reactive protein (aOR 1.13, 95%CI 1.02-1.25) , and interleukin 6 (aOR 1.1, 95%CI 1.02-1.19). In addition, protective factors were not identified, while the protection effect of COVID-19 vaccine was only detected in crude analysis (OR 0.09, 95%CI 0.02-0.36).

Table 19. Factors associated with maternal mortality among COVID-19 positive pregnant women

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
COVID-19 status				

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Asymptomatic-Mild	Ref		Ref	
Moderate-Severe	**69.33 (17.06-281.71)**	**<0.001**	**12.67 (1.79-89.76)**	**0.011**
Age group				
<20 years	Ref		Ref	
20-35 years	2.99 (0.41-21.87)	0.278	0.21 (0.02-2.57)	0.221
>35 years	3.54 (0.47-26.63)	0.219	0.18 (0.01-2.41)	0.194
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	1.23 (0.58-2.62)	0.585	0.59 (0.16-2.18)	0.427
Delta	**3.34 (1.99-5.63)**	**<0.001**	1.27 (0.48-3.36)	0.637
Omicron	**0.26 (0.09-0.69)**	0.007	0.46 (0.08-2.58)	0.375
Hospital type				
Type A	Ref		Ref	
Type B	**0.25 (0.14-0.46)**	<0.001	0.73 (0.2-2.62)	0.626
Educational level				
Not attending school	Ref		Ref	
Elementary school	0.90 (0.10-8.43)	0.925	0.5 (0-220.65)	0.824
Junior high school	1.50 (0.19-11.98)	0.701	1.27 (0-435.85)	0.935
High school	0.95 (0.13-7.16)	0.957	0.47 (0-153.82)	0.800

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
College education	1.21 (0.16-9.37)	0.854	0.28 (0-94.96)	0.671
Unknown	0.37 (0.04-3.09)	0.358	0.55 (0-197.81)	0.844
Occupational status				
Unemployed	Ref		Ref	
Employed	5.07 (0.70-36.72)	0.108	**37.72 (1.66-854.56)**	**0.023**
Unknown	1.29 (0.13-12.53)	0.827	13.2 (0.39-443.95)	0.150
Insurance status				
Out-of-pocket payment	Ref		Ref	
National health insurance	1.20 (0.35-4.12)	0.767	0.83 (0.1-7.25)	0.868
Private insurance	NA		NA	
COVID-19 insurance	1.67 (0.52-5.38)	0.389	0.48 (0.06-3.71)	0.482
Unknown	NA		NA	
Clinical characteristic				
Referral status				
No	Ref		Ref	
Yes	**0.46 (0.31-0.68)**	**<0.001**	0.19 (0.02-1.69)	0.135
Unknown	0.31 (0.04-2.28)	0.250	0.45 (0.02-10.14)	0.613
Referral due to COVID-19				

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
No	Ref		Ref	
Yes	**0.53 (0.35-0.80)**	**0.002**	2.21 (0.3-16.56)	0.439
Referral due to obstetric condition				
No	Ref		Ref	
Yes	0.63 (0.39-1.02)	0.060	1.36 (0.45-4.14)	0.586
ICU admission				
No	Ref		Ref	
Yes	**63.40 (37.53-107.09)**	**<0.001**	**6.53 (2.26-18.91)**	**0.001**
Use of mechanical ventilator				
No	Ref		Ref	
Yes	**109.25 (65.24-182.94)**	**<0.001**	**9.6 (3.23-28.55)**	**<0.001**
Number of Pregnancy				
1	Ref		Ref	
2-3	**1.60 (1.005-2.55)**	**0.048**	2.32 (0.9-5.98)	0.083
4+	1.33 (0.68-2.57)	0.404	1 (0.29-3.45)	0.995
Gestational diabetes				
No	Ref		Ref	
Yes	1.60 (0.49-5.23)	0.441	0.54 (0.07-4.34)	0.565

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Unknown	NA		NA	
Chronic hypertension				
No	Ref		Ref	
Yes	1.40 (0.67-2.95)	0.371	1.09 (0.26-4.62)	0.911
Unknown	0.47 (0.06-3.45)	0.459	0.91 (0.02-39.44)	0.959
Gestational hypertension				
No	Ref		Ref	
Yes	**1.85 (1.15-2.99)**	**0.012**	1.57 (0.37-6.7)	0.545
Unknown	NA		NA	
Preeclampsia				
No	Ref		Ref	
Yes	**1.72 (1.06-2.80)**	**0.028**	0.85 (0.2-3.61)	0.831
Unknown	NA		NA	
BMI[1] before pregnancy				
Underweight	0.98 (0.45-2.14)	0.956	0.59 (0.16-2.14)	0.418
Normal weight	Ref		Ref	
Overweight	1.003 (0.57-1.77)	0.992	0.98 (0.35-2.71)	0.964
Obese	**1.88 (1.12-3.16)**	**0.016**	0.92 (0.35-2.41)	0.859
Asthma				

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
No	Ref		Ref	
Yes	NA		NA	
Unknown	0.49 (0.15-1.55)	0.222	2.75 (0.14-52.6)	0.503
Tuberculosis				
No	Ref		Ref	
Yes	NA		NA	
Unknown	1.32 (0.83-2.12)	0.240	1.26 (0.1-15.65)	0.855
Cardiovascular disease				
No	Ref		Ref	
Yes	**3.07 (1.43-6.61)**	**0.004**	1.61 (0.42-6.16)	0.485
Unknown	0.37 (0.12-1.18)	0.093	0.25 (0.01-5.08)	0.365
Kidney disease				
No	Ref		Ref	
Yes	**6.98 (1.43-34.15)**	**0.016**	0.72 (0.04-12.64)	0.821
Unknown	1.06 (0.64-1.75)	0.819	0.94 (0.07-12.13)	0.960
Autoimmune disease				
No	Ref		Ref	
Yes	NA		NA	
Unknown	1.48 (0.96-2.29)	0.084	222.33 (10.43-4740.63)	0.001
Cancer				

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
No	Ref		Ref	
Yes	NA		NA	
Unknown	1.46 (0.94-2.27)	0.092	0.01 (0-0.13)	0.001
COVID-19 history				
Never	Ref		Ref	
At least once	1.30 (0.66-2.59)	0.446	0.75 (0.22-2.63)	0.656
Unknown	0.83 (0.52-1.32)	0.420	0.44 (0.16-1.22)	0.116
Vaccination status				
Not vaccinated	Ref		Ref	
Vaccinated	**0.09 (0.02-0.36)**	**0.001**	0.68 (0.05-8.4)	0.761
Unknown	0.54 (0.36-0.81)	0.003	0.98 (0.36-2.65)	0.965
Radiology result				
Non-pneumonia	Ref		Ref	
Unilateral pneumonia	2.82 (0.88-9.05)	0.082	1.5 (0.35-6.38)	0.580
Bilateral pneumonia	**33.51 (17.28-64.98)**	**<0.001**	**2.95 (1.1-7.96)**	**0.032**
Antiviral treatment				
No	Ref		Ref	
Yes	**4.96 (3.06-8.04)**	**<0.001**	0.39 (0.15-1)	0.051
Unknown	12.42 (4.37-35.34)	<0.001	0.6 (0.1-3.75)	0.586

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
Antibiotic treatment				
No	Ref		Ref	
Yes	**8.02 (2.53-25.39)**	**<0.001**	2.06 (0.44-9.71)	0.360
Unknown	22.67 (2.09-245.65)	0.010	9.05 (0.21-398.43)	0.254
Corticosteroid treatment				
No	Ref		Ref	
Yes	**14.40 (8.74-23.72)**	**<0.001**	1.38 (0.57-3.34)	0.470
Unknown	14.51 (3.07-68.52)	0.001	10.72 (0.34-335.88)	0.177
Immunotherapy treatment				
No	Ref		Ref	
Yes	**60.03 (28.15-127.99)**	**<0.001**	3 (0.75-11.95)	0.119
Unknown	NA		NA	
Neutrophil leukocyte ratio (NLR)	**1.057 (1.040-1.074)**	**<0.001**	1.02 (0.99-1.06)	0.181
Procalcitonin	**1.003 (1.001-1.005)**	**0.002**	1 (1-1.01)	0.234
C-Reactive protein (per 10 unit)	**1.222 (1.174-1.274)**	**<0.001**	**1.13 (1.02-1.25)**	**0.017**

Characteristic	Maternal mortality OR (95% CI)	P-value	Maternal mortality aOR (95% CI)	P-value
D-Dimer (per 100 unit)	**1.014 (1.011-1.017)**	**<0.001**	1 (1-1.01)	0.468
Interleukin 6 (per 10 unit)	**1.246 (1.162-1.336)**	**<0.001**	**1.1 (1.02-1.19)**	**0.011**
Random Blood Glucose				
Normal blood glucose	Ref		Ref	
Abnormal blood glucose	**6.35 (3.95-10.20)**	**<0.001**	1.72 (0.65-4.53)	0.273

5.1.2.5. Factors associated with miscarriage

There was no association between miscarriage and COVID-19 infections (**Table 20),** however, being infected in Delta wave (aOR 1.73, 95%CI 1.06-2.81), being admitted to hospital type B (aOR 3.22, 95%CI 2.16-4.80), being referred due to obstetric condition (aOR 3.97, 95%CI 1.86-8.45),ICU admission (aOR 2.74, 95%CI 1.41-5.32), parity ≥4 (aOR 2.06, 95%CI1.25-3.39), and having kidney diseases as comorbidity (aOR 12.76, 95%CI 2.55-63.91) were the risk factors for miscarriage. The protective factorsfor miscarriage were referral cases (aOR 0.20, 95%CI 0.09-0.47), having preeclampsia as comorbidity (aOR 0.09, 95%CI 0.02-0.32), and higher level of NLR (aOR 0.910, 95%CI 0.868-0.954).

Table 20. Association between COVID-19 infection and other risk factors for miscarriage among all participants using multiple logistic regression.

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
COVID-19 status				
COVID-19 positive	**0.45 (0.33-0.62)**	**<0.001**	0.55 (0.30-1.04)	0.064

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
COVID-19 negative	Ref		Ref	
Age group				
>35 years	4.02 (0.97-16.77)	0.056	4.04 (0.89-18.47)	0.071
20-35 years	3.24 (0.80-13.19)	0.101	3.30 (0.76-14.26)	0.110
<20 years	Ref		Ref	
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	**1.77 (1.04-3.00)**	**0.034**	1.46 (0.81-2.63)	0.206
Delta	**1.94 (1.26-2.99)**	**0.003**	**1.73 (1.06-2.81)***	**0.028**
Omicron	**2.21 (1.45-3.38)**	**<0.001**	1.63 (0.98-2.73)	0.062
Hospital type				
Type A	Ref		Ref	
Type B	**3.01 (2.22-4.08)**	**<0.001**	**3.22 (2.16-4.80)**	**<0.001**
Educational level				
Not attending school	Ref		Ref	
Elementary school	**0.14 (0.03-0.65)**	**0.012**	0.22 (0.04-1.07)	0.061
Junior high school	0.32 (0.10-1.02)	0.053	0.44 (0.13-1.51)	0.190
High school	**0.28 (0.10-0.79)**	**0.017**	0.42 (0.14-1.29)	0.131
College education	0.47 (0.16-1.37)	0.165	0.57 (0.18-1.79)	0.334
Unknown	0.64 (0.22-1.87)	0.416	0.74 (0.23-2.36)	0.615
Occupational status				
Unemployed	Ref		Ref	
Employed	**0.48 (0.25-0.90)**	**0.022**	0.78 (0.38-1.58)	0.485
Unknown	1.09 (0.54-2.19)	0.812	1.08 (0.49-2.36)	0.852
Insurance status				
Out-of-pocket payment	Ref		Ref	
National health insurance	0.69 (0.43-1.11)	0.125	1.05 (0.62-1.78)	0.862
Private insurance	NA		NA	

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
COVID-19 insurance	**0.45 (0.27-0.76)**	**0.002**	1.02 (0.48-2.17)	0.954
Unknown	1.79 (0.22-14.79)	0.588	7.46 (0.66-84.79)	0.105
Clinical characteristic				
Referral status				
Yes	**0.43 (0.32-0.59)**	**<0.001**	**0.20 (0.09-0.47)**	**<0.001**
No	Ref		Ref	
Unknown	NA		NA	
Referral due to COVID-19				
Yes	**0.42 (0.28-0.64)**	**<0.001**	1.19 (0.58-2.41)	0.637
No	Ref		Ref	
Referral due to obstetric condition				
Yes	0.72 (0.52-1.01)	0.050	**3.97 (1.86-8.45)**	**<0.001**
No	Ref		Ref	
ICU admission				
Yes	0.83 (0.49-1.40)	0.489	**2.74 (1.41-5.32)**	**0.003**
No	Ref		Ref	
Use of mechanical ventilator				
Yes	**0.23 (0.06-0.92)**	**0.037**	0.26 (0.05-1.21)	0.085
No	Ref		Ref	
Number of Pregnancy				
1	Ref		Ref	
2-3	1.05 (0.74-1.48)	0.805	1.06 (0.72-1.56)	0.757
4+	**1.91 (1.27-2.88)**	**0.002**	**2.06 (1.25-3.39)**	**0.004**
Gestational diabetes				
Yes	1.19 (0.43-3.28)	0.736	1.41 (0.44-4.52)	0.561
No	Ref		Ref	

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Unknown	1.14 (0.46-2.82)	0.779	0.27 (0.05-1.67)	0.160
Chronic hypertension				
Yes	0.71 (0.36-1.39)	0.316	1.90 (0.81-4.48)	0.141
No	Ref		Ref	
Unknown	1.89 (0.82-4.40)	0.138	1.56 (0.04-68.74)	0.818
Gestational hypertension				
Yes	**0.35 (0.19-0.65)**	**0.001**	0.82 (0.38-1.77)	0.614
No	Ref		Ref	
Unknown	2.38 (1.01-5.59)	0.046	7.98 (0.21-300.31)	0.261
Preeclampsia				
Yes	**0.09 (0.03-0.27)**	**<0.001**	**0.09 (0.02-0.32)**	**<0.001**
No	Ref		Ref	
Unknown	1.77 (0.76-4.13)	0.184	0.68 (0.05-10.13)	0.780
BMI[1] before pregnancy				
Underweight	**1.65 (1.07-2.55)**	**0.023**	1.41 (0.88-2.27)	0.155
Normal weight	Ref		Ref	
Overweight	1.35 (0.93-1.96)	0.329	1.03 (0.68-1.55)	0.892
Obese	**0.47 (0.29-0.77)**	**0.002**	**0.42 (0.25-0.72)**	**0.001**
Asthma				
Yes	0.75 (0.18-3.11)	0.697	1.07 (0.25-4.67)	0.926
No	Ref		Ref	
Unknown	0.83 (0.42-1.64)	0.594	0.81 (0.19-3.39)	0.768
Tuberculosis				
Yes	NA		NA	
No	Ref		Ref	
Unknown	0.68 (0.43-1.08)	0.099	3.54 (0.97-12.93)	0.056
Cardiovascular disease				
Yes	0.95 (0.41-2.18)	0.903	1.44 (0.55-3.74)	0.455
No	Ref		Ref	

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Unknown	0.82 (0.44-1.53)	0.536	0.58 (0.15-2.23)	0.424
Kidney disease				
Yes	**4.12 (1.21-14.13)**	**0.024**	**12.76 (2.55-63.91)**	**0.002**
No	Ref		Ref	
Unknown	0.63 (0.39-1.03)	0.052	1.36 (0.15-12.22)	0.787
Autoimmune disease				
Yes	0.80 (0.11-5.92)	0.829	0.66 (0.07-6.38)	0.722
No	Ref		Ref	
Unknown	0.59 (0.37-0.94)	0.025	0.25 (0.01-6.25)	0.399
Cancer				
Yes	2.84 (0.65-12.41)	0.165	1.39 (0.15-12.96)	0.772
No	Ref		Ref	
Unknown	0.57 (0.35-0.91)	0.018	1.04 (0.05-20.04)	0.979
COVID-19 history				
At least once	**0.29 (0.13-0.68)**	**0.004**	0.54 (0.22-1.32)	0.176
Never	Ref		Ref	
Unknown	0.37 (0.27-0.50)	<0.001	0.51 (0.35-0.74)	<0.001
Vaccination status				
Vaccinated	0.77 (0.46-1.28)	0.310	0.75 (0.41-1.39)	0.364
Unknown	0.67 (0.48-0.93)	0.016	0.57 (0.38-0.86)	0.008
Not vaccinated	Ref		Ref	
Neutrophil leukocyte ratio (NLR)	**0.884 (0.842-0.927)**	**<0.001**	**0.910 (0.868-0.954)**	**<0.001**
Random Blood Glucose				
Abnormal blood glucose	0.81 (0.37-1.73)	0.581	1.67 (0.70-3.96)	0.247
Normal blood glucose	Ref		Ref	

[1]Underweight: <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25.0-30.0 kg/m^2; obese ≥30kg/m^2

5.1.2.6. Factors associated with miscarriage among COVID-19 positive pregnant women

Among pregnant women with COVD-19 positive, association was not detected between miscarriage and having moderate-to-severe COVID-19 symptoms (**Table 21**). Risk factors for miscarriage included being referred due to obstetric conditions (aOR 4.29, 95%CI 1.66-11.08), parity≥4 (aOR 3.76, 95%CI 1.56-9.1), being underweight in before pregnancy (aOR 2.77, 95%CI 1.16-6.64), and having kidney disease as comorbidity (aOR 52.72, 95%CI 2.83-980.63). The protective factor for miscarriage included having higher educational level (completing junior high school aOR 0.14 [95%CI 0.038-0.8], senior high school aOR 0.16 [95%CI 0.04-0.69], and college aOR 0.18 [95%CI 0.04-0.88]).

Table 21. Association between COVID-19 symptoms severity status and other risk factors for miscarriage among COVID-19 positive pregnant women using multiple logistic regression

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
COVID-19 status				
Asymptomatic-Mild	Ref		Ref	
Moderate-Severe	0.78 (0.46-1.32)	0.360	1.01 (0.3-3.41)	0.982
Age group				
>35 years	2.59 (0,34-19.72)	0.642	1.73 (0.19-15.85)	0.629
20-35 years	1.61 (0.22-11.84)	0.359	1.14 (0.14-9.48)	0.904
<20 years	Ref		Ref	
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	0.91 (0.35-2.38)	0.841	0.86 (0.28-2.62)	0.792
Delta	1.02 (0.49-2.11)	0.955	1.31 (0.54-3.22)	0.550
Omicron	1.72 (0.88-3.36)	0.110	1.45 (0.58-3.6)	0.428
Hospital type				
Type A	Ref		Ref	
Type B	**1.84 (1.10-3.07)**	**0.020**	**2.22 (1.09-4.55)**	**0.029**
Educational level				
Not attending school	Ref		Ref	

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Elementary school	0.20 (0.04-1.07)	0.061	0.26 (0.04-1.73)	0.163
Junior high school	**0.16 (0.03-0.70)**	**0.015**	**0.14 (0.03-0.8)**	**0.027**
High school	**0.12 (0.03-0.44)**	**0.001**	**0.16 (0.04-0.69)**	**0.015**
College education	**0.18 (0.05-0.68)**	**0.012**	**0.18 (0.04-0.88)**	**0.034**
Unknown	0.21 (0.06-0.79)	0.022	0.26 (0.05-1.22)	0.088
Occupational status				
Unemployed	Ref		Ref	
Employed	1.28 (0.31-5.33)	0.735	2.13 (0.46-9.94)	0.335
Unknown	1.51 (0.31-7.41)	0.609	1.57 (0.28-8.72)	0.603
Insurance status				
Out-of-pocket payment	Ref		Ref	
National health insurance	**0.06 (0.01-0.61)**	**0.018**	0.8 (0.38-1.71)	0.571
Private insurance	NA		NA	
COVID-19 insurance	**0.08 (0.01-0.79)**	**0.031**	NA	
Unknown	NA		NA	
Clinical characteristic				
Referral status				
No	Ref		Ref	
Yes	0.74 (0.44-1.24)	0.258	0.57 (0.16-2.09)	0.397
Unknown	NA		NA	
Referral due to COVID-19				
No	Ref		Ref	
Yes	0.59 (0.35-1.01)	0.050	0.39 (0.15-1.06)	0.066
Referral due to obstetric condition				
No	Ref		Ref	
Yes	**1.69 (1.01-2.84)**	**0.048**	**4.29 (1.66-11.08)**	**0.003**

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
ICU admission				
No	Ref		Ref	
Yes	0.49 (0.15-1.60)	0.243	0.51 (0.04-6.08)	0.595
Use of mechanical ventilator				
No	Ref		Ref	
Yes	0.27 (0.04-1.96)	0.195	1.48 (0.06-36.23)	0.810
Number of Pregnancy				
1	Ref		Ref	
2-3	1.33 (0.69-2.53)	0.394	1.37 (0.65-2.90)	0.407
4+	**3.24 (1.59-6.59)**	**0.001**	**3.76 (1.56-9.10)**	**0.003**
Gestational diabetes				
No	Ref		Ref	
Yes	0.90 (0.12-6.63)	0.917	1.12 (0.11-11.20)	0.923
Unknown	1.38 (0.33-5.78)	0.661	1.04 (0.09-12.12)	0.974
Chronic hypertension				
No	Ref		Ref	
Yes	0.28 (0.04-2.01)	0.204	0.38 (0.04-3.70)	0.405
Unknown	1.59 (0.38-6.71)	0.526	0.73 (0.02-33.22)	0.874
Gestational hypertension				
No	Ref		Ref	
Yes	0.58 (0.23-1.45)	0.241	1.64 (0.43-6.20)	0.465
Unknown	2.13 (0.49-9.05)	0.307	4.75 (0.14-156.34)	0.382
Preeclampsia				
No	Ref		Ref	
Yes	0.33 (0.10-1.05)	0.061	0.38 (0.07-1.98)	0.252
Unknown	1.71 (0.41-7.25)	0.464	2.1 (0.07-66.48)	0.674
BMI[1] before pregnancy				

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Underweight	**2.39 (1.11-5.15)**	**0.026**	**2.77 (1.16-6.64)**	**0.022**
Normal weight	Ref		Ref	
Overweight	1.48 (0.76-2.88)	0.251	1.33 (0.63-2.83)	0.454
Obese	0.63 (0.27-1.45)	0.276	0.6 (0.23-1.57)	0.301
Asthma				
No	Ref		Ref	
Yes	2.13 (0.50-9.05)	0.305	3.54 (0.73-17.25)	0.117
Unknown	0.89 (0.28-2.88)	0.846	0.84 (0.08-9.04)	0.888
Tuberculosis				
No	Ref		Ref	
Yes	NA		NA	
Unknown	0.75 (0.36-1.52)	0.420	4.65 (0.66-32.81)	0.124
Cardiovascular disease				
No	Ref		Ref	
Yes	0.57 (0.08-4.18)	0.580	1.03 (0.11-9.65)	0.980
Unknown	0.61 (0.19-1.97)	0.410	0.32 (0.03-3.5)	0.350
Kidney disease				
No	Ref		Ref	
Yes	4.86 (0.59-39.59)	0.140	**52.72 (2.83-980.63)**	**0.008**
Unknown	0.66 (0.31-1.40)	0.275	90.77 (0.31-26457.99)	0.119
Autoimmune disease				
No	Ref		Ref	
Yes	3.42 (0.43-27.01)	0.243	10.56 (0.94-118.28)	0.056
Unknown	0.57 (0.27-1.20)	0.138	0.02 (0-8.08)	0.191
Cancer				
No	Ref		Ref	
Yes	**9.43 (1.04-85.83)**	**0.047**	**26.08 (1.26-541.42)**	**0.035**

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Unknown	0.56 (0.26-1.19)	0.133	0.13 (0-8.4)	0.342
COVID-19 history				
Never	Ref		Ref	
At least once	0.29 (0.09-1.001)	0.050	0.25 (0.05-1.2)	0.083
Unknown	0.43 (0.25-0.73*	0.002	0.5 (0.26-0.96)	0.037
Vaccination status				
Not vaccinated	Ref		Ref	
Vaccinated	1.20 (0.58-2.49)	0.618	1.07 (0.39-2.91)	0.901
Unknown	0.58 (0.32-1.04)	0.066	0.57 (0.27-1.22)	0.146
Radiology result				
Non-pneumonia	Ref		Ref	
Unilateral pneumonia	0.72 (0.28-1.83)	0.489	0.9 (0.32-2.51)	0.843
Bilateral pneumonia	0.46 (0.21-1.03)	0.058	0.63 (0.23-1.73)	0.370
Antiviral treatment				
No	Ref		Ref	
Yes	0.81 (0.47-1.39)	0.448	1.02 (0.31-3.38)	0.976
Unknown	1.27 (0.17-9.54)	0.818	1.89 (0.2-17.62)	0.576
Antibiotic treatment				
No	Ref		Ref	
Yes	1.05 (0.54-2.03)	0.888	0.86 (0.4-1.86)	0.696
Unknown	NA		NA	
Corticosteroid treatment				
No	Ref		Ref	
Yes	0.72 (0.37-1.39)	0.329	0.81 (0.36-1.81)	0.609
Unknown	2.76 (0.36-21.45)	0.331	2.51 (0.21-30.07)	0.467
Immunotherapy treatment				
No	Ref		Ref	
Yes	NA		NA	

Characteristic	Miscarriage OR (95% CI)	P-value	Miscarriage aOR (95% CI)	P-value
Unknown	NA		NA	
Neutrophil leukocyte ratio (NLR)	**0.893 (0.827-0.964)**	**0.004**	**0.91 (0.83-0.99)**	**0.022**
Procalcitonin	0.996 (0.959-1.034)	0.839	0.99 (0.93-1.05)	0.723
C-Reactive protein (per 10 unit)	0.881 (0.741-1.048)	0.153	0.83 (0.66-1.06)	0.134
D-Dimer (per 100 unit)	0.998 (0.991-1.006)	0.693	1 (0.99-1.01)	0.789
Interleukin 6 (per 10 unit)	0.895 (0.624-1.283)	0.546	1.01 (0.72-1.42)	0.939
Random Blood Glucose				
Normal blood glucose	Ref		Ref	
Abnormal blood glucose	0.52 (0.13-2.14)	0.363	0.74 (0.15-3.63)	0.714

[1]Underweight: <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25.0-30.0 kg/m^2; obese ≥30kg/m^2.

5.1.2.7. Factors associated with preeclampsia

Preeclampsia was not associated with COVID-19 infection after adjusting for relevant variables, listed in **Table 22**. Risk factors for preeclampsia were being referred due to obstetric conditions (aOR 1.89, 95%CI 1.17-3.05), ICU admission (aOR 1.61, 95%CI 1.02-2.55), having chronic hypertension as comorbidity (aOR 2.54, 95%CI 1.72-3.75), obesity before pregnancy (aOR 1.67, 95%CI 1.18-2.36), autoimmune diseases (aOR 4.89, 95%CI 1.38-17.39). In addition, being infected in Beta (aOR 0.57, 95%CI 0.36-0.90) and Delta waves (aOR 0.59, 95%CI 0.41-0.86), being referral cases (aOR 0.53, 95%CI 0.29-0.93), and vaccination at least one dose (aOR 0.49, 95%CI 0.28-0.86) were protective to preeclampsia.

Table 22. Association between COVID-19 infection and other risk factors for preeclampsia among all participants using multiple logistic regression.

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
COVID-19 status				
COVID-19 positive	**0.72 (0.61-0.83)**	**<0.001**	0.81 (0.53-1.24)	0.836
COVID-19 negative	Ref		Ref	
Age group				
>35 years	**1.64 (1.07-2.52)**	**0.025**	0.80 (0.37-1.72)	0.137
20-35 years	0.82 (0.54-1.24)	0.356	0.53 (0.27-1.08)	0.768
<20 years	Ref		Ref	
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	**0.79 (0.62-1.01)**	**0.065**	**0.57 (0.36-0.90)**	**0.003**
Delta	**0.59 (0.48-0.72)**	**<0.001**	**0.59 (0.41-0.86)**	**<0.001**
Omicron	0.83 (0.67-1.01)	0.063	1.21 (0.81-1.80)	0.785
Hospital type				
Type A	Ref		Ref	
Type B	**0.51 (0.43-0.61)**	**<0.001**	0.81 (0.58-1.14)	0.078
Educational level				
Not attending school	Ref		Ref	
Elementary school	1.88 (0.70-5.07)	0.210	0.62 (0.11-3.49)	0.391
Junior high school	1.49 (0.57-3.92)	0.419	0.69 (0.13-3.64)	0.241
High school	1.51 (0.59-3.86)	0.389	0.82 (0.16-4.16)	0.474
College education	1.31 (0.51-3.38)	0.579	0.67 (0.13-3.48)	0.304
Unknown	1.38 (0.53-3.55)	0.510	0.96 (0.18-4.96)	0.695
Occupational status				
Unemployed	Ref		Ref	
Employed	1.29 (0.82-2.04)	0.266	1.16 (0.53-2.52)	0.865
Unknown	1.19 (0.71-1.97)	0.513	1.23 (0.51-2.95)	0.49
Insurance status				

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Out-of-pocket payment	Ref		Ref	
National health coverage	1.29 (0.95-1.74)	0.106	0.69 (0.41-1.15)	0.084
Private insurance	**2.35 (1.10-4.99)**	**0.026**	1.97 (0.60-6.46)	0.127
COVID-19 insurance	0.88 (0.64-1.21)	0.443	0.64 (0.36-1.14)	0.098
Unknown	2.56 (0.64-10.22)	0.182	0.83 (0.03-21.69)	0.807
Clinical characteristic				
Referral status				
Yes	**2.27 (1.92-2.68)**	**<0.001**	**0.53 (0.29-0.93)**	**0.049**
No	Ref		Ref	
Unknown	1.96 (1.14-3.38)*	0.015	1.46 (0.57-3.76)	0.140
Referral due to COVID-19				
Yes	0.89 (0.76-1.07)	0.220	1.38 (0.85-2.23)	0.740
No	Ref		Ref	
Referral due to obstetric condition				
Yes	**3.37 (2.88-3.95)**	**<0.001**	**1.89 (1.17-3.05***	**<0.001**
No	Ref		Ref	
ICU admission				
Yes	**4.39 (3.60-5.35)**	**<0.001**	**1.61 (1.02-2.55)**	**0.001**
No	Ref		Ref	
Use of mechanical ventilator				
Yes	**3.53 (2.67-4.68)**	**<0.001**	1.40 (0.73-2.68)	0.161
No	Ref		Ref	
Number of Pregnancy				
1	Ref		Ref	
2-3	1.15 (0.97-1.37)	0.114	0.94 (0.68-1.30)	0.994
4+	**1.76 (1.41-2.21)**	**<0.001**	0.99 (0.64-1.56)	0.866

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Gestational diabetes				
Yes	**5.21 (3.43-7.90)**	**<0.001**	2.02 (0.94-4.34)	0.068
No	Ref	0.130	Ref	
Unknown	1.42 (0.90-2.24)		2.42 (0.77-7.61)	0.133
Chronic hypertension				
Yes	**15.55 (12.18-19.85)**	**<0.001**	**2.54 (1.72-3.75)**	**<0.001**
No	Ref		Ref	
Unknown	2.52 (1.54-4.12)	<0.001	11.42 (2.27-57.42)	0.007
Gestational hypertension				
Yes	**31.31 (25.70-38.13)**	**<0.001**	**3.92 (2.84-5.42)**	**<0.001**
No	Ref		Ref	
Unknown	0.96 (0.35-2.67)	0.945	0.33 (0.03-3.62)	0.064
BMI[1] before pregnancy				
Underweight	**0.66 (0.48-0.92)**	**0.014**	0.89 (0.54-1.48)	0.331
Normal weight	Ref		Ref	
Overweight	1.02 (0.81-1.28)	0.120	1.16 (0.79-1.71)	0.106
Obese	**2.89 (2.36-3.54)**	**<0.001**	**1.67 (1.18-2.36)**	**0.011**
Asthma				
Yes	1.47 (0.83-2.62)	0.187	1.21 (0.44-3.28)	0.367
No	Ref		Ref	
Unknown	1.03 (0.75-1.43)	0.851	0.99 (0.41-2.39)	0.849
Tuberculosis				
Yes	0.49 (0.12-2.08)	0.334	0.49 (0.07-3.43)	0.413
No	Ref		Ref	
Unknown	1.35 (1.11-1.65)	0.003	3.92 (1.60-9.61)	0.003
Cardiovascular disease				
Yes	**2.34 (1.66-3.28)**	**<0.001**	1.14 (0.62-2.11)	0.538

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
No	Ref		Ref	
Unknown	0.86 (0.63-1.18)	0.365	0.29 (0.12-0.68)	0.003
Kidney disease				
Yes	**2.82 (1.13-7.02)**	**0.026**	1.26 (0.25-6.34)	0.672
No	Ref		Ref	
Unknown	1.30 (1.07-1.58)	0.009	0.61 (0.17-2.19)	0.838
Autoimmune disease				
Yes	**3.57 (1.73-7.40)**	**0.001**	**4.89 (1.38-17.39)**	**0.036**
No	Ref		Ref	
Unknown	1.26 (1.04-1.52)	0.020	1.19 (0.23-6.24)	0.835
Cancer				
Yes	0.66 (0.15-2.85)	0.573	0.37 (0.01-11.86)	0.493
No	Ref		Ref	
Unknown	1.24 (1.02-1.50)	0.028	0.90 (0.20-3.99)	0.082
COVID-19 history				
At least once	0.74 (0.51-1.08)	0.125	0.63 (0.33-1.17)	0.453
Never	Ref		Ref	
Unknown	0.91 (0.77-1.08)	0.296	0.63 (0.46-0.88)	0.032
Vaccination status				
Vaccinated	1.03 (0.79-1.35)	0.824	**0.49 (0.28-0.86)**	**0.010**
Unknown	0.94 (0.78-1.13)	0.499	0.87 (0.61-1.26)	0.808
Not vaccinated	Ref		Ref	
Neutrophil leukocyte ratio (NLR)	**1.009 (1.002-1.017)**	**0.015**	1.004 (0.995-1.012)	0.628
Random Blood Glucose				
Abnormal blood glucose	**2.13 (1.58-2.88)**	**<0.001**	0.74 (0.40-1.36)	0.953
Normal blood glucose	Ref		Ref	

1Underweight: <18.5 kg/m2; normal 18.5-24.9 kg/m2; overweight 25.0-30.0 kg/m2; obese ≥30kg/m2.

5.1.2.7. Factors associated with preeclampsia among COVID-19 positive pregnant women

Among pregnant women with COVID-19 positive, having severe-to-moderate COVID-19 symptoms was not associated with preeclampsia after adjusting for other relevant variables, listed in **Table 23**. Being referred due to obstetric condition (aOR 2.81, 95%CI 1.75-4.51), gestational diabetes (aOR 3.32, 95%CI 1.36-8.07), chronic hypertension (aOR 6.47, 95%CI 3.86-10.87), and gestational hypertension (aOR 35.84, 95%CI 24.57-52.29) as comorbidities, being overweight (aOR 1.73, 95%CI 1.06-2.82) and obesity before pregnancy (aOR 2.43, 95%CI 1.53-3.84), receiving corticosteroid (aOR 1.63, 95%CI 1.07-2.49) were risk factors for preeclampsia. Infection in Beta (aOR 0.52, 95%CI 0.28-0.94) and Delta waves (aOR 0.44, 95%CI 0.26-0.73), receiving COVID-19 insurance (aOR 0.32, 95%CI 0.15-0.67), receiving immunotherapy treatment (aOR 0.14, 95%CI 0.02-0.9) were protective to preeclampsia, in this sub-sample.

Table 23. Association between COVID-19 symptom severity status and other risk factors for preeclampsia among COVID-19 positive pregnant women using multiple logistic regression.

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
COVID-19 status				
Asymptomatic-Mild	Ref		Ref	
Moderate-Severe	1.24 (0.99-1.56)	0.063	0.74 (0.38-1.43)	0.366
Age group				
>35 years	**2.47 (1.10-5.55)**	**0.028**	0.88 (0.28-2.72)	0.531
20-35 years	1.29 (0.59-2.85)	0.525	0.71 (0.25-2.06)	0.821
<20 years	Ref		Ref	
COVID-19 wave				
Original and Alpha	Ref		Ref	
Beta	0.99 (0.69-1.42)	0.953	**0.52 (0.28-0.94)**	**0.032**
Delta	**0.59 (0.43-0.81)**	**0.001**	**0.44 (0.26-0.73)**	**0.002**
Omicron	0.95 (0.71-1.27)	0.724	1.02 (0.6-1.72)	0.945
Hospital type				
Type A	Ref		Ref	
Type B	**0.64 (0.49-0.82)**	**0.001**	0.71 (0.45-1.12)	0.142

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Educational level				
Not attending school	Ref		Ref	
Elementary school	1.15 (0.30-4.35)	0.838	0.37 (0.05-2.94)	0.350
Junior high school	1.02 (0.28-3.64)	0.979	0.7 (0.1-4.96)	0.717
High school	1.01 (0.30-3.44)	0.985	0.72 (0.11-4.83)	0.738
College education	1.06 (0.31-3.67)	0.926	0.61 (0.09-4.22)	0.615
Unknown	1.11 (0.32-3.83)	0.871	1.14 (0.16-7.93)	0.894
Occupational status				
Unemployed	Ref		Ref	
Employed	1.05 (0.59-1.86)	0.875	0.76 (0.32-1.8)	0.531
Unknown	1.12 (0.58-2.17)	0.740	0.87 (0.32-2.38)	0.793
Insurance status				
Out-of-pocket payment	Ref		Ref	
National health insurance	0.92 (0.53-1.56)	0.739	0.47 (0.21-1.03)	0.059
Private insurance	1.82 (0.44-7.48)	0.409	0.67 (0.12-3.91)	0.659
COVID-19 insurance	0.69 (0.41-1.15)	0.151	**0.32 (0.15-0.67)**	**0.002**
Unknown	1.61 (0.16-16.37)	0.685	NA	
Clinical characteristic				
Referral status				
No	Ref		Ref	
Yes	**1.77 (1.37-2.28)**	**<0.001**	1.02 (0.48-2.14)	0.962
Unknown	2.30 (1.11-4.75)	0.024	2.49 (0.89-6.99)	0.082
Referral due to COVID-19				
No	Ref		Ref	
Yes	1.20 (0.96-1.52)	0.115	0.73 (0.41-1.3)	0.282
Referral due to obstetric condition				
No	Ref		Ref	

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Yes	**3.32 (2.63-4.19)**	**<0.001**	**2.81 (1.75-4.51)**	**<0.001**
ICU admission				
No	Ref		Ref	
Yes	**3.72 (2.76-5.02)**	**<0.001**	1.75 (0.82-3.73)	0.150
Use of mechanical ventilator				
No	Ref		Ref	
Yes	**3.40 (2.36-4.89)**	**<0.001**	1.61 (0.62-4.2)	0.331
Number of Pregnancy				
1	Ref		Ref	
2-3	1.15 (0.89-1.48)	0.300	1.03 (0.68-1.53)	0.903
4+	1.31 (0.92-1.87)	0.131	0.7 (0.39-1.27)	0.237
Gestational diabetes				
No	Ref		Ref	
Yes	**6.58 (3.67-11.80)**	**<0.001**	**3.32 (1.36-8.07)**	**0.008**
Unknown	1.48 (0.76-2.87)	0.246	1.04 (0.19-5.77)	0.967
Chronic hypertension				
No	Ref		Ref	
Yes	**17.52 (12.11-25.36)**	**<0.001**	**6.47 (3.86-10.87)**	**<0.001**
Unknown	2.68 (1.39-5.19)	0.003	4.06 (0.64-25.92)	0.138
Gestational hypertension				
No	Ref		Ref	
Yes	**39.31 (29.21-52.90)**	**<0.001**	**35.84 (24.57-52.29)**	**<0.001**
Unknown	0.49 (0.07-3.67)	0.495	0.37 (0.03-5.27)	0.463
BMI[1] before pregnancy				
Underweight	0.91 (0.54-1.54)	0.735	1.06 (0.52-2.14)	0.881
Normal weight	Ref		Ref	
Overweight	1.34 (0.94-1.89)	0.104	**1.73 (1.06-2.82)**	**0.030**

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Obese	**3.70 (2.69-5.09)**	**<0.001**	**2.43 (1.53-3.84)**	**<0.001**
Asthma				
No	Ref		Ref	
Yes	1.11 (0.46-2.67)	0.808	0.87 (0.24-3.19)	0.832
Unknown	1.31 (0.83-2.07)	0.243	0.88 (0.29-2.68)	0.829
Tuberculosis				
No	Ref		Ref	
Yes	0.74 (0.10-5.88)	0.778	0.45 (0.03-6.66)	0.558
Unknown	1.26 (0.96-1.67)	0.098	2.47 (0.90-6.79)	0.080
Cardiovascular disease				
No	Ref		Ref	
Yes	**2.66 (1.56-4.53)**	**<0.001**	1.77 (0.81-3.86)	0.151
Unknown	1.06 (0.70-1.62)	0.777	0.47 (0.17-1.28)	0.139
Kidney disease				
No	Ref		Ref	
Yes	0.83 (0.10-6.67)	0.862	0.13 (0.26-8.22)	0.338
Unknown	1.23 (0.93-1.63)	0.142	0.96 (0.21-4.34)	0.954
Autoimmune disease				
No	Ref		Ref	
Yes	2.21 (0.59-8.23)	0.235	1.75 (0.26-11.84)	0.568
Unknown	1.17 (0.89-1.54)	0.242	0.45 (0.07-2.90)	0.403
Cancer				
No	Ref		Ref	
Yes	NA		NA	
Unknown	1.19 (0.91-1.55)	0.204	1.14 (0.22-5.84)	0.875
COVID-19 history				
Never	Ref		Ref	
At least once	0.96 (0.60-1.54)	0.868	0.7 (0.34-1.43)	0.328
Unknown	1.19 (0.89-1.57)	0.236	0.63 (0.40-1.01)	0.50
Vaccination status				
Not vaccinated	Ref		Ref	

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Vaccinated	**1.53 (1.02-2.29)**	**0.040**	1.04 (0.50-2.16)	0.917
Unknown	1.65 (1.23-2.22)	0.001	1.99 (1.20-3.31)	0.008
Radiology result				
Non-pneumonia	Ref		Ref	
Unilateral pneumonia	**1.62 (1.14-2.29)**	**0.007**	1.08 (0.64-1.83)	0.774
Bilateral pneumonia	1.29 (0.98-1.70)	0.065	0.84 (0.51-1.41)	0.516
Antiviral treatment				
No	Ref		Ref	
Yes	1.10 (0.87-1.39)	0.411	1.5 (0.79-2.84)	0.217
Unknown	4.32 (2.06-9.04)	<0.001	2.17 (0.54-8.72)	0.276
Antibiotic treatment				
No	Ref		Ref	
Yes	**1.47 (1.07-2.03)**	**0.018**	1.44 (0.88-2.38)	0.150
Unknown	NA		NA	
Corticosteroid treatment				
No	Ref		Ref	
Yes	**1.77 (1.39-2.27)**	**<0.001**	**1.63 (1.07-2.49)**	**0.024**
Unknown	0.53 (0.07-4.08)	0.545	1.27 (0.12-13.74)	0.847
Immunotherapy treatment				
No	Ref		Ref	
Yes	0.64 (0.19-2.10)	0.457	**0.14 (0.02-0.90)**	**0.039**
Unknown	1.41 (0.30-6.57)	0.659	0.48 (0.03-8.40)	0.613
Neutrophil leukocyte ratio (NLR)	1.012 (0.998-1.025)	0.075	0.991 (0.969-1.013)	0.437
Procalcitonin	0.998 (0.995-1.003)	0.613	0.999 (0.992-1.007)	0.836
C-Reactive protein (per 10 unit)	0.972 (0.926-1.020)	0.253	1.010 (0.934-1.086)	0.846

Characteristic	Preeclampsia OR (95% CI)	P-value	Preeclampsia aOR (95% CI)	P-value
Random Blood Glucose				
Abnormal blood glucose	**2.43 (1.67-3.53)**	**<0.001**	1.04 (0.53-2.03)	0.917
Normal blood glucose	Ref		Ref	
D-Dimer (per 100 unit)	**1.005 (1.003-1.007)**	**<0.001**	**1.010 (1.003-1.011)**	**0.001**

5.1.3. Neonatal outcomes

A total of 4,920 neonates of 4,945 mothers were included in this study (miscarriage cases were excluded). Of them, 176 (out of 4,920, 3.58%) were stillbirth cases and 325 (out of 4,920, 6.61%) died. Among those who died, 31.7% (104/325) babies had mothers with COVID-19 positive in pregnancy. In addition, our study reported that stillbirth (48.9%, 86/176), respiratory distress (42.7%, 444/1,039), low birth weight (39.7%, 549/1,384), and low Apgar score at 5 minutes (score<7, 42.9%, 239/557) were lower in mothers with COVID-19 positive in their pregnancies, except neonatal infection which was 53.7% (414/771). Distribution of neonatal outcomes is summarized in **Table 24**.

Table 24. Distribution of neonatal outcomes by mothers' COVID-19 status

Outcomes	**Mothers with COVID-19 positive (N=2,525)**		**Mothers with COVID-19 negative (N=2,420)**		**P-Value**
Stillbirth	86	48.9	90	51.1	0.543
Neonatal death	103	31.7	222	68.3	**<0.001**
Poor fetal outcome					
Respiratory distress	444	42.7	595	57.3	**<0.001**
Low birth weight	549	39.7	835	60.3	**<0.001**
Low Apgar score at 5 minutes (<7)	239	42.9	318	57.1	**<0.001**
Neonatal infection	414	53.7	357	46.3	0.143

5.1.3.1. Factors associated with neonatal mortality

The number of babies included in this analysis was 4,716 babies due to excluding stillbirth cases. A crude analysis showed that the risk of neonatal death in newborns born to COVID-19 negative mothers (68.3%, 222/325) is higher than in COVID-19-positive mothers (31.7%, 103/325), which was also consistent in adjusted model (**Table 25**). This is due to significantly higher morbidity rates in pregnant women with negative COVID-19, such as gestational hypertension, chronic hypertension, preeclampsia and tuberculosis (**Table 12**) which might increase the risk of neonatal death. In the adjusted model, the risk factors associated with neonatal mortality in all pregnant women with COVID-19 positive and negative were respiratory distress, low birth weight, birth defect, seizure, sepsis, neonatal infection, anemia requiring transfusion, lower gestational age (<28 weeks), preterm birth (<37 weeks of gestation) lower Apgar score (<7), and NICU admission.

Table 25. Association between mothers' COVID-19 infection and other risk factors for neonatal mortality among all participants using simple and multiple logistic regression.

Variables	Total (N= 4,716) No. (%)	Death (N= 325) No. (%)	Alive (N= 4,391) No. (%)	Crude OR (95%CI)	Adjusted OR (95%CI)[a]
COVID-19					
Positive	2416 (51.2)	103 (31.7)	2313	**0.42 (0.33-0.53)*** **	**0.48 (0.37-0.62)*** **
Negative	2300 (48.8)	222 (68.3)	2078	Ref	Ref
Respiratory Distress					
Yes	989 (21.0)	273 (84.3)	716 (16.3)	**27.42 (20.30-**	**22.95 (16.73-**
No	3718 (79.0)	51 (15.7)	3667	Ref	Ref
Birth Weight					
Low birth weight	1297 (27.6)	188 (59.1)	1109	**4.26 (3.38-5.39)*** **	**5.85 (4.45-7.75)*** **
Normal	3397 (72.4)	130 (40.9)	3267	Ref	Ref
Birth Defect					
Yes	382 (8.1)	118 (36.3)	264 (6.0)	**8.91 (6.87-11.52)*** **	**8.02 (6.02-10.66)*** **
No	4334 (91.9)	207 (63.7)	4127	Ref	Ref
Seizure					
Yes	24 (0.5)	7 (2.3)	17 (0.4%)	**6.00 (2.30-14.01)*** **	**5.93 (2.07-14.79)*** **
No	4653 (99.5)	299 (97.7)	4354	Ref	Ref
Sepsis					
Yes	393 (8.4)	135 (44.3)	258 (5.9)	**12.66 (9.77-**	**11.99 (8.99-15.98)*** **
No	4282 (91.6)	170 (55.7)	4112	Ref	Ref
Neonatal					
Yes	766 (16.4)	146 (46.8)	620 (14.2)	**5.32 (4.19-6.75)*** **	**4.85 (3.72-6.30)*** **
No	3916 (83.6)	166 (53.2)	3750	Ref	Ref
Anemia					
Yes	144 (3.1)	53 (17.3)	91 (2.1)	**9.85 (6.83-14.10)*** **	**9.21 (6.18-13.59)*** **
No	4533 (96.9)	253 (82.7)	4280	Ref	Ref
Gestational Age					
<28 weeks	84 (1.8)	64 (19.7)	20 (0.5)	**53.54 (32.50-**	**60.61 (36.47-**
≥28 weeks	4628 (98.2)	261 (80.3)	4367	Ref	Ref
Preterm birth					
Yes	1268 (26.9)	254 (78.2)	1014	**11.90 (9.11-**	**4.29 (2.91-6.38)*** **
No	3443 (73.1)	71 (21.8)	3372	Ref	Ref
Apgar 5 Minutes					
<7	423 (9.3)	188 (60.8)	235 (5.5)	**26.54 (20.43-**	**20.04 (15.11-**
≥7	4135 (90.7)	121 (39.2)	4014	Ref	Ref
NICU					
Yes	956 (20.6)	222 (73.5)	734 (16.9)	**13.64 (10.48-**	**12.03 (9.04-16.15)*** **
No	3687 (79.4)	80 (26.5)	3607	Ref	Ref

** p<0.05 ** p<0.01 *** p<0.001*

[a] Adjusted for gestational age, preeclampsia, PROM, placental abruption, gestational diabetes

5.1.3.2. The impact of COVID-19 severity on neonatal mortality among COVID-19 positive pregnant women

Analysis among COVID-19 positive mothers showed that having moderate-to-severe COVID-19 symptoms increased the risk of neonatal mortality, either in the simple model and adjusted model (**Table 26**). Other risk factors for neonatal mortality in this sub-sample were similar to that of in all samples (**Table 25**), including respiratory distress, low birth weight, birth defect, seizure, sepsis, neonatal infection, anemia requiring transfusion, lower gestational age (<28 weeks), preterm birth (<37 weeks of gestation), lower Apgar score (<7), and NICU admission.

Table 26. Association between mothers' COVID-19 symptom severity status and other risk factors for neonatal mortality among COVID-19 positive pregnant women using simple and multiple logistic regression.

Variables	Total (N=2,416) No. (%)	Death (N=103) No. (%)	Alive (N=2,313) No. (%)	Crude OR (95%CI)	Adjusted OR (95%CI)[a]
COVID-19 Severity					
Moderate-severe	1058	57	1001	**1.62 (1.09-2.42)***	**1.63* (1.07-2.48)**
Asymptomatic-	1355	46	1309	Ref	Ref
Respiratory Distress					
Yes	411 (17.0)	74	337 (14.6)	**14.94 (9.68-**	**13.00 (8.24-**
No	2002	29	1973	Ref	Ref
Birth Weight					
Low birth weight	516 (21.5)	66	450 (19.5)	**7.76 (5.12-**	**8.96 (5.66-14.56)*** **
Normal	1888	35	1853	Ref	Ref
Birth Defect					
Yes	145 (6.0)	31	114 (4.9)	**8.31 (5.18-**	**6.83 (4.10-11.14)*** **
No	2271	72	2199	Ref	Ref
Seizure					
Yes	12 (0.5)	2 (2.0)	10 (0.4)	**4.77 (0.73-18.41)***	**5.57 (0.84-21.99)***
No	2386	96	2290	Ref	Ref
Sepsis					
Yes	139 (5.8)	37	102 (4.4)	**12.85 (8.13-**	**10.66 (6.45-**
No	2259	62	2197	Ref	Ref
Neonatal Infection					
Yes	410 (17.1)	49	361 (15.7)	**5.06 (2.97-6.49)*** **	**4.60 (2.98-7.09)*** **

No	1991	52	1939	Ref	Ref
Anemia requiring					
Yes	38 (1.6)	10	28 (1.2)	**9.12 (4.10-**	**6.99 (2.89-15.47)*** **
No	2362	89	2273	Ref	Ref
Gestational Age					
<28 weeks	23 (1.0)	13	10 (0.4)	**15.75 (7.56-**	**40.54 (17.08-**
≥28 weeks	2390	90	2300	Ref	Ref
Preterm birth (<37 weeks)					
Yes	484 (20.1)	71 (68.9)	413 (17.9)	10.19 (6.68-15.86)***	6.04 (3.77-9.85)***
No	1928 (79.9)	32 (31.1)	1896 (82.1)	Ref	Ref
Apgar 5 Minutes					
<7	170 (7.3)	57 (59.4)	113 (5.0)	**22.06 (14.50-34.01)*** **	**23.90 (14.80-39.00)*** **
≥7	2169 (92.7)	39 (40.6)	2130 (95.0)	Ref	Ref
NICU Admission					
Yes	475 (19.9)	66 (67.3)	409 (17.9)	**7.39 (4.97-11.10)*** **	**8.40 (5.35-13.43)*** **
No	1909 (80.1)	32 (32.7)	1877 (82.1)	Ref	Ref

* p<0.05 ** p<0.01 *** p<0.001

a) Adjusted for gestational age, preeclampsia, PROM, placental abruption, gestational diabetes

5.1.3.3. Factors associated with stillbirth

A total of 4,903 data of babies included in this analysis due to the absence of 17 babies' data. We found that COVID-19 infection in pregnancy was not associated with stillbirth (**Table 27**). Gestational hypertension, prematurity, lower gestational age (<28 weeks), placental abruption, and mothers' ICU admission were the risk factors for stillbirth identified in the adjusted model.

Table 27. Association between mothers' COVID-19 infection and other risk factors for stillbirth among all participants using simple and multiple logistic regression.

Variables	Total (N= 4,903) No. (%)	Stillbirth (N= 176) No. (%)	Live birth (N= 4,727) No. (%)	Crude OR (95% CI)	Adjusted OR (95%CI)[a]
COVID-19					
Positive	2506 (51.1)	86	2420 (51.2)	0.91 (0.67-	1.06 (0.78-

Variables	Total (N= 4,903) No. (%)	Stillbirth (N= 176) No. (%)	Live birth (N= 4,727) No. (%)	Crude OR (95% CI)	Adjusted OR (95%CI)[a]
Negative	2397 (48.9)	90	2307 (48.8)	Ref	Ref
PROM					
Yes	978 (20.0)	15 (8.5)	963 (20.4)	**0.36 (0.20-**	**0.33 (0.18-**
No	3924 (80.0)	161	3763 (79.6)	Ref	Ref
Gestational hypertension					
Yes	784 (16.2)	44	740 (15.9)	**1.78 (1.24-**	**1.76 (1.22-**
No	4058 (83.8)	131	3927 (84.1)	Ref	Ref
Preeclampsia					
Yes	812 (16.8)	43	769 (16.5)	**1.64 (1.14-**	1.13 (0.67-
No	4013 (83.2)	132	3881 (83.5)	Ref	Ref
Maternal age					
20-34 years	3557 (72.6)	107	3450 (73.1)	1.02 (0.42-	1.00 (0.40-
≥35 years	1206 (24.6)	65	1141 (24.2)	1.87 (0.76-	1.61 (0.63-
≤19 years	135 (2.8)	4 (2.3)	131 (2.8)	Ref	R
Preterm birth					
Yes	1397 (28.5)	120	1277 (27.0)	**6.23 (4.50-**	**5.27 (3.73-**
No	3497 (71.5)	52	3445 (73.0)	Ref	R
Gestational Age					
<28 weeks	117 (2.4)	31	86 (1.8)	**11.53 (7.31-**	**13.43 (8.38-**
≥28 weeks	4782 (97.6)	145	4637 (98.2)	Ref	R
Parity					
Multipara	1342 (27.4)	54	1288 (27.3)	1.18 (0.85-	1.09 (0.77-
Primipara	3560 (72.6)	122	3438 (72.7)	Ref	R
Placental					
Yes	25 (0.5)	8 (4.5)	17 (0.4)	**13.19 (5.32-**	**8.54 (3.04-**
No	4877 (99.5)	168	4709 (99.6)	Ref	R
Gestational					
Yes	92 (1.9)	5 (2.9)	87 (1.9)	1.54 (0.54-	1.44 (0.50-
No	4690 (98.1)	169	4521 (98.1)	Ref	R
Body Mass					
Underweight	614 (12.5)	23	591 (12.5)	0.91 (0.55-	0.79 (0.46-
Normal	2847 (58.1)	99	2748 (58.1)	Ref	R
Overweight	960 (19.6)	37	923 (19.5)	0.87 (0.57-	0.81 (0.52-

Variables	Total (N= 4,903) No. (%)	Stillbirth (N= 176) No. (%)	Live birth (N= 4,727) No. (%)	Crude OR (95% CI)	Adjusted OR (95%CI)[a]
Obese	482 (9.8)	17 (9.7)	465 (9.8)	0.73 (0.40-	0.62 (0.33-
ICU Admission					
Yes	511 (10.4)	38 (21.6)	473 (10.0)	**2.47 (1.69-**	**1.87 (1.24-**
No	4388 (89.6)	138	4250 (90.0)	Ref	Ref

** p<0.05 ** p<0.01 *** p<0.001*

[1]Underweight: <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25.0-30.0 kg/m^2; obese ≥30kg/m^2.

a) Adjusted for PROM, hypertension in pregnancy, gestational age

5.1.3.4. The impact of COVID-19 severity on stillbirth among COVID-19 positive pregnant women

Among mothers with COVID-19 positive, having moderate-to-severe COVID-19 symptoms significantly increased the risk of stillbirth, in either crude and adjusted model (**Table 28**). Other significant risk factors were gestational hypertension, prematurity, lower gestational age (<28 weeks), placental abruption, and mothers' ICU admission were the risk factors for stillbirth identified in the adjusted model.

Table 28. Association between mothers' COVID-19 symptom severity status and other risk factors for stillbirth among COVID-19 positive pregnant women using simple and multiple logistic regression

Variables	Total (N= 2,506) No. (%)	Stillbirth (N=86) No. (%)	Live birth (N= 2,420) No. (%)	Crude OR (95% CI)	Adjusted OR (95%CI)[a]
COVID-19 Severity					
Moderate-severe	1109	49 (57.0)	1060	**1.70 (1.10-2.63)***	**1.58* (1.02-**
Asymptomatic-	1394	37 (43.0)	1357	Ref	Ref
PROM					
Yes	466 (18.6)	8 (9.3)	458 (18.9)	**0.44 (0.19-0.86)***	**0.42 (0.18-**
No	2039	78 (90.7)	1961	Ref	Ref
Gestational hypertensio					
Yes	355 (14.4)	21 (24.4)	334 (14.0)	**1.98 (1.17-3.23)****	**1.94 (1.13-**
No	2114	65 (75.6)	2049	Ref	Ref
Preeclampsia					
Yes	358 (14.5)	17 (19.8)	341 (14.4)	1.47 (0.83-2.47)	0.81 (0.35-1.81)

Variables	Total (N= 2,506) No. (%)	Stillbirth (N=86) No. (%)	Live birth (N= 2,420) No. (%)	Crude OR (95% CI)	Adjusted OR (95%CI)[a]
No	2103	69 (80.2)	2034	Ref	Ref
Preterm birth					
Yes	541 (21.6)	54 (64.3)	487 (20.2)	**7.13 (4.55-**	**6.15 (3.84-**
No	1959	30 (35.7)	1929	Ref	Ref
Gestational Age					
<28 weeks	35 (1.4)	11 (12.8)	24 (1.0)	**14.62 (6.67-**	**16.65 (7.42-**
≥28 weeks	2468	75 (87.2)	2393	Ref	Ref
Parity					
Multipara	647 (25.8)	28 (32.6)	619 (25.6)	1.40 (0.87-2.20)	1.33 (0.82-2.12)
Primipara	1859	58 (67.4)	1801	Ref	Ref
Placental abruption					
Yes	9 (0.4)	4 (4.7)	5 (0.2)	**23.55 (5.74-**	**26.07 (6.16-**
No	2496 (99.6)	82 (95.3)	2414 (99.8)	Ref	Ref
Gestational					
Yes	48 (2.0)	4 (4.7)	44 (1.9)	2.60 (0.77-6.60)	2.08 (0.59-5.54)
No	2396 (98.0)	81 (95.3)	2315 (98.1)	Ref	Ref
Body Mass Index					
Underweight	268 (10.7)	14 (16.3)	254 (10.5)	1.52 (0.76-2.86)	1.35 (0.66-2.58)
Normal	1519 (60.7)	47 (54.7)	1472 (60.9)	Ref	Ref
Overweight	472 (18.8)	17 (19.8)	455 (18.8)	0.91 (0.48-1.66)	0.89 (0.46-1.64)
Obese	245 (9.8)	8 (9.3)	237 (9.8)	0.69 (0.26-1.54)	0.52 (0.19-1.24)
ICU Admission					
Yes	240 (9.6)	28 (32.6)	212 (8.8)	**5.02 (3.09-7.98)*** **	**3.97 (2.36-**
No	2263 (90.4)	58 (67.4)	2205 (91.2)	Ref	Ref

** p<0.05 ** p<0.01 *** p<0.001*

[1]Underweight: <18.5 kg/m^2; normal 18.5-24.9 kg/m^2; overweight 25.0-30.0 kg/m^2; obese ≥30kg/m^2.

a) Adjusted for PROM, hypertension in pregnancy, gestational age

5.2. Qualitative Study

5.2.1. Study participants

We conducted 13 in-person and 18 online sessions of semi-structured individual and group interviews to explore supply-side readiness in providing maternal and neonatal services

during the COVID-19 pandemic. A total of 66 respondents participated in the study, encompassing hospital managers/directors, obstetricians, pediatrician/neonatologists, staff in the emergency room (triage), medical record officers, and infection prevention and control managers/staff in the eight selected hospitals in East Java, Central Java, West Java, and Yogyakarta. Details of participants are presented in **Table 29**.

Table 29. List of participants

Participants	**Hospital Type A No. (%)**	**Hospital Type B No. (%)**	**Total No. (%)**
Hospital manager/director	4 (44)	5 (56)	9 (14)
Obstetrician	7 (50)	7 (50)	14 (21)
Pediatrician/neonatologist	6 (55)	5 (45)	11 (17)
Doctor/nurse/midwife in emergency room	8 (50)	8 (50)	16 (24)
Medical record officer	4 (50)	4 (50)	8 (12)
Infection Prevention and Control	4 (50)	4 (50)	8 (12)

5.2.2. Supply-side readiness

To assess supply-side readiness, we used data derived from primary data collection (for data on number of beds) and a MoH online database on hospitals (30) (for data on hospital type, number of ICU beds, ventilators, anesthesiologists, obstetricians, and pediatricians). Distribution of equipment, and human resources availability in each hospital are summarized in **Table 30**.

Table 30. . Distribution of equipment, and human resources availability in each hospital

	Hospital 1	**Hospital 2**	**Hospital 3**	**Hospital 4**	**Hospital 5**	**Hospital 6**	**Hospital 7**	**Hospital 8**
Hospital type	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B
Number of								
2020	969	365	N/A	301	761	137	1444	245
2021	892	464	1152	348	732	157	1471	245
2022	884	617	N/A	329	850	245	1681	307
Number of ICU beds	36	19	37	11	36	12	113	26
Number of ventilators	54	22	30	13	23	26	N/A	35

Number of anesthesiologist	27	4	26	2	16	2	35	7
Number of obstetricians	38	6	13	6	28	2	28	3
Number of pediatricians	45	5	11	5	34	5	47	5

**Based on primary data collection only

Nearly all hospitals witnessed an increase in the number of beds, ranging from 6.3% to 78.8%, however, Hospital A saw a decline of 8.7%. Overall, the increase in type B hospitals was significantly greater than that of type A hospitals (42.9% compared to 14.8%). Additionally, Hospital G, in comparison to the other type A hospitals, had the most beds–including ICU beds.

5.2.3 Service disruption: Bed Occupancy Rate (BOR)

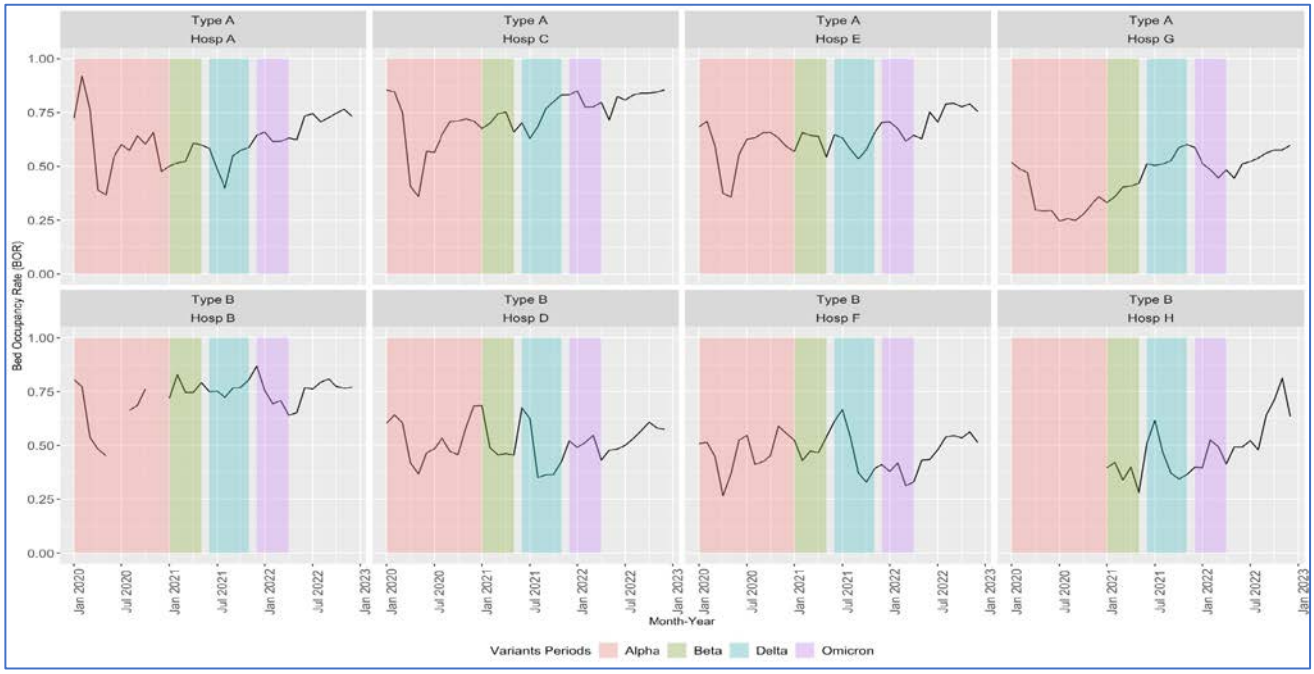

Figure 17. Bed occupancy rate (BOR) in different COVID-19 waves

Figure 17 demonstrates how the bed occupancy rate (BOR) varied in response to COVID-19 waves. Since BOR measures a hospital's overall preparedness, we interpret higher BOR values as more hospital capacity to handle both COVID-19 cases and general patient care. Type A hospitals fared better during the COVID-19 pandemic due to fewer fluctuations following the abrupt decline at the start of the Alpha wave. Nevertheless, the larger variations observed in type B hospitals may also be attributed to the substantial increase in bed capacity relative to type A hospitals.

5.2.4 Service disruption: temporary closure of particular service

Some services for non-COVID or non-emergency cases, such as elective catheterization, elective surgery, immunization, and cancer treatment were temporarily stopped. For example: Hospital A, C, E, and G paused the cancer treatment (chemotherapy) in the early months of the pandemic. Hospital C also paused the dental services due to the low number of patients.

5.2.5. Facilitating and impeding factors to supply-side readiness

We employed the 4S framework (staff, stuff, structures, systems) in the design of our research questions and data collection instrument. In order to comprehensively address the six health systems building blocks, two new codes–financing and health information systems–are added to the analysis. Our findings are, hence, categorized to showcase the potential facilitating and impeding factors to the six building blocks: service delivery, workforce, information system, equipment and supplies, financing, and leadership/governance.

5.2.5.1. Service delivery (Structure)

Challenges on structure

The MoH designated 132 hospitals as referral facilities for the treatment of COVID-19 upon the confirmation of the initial case, and subsequently advised hospitals under its supervision to reserve 20–40% of their beds for COVID-19 patients. However, the patient surge urged the hospitals to modify the arrangements in hospital buildings to adjust with the patient surge and other requirement to treat these patients.

Hospital architecture

This study offered several insights regarding hospital architecture to anticipate a sudden influx of patients with airborne diseases. In times of health crises such as the COVID-19 pandemic, efficient utilization of available resources becomes crucial. One strategy involves the rapid transformation of unused structures or areas into designated quarantine zones, providing an immediate solution to accommodate individuals requiring isolation. Hospitals with multiple wings possess the flexibility to allocate one or more of these wings as isolated areas, effectively segregating patients and minimizing the risk of transmission within the facility. Emergency rooms (ER) with expansive, unoccupied front areas are invaluable, serving as temporary holding spaces for patients until more appropriate treatment spaces become available. Additionally, setting up temporary wards in tents

proves to be a practical and resourceful solution when the volume of patients exceeds the building's capacity, allowing for the expansion of healthcare facilities to meet the escalating demand for medical care. These adaptive measures contribute to the overall preparedness and responsiveness of healthcare systems during periods of heightened public health challenges.

Delivery room and Operating theater

To care for laboring and post-partum mothers affected by COVID-19, hospitals made the following adjustments. To enhance infection control measures during the COVID-19 pandemic, hospitals implemented specific protocols in maternity and emergency care settings. An infectious delivery room was established, featuring plastic partitions to create a barrier between the patient's upper body and the attending health personnel, reducing the risk of viral transmission. In a subsequent refinement, some hospitals upgraded these rooms with a negative pressure system, further enhancing the containment of airborne pathogens. Emergency rooms were strategically adapted to address the needs of laboring women requiring immediate delivery. Dedicated spaces within the ER were set up to provide timely and specialized care for these individuals, ensuring swift and appropriate responses to their unique requirements. In the operating theater, particularly during c-section surgeries, hospitals introduced negative air pressure systems to minimize the dissemination of infectious particles. Furthermore, anterooms were constructed adjacent to operating theaters, serving as contamination zones to control and contain potential spread of the virus. Notably, only one hospital reported having existing operating theaters with anterooms, while others proactively constructed these spaces in response to the pandemic, showcasing a flexible and adaptive approach. A proactive measure involved certain hospitals designating a specific number of beds within the infectious ward exclusively for maternal care. This segregation aimed to provide specialized care for pregnant individuals with COVID-19, ensuring a focused and controlled environment for managing maternal health amid the ongoing public health crisis. These strategic adjustments underscore the commitment of healthcare institutions to prioritize safety and optimize care delivery during challenging circumstances.

5.2.3. Workforce (Staff)

Challenges on Workforce

As described in other studies, the key challenge in healthcare service provision during the COVID-19 pandemic, whether for maternal and newborn or any general care, was the lacking number of

health workers. In the pre-pandemic period, Indonesia had a low number of doctors, 0.38 doctors per 1,000 population. The doctor-to-population ratio is relatively low when compared to other countries in the South East Asian countries. Although the ratio of nurses and midwives per population is quite high, at 4 per 1,000 population, less than half of them are nurses. The existence of the COVID-19 pandemic certainly increases the burden on health workers in handling patients, especially the need for doctors and nurses as the main first-line providers for triage and COVID-19 treatment.

The government is addressing the surge in the need for doctors and nurses by recruiting volunteers. By April 2020, there were 3,412 volunteer health workers (31), most of whom were doctors and nurses. The results of interviews in this study are in accordance with previous information that most of the volunteers are doctors and nurses who support services in the emergency room and COVID wards. Maternal and newborn services generally do not use volunteers because the officers here are generally midwives or nurses who have been specially trained to take care of the newborns.

Another challenge faced by the health workers, according to the study participants,is stigma from the community. There are many reports that health workers, especially those working in hospitals, are not allowed to return to

their homes due to rejection from the surrounding community. Some workers also feel uncomfortable returning to their homes due to the presence of family members who are vulnerable to COVID-19.

Support from national and provincial governments: volunteers, incentives and daily living needs

Support related to human resources from external parties of the Hospital is in the form of volunteer labor supply, incentives, and accommodation with food and vitamin needs. Support for health worker volunteers during the pandemic was mainly provided by the Ministry of Health. Hospitals can recruit directly and the Ministry of Health provides funding, or the Ministry of Health does the recruitment and allocation. As the pandemic progresses, volunteer support is also provided by the provincial government in handling COVID-19 in hospitals.

In terms of incentives, the central government and universities provide incentives for health workers involved in handling COVID-19 patients. The distribution of these incentives is considered to be a fair compensation for the hard work of health workers in handling COVID-19 patients. Some hospitals reported delays in incentive payments, so the hospital had to cover them in advance. However, the presence of the COVID-19 incentives is deemed positive, especially for resident doctors who have not received incentives so far, this COVID-19 incentive is the first time they have received income from patient care activities (Ratna and Anwar, 2023).

Shifts modification

In addition to anticipating a surge in patients, strategies related to human resources also aim to protect health workers. One of the strategies is to modify shifts for health workers, for example by implementing shorter work shifts than usual, on-off work shifts per 2 weeks so that health workers can be monitored continuously for their COVID-19 status.

Task shifting, sharing, and delegation

The hospital implemented task shifting, sharing and delegation, which was initially a voluntary or emergency individual initiative, then supported to become more planned and systematic by the hospital. Some examples are the training of all nurses, including dental nurses, in performing swabs. This divides the workload in the implementation of swabs, which during the last

pandemic was very high because swabs were not only carried out on patients but also routinely for officers. Another example is the ‘patient visit volunteer’, in which specialists from various specialties volunteered to visit any patients regardless of being the main ‘doctor in charge’ for the patients. Some hospitals arranged it by type of specialty, where, for example, pediatrician A visited all pediatric patients on Monday, Wednesday, and Friday while pediatrician B did so on Tuesday, Thursday, and Saturday. Meanwhile, other hospitals arranged the ‘patient visit volunteer’ for any specialists, such as the neurologists visiting cardiologists’ patients on a specific schedule, cardiologists visiting pulmonologists’ patients, etc. This approach has made the work burden more bearable.

5.2.5.3 Information system and the use of technology

Challenges on information systems and technology

As the number of patients increased, so did the number of medical records that needed to be managed. This had been a specific challenge in medical record management, especially for hospitals that have not used electronic medical records at all. Another challenge is how hospitals need to quickly adopt the online platforms for teleconsultation. In one hospital, the challenge is especially heightened when some of the service was provided in tents, as the access to computers is more difficult than usual.

The pandemic has facilitated the conversion from paper-based to electronic medical records

At the beginning of the pandemic, many things were still unknown about the methods of transmission of COVID-19, especially regarding surface contact. So, the anticipation carried out by the medical record manager is to separate the medical record from the red zone (specifically COVID-19) in a certain area, disinfect it, use protective plastic, before putting it back into the medical record room. This is seen as quite effective in ensuring the safety of medical record officers but is quite difficult and increases the workload of officers. This is one of the contributors to the acceleration towards electronic medical records, in addition to the regulations from the Ministry of Health. Particularly in hospitals that before the pandemic had started a gradual conversion to electronic medical records, they acknowledged that the pandemic helped accelerate the conversion.

The use of teleconsultation for patient screening and follow up

The use of teleconsultation for screening, patient triage, and follow-up for patients previously treated for COVID-19 is carried out in several hospitals. Teleconsultation is especially used for patients who do not require direct contact examinations or require radiology, laboratory, and other examinations that can only be done when the patient comes to the hospital, such as psychiatric services, some internal medicine services, drug consultations, and COVID-19 symptom consultations. Teleconsultation-based services for patients for antenatal care are generally not implemented, due to the limited capacity of examinations that can be carried out and the resources available.

5.2.5.4. Equipment, medicines, and supplies (Stuff)

Challenges on equipment, medicines, and supplies

The lack of PPE was prominent during the early months of the pandemic. In this period, many hospitals relied on donations from external parties, including from the community. In addition to PPE, the availability of oxygen and COVID testing (PCR) was a significant challenge during the COVID-19 pandemic, especially during the delta phase where there was a very high surge in the number of patients in a short period of time. Radiology services also experience limitations because in the process of patient claims and reimbursement, evidence in the form of X-ray examinations is required. Medicines that lacked during the COVID-19 pandemic were those used to treat COVID-19, such as antivirus, Regarding maternal and neonatal services, supplies that are quite limited were incubators and child-sized ventilator equipment. The respondents reported that no significant challenges were encountered related to the medicines or drugs specific for maternal and neonatal cases.

Borrowing equipment and supplies across hospitals

Various strategies were employed to address the lack of equipment, such as incubators, and supplies, such as oxygen. To cover the limited oxygen supply encompassing renting/lending from external institutions and optimizing logistical resource utilization. Some referral hospitals required the sender hospitals to include the incubators when referring newborn patients.

Set up a special taskforce on oxygen monitoring

Oxygen is the most important element in the management of COVID-19. Oxygen limitations occurred in several hospitals, and one hospital experienced a shortage due to a surge in patients at the peak of Delta. Apart from the demand side, oxygen limitations also occur due to insufficient supply, so that the oxygen shortage mainly occurs in areas that do not have oxygen producers. Due to these problems, one hospital innovated by forming a team to monitor and analyze the actual use of oxygen. The oxygen stock is checked every 4 hours, and if the stock starts to decrease, the oxygen flow is adjusted as long as the patient's saturation remains stable at the same level. In addition, the team also monitors oxygen transportation, and if there is a problem from one route, oxygen delivery is diverted through another route.

Utilizing non-functional incubators to support ‘keeping mother and baby together’

As discussed above, one of the keys of equipment considered to be lacking was the incubator for newborns.

5.2.5.5. Financing

Challenges on financing

The interventions to address the patient surge and efforts on disease control during COVID-19 required immense resources while the hospitals also facing significant decrease of income due to the plummeting number of general patient visits, especially for elective surgery and other treatments.

Hospital autonomy

Despite the rising needs, none of the hospitals reported experiencing serious financial difficulties. On top of support from the MoH, provincial government, and universities, they also received considerable donations from private businesses and the communities. Interestingly, one provincial hospital reported a large amount of PPE and medication supplies from the MoH in the early stage of the pandemic, only to be informed later that payment was required.

Alongside the consensus regarding relaxation of financial management regulations, the fact that six hospitals are public service entities (*badan layanan umum*)—government-owned institutions with autonomy over their own resources—made it much simpler to reallocate less-priority budget items to address COVID-19-related demands. These hospitals may also have some reserved funds available for use in case of an emergency.

Support from external parties

While the national level did not directly provide additional budgetary support for the non-national government-owned hospitals, it arranged and funded the recruitment of additional health workers to fill the workforce needs of the hospitals. It was also decided that all costs of care for COVID-19 patients is reimbursable by the national government, thus hospitals were assured to provide care for COVID-19 patients. The national government also provided incentives that motivate health workers; this indirectly contributed to better resilience in health service delivery. The national government also provided equipment and medical consumables during the later stages of pandemic for facilities designated for COVID-19 referral hospitals.

5.2.5.6. Leadership/governance (Systems)

Challenges in governance

During the initial stages of pandemic, there were uncertainties about the mode of transmission, personal protective equipment required for transmission prevention, and drugs effectiveness. One of the most important elements that is deemed as the key to clinical management is the need for guidelines for COVID-19 treatment and hospital care delivery. Hospitals were expected to adjust to the new guidelines and evidence on the treatment.

Standard Operating Procedure (SOP)

Each hospital organized a COVID-19 task force, one of whose key responsibilities was to formulate and revise regulations. To help hospitals cope with the pandemic, the MoH issued a checklist on hospital preparedness (adapted from WHO) comprising twelve assessment areas. The results of the analysis, presented in the form of a spider web graph, assisted hospital administrators in identifying areas that required improvement and allocating resources to enhance them.

SOP for maternal and newborn care were mostly based on recommendations released by professional organizations (POGI, IDAI). Throughout the duration of the pandemic, the SOP underwent multiple revisions. Nevertheless, the majority of the changes pertained to COVID-19 itself (screening, testing, medication, discharge protocols); very little concerned about treatment procedure. One notable modification was observed in the selection of pregnancy termination method. At the beginning of the pandemic, all full-term pregnancies were terminated by c-section to mitigate the risk of contamination. In the subsequent period, as knowledge on the disease progressively advanced, the termination methods became contingent upon obstetric indication, so c-section was no longer the sole option. Adherence to the SOP for surgery was compromised due

to the protracted preparation and sterilization time as well as the hindrance to visibility and mobility experienced by health personnel as a result of wearing the level 3 PPE.

Post-delivery treatment

As no hospitals had the capacity for rooming-in, infants were isolated from their COVID-19-infected mothers shortly after delivery. The mothers were relocated to the infectious ward, whereas infants were managed based on whether they required NICU care or could be admitted to the baby ward. Infants and mothers may be discharged individually from the hospital, contingent upon their respective conditions, in order to reduce accumulation of patients. Families would need to sign an informed consent form before bringing home positive infants.

Hospital Disaster Plan (HDP)

While all hospitals were required to have an HDP in place for accreditation prior to the pandemic, none of them had incorporated an outbreak of airborne disease into their plan. The

presence of HDP was especially beneficial during the pandemic in terms of the clear delineation of roles and responsibilities, resulting in effective communication and coordination throughout the hospital.

The identification of COVID-19 cases in Wuhan prompted one hospital to conduct simulations in preparation for a potential outbreak in Indonesia, which led to improved readiness and increased vigilance among the hospital staff during the actual pandemic. Every hospital has now integrated an airborne pandemic scenario into its HDP and emphasized the significance of conducting periodic simulations to maintain personnel on constant alert for any disaster.

External collaboration

The COVID-19 pandemic highlighted the importance of external collaboration in providing all patients in need with the best possible care. An excellent example was the initiative of creating a WhatsApp Group to share information about the immediate capacity of hospitals within a certain area in order to prevent patients from being turned away from a hospital that had reached its maximum capacity. Learning from this, local health offices are expected to take the lead in creating a clear and reliable referral system to avoid confusion in the event of an emergency. It was also evident that penta-helix collaboration among academics, business, community, government, and media was critical in getting us through such a crisis, and that it needs to be strengthened.

Table 31. Quotations pertinent to the qualitative findings

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
Service delivery (structure)	*"Our building was not well ventilated and might not meet the criteria to care for patients with airborne infection"* **(ER nurse, type-B hospital)** *"At that time, the majority of the symptoms were severe while the emergency room resources we only had that much, at most up to 20 beds in the emergency room while at that time the ward was full ... In the ER itself, the maximum we can add is only up to 20 beds and for beds specifically for pregnant women, we do have special CEMOC beds but at most we can only get around 2 or 3 beds like that and even though at that time there were a lot of pregnant women patients, a lot of them from early*		*" Our hospital consist of several building, so it is relatively easy to transform one building into an infectious area. We even had VIP rooms for COVID, since there were quite many government officials who contracted the virus and were admitted to our hospital."* **(Hospital manager, type-B hospital)** **"***We set up three sturdy tents that could accommodate 80 patients in total, where we attended a good number of deliveries for COVID mothers. The tents were equipped with ample facilities, such as toilets, bedside monitors, and resuscitation equipment to anticipate for emergencies."* **(ER nurse, type-B hospital)**

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
	pregnancy to late pregnancy whose symptoms were severe, so even though at that time also because the maximum can be 20 beds and what is the name of oxygen itself was also lacking at that time so it was indeed lacking and there were some pregnant women who were only, just what they could" **(ER doctor, type-B hospital)**		
Workforce (Staff)	*"Incentives for volunteers were not paid on time, so the hospital had to take loans to back up the payment"* **(Hospital manager, type-A hospital)**	*"All HCW were given incentives by MOH. In particular, there was a one-off incentive to all resident doctors (IDR 75 million)"* **(Hospital manager, type-A hospital)** *"The incentives from government was at least something to keep us going"* **(Staff at emergency unit, type-A hospital)** *"Pandemic is the only time when the government*	

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
		appreciated resident doctors by giving them incentives, and the amount they received was much higher than specialists/professors. They deserved that, they're the real hero, they were always in the frontline" **(Staff at emergency unit, type-A hospital)** *"Regarding human resources, at that time we were fully supported by the government, yes, then both the provincial government and the central government,* *.... so that in the early days because we were appointed as a COVID referral center, the assistance for medical devices and human resources was extraordinary.. we also got financial assistance for recruiting HR, specifically COVID"* *"They were given special incentives, food, supplements. We also set their working hours to be*	

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
		shorter, so they could get a longer rest time" **(Hospital manager, Type-A hospital)**	
Equipment, medicine, and supplies (Stuff)	*"We experienced a shortage of masks, a certain model of mask. But overall, PPE was sufficient"* **(Hospital manager, type A)** *"Our obstacle is, when compared to the vertical (central-government-owned) hospital, the funding from the central government may be arrived later for our hospital"* **(Hospital manager, type B hospital)** *"Overall everything was provided by the hospital; however this was a matter of perception, they provided hazmat suit, masks, while we knew there are better options out there, so we would use our own PPE rather than those provided by the hospital, just trying to be more protective and ensuring our own safety. The most recent*	*"It was hard in the beginning...the donation really helped, we got it from many parties, yes even though some of it was not appropriate, but everything was very useful at that time....(province-owned hospital, type A) "because it was such a difficult time, everyone helped each other, … if there was a hospital that was having difficulties, there was a (chat) group too 'we have a shortage of oxygen can, we want we only have this much, who has extra?' 'We do have, but only 2 tubes' that was the example of what happened.. and then we returned the can later"* (**Hospital manager, type B hospita**l) *"A lot of medicines were under trial during the pandemic, so*	*"We experienced a shortage of masks, a certain model of mask. But overall, PPE was sufficient. We procured some, and at the same time, also received many donations. We also made our own hazmat suit with approval from our infection control committee. In reality, some doctors might bring their own PPE, it is hard to control since this is a teaching hospital. For oxygen, it wasn't until stock out, but the price had greatly increased. We even succeeded in adding a big tank of 15,000 liters as reserve stock. We always did our best to provide every need."* **(Hospital manager, hospital C, type A)** *"We set it up, so in 4 hours we have to know how much*

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
	SOP suggests using apron rather than hazmat, but some doctors would still wear hazmat though." **(Obstetrician, type-A hospital)** *"We received many referrals, but we didn't have enough equipment for babies. So the referring hospitals (6 hospitals) would send the mother along with the incubator for the baby. When we ran out of ventilators, we could just explain to the patient's family about our limitations."* **(Pediatrician, type-A hospital)**	*we only procured those recommended by MoH through the national formulary. Many times, patients knew about certain medication from somewhere, we had difficulties in getting those."* **(Hospital manager, type A hospital)**	*oxygen is left. so some are high concentration and some are not, we have HFNC (High Flow Nasal Cannula). So we have HFNC that wastes the most oxygen and then we use a ventilator and then NRM which is also high concentration oxygen. So we record how much the high concentration is with the number of our patients and the daily exhaustion is actually every hour, because the number of patients increases the amount of oxygen again, we count it and then we monitor it every 4 hours, every 4 hours someone is traveling around. So there is a roving officer around, we make the roving officer a security guard and a security guard who roams with the pharmacy. So if it's 4 hours he asks to take a photo, we have a taskforce, the covid team, 4 hours they takes a photo there are only so many doctors 'oh*

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
			that means this will run out in a few hours' well that's because it's very important because yesterday the oxygen in the building was pulled by all hospitals, so it was like a very valuable object, so one of the tasks is that I made a team like that so that there is no shortage of oxygen." (**Hospital manager, type-B hospital)** *"In early 2020, we might be the only MoH-owned hospital that received nearly no funding for COVID. So we reallocated our own budget to build the isolation room. By the end of 2020, there was a regulation that we could request funding from the MoH, but our director had been displeased and insisted on not making any request."* **(Hospital manager, type-A hospital)**

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
Leadership/ governance (Systems)	*"We could not find any recommendations for surgery during the pandemic, whether from MoH or international organizations. There were many directions related to physical distancing, isolation, tracing, but none were about surgical protocols. Maternal surgery is typically life-saving, so the 30 minute golden time rule should apply. But at that time we could not meet the standard, and there was zero information how we should adjust"* **(ER/Anesthesiologist, type-A hospital)**	*"Every hospital has to meet the standards set by MoH and formed special teams to continuously update information and knowledge."* **(Hospital manager, type A hospital)** *"The government needs to reinforce a stricter regulation in controlling prices and supplies in time of emergency."* **(Obstetrician, type A hospital)**	*"When many other hospital paused their elective surgeries, we decided to proceed. I consider this as an innovation. We collaborated with a car rental company to transfer patients to our hospital and equipped them with an official letter. This is very helpful as intercity mobility was highly restricted at that time. We also provided care pathway for each patient, so they were aware of the timing of each treatment."* **(Hospital manager, type-A hospital)**
Financing	*"We thought those PPE and medication were given as aids, but later they deducted it from the hospital's reimbursement for treating COVID patients. The unit price charged by MoH was far too high from the market price."* **(Hospital manager, type-B)**		*"In 2021-2022, MoH allocated funding for our hospital, so we took our portion."* **(Hospital manager, type-A hospital)**

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
Information systems	*"I don't think we had the teleconsultation for antenatal care.. it feels like we are tired enough for those (COVID cases) in the field. But what is clear is that with the pandemic, there are many zoom classes"* (**Obstetrician, type B hospital**) *"We actually applied telemedicine to our staff (who contracted COVID) before launching it to the public."* **(Hospital manager, type A hospital)** *"Telemedicine is mostly used for patients who needed consultation form psychiatrists because physical examination was less needed." (Hospital manager, type A hospital)* *"We provided telemedicine services for all departments actually, but only a few would utilize it. The majority is from internal medicine. For obstetrics,*		*"During the pandemic, we examined patients who were admitted to the hospital by phone. So that means there is no complaint at all, we don't meet the patient.. so the patients were not visited by the doctor, it's like having CCTV that directed to patients' bed"* (**Obstetrician, type B hospital**) *"For those who needed control after being charged, we set up a virtual clinic called virtual home care. The setting is similar to a phone booth, it has 2 consultation related to drugs, then consultation about the flow." (ER nurse, type A hospital)*

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
	it was less used, because we need to do a physical examination. With telemedicine, our care became substandard." (Obstetrician, type A hospital) *"Now if from the system it turns out that he has a warning to check, the patient can choose between two, want telemedicine or want to check directly to the hospital. Well, since then, telemedicine being developed at the hospital, but not always for Covid patients. Until now, there are telemedicine patients at home." (ER doctor, type B hospital)* *"Yes, we did that too (telemedicine). yes consultation about COVID itself, then* *screens, one for medical records, another for communicating with patients. It is still functioning until now, especially for post-discharge patients, including for*		

Health systems building blocks	Impeding factors	Facilitating factors	
		External	**Internal (strategies/innovations)**
	maternal neonatal services. It is a free service, part of the hospital's CSR to care for patients who are not local residents. However, it is less used for consultation because our culture is not used to it, patients are not satisfied if they don't have face-to-face interaction with doctors." (Hospital manager, type A hospital)		

6. KEY FINDINGS, CONCLUSION, CHALLENGES, AND RECOMMENDATIONS

6.1. Key findings

Key findings of this study are summarized in **Table 30**.

Table 30. Study key findings classified by study objective

Objective	Key findings
To Assess the impact of COVID-19 on maternal, birth, and newborn outcomes	**COVID-19 positive in pregnancy was associated with** • Increased risk for maternal mortality for participants who either test positive for SARS-CoV-2 infections or become infected during the Delta wave), but not with risk of miscarriage, preeclampsia, neonatal mortality and stillbirth.
	Factors strongly associated with maternal mortality • Increase risk of mortality: having infection during Delta wave, being employed, having ICU admission, using mechanical ventilator, parity of 2-3, higher NLR level, and abnormal blood glucose level. • Decrease risk of mortality: referral cases. **Factors strongly associated with miscarriage** • Increase risk of miscarriage: having infection during Delta wave, being admitted to hospital type B, being referred due to obstetric condition, ICU admission, parity ≥4, having kidney diseases as comorbidity • Decrease risk of miscarriage: referral cases, having preeclampsia as

Objective	Key findings
	comorbidity, and higher level of NLR
	Factors strongly associated with preeclampsia • Increase risk of preeclampsia: referred due to obstetric condition, ICU admission, having chronic hypertension, autoimmune disease as comorbidity, obesity before pregnancy. • Decrease risk of preeclampsia: infection during Beta and Delta waves, referral cases, vaccination at least one dose.
	Factors strongly associated with neonatal mortality • Increase risk of neonatal mortality: respiratory distress, low birth weight, birth defect, seizure, sepsis, neonatal infection, anemia requiring transfusion, lower gestational age (<28 weeks), preterm birth (37 weeks of gestation), lower Apgar score (<7), and NICU admission
	Factors strongly associated with stillbirth • Increase risk of stillbirth: gestational hypertension, prematurity, lower gestational age (<28 weeks), placental abruption, and mothers' ICU admission
To compare maternal characteristics, maternal, birth, and newborn outcomes among pregnant women with COVID-19 during pregnancy by illness severity	**Moderate-to-severe COVID-19 symptoms was associated with** • Increased the risk of maternal and neonatal mortality, and stillbirth, but not with risk of miscarriage, and preeclampsia.
	Factors strongly associated with maternal mortality among positive cases • Increase risk of mortality: being employed, ICU admission, using

Objective	Key findings
	maternal mechanical ventilator, bilateral pneumonia, higher level of C-reactive protein, and interleukin-6.
	Factors strongly associated with miscarriage among positive cases • Increase risk of miscarriage: being referred due to obstetric conditions, being underweight in before pregnancy, having kidney disease as comorbidity • Decrease risk of miscarriage: higher educational level
	Factors strongly associated with preeclampsia among positive cases • Increase risk of preeclampsia: being referred due to obstetric condition, comorbidities: gestational diabetes, chronic hypertension, and gestational hypertension, being overweight and obesity before pregnancy, receiving corticosteroid. • Decrease risk of preeclampsia: infection in Beta and Delta waves, receiving COVID-19 insurance, receiving immunotherapy treatment.
	Factors strongly associated with neonatal mortality among positive cases • Increase risk of neonatal mortality: respiratory distress, low birth weight, birth defect, seizure, sepsis, neonatal infection, anemia requiring transfusion, lower gestational age (<28 weeks), preterm birth (37 weeks of gestation), lower Apgar score (<7), and NICU admission
	Factors strongly associated with stillbirth among positive cases • Increase risk of stillbirth: gestational hypertension, prematurity, lower

Objective	Key findings
	gestational age (<28 weeks), placental abruption, and mothers' ICU admission
To assess supply-side readiness and service disruption during COVID-19 pandemic	Hospitals were incapable to anticipate the patient surge, especially in the first months of pandemic, but hospitals learned and adapted over time, and supported by both government and non-government actors
	Hospitals' capacities to adapt to the fluctuating COVID-19 cases were varied, depends on their structure
	Disruptions to maternal-newborn health (MNH) services were attributed to limited surge capacity of staff and medical devices in the hospitals; limited capacity of primary care on MNH treatment

6.2. Conclusion

COVID-19-positive pregnancies are associated with an elevated risk of maternal mortality, particularly for those testing positive for SARS-CoV-2 infections or during the Delta wave. Referral cases were less likely to have poor maternal complications and mortality during pregnancy which highlight the need to strengthen the referral systems with appropriate case management in a timely manner. Moderate-to-severe COVID-19 symptoms in pregnancy elevate maternal and neonatal mortality risks and stillbirth. From qualitative study, the initial challenges faced by hospitals in anticipating the patient surge during the early months of the pandemic underscored the unprecedented nature of the situation. However, as time progressed, hospitals demonstrated adaptability and resilience, with support from both government and non-government entities. The varying capacities of hospitals to cope with fluctuating COVID-19 cases highlight the crucial role of organizational structures in effectively managing healthcare challenges. The disruptions to maternal-newborn health services were primarily attributed to the limited surge capacity of staff and medical devices in hospitals, as well as constraints in the capacity of primary care for maternal-newborn treatment.

Moving forward, future research should delve into refining our understanding of the nuanced interactions between COVID-19 infection during pregnancy and maternal and neonatal outcomes. Investigating the long-term impacts of SARS-CoV-2 infection on both maternal and neonatal health is crucial, including potential effects on neurodevelopment, respiratory function, and overall well-being. Additionally, exploring the effectiveness and safety of vaccination in pregnant individuals and its impact on reducing adverse outcomes warrants thorough investigation. Although the association between vaccination and maternal mortality disappeared

after confounding adjustment, we still emphasize the need for vaccination. Detailed data on vaccines that were received by participants was not available in the medical record, which has limited our finding interpretation. The protective effects of vaccination depend on the type of vaccines administered, number of doses and the receipt of booster doses, aspects that we were unable to explore further in this study. Further research into the mechanisms underlying the associations identified, such as the specific pathways through which Delta wave infection contributes to increased maternal mortality, will contribute to targeted preventive measures. Studying the interplay between socio-economic factors, healthcare access, and outcomes is vital for developing comprehensive strategies to mitigate disparities. Finally, ongoing surveillance and collaborative efforts are essential for monitoring the evolving landscape of the pandemic and adapting healthcare strategies accordingly. Future directions should focus on refining strategies for enhancing surge capacity, both in terms of personnel and medical resources, across diverse healthcare settings. Additionally, continued collaboration between government and non-government actors is imperative to build sustained resilience within healthcare systems to effectively respond to future public health crises. Future research should explore preventive strategies and long-term outcomes for mothers and infants in the context of these identified risk factors.

6.3. Challenges

1. Limited time frame for such a big multicenter study with the details as follows:
    a. Proposal preparation: 6 months
    b. Data collection and verification: 4.5 months
    c. Data analyses: 15 days
    d. Writing report: 17 days
2. Different bureaucracy in obtaining permit and ethical approval from each hospital.
3. Difficulty in retrieving data from medical records for patients during COVID-19 pandemic due to transition from paper-based to electronic medical record, fragmented data sources, displaced medical records during catastrophic situation in COVID-19 pandemic.
4. Limited daily capacity to access medical record within limited time frame of research.

6.4. Recommendation

1. **Vaccination for pregnant women.** It is imperative to prioritize the vaccination of pregnant women to safeguard against COVID-19 infection, minimizing the risk of adverse pregnancy and neonatal outcomes.
2. **Strengthening referral system and appropriate case management**. Enhance referral systems and implement appropriate case management strategies to prevent the clinical deterioration of COVID-19 cases, ensuring timely and effective healthcare interventions.
3. **Improving data storage systems.** Address the need for improved data storage systems to facilitate more efficient data retrieval processes, enhancing the overall efficiency of healthcare information management.
4. **Enhancing surge capacity based on six pillars of health systems**

    a. Service delivery
        i. Build dedicated spaces or structures designed to anticipate surges in patient numbers, providing adequate facilities for comprehensive healthcare.

    b. Workforce (Staff)
        i. Involve doctors in clinical rotation in non-COVID-19 services, such as telemedicine and screening for non-COVID-19 conditions.
        ii. Formalize task delegation in emergency settings for optimized healthcare delivery.

    c. Information system and the use of technology
        i. The pandemic has encouraged private healthcare providers to provide telemedicine and teleconsultation. These providers should be engaged in the district disaster plan to ensure sustainable healthcare services for essential diseases.

    d. Equipment, medicines, and supplies
        i. Establish standard operating procedures for lending health equipment between public and private facilities, ensuring resource optimization.

    e. Financing
        i. Ensuring flexibility in budgeting during the disaster could help hospitals

improve their preparedness in dealing with surge capacity.

f. Leadership/governance

   i. Develop hospital disaster plans that incorporate infectious disease outbreak responses.

   ii. Ensure Puskesmas (Community Health Centers) have disaster plans and actively participate in disaster mitigation responses.

   iii. Back referral systems and insurance scheme

      - Establish back referral systems between hospitals to efficiently manage patient transfers.
      - Address gaps in the insurance scheme to allow for appropriate treatment levels, preventing higher tier hospitals from managing cases that could be adequately treated in lower tier hospitals (e.g., LBW neonates with COVID-19 positive and negative mothers requiring Kangaroo Mother Care at type D hospitals).

7. REFERENCES

1. World Health Organization. Coronavirus disease 2019 (COVID-19) Situation report - 51 [Internet]. World Health Organization; 2021 Mar [cited 2021 Nov 12] p. 9. (Situation Report). Report No.: 51. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10
2. World Health Organization. COVID-19 epidemiology update - 27 October 2023 [Internet]. World Health Organization; 2023 Oct [cited 2023 Nov 21] p. 25. (Emergency Situational Updates). Report No.: Edition 160. Available from: https://www.who.int/publications/m/item/covid-19-epidemiological-update---27-october-2023
3. Pereira A, Cruz-Melguizo S, Adrien M, Fuentes L, Marin E, Perez-Medina T. Clinical course of coronavirus disease-2019 in pregnancy. Acta Obstet Gynecol Scand. 2020;99(7):839–47.
4. Karaçam Z, Kizilca-Çakaloz D, Güneş-Öztürk G, Çoban A. Maternal and perinatal outcomes of pregnancy associated with COVID-19: Systematic review and meta-analysis. Eur J Midwifery. 2022 Jul 6;6(July):1–22.
5. Mehta N, Chen K, Hardy E, Powrie R. Respiratory disease in pregnancy. Best Pract Res Clin Obstet Gynaecol. 2015 Jul;29(5):598–611.
6. Abou Ghayda R, Li H, Lee KH, Lee HW, Hong SH, Kwak M, et al. COVID-19 and Adverse Pregnancy Outcome: A Systematic Review of 104 Cases. J Clin Med. 2020 Oct 26;9(11):3441.
7. Allotey J, Fernandez S, Bonet M, Stallings E, Yap M, Kew T, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. BMJ. 2020 Sep 1;m3320.
8. Dewi A, Junaedi F, Safaria T, Supriyatiningsih S, Dewanto I, Dewi DTK. COVID-19 pandemic: maternal anxiety increases during pregnancy, Indonesia. Bali Med J. 2021 Dec 28;10(3):1053–7.
9. Kusuma AANJ, Putra IGM, Suardika A, Novrita Sari A. Clinical Overview in Pregnancy with COVID-19 at prof. Dr. I.G.N.G. Ngoerah Hospital Period of April 2020-March 2021.

Open Access Maced J Med Sci. 2022 Dec 5;10(B):2513–9.

10. Kusuma AANJ, Aryana MBD, Mahendra INB, Susanto DH. Description of Neutrophil-to-lymphocyte Ratio, C-reactive Protein, and Procalcitonin Levels in Pregnancy with COVID-19 at Sanglah General Hospital Period of April 2020–April 2021. J South Asian Fed Obstet Gynaecol. 2022 Aug 22;14(4):445–52.
11. Angelika D, Etika R, Vita AD, Mithra S, Ugrasena IDG. Necrotizing Enterocolitis in Preterm Infants Born to Mother with COVID-19. Open Access Maced J Med Sci. 2021 Oct 22;9(B):1499–504.
12. Akbar MIA, Gumilar KE, Andriya R, Wardhana MP, Mulawardhana P, Anas JY, et al. Clinical manifestations and pregnancy outcomes of COVID-19 in indonesian referral hospital in central pandemic area. Obstet Gynecol Sci. 2022 Jan 15;65(1):29–36.
13. Thahir AIA, Nasir S, Holmes A, Li M, Gordon A. Mothers' and Midwives' Experiences of Maternal and Child Health Services during the COVID-19 Pandemic in Banggai, Indonesia: A Qualitative Study. Int J Community Based Nurs Midwifery [Internet]. 2023 Apr [cited 2023 Nov 29];11(2). Available from:https://doi.org/10.30476/ijcbnm.2023.97114.2187
14. McGowan L, Astuti A, Hafidz F, Pratiwi C, Yulian V, Hughes E, et al. The effect of COVID-19 on women's experiences of pregnancy, birth and postpartum in Indonesia: a rapid online survey. BMC Pregnancy Childbirth. 2023 May 1;23(1):304.
15. Herwansyah H, Czabanowska K, Schröder-Bäck P, Kalaitzi S. Barriers and facilitators to the provision of maternal health services at community health centers during the COVID-19 pandemic: Experiences of midwives in Indonesia. Midwifery. 2023 Aug;123:103713.
16. Hazfiarini A, Akter S, Homer CSE, Zahroh RI, Bohren MA. 'We are going into battle without appropriate armour': A qualitative study of Indonesian midwives' experiences in providing maternity care during the COVID-19 pandemic. Women Birth. 2022 Sep;35(5):466–74.
17. Asmaningrum N, Ferguson C, Ridla AZ, Kurniawati D. Indonesian hospital's preparedness for handling COVID-19 in the early onset of an outbreak: A qualitative study of nurse managers. Australas Emerg Care. 2022 Sep;25(3):253–8.
18. Chemali S, Mari-Sáez A, El Bcheraoui C, Weishaar H. Health care workers' experiences during the COVID-19 pandemic: a scoping review. Hum Resour Health. 2022 Dec;20(1):27.

19. Dhamanti I, Rachman T, Nurhaida I, Muhamad R. Challenges in Implementing the WHO Hospital Readiness Checklist for the COVID-19 Pandemic in Indonesian Hospitals: A Qualitative Study. J Multidiscip Healthc. 2022 Jun;Volume 15:1395–402.
20. World Health Organization. Generic protocol: a prospective cohort study investigating maternal, pregnancy and neonatal outcomes for women and neonates infected with SARS-CoV-2, 2 December 2020, version 2.6 [Internet]. World Health Organization; 2020. Available from: https://apps.who.int/iris/handle/10665/337325
21. Ministry of Health. Indonesia Health Profile 2021. Jakarta: Ministry of Health; 2022.
22. Mndala L, Monk EJM, Phiri D, Riches J, Makuluni R, Gadama L, et al. Comparison of maternal and neonatal outcomes of COVID-19 before and after SARS-CoV-2 omicron emergence in maternity facilities in Malawi (MATSurvey): data from a national maternal surveillance platform. Lancet Glob Health. 2022 Nov;10(11):e1623–31.
23. Papageorghiou AT, Deruelle P, Gunier RB, Rauch S, García-May PK, Mhatre M, et al. Preeclampsia and COVID-19: results from the INTERCOVID prospective longitudinal study. Am J Obstet Gynecol. 2021 Sep;225(3):289.e1-289.e17.
24. Kementrian Kesehatan RI. Pedoman nasional asuhan pasca keguguran yang komprehensif. 2020.
25. Pathirana J, Muñoz FM, Abbing-Karahagopian V, Bhat N, Harris T, Kapoor A, et al. Neonatal death: Case definition & guidelines for data collection, analysis, and presentation of immunization safety data. Vaccine. 2016 Dec;34(49):6027–37.
26. Stillbirth [Internet]. [cited 2023 Nov 3]. Available from: https://www.who.int/health-topics/stillbirth
27. Marshall JC, Murthy S, Diaz J, Adhikari NK, Angus DC, Arabi YM, et al. A minimal common outcome measure set for COVID-19 clinical research. Lancet Infect Dis. 2020 Aug;20(8):e192–7.
28. Wiratama BS, Chen PL, Ma ST, Chen YH, Saleh W, Lin HA, et al. Evaluating the combined effect of alcohol-involved and un-helmeted riding on motorcyclist fatalities in Taiwan. Accid Anal Prev. 2020 Aug;143:105594.
29. Mahendradhata Y, Andayani NLPE, Hasri ET, Arifi MD, Siahaan RGM, Solikha DA, et al. The Capacity of the Indonesian Healthcare System to Respond to COVID-19. Front Public

Health. 2021 Jul 7;9:649819.

30. RS Online [Internet]. [cited 2023 Nov 29]. Available from: https://sirs.kemkes.go.id/fo/home/dashboard_rs?id=0
31. Finaka AW, Nurhanisah Y, Naufal A. Indonesiabaik.id. 2021 [cited 2023 Nov 29]. Relawan Bantu Jadi Garda Terdepan Tangani Covid-19 | Indonesia Baik. Available from: https://indonesiabaik.id/infografis/relawan-bantu-jadi-garda-terdepan-tangani-covid-19
32. Quinn JA, Munoz FM, Gonik B, Frau L, Cutland C, Mallett-Moore T, Kissou A, Wittke F, Das M, Nunes T, Pye S, Watson W, Ramos AA, Cordero JF, Huang WT, Kochhar S, Buttery J; Brighton Collaboration Preterm Birth Working Group. Preterm birth: Case definition & guidelines for data collection, analysis, and presentation of immunisation safety data. Vaccine. 2016 Dec 1;34(49):6047-6056. doi: 10.1016/j.vaccine.2016.03.045. Epub 2016 Oct 13. PMID: 27743648; PMCID: PMC5139808.
33. Cutland CL, Lackritz EM, Mallett-Moore T, Bardají A, Chandrasekaran R, Lahariya C, Nisar MI, Tapia MD, Pathirana J, Kochhar S, Muñoz FM; Brighton Collaboration Low Birth Weight Working Group. Low birth weight: Case definition & guidelines for data collection, analysis, and presentation of maternal immunization safety data. Vaccine. 2017 Dec 4;35(48 Pt A):6492-6500. doi: 10.1016/j.vaccine.2017.01.049. PMID: 29150054; PMCID: PMC5710991.
34. Montgomery KS. Apgar Scores: Examining the Long-term Significance. J Perinat Educ. 2000 Summer;9(3):5-9. doi: 10.1624/105812400X87716. PMID: 17273212; PMCID: PMC1595023.

Annexure

Table 32. Data elements and definition

Data Element	Definition
Demographic information	
Province	35. East Java 36. Central Java 37. West Java 38. Daerah Istimewa Yogyakarta
Name of hospital	39. RSUD Dr. Soetomo, East Java 40. RS Universitas Airlangga, East Java 41. RSUP Dr. Kariadi Semarang, Central Java 42. RSUD Tugurejo Semarang (RSUD Dr. Adhyatma, MPH), Central Java 43. RSUP Dr. Hasan Sadikin, West Java 44. RSUD Al Ihsan Provinsi Jawa Barat, West Java 45. RSUP Dr. Sardjito, Yogyakarta 46. UGM Academic Hospital (RS Akademik UGM), Yogyakarta
Type of hospital	47. Type A 48. Type B
Mother's age	In years
Mother's educational level	49. Not attending school 50. Elementary School 51. Junior High School 52. Senior High School 53. College/University or above 54. Not known
Mother's insurance	55. General patient 56. National Health Insurance (JKN or BPJS), non-PBI 57. JKN PBI 58. Private insurance
Mother's occupation	59. Unemployed 60. Employed 61. Not known
	If yes, specify
	62. Student 63. Housewife 64. Army/Police 65. Public servant

Data Element	Definition
	66. State enterprise 67. Own company 68. Self-employed 69. Health worker 70. Farmer 71. Fisherman 72. Day laborer
Mother's area of residence	Province, City/district, Subdistrict
Maternal clinical characteristics	
Admission date	DD/MM/YYYY
Admission time	HH:MM (in WIB)
Referral	73. No 74. Yes
Reason for referral	Reason for referral (multiple answers allowed) 75. COVID-19 positive 76. Other medical complication (non-COVID-19) 77. Obstetric complication
Vital sign at admission	Including: • Body temperature (^{o}C) • Respiratory rate (breaths/minute) • Systolic blood pressure (mmHg) • Diastolic blood pressure (mmHg) • Pulse (beats/minute) • Pulse oximetry (%) • Fetal heart rate (beats/minute)
Gestational age at admission	In weeks
GPA status	In number for each G, P, A
Number of fetuses	In number
Pre-pregnancy weight	in kg, if not available, weight in first trimester will be recorded
Weight at admission	in kg
Height	in cm
Vaccination status (last dose)	78. Booster (third dose) 79. Second dose 80. First dose 81. Not vaccinated

Data Element	Definition
	82. Not known
Comorbidities related to COVID-19	List of comorbidities: • Gestational diabetes mellitus • chronic hypertension • hypertension in pregnancy • pre-eclampsia • obesity (based on pre-pregnancy BMI calculation) • asthma • tuberculosis (under treatment) • cardiovascular disease • renal disease • autoimmune disease (i.e., ITP, SLE) • cancer • anemia • others (mention) For each comorbidity, the answers will have options: 83. No 84. Yes 85. Not known
History of COVID-19 infection (prior to admission)	86. Never 87. Yes, at least once 88. Not known
SARS-CoV-19 test date (at admission)	DD/MM/YYYY
SARS-CoV-19 test type (at admission)	89. PCR test 90. RDT-Ag test
COVID-19 signs and symptoms (at admission)	List of signs and symptoms: • Fever • cough • anosmia • myalgia • diarrhea • shortness of breath • fatigue • abdominal pain • chest pain • loss of appetite • delirium • seizure For each sign/symptom will have options:

Data Element	Definition
	91. No 92. Yes 93. Not known
Laboratory results and date of test	94. The highest NLR, and date of test 95. CRP, and date of test 96. D-dimer, and date of test 97. Procalcitonin, and date of test 98. IL-6, and date of test
Radiography results and date of test	99. Not pneumonia, date 100. Pneumonia, date 101. Pneumonia bilateral, date
Maternal COVID-19 treatment	
Date of discharge	DD/MM/YYYY
ICU care	102. No 103. Yes
ICU admission date	DD/MM/YYYY
ICU admission time	HH:MM (in WIB)
ICU discharge date	DD/MM/YYYY
Critical care level	104. Level 2 105. Level 3
Oxygen supplementation	106. No 107. Mask or nasal prong 108. NIV or high flow 109. Mechanical ventilator and endotracheal intubation
Antiviral therapy	List of antiviral therapy: • Ribavirin • Lopinavir/Ritonavir • Neuraminidase inhibitor • Interferon alpha • Interferon beta • Remdesivir • Favipiravir For each therapy will have options: 110. No 111. Yes 112. Not known

Data Element	Definition
Oral/orogastric fluids	113. No 114. Yes 115. Not known
Intravenous fluids	116. No 117. Yes 118. Not known
Corticosteroids	119. No 120. Yes 121. Not known If yes, • Route: oral, intravenous, or inhaled • Specify agent and maximum dose
Antibiotic	122. No 123. Yes, specify 124. Not known
Antifungal agen	125. No 126. Yes, specify 127. Not known
Antimalarial agent	128. No 129. Yes, specify 130. Not known
Experiment agent	131. No 132. Yes, specify 133. Not known
Immunotherapy	List of immunotherapy: • Convalescent plasma • Monoclonal antibodies • Interferons For each immunotherapy will have options: 134. No 135. Yes, duration of treatment 136. Not known
Non-steroidal anti-inflammatory (NSAID)	137. No 138. Yes 139. Not known
Angiotensin II receptor blockers (ARBs)	140. No 141. Yes 142. Not known
Systemic anticoagulants	143. No

Data Element	Definition
	144. Yes 145. Not known
Inotrope or vasopressor	146. No 147. Yes 148. Not known
Actemra tocilizumab	149. No 150. Yes 151. Not known
Other medications received	152. No 153. Yes, specify 154. Not known
Iatrogenic delivery or termination due to maternal compromised from COVID-19	155. No 156. Yes
Blood transfusion	157. No 158. Yes
Exposure status	
COVID-19 test positive	**1. Yes** **COVID-19 test positive**: a positive test result for SARS-CoV-2 at any point during hospitalization based on results of laboratory confirmed reverse transcription polymerase chain reaction (RT-PCR) test or rapid diagnostic test antigen (RDT-Ag) test. **2. No** **COVID-19 test negative:** a negative test result for SARS-CoV-2 during hospitalization.
Maternal Outcomes	
Pregnancy completion	159. Delivery (including spontaneous delivery, induction, or and cesarean section) 160. Abortus
Date of pregnancy completion	DD/MM/YYYY
Delivery method	161. Spontaneous 162. Induction 163. Cesarean section, mention indication, e.g., COVID-19, CPD, Placenta previa, fetal malpresentation, fetal distress, and others
Premature membrane rupture	164. No 165. Yes

Data Element	Definition
Placental abruption	166. No 167. Yes
Hypertension	168. No 169. Yes
Pre-eclampsia	170. No 171. Yes
COVID-19 severity (18) Only for COVID-19 testing positive group	COVID-19 severity will be classified based on WHO progression clinical scale (Table 5): 172. Ambulatory mild disease 173. Hospitalized: moderate disease 174. Hospitalized: severe diseases (Dialysis, ECMO, vasopressor/inotropic) 175. Dead
Neonatal outcomes	
Gestational age at delivery	In weeks
Birth weight	In grams
Birth length	In cm
Birth head circumference	In cm
Sex	176. Female 177. Male 178. Not reported
Neonatal mortality	179. No 180. Yes
Still birth	181. No 182. Yes
Fetal distress	183. No 184. Yes
Preterm	185. No 186. Yes
Apgar score at 1 minute	in scores
Apgar score at 5 minutes	In scores
Neonatal infection	187. No 188. Yes
Neonate with COVID-19 swab or serology result based on the RT-PCR result) in the first 12 hours	189. Negative 190. Positive

Data Element	Definition
Neonate with COVID-19 swab or serology result based on the RT-PCR result) in the first 48 hours	191. Negative 192. Positive
Birth defect	193. No 194. Yes, Atresia Ani 195. Yes, Omphalocele 196. Yes, Gastroschisis 197. Yes, Labioschisis/Palatoschisis/Labiopalatochisis 198. Yes, Epispadias 199. Yes, Hypospadias 200. Yes, Meningocele/Encephalocele 201. Yes, Upper and Lower Limb Reduction Defects 202. Yes, Spina Bifida 203. Yes, Anencephaly 204. Yes, Congenital Cataract 205. Yes, Talipes/CTEV 206. Yes, Identical Twin 207. Yes, Hydrocephaly 208. Yes, Ambiguous Genitalia 209. Yes, Exstrophy Bladder/exstrophy Cloaca 210. Yes, Teratoma Sacrococcygeal 211. Yes, Congenital Syphilis 212. Yes, Critical Congenital Heart Disease 213. Yes, Microcephaly 214. Yes, not known
Neonatal ICU care admission	215. No 216. Yes
Neonatal ICU date of admission	DD/MM/YYYY
Neonatal ICU date of discharge	DD/MM/YYYY
Oxygen supplementation	217. No 218. Mask or nasal prong 219. NIV or high flow 220. Mechanical ventilator and intubation
Sepsis	221. No 222. Yes
Seizure	223. No 224. Yes
Anemia requiring transfusion	225. No 226. Yes
Hypoxic-ischemic encephalopathy	227. No 228. Yes
Date of discharge	DD/MM/YYYY