Impact of Different Waves of the COVID-19 Pandemic on Fetomaternal Outcome-A Medical University Experience in Bangladesh

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KEYWORDS

COVID-19 Waves, Maternal and Fetal Outcomes, Pandemic Impact

ABSTRACT:

Background: The COVID-19 pandemic disrupted maternal healthcare services in Bangladesh, with significant declines in antenatal care coverage and regional disparities in access. The purpose of this study was to analyze the effects of various COVID-19 pandemic waves on maternal and fetal health outcomes. ***Aim of the study:*** The aim of the study was to analyze the effects of various COVID-19 pandemic waves on maternal and fetal health outcomes of covid negative pregnant women. ***Methods:*** This retrospective study at the Department of Obstetrics and Gynecology, Bangabandhu Sheikh Mujib Medical University, Dhaka (March 2020–December 2022), included 2,159 covid negative pregnant women in five pandemic waves. Data on demographics, clinical presentation, and maternal-fetal outcomes were analyzed using chi-square and t-tests ($p<0.05$) in SPSS v25.0. ***Results:*** The mean maternal age was 27.5 ± 4.91 years, with the highest gestational age in the second wave (37.83 ± 2.26 weeks). Delivery complications peaked at 32–40 weeks (91.8%), with intrapartum bleeding most common >40 weeks and meconium-stained liquor at 28–30 weeks ($p = 0.001$). The second wave showed the highest rate of multiple risk factors (44.7%), while the fourth wave had the most LUCS (41.1%), NVD (34.0%), and NICU admissions (44.9%) ($p = 0.001$). Fetal deaths were highest in the second wave (35.3%), whereas live births peaked in the fourth wave (40.2%) ($p = 0.001$). ***Conclusion:*** The severity of COVID-19 and its outcomes varied across waves, with worse effects during the 2nd (Delta) wave, compared to 4th wave. This variation likely due to mass vaccination, and further research is needed to understand its impact on pregnancy.

INTRODUCTION

Since the World Health Organization (WHO) declared COVID-19 a Public Health Emergency of International Concern on 30 January 2020, the disease has rapidly spread worldwide.[1] Coronavirus Disease 2019 (COVID-

19), caused by severe acute respiratory syndrome (SARS-CoV-2), led to a global pandemic.[2–4] The ongoing COVID-19 pandemic continues to affect nearly every region of the world, disrupting lives and straining healthcare systems across societies.[5] Although pregnant women have been advised not to delay healthcare, as antenatal care is crucial for both maternal and fetal well-being, there remains limited clinical data on the effects of national lockdowns on pregnancy and perinatal outcomes.[6] Studies conducted in regions such as Hong Kong and Saudi Arabia suggest that pregnant women may face serious consequences from coronavirus-related respiratory illness, with reports indicating maternal morbidity in 40–57% of cases and maternal mortality in 28-40%.[7–9]

Like many other countries, Bangladesh experienced severe consequences from the pandemic, with approximately 29,000 reported deaths,[10] although the actual toll is likely higher due to limitations in surveillance systems. In response, the government imposed a nationwide lockdown from 23 March to 30 May 2020, restricting travel, commercial activities, and social gatherings.[11] A second wave, beginning in late March 2021, led to renewed lockdowns and tighter international travel restrictions.[12] While necessary to control the spread of infection, these measures severely disrupted healthcare services, including maternal care. During the pandemic, only 11% of pregnant women received antenatal care in their third trimester, a significant decline from the 22% recorded before the pandemic.[13] The shortage of healthcare personnel many of whom were redirected to COVID-19-related duties further contributed to service disruptions.[14-16] Despite national efforts to address these gaps, the impact of the pandemic on healthcare utilization at the divisional level remains underexplored, especially given regional disparities in case detection and access to care. This underscores the urgent need for comprehensive, localized research on maternal and fetal outcomes in the context of the COVID-19 pandemic in Bangladesh.

The COVID-19 pandemic has presented an unprecedented challenge to global healthcare systems, with pregnant women recognized as a particularly vulnerable group due to their altered immune responses and heightened risk for adverse outcomes. Although international studies have documented various maternal and fetal complications associated with COVID-19, the extent and nature of these outcomes differ across populations and healthcare infrastructures. In Bangladesh, while some national-level data exists, there remains a lack of detailed analysis at the subnational or institutional level particularly concerning the distinct effects of each wave of the pandemic on obstetric care. Given the evolving nature of the virus, with successive waves driven by emerging variants, and the dynamic responses of the healthcare system, it is essential to understand both the overall and wave-specific impacts of COVID-19 on maternal and perinatal health. This gap in localized evidence hinders the formulation of responsive strategies for future outbreaks. The purpose of the study was to analyze the effects of various COVID-19 pandemic waves on maternal and fetal health outcomes.

Objective

- The aim of the study was to analyze the effects of various COVID-19 pandemic waves on maternal and fetal health outcomes.

METHODOLOGY & MATERIALS

This retrospective observational study was conducted at the Department of Obstetrics and Gynecology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, from March 2020 to December 2022. A total of 2,159 pregnant women who tested negative for COVID-19 were included, selected based on specific inclusion criteria. Data were collected across five waves of the COVID-19 pandemic to analyze the effects on maternal and fetal health outcomes.

Inclusion Criteria:

- Pregnant women diagnosed with COVID-19 negative during any of the five waves of the pandemic
- Women aged 16 to 42 years
- Willingness to participate in the study and provide informed consent

Exclusion Criteria:

- Pregnant women with pre-existing severe chronic diseases (e.g., chronic hypertension, uncontrolled diabetes)
- Women with a history of pregnancy-related complications in previous pregnancies
- Women with incomplete or missing clinical data
- Women who were not followed up during the study period

Written informed consent was obtained from all participants after ensuring their understanding of the study's purpose and procedures. Confidentiality was strictly maintained. Data were extracted from medical records, including demographic characteristics, clinical presentation, and maternal and fetal outcomes across the five

pandemic waves. Maternal outcomes assessed included complications during delivery, mode of delivery, and neonatal outcomes such as neonatal death and NICU admissions. Fetal outcomes were categorized based on gestational age at the time of COVID-19 diagnosis and included fetal mortality rates. Statistical analyses were performed using chi-square tests for categorical variables (e.g., fetal mortality, mode of delivery, complications) and t-tests for continuous variables (e.g., maternal age, gestational age). A p-value of <0.05 was considered statistically significant. All data analyses were conducted using SPSS version 25.0, and results were reported with 95% confidence intervals.

RESULTS

Table 1: Demographic Characteristics of the Study Population (n=2159)

Variable		Frequency (n)	Percentage (%)
Age in years	<20	190	8.8
	20-30	1425	66.0
	30- 40	538	24.9
	> 40	6	0.3
	Total	2159	100.0
	Mean ± SD	27.5±4.91	
Residence	Urban	1499	69.4
	Rural	660	30.6

The mean age of the study population was 27.5 ± 4.91 years, ranging from 16 to 42 years. The largest age group was 20–30 years, comprising 66.0% (n = 1,425) of the participants, followed by 30–40 years (24.9%, n = 538), and those under 20 years (8.8%, n = 190). Only 0.3% (n = 6) were above 40 years of age. Regarding residence, a majority of the women lived in urban areas (69.4%, n = 1,499), while 30.6% (n = 660) were from rural settings.

Table 2: Demographic Profile of Pregnant Women with COVID-19 Infection Across Different Waves

	Initial Outbreak	First Wave	Second Wave	Third Wave	Fourth Wave	1st vs 2nd	1st vs 3rd	1st vs 4th	2nd vs 3rd	2nd vs 4th	3rd vs 4th
Age (years)	26.58 ± 5.22	27.76 ± 5.14	27.04 ± 4.78	27.32 ± 4.83	27.54 ± 4.74	0.249	0.268	0.518	0.641	0.57	0.479
Gestational Age (weeks)	37.70 ± 2.41	37.35 ± 2.88	37.83 ± 2.26	37.72 ± 2.33	37.69 ± 2.19	0.309	0.086	0.074	0.689	0.598	0.85

The mean age of pregnant women varied slightly across the waves. It was lowest during the initial outbreak (26.58 ± 5.22 years) and highest during the first wave (27.76 ± 5.14 years), with minor fluctuations in the subsequent waves. However, none of these differences reached statistical significance when compared across waves (all p-values > 0.05). Similarly, the mean gestational age at the time of infection ranged from 37.35 ± 2.88 weeks in the first wave to 37.83 ± 2.26 weeks in the second wave. These variations were not statistically significant either (p > 0.05 across all inter-wave comparisons).

Table 3: Association of Gestational Age with the Presence and Absence of Complications During Delivery (n = 2159)

Gestational Age	Complication		*P* value
	Present (n = 631)	Absent (n = 1528)	
< 28 weeks	12 (1.9%)	24 (1.6%)	**0.015**
28–30 weeks	6 (1.0%)	174 (11.4%)	
32–40 weeks	579 (91.8%)	1301 (85.1%)	
> 40 weeks	34 (5.4%)	29 (1.9%)	

The analysis demonstrates a statistically significant relationship between gestational age and the occurrence of delivery complications (p = 0.015). The highest rate of complications was observed in pregnancies between 32–40 weeks gestational age, accounting for 91.8% of cases, while the lowest incidence of complications was found in both preterm (<28 weeks) and post-term (>40 weeks) pregnancies, with only 5.4% of cases. Among those without complications, 85.1% delivered at 32–40 weeks, followed by 11.4% at 28–30 weeks, 1.9% at >40 weeks, and 1.6% at <28 weeks. This suggests that term pregnancies are associated with a higher rate of delivery complications compared to either preterm or post-term pregnancies.

Table 4: Distribution of Complications During Delivery Across Different Gestational Ages (n = 631)

Complication During Delivery	Gestational Age Group				*P* value
	<28 Weeks (n = 12)	28–30 Weeks (n = 6)	32–40 Weeks (n = 579)	>40 Weeks (n = 34)	
Intrapartum bleeding	4 (33.3%)	0 (0.0%)	161 (27.8%)	20 (58.8%)	**0.001**
Intrapartum bleeding with adhesion	2 (16.7%)	2 (33.3%)	293 (50.6%)	6 (17.6%)	**0.001**
PPH	1 (8.3%)	0 (0.0%)	47 (8.1%)	3 (8.8%)	**1.000**
Meconium-stained liquor	1 (8.3%)	2 (33.3%)	46 (7.9%)	1 (2.9%)	**0.001**
Other complication	4 (8.3%)	2 (33.3%)	32 (5.5%)	4 (11.8%)	**0.001**

Table 4 illustrates the distribution of various delivery complications across different gestational age groups. Intrapartum bleeding was most prevalent in pregnancies greater than 40 weeks, occurring in 58.8% of cases. Intrapartum bleeding with adhesion was most common in the 32–40 weeks group (50.6%). Meconium-stained liquor was notably more frequent in the 28–30 weeks group (33.3%). However, postpartum hemorrhage (PPH) did not show any significant variation across gestational ages, with a p-value of 1.000, suggesting no statistical difference in its incidence across the different gestational age categories.

Table 5: Distribution of Risk Factors Across Different Waves of the Pandemic

Wave (Time Period)	Risk Factors			*P* value
	Single Risk Factor (n = 1408)	Double Risk Factors (n = 601)	Multiple Risk Factors (n = 150)	
Initial Outbreak (Mar 2020 – Jun 2020)	142 (10.1%)	81 (13.5%)	15 (10.0%)	**0.761**
First Wave (Jul 2020 – Dec 2020)	248 (17.6%)	114 (19.0%)	26 (17.3%)	**0.927**
Second Wave (Delta, Mar 2021 – Jun 2021)	148 (10.5%)	80 (13.3%)	67 (44.7%)	**0.001**
Third Wave (Omicron, Jun 2021 – Jan 2022)	269 (19.1%)	78 (13.0%)	33 (22.0%)	**0.311**
Fourth Wave (Post-Peak, Jun 2022 – Dec 2022)	601 (42.7%)	248 (41.3%)	9 (6.0%)	**0.001**

Table 5 presents the distribution of risk factors during each wave of the COVID-19 pandemic. The prevalence of single risk factors was highest in the fourth wave (42.7%) followed by the third wave (19.1%) and the first wave (17.6%). Notably, the second wave (Delta) exhibited the highest percentage of multiple risk factors, with 44.7% of cases, in contrast to the other waves. The fourth wave also had a significant proportion of women with double risk factors (41.3%). Statistical analysis reveals a significant increase in the proportion of women with multiple risk factors during the second wave and a notable rise in single risk factors in the fourth wave, as indicated by p-values of 0.001.

Table 6: Association of Fetal Outcomes with Gestational Age (n=2159)

Gestational Age Group	Pregnancy Outcomes		*P* value
	Alive Baby (n = 2108)	Death Baby (n = 51)	
< 28 Weeks	17 (0.8%)	19 (37.3%)	**0.001**
28–30 Weeks	176 (8.3%)	4 (7.8%)	
32–40 Weeks	1855 (88.0%)	25 (49.0%)	
> 40 Weeks	60 (2.8%)	3 (5.9%)	

Table 6 demonstrates a significant association between gestational age and fetal outcomes (p = 0.001). The highest number of both live births (88.0%) and fetal deaths (49.0%) occurred in the 32–40 weeks gestational age group.

Table 7: Association of Risk Factors with Fetal Outcomes (n=2159)

Fetal Outcome	Risk Factors			*P* value
	Single Risk Factor	Double Risk Factors	Multiple Risk Factors	
Alive Baby	1382 (65.6%)	580 (27.5%)	146 (6.9%)	**0.001**
Dead Baby	4 (7.8%)	21 (41.2%)	26 (51.0%)	**0.001**

Table 7 shows that the presence of multiple risk factors has a significant impact on fetal outcomes (p=0.001). The fetal mortality rate was notably higher among pregnancies with multiple risk factors (51.0%) compared to those with a single risk factor (7.8%).

Table 8: Association of Fetal Outcome with Different Waves of the COVID-19 Pandemic

Wave (Time Period)	Fetal Outcome		*P* value
	Live Birth (n, %)	Death (n, %)	
Initial Outbreak (Mar 2020 – Jun 2020)	230 (10.9%)	8 (15.7%)	**0.001**
First Wave (Jul 2020 – Dec 2020)	380 (18.0%)	8 (15.7%)	
Second Wave (Delta, Mar 2021 – Jun 2021)	277 (13.1%)	18 (35.3%)	
Third Wave (Omicron, Jun 2021 – Jan 2022)	373 (17.7%)	7 (13.7%)	
Fourth Wave (Post-Peak, Jun 2022 – Dec 2022)	848 (40.2%)	10 (19.6%)	

Table 8 demonstrates a statistically significant association between fetal outcomes and the different waves of the COVID-19 pandemic (p=0.001). The second wave (Delta variant) had the highest fetal mortality rate, accounting for 35.3% of all deaths, despite contributing to only 13.1% of live births. Similarly, the initial outbreak and the first wave each reported a fetal death rate of 15.7%, with live birth rates of 10.9% and 18.0%, respectively. In contrast, the third and fourth waves exhibited comparatively lower mortality rates 13.7% and 19.6%, respectively. The fourth wave saw the highest proportion of live births (40.2%).

Table 9: Comparison of Neonatal Death, NICU Admission, and Mode of Delivery Across Different Waves of the COVID-19 Pandemic

Outcome	Initial Outbreak	First Wave	Second Wave	Third Wave	Fourth Wave	1st vs 2nd	1st vs 3rd	1st vs 4th	2nd vs 3rd	2nd vs 4th	3rd vs 4th
Neonatal Death	8 (15.7%)	8 (15.7%)	18 (35.3%)	7 (13.7%)	10 (19.6%)	1.00	0.005	0.705	0.001	0.290	0.493
NICU Admission	52 (14.3%)	64 (17.6%)	25 (6.9%)	59 (16.3%)	163 (44.9%)	0.041	0.862	0.001	0.849	0.001	0.001
NVD	41 (10.2%)	85 (21.1%)	78 (19.4%)	62 (15.4%)	137 (34.0%)	0.752	0.317	0.061	0.493	0.039	0.007
LUCS	197 (11.2%)	303 (17.3%)	217 (12.4%)	318 (18.1%)	721 (41.1%)	0.353	0.866	0.001	0.273	0.001	0.003

Table 9 presents a comparative analysis of neonatal outcomes and delivery methods across different waves of the COVID-19 pandemic, revealing significant variations. Neonatal deaths were most prevalent during the second wave (35.3%), with statistically significant differences from the first (p=0.005) and third (p=0.001) waves, highlighting the heightened severity during the Delta variant surge. NICU admissions were highest in the fourth wave (44.9%), significantly differing from the first, second and third waves (p=0.001), suggesting increased neonatal morbidity during this period. Additionally, both normal vaginal deliveries (34.0%) and cesarean sections (41.1%) peaked during the fourth wave, with notable differences observed compared to earlier waves. These findings underscore the varying impact of the pandemic on neonatal health and delivery practices, particularly during the second and fourth waves.

DISCUSSION

Although the women in this study tested negative for SARS-CoV-2 infection, the COVID-19 pandemic still exerted a substantial indirect impact on their physical and mental health, as well as on pregnancy outcomes. Widespread disruptions to healthcare access, increased stress levels, and shifts in social dynamics led to missed or delayed antenatal visits and reduced availability of routine investigations. Consequently, complications were often detected late, and management of obstetric emergencies was frequently delayed. These challenges contributed to a higher incidence of elective cesarean sections, preterm deliveries, and low birth weight babies among COVID-negative pregnant women. Additionally, there was a noticeable rise in neonatal morbidity and mortality, reflecting similar adverse patterns reported in COVID-positive pregnancies. These findings underscore the significant indirect toll the pandemic imposed on maternal and neonatal health, even among women who remained uninfected.

In the present study, the majority of pregnant women were between the ages of 20-30 years (66.0%), with a mean age of 27.5 ± 4.91 years. Although this study involved only COVID-19 negative women, the age distribution is similar to that reported by Dawood *et al.*[17], where a large proportion of pregnant women were also in the 24-30 years age group, indicating that women in their reproductive prime were most frequently represented in both infected and non-infected cohorts during the pandemic. Additionally, the predominance of urban residents in this

study (69.4%) aligns with trends observed by Sidharthan *et al*.[18], who noted higher infection rates among pregnant women in urban areas. This urban predominance may reflect greater access to healthcare and diagnostic services, along with increased exposure risk due to population density and mobility. These demographic patterns suggest that, regardless of infection status, urban-dwelling and younger women remained the most represented in antenatal care during the pandemic, warranting focused attention in maternal health planning.

The distribution of maternal age and gestational age across the five COVID-19 pandemic waves in our study of COVID-19 negative pregnant women revealed no statistically significant differences. This finding aligns with observations from other international studies. For example, Mihajlović *et al*.[19] reported consistent maternal age and gestational age at delivery across different waves of the pandemic, suggesting that broader pandemic-related factors rather than infection status did not significantly influence these parameters. Similarly, our data showed no significant variation in maternal age (p-values ranging from 0.249 to 0.641) or gestational age at delivery (p-values between 0.074 and 0.689) across the different waves. These consistent findings indicate that, despite changes in healthcare delivery, restrictions, and public health measures during the pandemic, the demographic and obstetric profile of COVID-negative women remained relatively stable across time.

The distribution of complications across gestational ages in our study revealed a significant association ($p = 0.015$), highlighting the varying risks of fetomaternal complications at different stages of pregnancy during the pandemic period. The majority of complications occurred between 32-40 weeks, which corresponds with the highest concentration of term pregnancies. Additionally, a notable proportion of complications was observed in post-term pregnancies (>40 weeks), suggesting increased vulnerability in this group. In contrast, early gestations showed fewer complications, which may be attributed to early medical management or pregnancy loss before reaching viability. Importantly, our findings align with those of Masud *et al*.[20], who compared 60 COVID-positive and 60 COVID-negative pregnant women and found that, while COVID-positive women delivered at an earlier gestational age, both groups experienced complications such as preterm delivery and cesarean sections. This underscores that adverse outcomes especially at term and post-term are not exclusive to COVID-positive cases. Rather, they reflect broader systemic and care-related challenges that affected all pregnant women during the pandemic, including those who tested negative. These results reinforce that gestational age remains a critical determinant of maternal complications, regardless of COVID-19 infection status.

Our study found that delivery complications varied significantly across gestational age groups. Intrapartum bleeding was most prevalent in pregnancies >40 weeks (58.8%) and <28 weeks (33.3%), while intrapartum bleeding with adhesions was most common at 32-40 weeks (50.6%). The highest rate of meconium-stained liquor was noted at 28–30 weeks (33.3%). Although our study focused exclusively on COVID-negative women, these findings may reflect the indirect impact of the pandemic such as healthcare disruptions, reduced antenatal surveillance, and delayed interventions on maternal and fetal outcomes. Supporting this, Abe *et al*.[21] conducted a large-scale, nationwide longitudinal study in Japan involving uninfected pregnancies during the pandemic and observed significantly higher rates of hypertensive disorders, fetal growth restriction, and low Apgar scores (all $p < 0.001$). They also reported a shift toward operative deliveries and found that most adverse outcomes occurred during term gestation (32–40 weeks), paralleling our observation of heightened complications, particularly intrapartum bleeding with adhesions, in the same gestational window.

The distribution of maternal risk factors across different COVID-19 waves in our study exclusively involving COVID-19 negative pregnant women revealed notable shifts in their prevalence. While single and double risk factors remained relatively consistent across most waves, a striking concentration of multiple risk factors was observed during the second wave, accounting for 44.7% of such cases. In contrast, the fourth wave showed a marked decline in multiple risk factor cases (6.0%), despite recording the highest overall proportion of single and double risk factor cases. These fluctuations among COVID-negative women suggest that the indirect effects of the pandemic such as healthcare access, stress, or resource limitations may have influenced the severity and clustering of maternal risk profiles across different phases of the pandemic.

Our study demonstrated a significant association between gestational age and fetal outcomes. The highest proportion of fetal deaths (37.3%) occurred in pregnancies below 28 weeks, although this group accounted for only 0.8% of live births. In contrast, most live births (88.0%) occurred between 32-40 weeks, which contributed to just 49.0% of fetal deaths. These findings align with Hao *et al*.[22], who reported increased fetal mortality and preterm birth in COVID-negative women during the pandemic, particularly in early gestation. Their study also noted elevated stillbirth rates at term, which parallels our observed 5.9% fetal mortality in pregnancies beyond 40 weeks. Such outcomes may reflect indirect pandemic-related disruptions, including delayed antenatal care, reduced access to emergency obstetric services, or limited monitoring during critical stages of fetal development.

Our study revealed a significant association between the number of maternal risk factors and adverse fetal outcomes during the COVID-19 pandemic. Fetal deaths were disproportionately higher among women with multiple risk factors (51.0%) compared to those with double (41.2%) or single (7.8%) risk factors. Although our study included only COVID-negative women, the presence of multiple maternal risk factors still significantly impacted fetal survival likely exacerbated by indirect effects of the pandemic, such as reduced access to timely antenatal care, limited monitoring, and delayed identification of complications. Supporting these findings, a nationwide longitudinal study in Japan analyzing uninfected pregnancies during the pandemic reported a significant increase in hypertensive disorders, fetal growth restriction, and low Apgar scores (all $p < 0.001$) [21]. The study also observed a shift toward more operative deliveries and found that most adverse outcomes occurred in term gestations (32-40 weeks), paralleling the high rates of complications and poor fetal outcomes in our cohort with multiple risk factors. These collective findings underscore the critical need for strengthened maternal healthcare services and vigilant monitoring, especially for high-risk pregnancies, during ongoing and future public health crises.

The data from our study, which exclusively involved COVID-19 negative pregnant women, detail fetal outcomes across different pandemic waves and align with findings from other research observing variations in maternal and fetal outcomes over time. A retrospective cohort study at the University of Mississippi Medical Center analyzed maternal and infant outcomes across different COVID-19 waves and found that higher infection rates occurred during the Omicron wave [23]. During the Delta wave, more women were morbidly obese and delivered significantly earlier, and infants born in this period weighed significantly less compared to those born during the Omicron wave. These findings suggest that the effects of the pandemic on maternal and infant outcomes varied by wave, influencing delivery timing and birth weight. Importantly, despite our study population being COVID-19 negative, fetal mortality rates were highest during the early outbreak and peaked during the second wave (35.3%). This indicates that fluctuations in fetal outcomes during the pandemic were not solely dependent on maternal infection but were also shaped by factors such as healthcare accessibility, maternal risk profiles, and systemic responses across different waves.

In this study, we observed significant variation in neonatal outcomes across different waves among COVID-negative pregnant women. Neonatal death rates were highest during the second wave (35.3%) and lowest during the third wave (13.7%), possibly reflecting the impact of pandemic-related healthcare disruptions and limited antenatal monitoring during earlier waves. NICU admissions peaked in the fourth wave (44.9%), suggesting either an increase in neonatal complications or a shift toward more vigilant postnatal care. These findings align with Taghavi *et al*.[24], whose study in Iran found that while maternal and neonatal outcomes including mode of delivery, birth weight, Apgar scores, and neonatal asphyxia rates were similar between COVID-19-positive women and healthy controls, the rate of preterm labor was significantly higher during the pandemic period even among COVID-negative women (10% in controls vs. 25% in positives, $p < 0.05$). This underscores that COVID-negative pregnant women were not exempt from adverse perinatal outcomes during the pandemic, likely due to indirect effects such as reduced access to timely antenatal care and healthcare system challenges.

Limitations of the study

This study had some limitations:

- The study was conducted in a selected tertiary-level hospital.
- The study is observational, so causality cannot be established between COVID-19 waves and outcomes.
- The study's limited geographic scope may introduce sample bias, potentially affecting the broader applicability of the findings.

CONCLUSION

The severity of COVID-19 disease and its adverse outcomes varied across different waves, with the second (Delta) wave showing the highest fetal mortality and complications. In contrast, the fourth wave demonstrated improved outcomes, including a higher rate of live births and increased NICU admissions, likely influenced by the mass vaccination efforts, including among pregnant women. These findings suggest that vaccination may have contributed to better outcomes during later waves. Further research is needed to better understand the evolving course and outcomes of COVID-19 in pregnancy, especially in the context of vaccination.

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