

# Impact of Covid-19 Pandemic on Delivery Outcomes, Neonatal Morbidity and Mortality: Evidence from A Tertiary Level Maternity Hospital in Nepal

Kalpna Upadhyaya Subedi<sup>1</sup>, Prajwal Paudel<sup>1</sup>, Shailendra Bir Karmacharya<sup>1</sup>, Avinash K Sunny<sup>2</sup>, Sarita Shrestha<sup>1</sup>, Bijaya Laxmi Shrestha<sup>1</sup>, Neelam Gupta<sup>1</sup>, Needa Shrestha<sup>1</sup>, Binod Rana Magar<sup>1</sup>, Shraddha Shrestha<sup>1</sup>, Asia Tamrakar<sup>1</sup>, Kirtipal Subedi<sup>1</sup>, Sangeeta Kaushal Mishra<sup>3</sup>

<sup>1</sup>Paropakar Maternity and Women's Hospital, Thapathali, Kathmandu, Nepal

<sup>2</sup>Nepalese Society of Community Medicine, Sanepa Lalitpur, Nepal

<sup>3</sup>Ministry of Health and Population, Ram Shah Path, Kathmandu, Nepal

ISSN: 2976-1050 (Online)

ISSN : 2976-1042 (Print)

Received : 22 Feb, 2023

Accepted : 20 Apr, 2023

Online Access



DOI: 10.59881/jpeson15

Funding Source : None

Conflict of Interest : None

Corresponding Author

Dr Prajwal Paudel,  
Department of Neonatology,  
Paropakar Maternity and Women's  
Hospital, Kathmandu, Nepal;  
Email:  
prajwal.paudel999@gmail.com

Copyright: The Author(s) 2023  
This is an open access article under  
the CC BY-NC License.



## ABSTRACT

**Introduction:** Ripple effects of the ongoing COVID-19 pandemic on disruption of services in labor, delivery room and sick newborn units have been a major challenge in the current context. We aimed to provide a comprehensive overview on how this has impacted the maternal health services and neonatal outcome.

**Methods:** A 20-month retrospective, cross sectional comparative study before and during the COVID pandemic on Delivery outcomes, Neonatal Morbidity and Mortality was conducted at Paropakar Maternity and Women's Hospital (PMWH). Descriptive statistics using frequency and percentage were used to describe the maternal and newborn outcome. Pearson's Chi-squared test was used to determine the level of significance.

**Results:** A total of 2907 newborn babies admitted in the Sick Newborn Unit and 38,173 mothers who delivered during the study period were included. Among them, 19511 (51.1%) mothers delivered before pandemic, while 18662 (48.9%) mothers delivered during the pandemic with a fall in childbirth during initial six months by 6.3% thereafter rising steadily with an overall decrease by just 2.2%. Among the obstetric factors, there was rise in primiparity (49.37% vs. 54.29%;  $p < 0.001$ ), Gestational hypertension (1.78% vs 2.10%;  $p < 0.03$ ), Abnormal lie (0.27% vs. 0.5%;  $p < 0.002$ ), twins (1.59% vs. 1.86%,  $p < 0.03$ ) and instrumental delivery (0.6% vs. 1.00%;  $p < 0.001$ ). There was a rise in sick newborn admissions (6.9% vs. 9.3%,  $p < 0.0001$ ), preterm births (26.08% vs 36.38%,  $p < 0.0001$ ), Low birth weight (LBW) (23.5% vs. 29.7%;  $p < 0.0001$ ), perinatal asphyxia (28.5% vs. 38.3%;  $p < 0.0001$ ), neonatal sepsis (42.9% vs. 47.2%;  $p < 0.0001$ ), congenital anomalies (1.8% vs. 2.3%,  $p < 0.001$ ). Decline in neonatal jaundice (10.1% vs. 6.6%;  $p < 0.001$ ) was noted. Significant rise in neonatal mortality rate [NMR: (11/1000 vs. 21/1000 live births) and still birth rate (21/1000 deliveries vs. 28/1000 deliveries) was noted. Preterm related complications were major cause of mortality and were significantly associated (6.18% vs. 10%;  $p < 0.0002$ ) with increased NMR.

**Conclusion:** Indirect effects of pandemic were reflected in terms of reduced facility births especially when travel restrictions were in place. Random pandemic control policies in low resilience settings can do unintended harms for mothers and newborns in the form of increased burden of sick newborns, mortality, and stillbirths. While the core maternal and newborn functions should be executed without disruptions, containment measures should be taken with better understanding on its impact on mothers and newborns during the pandemic.

**Keywords:** Covid-19, indirect effect, Maternal, Neonatal, sick newborn

## Citation

Subedi KU, Paudel P, Karmacharya SB, Sunny AK, Shrestha S, et al. Impact of Covid-19 Pandemic on Delivery Outcomes, Neonatal Morbidity and Mortality: Evidence from A Tertiary Level Maternity Hospital in Nepal. J. Per. Soc. Nepal 2023;02(01):13-19. DOI: 10.59881/jpeson15

## INTRODUCTION

Covid-19 pandemic has threatened the significant gains in health since the turn of the millennium as, majority of the countries have reported disruptions in maternal and newborn care service utilization followed by adverse outcomes.<sup>1</sup> Globally, institutional deliveries, stillbirths and neonatal mortality rate in 2019, were 80 %, 13.9 per 1000 births and 17 per 1000 live births respectively which is much lower in comparison to last two decades [The Demographic and Health Surveys (DHS) Program, ICF, 2019].<sup>2</sup> Concentrated efforts to end preventable newborn deaths with the implementation of safe motherhood program, community and hospital based newborn program, free newborn care services have been a game changer for improved birth outcomes in majority of low- and middle-income countries including Nepal. However, the ongoing pandemic has strained the maternal and newborn health not just directly by Covid-19 infection, but also indirectly because of haphazard Covid-19 infection control policies which has resulted in reduced facility births, poor intrapartum care, and increased still births and neonatal deaths.<sup>3,4</sup> Heterogeneity and inconsistency in implementing protocols (on labor and delivery management, immediate newborn care practice, breast feeding practices etc.) based on minimal evidence in labor, delivery room and Sick Newborn Units have resulted in poor intrapartum care. Limited emotional support during delivery due to fear of infection prevention and disruptions in family centered care may have contributed to the increase in stillbirths and neonatal deaths.<sup>3,5</sup> Furthermore, surge in domestic violence, financial insecurity, fear, and mental health issues have negatively impacted the health of pregnant mothers and newborns.<sup>6</sup>

Although COVID infection in neonates is rare, studies have reported increment in the neonatal mortality rate during the pandemic which might be due to compromised quality of newborn care due to diversion of resources for the sake of COVID-focused care.<sup>5</sup> Flaring up of nosocomial infections leading to newborn sepsis, increased home births and poor intrapartum monitoring resulting in perinatal asphyxia and meconium aspiration syndrome and rise in preterm births and low birth weight babies because of COVID collateral effects have overburdened sick newborn units.<sup>3, 4, 7, 8</sup>

Ensuring quality inpatient care for small and sick newborns in NICU/SNCU (Neonatal intensive care unit/Special newborn care unit) is deemed as cornerstone to save lives of more than half of 2.6 million newborns who die annually (SURVIVE AND THRIVE UNICEF). However, the unparalleled effects in the sick newborn units stemming out from compromised quality care can result in backlog of the burden because it is predicted that even 1/10<sup>th</sup> reduction in maternal and newborn service utilization would account to more than 1.5 million surplus neonatal deaths.<sup>9</sup>

Containment measures for COVID 19 control like lockdown and curfews adopted by Nepal, restricted transportation and movement during the initial months of pandemic and had detrimental effects in maternal and newborn health with sharp reduction in institutional deliveries and heightened

stillbirth and neonatal mortality rate.<sup>4</sup>

It is predicted that the hard-won gains of the country in maternal and newborn health sector in the form of increased hospital deliveries by 50% and decrease in stillbirth rate and neonatal mortality rate by 58% and 68% respectively in the last 20 years could face reversals if this situation persists and appropriate strategies are not timely undertaken.<sup>10, 11</sup> Till now, nationwide evidence to shed light on the magnitude of disruptions in maternal and neonatal health and the associated consequences are still unavailable.<sup>4</sup> Addressing the changes in facility births, intrapartum care and monitoring, incidence of pattern and number of admitted sick newborns, along with perinatal outcome during the initial era of pandemic can help in the in-depth measurement of the magnitude of problems and set context-specific targets and goals for improved maternal and newborn outcomes. Given the context of myriad ways the pandemic has impacts on the health of pregnant mothers and their newborns, this study was done in the only public maternity hospital of the nation with the highest number of deliveries and the pioneer for sick newborn care could be conducive to synthesize the evidence on indirect consequences of the pandemic on childbirth and newborn health. In this study, we aimed to evaluate the effects of the ongoing pandemic on childbirth and sick newborns outcome making a comparison during and before the pandemic period.<sup>3,5</sup>

## METHODS

**Study design and setting:** A cross-sectional retrospective study was conducted at Paropakar Maternity and Women's hospital (PMWH), Kathmandu, Nepal which serves 22000 to 24000 deliveries per year. This hospital serves as a referral hospital for many neighboring districts like Bhaktapur, Lalitpur, Dhulikhel, Nuwakot, Dhading, Kavrepalanchowk, Sindhupalanchowk etc. Most of these places are connected to the study hospital by road which were almost unavailable during the national lock down except for ambulances and emergencies. Total data of 20 month's period was collected and analyzed. Pre pandemic data of the 10 months (March 15 to December 14, 2019) was compared with the data during the initial 10 months of the pandemic (March 15-December 14 2020).

**Participants:** All the newborns admitted in sick newborn unit during the study period were included in the study. Similarly, all the mothers who delivered either vaginally or by Caesarean sections in the hospital during the study period were included in the study.

**Data collection, management, and statistical analysis:**

All the information regarding the deliveries, mode of deliveries, relevant clinical status and condition of the mothers at the time of admission, and birth outcome as preterm, low birth weight and still births were extracted from maternity registers. Similarly, details on admitted sick newborns regarding causes of admission and mortality were recorded from sick newborn registers. Descriptive statistics using frequency and percentage was used to describe the maternal and newborn outcome. Comparison

of the deliveries and sick newborn admission during and before pandemic was done using a trend analysis using a linegraph.

**Variables**

**Neonatal Morbidity**

Sick babies were classified having any of the following morbidity (Annual Report. 2072):

Perinatal asphyxia: APGAR score of baby less than 7 at 1 or 5 minutes of birth, with clinical evidences or abnormal ABG (Arterial blood gas analysis)

Neonatal sepsis: clinical signs of severe bacterial infection, with a blood culture positive for a pathogenic organism.

Neonatal jaundice: babies with total Serum Bilirubin (TSB) increasing by > 5 mg/dl/day or 0.5 mg/dl/h, TSB > 15 mg/dl, conjugated serum bilirubin > 2 mg/dl.

Congenital malformation: a major physical defect seen in baby at birth which involves different part of body such as neuro-muscular, cardiac, lungs and intestinal tract.

Meconium aspiration syndrome (MAS): breathing problems that a newborn baby may have when there are no other causes, and the baby has passed meconium (stool) into the amniotic fluid during labor or delivery.

Low birth weight: Birth weight of the baby less than 2500 grams

Preterm: Babies born before 37 weeks of gestation.

Stillbirth: death of fetus after 28 weeks of pregnancy, but before or during birth, is classified as a stillbirth.

**Obstetric characteristics:**

Following obstetric variables were included in the study.<sup>12</sup>

Parity: Parity is defined as the number of times that a mother has given birth to a fetus with a gestational age of 22 weeks or more, regardless of whether the child was born alive or was stillborn.

Twins: two offspring produced by the same pregnancy.

Presentation/lie: Refers to the part of the fetus body that leads the way out through the birth canal

Gestational hypertension: blood pressure higher than 140/90 measured on two separate occasions, more than 6 hours apart, without the presence of protein in the urine and diagnosed after 20 weeks of gestation

Ethical approval-The study was ethically approved by the Institutional Review Board of Paropakar Maternity and Women’s Hospital (Ref.no. 61/1435). All data were fully anonymized and confidentiality was fully maintained.

**RESULTS**

A total of 38,173 mothers along with 2907 newborn babies who were admitted in NICU and SNCU during the study period were enrolled in the study, of whom

19511(51.1%) delivered before the COVID-19 pandemic and 18662(48.9%) delivered during the pandemic (Table 1.). Monthly comparison of hospital delivery showed a slight decrease in the number of deliveries in the initial six months during the pandemic (fig. 1); followed by an increase in the later four months during the pandemic. During the pandemic period, the deliveries decreased by 6.3%,in the initial six months and increased steadily thereafter till the study period leading to an overall decrease of 2.2% (Table 1).

More of primiparous women delivered during the pandemic (49.37% vs. 54.29%; p <0.001) than other parity. Some of the obstetric complications showed an increasing trend during pandemic. The proportion of mothers who had complications like gestational hypertension increased from 1.78%(n=344) to 2.1% (n=335) during the pandemic(p=0.03). Similarly, the proportion of mothers who had abnormal lie or presentation during delivery increased from 0.27%(n=54) to 0.5% (88) during the pandemic (p=0.002), similarly women presenting with twin pregnancy also increased from 1.59%(n=307) to 1.86% (n=306) during the pandemic (p=0.03). (34.6%vs. 34.1%and 65.32% vs. 65.8%; respectively). However, there was a significant rise in instrumental deliveries (0.60% vs. 1.0%) during the pandemic (p <0.0001) (Table 2).

**Table 1.** Delivery outcomes

	PRE- COVID (Mar 15-Dec 14,2019)	POST-COVID ( Mar 15-Dec 14,202020)	P-value
Total deliveries	19511(51.1%)	18662(48.9%)	
Stillbirth	412(2.1%)	467 (2.8%)	<0.001

**Table 2.** Obstetrics characteristics

Obstetric characteristics	PRE-COVID	POST-COVID	p-value
Primiparity	9523 (49.37%)	8926 (54.29%)	<0.0001
Gestational HTN	344 (1.78%)	335 (2.10%)	0.03
Abnormal lie	54 (0.27%)	88 (0.5%)	0.002
Twins	307 (1.59%)	306 (1.86%)	0.03
Vaginal delivery	12745 (65.32%)	12287 (65.8%)	0.30
Total CS	6766 (34.6%)	6375 (34.1%)	0.30
Instrumental delivery	119 (0.60%)	178 (1.00%)	<0.0001

**Table 3.** Newborn details

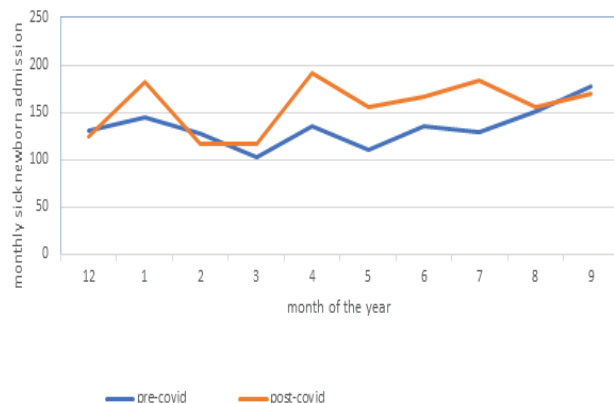
	PRE-COVID	POST-COVID	
Total admissions	1342 (6.9%)	1564 (9.3%)	<0.0001
Total preterm birth	1557 (7.9%)	1503 (8.9%)	0.001
Total LBW	2441 (12.65%)	2147 (13.05%)	0.26
preterm admitted	350 (26.08%)	569 (36.38%)	<0.0001
LBW admitted	315 (23.5%)	464 (29.7%)	<0.0001
Perinatal asphyxia	382 (28.5%)	599 (38.3%)	<0.0001
Neonatal sepsis	575 (42.9%)	738 (47.2%)	<0.0001
Jaundice	134 (10.1%)	103 (6.6%)	<0.0001
Congenital anomalies	24 (1.8%)	35 (2.3%)	0.001

**Table 4.** Mortality outcomes of babies admitted in NICU

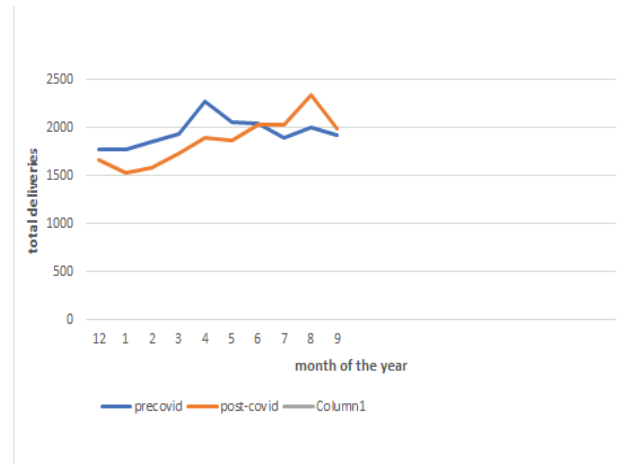
	PRE- COVID	Post-covid	
Neonatal mortality	207 (15.42%)	333 (21.29%)	<0.0001
Preterm mortality	83 (6.18%)	156 (10%)	0.0002
Asphyxia mortality	57 (4.24%)	89 (5.70%)	0.07
Neonatal sepsis	74 (5.51%)	110 (7.03%)	0.09

**Table 5.** Neonatal mortality rate and still birth rate

	PRE- COVID	POST-COVID
Neonatal mortality rate	11/1000 live births	21 per 1000 livebirths
Still birth rate	21/1000 total births	28/1000 deliveries



**Figure 1** Seasonal variation in sick newborn admissions during PRE COVID and POST COVID time



**Figure 2.** Seasonal variation in number of deliveries during PRE-COVID and POST-COVID period.

Across the study period, preterm deliveries increased from 7.9%(n=1557) before the pandemic to 8.9% (n= 1503) during the pandemic (p=0.001) (Table 3). Similarly, there was a rise in proportion of (birth weight less than 2.5 kilograms) during the pandemic (12.65% vs.13.05%, p<0.26). (Table 2)

Regarding the sick newborn admissions, this study and that the proportion of babies admitted in NICU/SNCU rose from 6.9%(n=1342) to 9.3%(n=1564) during the pandemic (p<0.0001).The pattern of sick newborn admissions showed a considerable variation with increase in admissions for preterm (26.08% vs 36.38%,p <0.0001), Low birth weight(LBW)(23.5% vs. 29.7%;p <0.0001), perinatal asphyxia(28.5% vs. 38.3%; p <0.0001), neonatal sepsis(42.9% vs. 47.2%; p < 0.0001), congenital anomalies (1.8% vs. 2.3%,p<0.001) during the pandemic. However, there was decline in admission due to neonatal jaundice (10.1% vs. 6.6%; p<0.001) during the pandemic (Table 3).

The institutional neonatal mortality increased from 15.42%(n=207) before the pandemic to 21, 29% (n= 333) during the pandemic (p <0.0001). This indirectly means, the Neonatal mortality rate increased from 11 per 1000 live births during the pre-pandemic time to 21 per 1000live births during the pandemic. There was an increase in mortality due to preterm complications (6.18% vs.10%; p=0.002), perinatal asphyxia (4.24% vs.5.7%; p=0.07) and neonatal sepsis (5.51% vs 7.03%; p=0.09) during the pandemic as compared to the pre-pandemic period. The proportion of still births also increased during the pandemic (2.1% vs.2.8%; p <0.0001). Stillbirth rate increased from 21 per 1000 total births before pandemic to 28 per 1000 total births during pandemic. (Table 4 & 5).

## DISCUSSION

This is probably one of the first hospital-based study to report the indirect consequences of the ongoing pandemic on childbirths, together with the changes in the pattern of sick newborn and the factors contributing to increased neonatal morbidity and mortality. This study tried to find out

the differences in the institutional deliveries, incidence of complicated deliveries, stillbirths, sick newborns admission pattern, causes of admissions and the mortality in sick newborn during the pandemic and in the same months of previous year to avoid the impact of any associated seasonal factors that could affect these outcomes.

Compared to the pre-COVID period, hospital deliveries decreased during the pandemic notably in the initial six months, but the deliveries peaked up towards the latter half of the study. This is comparable to a multi-centric study done in Nepal that also reported decrement in facility births by half during the COVID-19 pandemic.<sup>4</sup> With the abrupt announcement of lock down in Nepal and travel restrictions could have possibly hindered pregnant mothers in reaching the health facility. Furthermore, the fear of contracting the disease during travel and hospital stay, along with anxiety arising from the fear of being mistreated in facilities might be the factors associated with it.<sup>10</sup> The rise in deliveries in the hospital after five months of pandemic may be due to ending up of the lock down, reduced fear and anxiety for travel and increased referral of the pregnant mothers from other public and private hospitals. There was a slight increment in hospital delivery among the primiparous mothers as compared to nulliparous or multiparous during the pandemic period. This is in line with the study conducted in Nepal that found a decrement in hospital delivery among nulliparous and multiparous group with a significant rise among the primiparous mothers (<https://jkahs.org.np/jkahs/index.php/jkahs/article>). This is explained by the fact that marriages have declined during the outbreak resulting in lesser number of women getting pregnant or delivering baby resulting in a comparative rise in delivery of primiparous mothers.

Among the obstetric factors, mode of delivery, abnormal lie, twin delivery, and gestational hypertension showed similar trends in the study period. Caesarian Section rates were similar in the studies conducted in Nepal and in New York during the COVID-19 pandemic.<sup>14</sup> As there were no significant changes in obstetric complication requiring CS during the study period, this might be the rationale behind similar CS rates during and before the pandemic.

Among the birth outcomes, we found increment in the number of preterm and low birth weight babies, which is similar to many studies which reported increased incidence of premature and LBW babies during the pandemic during this period.<sup>3,4,7</sup>

One of the most striking findings from our study was rise in still birth rate from 21 to 28 per 1000 deliveries. Several studies have reported rise in stillbirths which could be due to indirect as well as direct effects of the COVID-19.<sup>3,4</sup> Higher stillbirths may have resulted from collateral effects like delay in seeking timely care due to travel restrictions, fear, and anxiety of contracting the virus during visits, reduced antenatal visits, screening and ultrasound scan(6,8). The status of sick newborn health and outcome showed a significant variation at the time of pandemic. There was a notable rise in sick newborn admissions during the COVID-19 pandemic not from the disease itself (as none of

the admitted babies were COVID positive) but due to rise in prematurity and LBW complications, increased perinatal asphyxia and Neonatal sepsis. Increased admissions in NICU were also reported in another study conducted in Nepal comparing the pre and post COVID incidences on newborn admissions however, study done in Uganda noted a drop in newborn admissions because of the proportion of the monthly deliveries.<sup>7</sup> Similarly, overall reduction in sick newborn admissions along with decrease in neonatal sepsis was observed in the study conducted in northern Ghana.<sup>15</sup> Newborn unit at PMWH admits only intramural sick newborns, while the facilities in which extramural admissions are also taken can have different scenario regarding the admission patterns. Delay in reaching hospital due to travel restrictions during the lock down could be one of the reason behind perinatal asphyxia. Intrapartum monitoring was compromised in many hospital settings due to fear of contracting the disease which directly affects quality of care.<sup>4</sup> Factors such as uncertainty about dealing with exposure risk for maternal and newborn populations, reduced human resources due to diversion of workforce or absenteeism for isolation and quarantine etc. might have contributed to flaring up of nosocomial infections in NICU/ SNCU. which may be the reason of increased neonatal sepsis in our study.<sup>16</sup> This study reports decrease in cases of neonatal jaundice during pandemic, which may be due to overburdening of the neonatal units with other severe conditions. There was rise in the number of congenital birth defects cases during the pandemic in our study and probably due to increased extreme preterm babies being admitted and detection of more congenital heart diseases in that age group.<sup>17</sup> There was a significant rise in neonatal mortality rate stemming from more newborns dying due to prematurity, perinatal asphyxia, and neonatal sepsis. There was significant association of preterm deaths for increased neonatal mortality during the pandemic. Our study reinforces the hypothesis that prematurity, asphyxia, and sepsis are the major killer disease of the newborns. Shoot up in the neonatal mortality rate was also observed in other studies done in different parts of the nation and in other countries as well.<sup>3,4,8</sup>

Besides being one of a largest study documenting the effects of the pandemic on maternal and newborn health, our study has used a comparable period in 2019. Similarly, it is one of the first study in which trends and outcome of institutional deliveries along with sick newborns admission and mortality has been discussed in the same study. However, we have limitations. First, it is a retrospective study, done in a single-center setting. Second, we lack the information regarding the cause of stillbirth and maternal outcome during the study period.

## CONCLUSION

Both mother and newborns suffered from indirect consequences of the COVID-19 pandemic. Strengthening and increased vigilance of routine services during labor and delivery in the hospital during the crisis is of utmost importance for better outcome. The findings of this study have reappraised the importance of a resilient system to

save the vulnerable newborns during the time of pandemic.

**Strengths and Limitations:** This study is one of the largest study documenting the effects of the pandemic on maternal and newborn health providing comparison with pre pandemic period. Similarly, it is one of the first study in which trends and outcome of institutional deliveries along with sick newborn admission and mortality has been discussed in the same study. However, this study has some limitations in terms of being a retrospective study, done in a single-center setting and in lacking information regarding the cause of stillbirth and maternal outcome during the study period.

**Acknowledgement:** We would like to thank all the nursing staffs, and doctors from the delivery room and sick newborn units of the hospital. We also would like to thank the hospital record section team for providing the various information regarding mothers and admitted sick newborns.

## REFERENCES

- Menendez C, Gonzalez R, Donnay F, Leke RGF. Avoiding indirect effects of COVID-19 on maternal and child health. *Lancet Glob Health*. 2020 Jul;8(7):e863-e864. DOI: 10.1016/S2214-109X(20)30239-4. Epub 2020 May 12. PMID: 32413281 PMCID: PMC7252153,
- Boerma T, Requejo J, Victora CG, Amouzou A, George A, Agyepong I, et al. Countdown to 2030: tracking progress towards universal coverage for reproductive, maternal, newborn, and child health. *Lancet*. 2018 Apr 14;391(10129):1538-1548. DOI: 10.1016/S0140-6736(18)30104-1. Epub 2018 Jan 31. PMID: 29395268
- Khalil A, Von Dadelszen P, Draycott T, Ugwumadu A, O'Brien P, Magee L. Change in the Incidence of Stillbirth and Preterm Delivery during the COVID-19 Pandemic. *JAMA*. 2020 Jul 10;324(7):705-706. DOI: 10.1001/jama.2020.12746. Online ahead of print. PMID: 32648892. PMCID: PMC7435343.
- KC A, Gurung R, Kinney M V., Sunny AK, Moinuddin M, Basnet O, et al. Effect of the COVID-19 pandemic response on intrapartum care, stillbirth, and neonatal mortality outcomes in Nepal: a prospective observational study. *Lancet Glob Health*. 2020 Oct;8(10):e1273-e1281. DOI: 10.1016/S2214-109X(20)30345-4. Epub 2020 Aug 10. PMID: 32791117 PMCID: PMC7417164
- Kotlar B, Gerson E, Petrillo S, Langer A, Tiemeier H. The impact of the COVID-19 pandemic on maternal and perinatal health: a scoping review. *Reprod Health*. 2021 Jan 18;18(1):10. DOI: 10.1186/s12978-021-01070-6 PMID: 33461593 PMCID: PMC7812564
- Dennis CL, Vigod S. The Relationship Between Postpartum Depression, Domestic Violence, Childhood Violence, and Substance Use: Epidemiologic Study of a Large Community Sample. *Violence Against Women*. 2013 Apr;19(4):503-17. DOI: 10.1177/1077801213487057. Epub 2013 May 8. PMID: 23660619
- Burt J, Ouma J, Amone A, Aol L, Sekikubo M, Nakimuli A, et al. Indirect effects of COVID-19 on maternal, neonatal, child, sexual and reproductive health services in Kampala, Uganda. *BMJ Glob Health*. 2021 Aug;6(8):e006102. DOI: 10.1136/bmjgh-2021-006102 PMID: 34452941. PMCID: PMC8406460,
- Kharrat A, Neish A, Diambomba Y, Jain A. Non-COVID co-morbidity: potential indirect consequences of the SARS-CoV-2 pandemic in a neonatal intensive care unit [Internet]. Vol. 109, *Journal of Hospital Infection*. J Hosp Infect. 2021 Mar;109:65-67. DOI: 10.1016/j.jhin.2020.12.010. Epub 2020 Dec 19. PMID: 33352246. PMCID: PMC7749731
- Riley T, Sully E, Ahmed Z, Biddlecom A. Estimates of the potential impact of the covid-19 pandemic on sexual and reproductive health in low-and middle-income countries *Int Perspect Sex Reprod Health*. 2020 Apr 16;46:73-76. DOI: 10.1363/46e9020 PMID: 32343244
- Graham WJ, Afolabi B, Benova L, Campbell OMR, Filippi V, Nakimuli A, et al. Protecting hard-won gains for mothers and newborns in low-income and middle-income countries in the face of COVID-19: Call for a service safety net. *BMJ Glob Health*. 2020 Jun;5(6):e002754. DOI: 10.1136/bmjgh-2020-002754. PMID: 32499220. PMCID: PMC7298807
- Carlo C Di I, Iannotti G, Sparice S, Chiacchio MP, Greco E, Tommaselli GA, Nappi C The role of a personalized dietary intervention in managing gestational weight gain: a prospective, controlled study in a low-risk antenatal population. *Arch Gynecol Obstet*. 2014 Apr;289(4):765-70. DOI: 10.1007/s00404-013-3054-y. Epub 2013 Oct 16. PMID: 24129610
- Bahadoer S, Gaillard R, Felix JF, Raat H, Renders CM, Hofman A, et al. Ethnic disparities in maternal obesity and weight gain during pregnancy. The Generation R Study. *Eur J Obstet Gynecol Reprod Biol*. 2015 Oct;193:51-60. DOI: 10.1016/j.ejogrb.2015.06.031. Epub 2015 Jul 8. PMID: 26232727 PMCID: PMC5408938
- Wagner BG, Choi KH, Cohen PN. Decline in Marriage Associated with the COVID-19 Pandemic in the United States. *Socius*. 2020 Dec 29;6:2378023120980328. DOI: 10.1177/2378023120980328. eCollection 2020. PMID: 34192140 PMCID: PMC7780066.
- Malhotra Y, Miller R, Bajaj K, Sloma A, Wieland D, Wilcox W. No change in cesarean section rate during COVID-19 pandemic in New York City. *Eur J Obstet Gynecol Reprod Biol*. 2020 Oct; 253:328 329. DOI: 10.1016/j.ejogrb.2020.06.010. Epub 2020 Jun 11. PMID: 32620511 PMCID: PMC7287463
- Abdul-Mumin A, Cotache-Condor C, Bimpong KA, Grimm A, Kpiniong MJ, Yakubu RC, et al. Decrease in Admissions and Change in the Diagnostic Landscape in a Newborn Care Unit in Northern Ghana During the COVID-19 Pandemic. *Front Pediatr*. 2021 Mar 25;9:642508. eCollection 2021. DOI: 10.3389/fped.2021.642508. PMID: 33842411. PMCID: PMC8027062

16. Griffin I, Benarba F, Peters C, Oyelese Y, Murphy T, Contreras D, et al. The Impact of COVID-19 Infection on Labor and Delivery, Newborn Nursery, and Neonatal Intensive Care Unit: Prospective Observational Data from a Single Hospital System. *Am J Perinatol*. 2020 Aug 1;37(10):1022–30. DOI: 10.1055/s-0040-1713416. Epub 2020 Jun 13. PMID: 32534458. PMCID: PMC7416206
17. Laas E, Lelong N, Thieulin AC, Houyel L, Bonnet D, Ancel PY, et al. Preterm birth and congenital heart defects: A population-based study. *Pediatrics [Internet]*. 2012 Oct; ;130(4): e829-37. DOI: 10.1542/peds.2011-3279. Epub 2012 Sep 3. PMID: 22945415