Accepted: 28 March 2022

DOI: 10.1111/1471-0528.17175

BJOG An International Journal of Obstetrics and Gynaecology

RESEARCH ARTICLE

Epidemiology

Health care in pregnancy during the COVID-19 pandemic and pregnancy outcomes in six low- and-middle-income countries: Evidence from a prospective, observational registry of the Global Network for Women's and Children's Health

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Abstract

Objective: To assess, on a population basis, the medical care for pregnant women in specific geographic regions of six countries before and during the first year of the coronavirus disease 2019 (COVID-19) pandemic in relationship to pregnancy outcomes.

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Design: Prospective, population-based study.

Setting: Communities in Kenya, Zambia, the Democratic Republic of the Congo, Pakistan, India and Guatemala.

Population: Pregnant women enrolled in the Global Network for Women's and Children's Health's Maternal and Newborn Health Registry.

Methods: Pregnancy/delivery care services and pregnancy outcomes in the pre-COVID-19 time-period (March 2019–February 2020) were compared with the COVID-19 time-period (March 2020–February 2021).

Main outcome measures: Stillbirth, neonatal mortality, preterm birth, low birthweight and maternal mortality.

Results: Across all sites, a small but statistically significant increase in home births occurred between the pre-COVID-19 and COVID-19 periods (18.9% versus 20.3%, adjusted relative risk [aRR] 1.12, 95% CI 1.05–1.19). A small but significant decrease in the mean number of antenatal care visits (from 4.1 to 4.0, p = <0.0001) was seen during the COVID-19 period. Of outcomes evaluated, overall, a small but significant decrease in low-birthweight infants in the COVID-19 period occurred (15.7% versus 14.6%, aRR 0.94, 95% CI 0.89–0.99), but we did not observe any significant differences in other outcomes. There was no change observed in maternal mortality or antenatal haemorrhage overall or at any of the sites.

Conclusions: Small but significant increases in home births and decreases in the antenatal care services were observed during the initial COVID-19 period; however, there was not an increase in the stillbirth, neonatal mortality, maternal mortality, low birthweight, or preterm birth rates during the COVID-19 period compared with the previous year. Further research should help to elucidate the relationship between access to and use of pregnancy-related medical services and birth outcomes over an extended period.

KEYWORDS
COVID-19, Global Network, health care, low and middle-income countries, pregnancy

1 | INTRODUCTION

The impact of coronavirus disease 2019 (COVID-19) on pregnancy outcomes has been studied using different approaches. To assess the direct impact of COVID-19, the outcomes of pregnant women with documented COVID-19 have been compared with outcomes among women without documented COVID-19.[1–4] This approach, such as in the paper by Villar et al., suggests that symptomatic or severe COVID-19 during pregnancy are associated with increases in adverse maternal and neonatal outcomes.[1]

Another approach evaluates the indirect impact of the COVID-19 pandemic on outcomes through disruption of medical services.[5–12] These studies generally compare services and outcomes from before the COVID-19 pandemic to a time during the pandemic. As the time-periods compared are often long, these studies may take a substantial time to accumulate sufficient data to accurately assess services and outcomes. To reduce the time necessary to estimate the impact of a pandemic on health services, modelling is another approach used. For example, a modelling exercise using the Lives Saved Tool estimated a potential excess of 56 700 maternal and 1 157 000 child deaths assuming up to 45% coverage reductions in 118 countries for 6 months during the COVID-19 pandemic outbreak.[10] How precisely the modelling results reflect reality is often unknown. For that reason, to understand the indirect impact of the COVID-19 pandemic on important pregnancy outcomes, it is crucial to collect actual data on health service use and pregnancy outcomes.

The influence of pandemics on health service delivery and demand, especially in countries where resources are already constrained, may be substantial.[13–17] Challenges to service delivery include lack of key commodities, staff reassignment and diversion of equipment and supplies to emergency care. Specific mitigation measures such as lockdowns and curfews can also disrupt the provision of and access to services.[6–8] Fear of contracting infection and lack of trust in the healthcare system may also adversely affect the demand for services. For example, during the Ebola virus outbreak in West Africa, many hospitals were closed because of transmission concerns, while available healthcare staff and resources were reallocated from routine health services to care for those with the virus.[18,19] Disruptions in access to healthcare services during pandemics often disproportionately impact the most vulnerable populations, including pregnant women, neonates and children, especially in resource-constrained settings.[8]

To minimise the impact of the ongoing COVID-19 pandemic on essential health services, and in particular, upon women's and newborns' health care, it is essential to understand the impact of the COVID-19 pandemic on healthcare service delivery and on pregnancy outcomes.[20] As an example, a study from Nepal reported that the COVID-19 outbreak reduced coverage of health-facility births, with significantly increased stillbirth and neonatal mortality rates.[15] In contrast, a report from Bangladesh reported no impact of the pandemic on services.[21] A systematic review by Chmielewska et al., which did not evaluate services, reported that in the COVID-19 period, compared with the pre-COVID-19 period, there was a significant increase in stillbirths (odds ratio [OR] 1.28, 95% CI 1.07–1.54) but no increase in preterm births, low birthweight or neonatal deaths.[16] Vaccaro et al. compared pregnancy outcomes in pre-lockdown time-periods with those during the lockdown and found an increase in stillbirths (OR 1.33, 95% CI 1.04–1.60) but no change in low birthweight.[11] In a review of 11 studies comparing preterm births and low birthweight and associated outcomes in the pre-COVID-19 and lockdown periods, we found no consistent relationship of the lockdowns to birth outcomes.[12] Few reports included in the above studies were population-based, and few originated in low-resource settings. Nevertheless, they raised questions about the indirect impact of the COVID-19 pandemic on maternal and neonatal health outcomes in resource-constrained settings. To facilitate understanding of the impact of the COVID-19 pandemic on perinatal health care, we used an ongoing population-based database to compare access to pregnancy and delivery care by pregnant women, and pregnancy outcomes in seven sites in six low- and middle-income countries before and during the pandemic.

2 | METHODS

The *Eunice Kennedy Shriver* Global Network for Women's and Children Health's (Global Network) Maternal and Newborn Health Registry (MNHR) is a prospective, population-based observational study that was initiated in 2009.[22,23] All pregnant women in defined geographic communities that include approximately 300–500 births annually, are identified and enrolled. For this study, we analysed population-based data from the eight to ten communities at the sites in western Kenya, Zambia (Kafue and Chongwe), the Democratic Republic of the Congo (North and South Ubangi Provinces), Pakistan (Thatta in Sindh Provence), India (Belagavi and Nagpur) and Guatemala (Chimaltenango).

Registry administrators, trained study healthcare staff, identified pregnant women in their respective communities and following consent, enrolled them in the MNHR.[22,23] Once a pregnant woman was identified, the registry administrators obtained basic health information at enrolment, and recorded the date of last menstrual period or early ultrasound report to assess gestational age and other basic demographic information. A follow-up visit was carried out following delivery to collect information on pregnancy outcomes as well as the health care received during delivery. The maternal and newborn health statuses were collected at 42 days post-delivery.

The study outcomes were based on medical record reviews and birth attendant and family interviews. Birthweights for babies born in facilities were available from the birth certificates or hospital records and for home deliveries, babies were weighed within 48 hours of birth by the registry administrators using standardised study scales. During the onset of the COVID-19 pandemic, some of the participating sites went through lockdown periods, when the field activities were either partially or fully halted. However, the registry administrators continued to collect information on pregnancy and neonatal outcomes either through telephone contacts or by making home visits.

Stillbirths were defined as fetuses born at 20 weeks of gestation or more with no signs of life including movement, cry or respirations. Neonatal deaths were defined as the death of any live-born infant, regardless of gestational age or birthweight, who died before 28 days of life. Maternal mortality was defined as death of the mother at any time in the pregnancy and up to 42 days postpartum. The outcome of miscarriages and medical terminations of pregnancy included any pregnancy registered in the MNHR that ended before 20 weeks of gestation. Although we attempted to capture every pregnancy ending at 20 weeks or more, some pregnancies, especially those with an early termination or miscarriage, may not be captured in the MNHR. Also, especially in Pakistan and Guatemala, the babies delivered at home may not have been weighed because of the absence of personal contact because of the COVID-19 pandemic. However, most of the other data were collected by telephone in those sites.

2.1 | Statistical analyses

The analysis population included women screened for the MNHR who were eligible, consented and delivered at 20 weeks of gestation between March 2019 and February 2021. The pre-COVID-19 period was defined as extending from March 2019 through February 2020 and the COVID-19 period from March 2020 through February 2021, based on the World Health Organization's declaration of a global pandemic.[24] We compared the pregnancy and delivery care practices of women in the pre-COVID-19 time-period and during the COVID-19 time-period. For analyses, we combined data from the Democratic Republic of the Congo, Zambian and Kenyan sites as the African sites, and Belagavi and Nagpur, India, as the Indian sites. Pakistan and Guatemala were considered separately.

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The percentage of women with four or more antenatal care (ANC) visits as well as the mean number of ANC visits in women at each site, the percentage of deliveries by a physician and the percentage of women delivering at home were analysed by site and year overall and for each of the two time-periods. Maternal mortality ratios, the rates of stillbirths, neonatal deaths until 28 days, early neonatal deaths before 7 days, perinatal mortality defined as stillbirths plus early neonatal mortality, low birthweight (<2500 g) and preterm birth (<37 weeks of gestation at delivery) were compared by site and overall, for both time-periods. The rates of stillbirth and perinatal mortality are reported per 1000 live births and stillbirths, whereas neonatal mortality was calculated per 1000 live births. For display purposes, the absolute changes in healthcare measures were calculated as the values during COVID-19 minus the pre-pandemic values.

Finally, we calculated the relative risks (RR) and corresponding 95% CI from Poisson models for categorical variables and normal distribution model for continuous ANC visits with generalised estimating equations to account for the correlation of outcomes within community, accounting for site and the interaction of pre-COVID-19 or during COVID-19 and site. We ran the same models adjusting for the potential confounders, maternal age, education and parity. All statistical analyses were conducted in SAS v. 9.4 (SAS Institute, Cary, NC, USA).

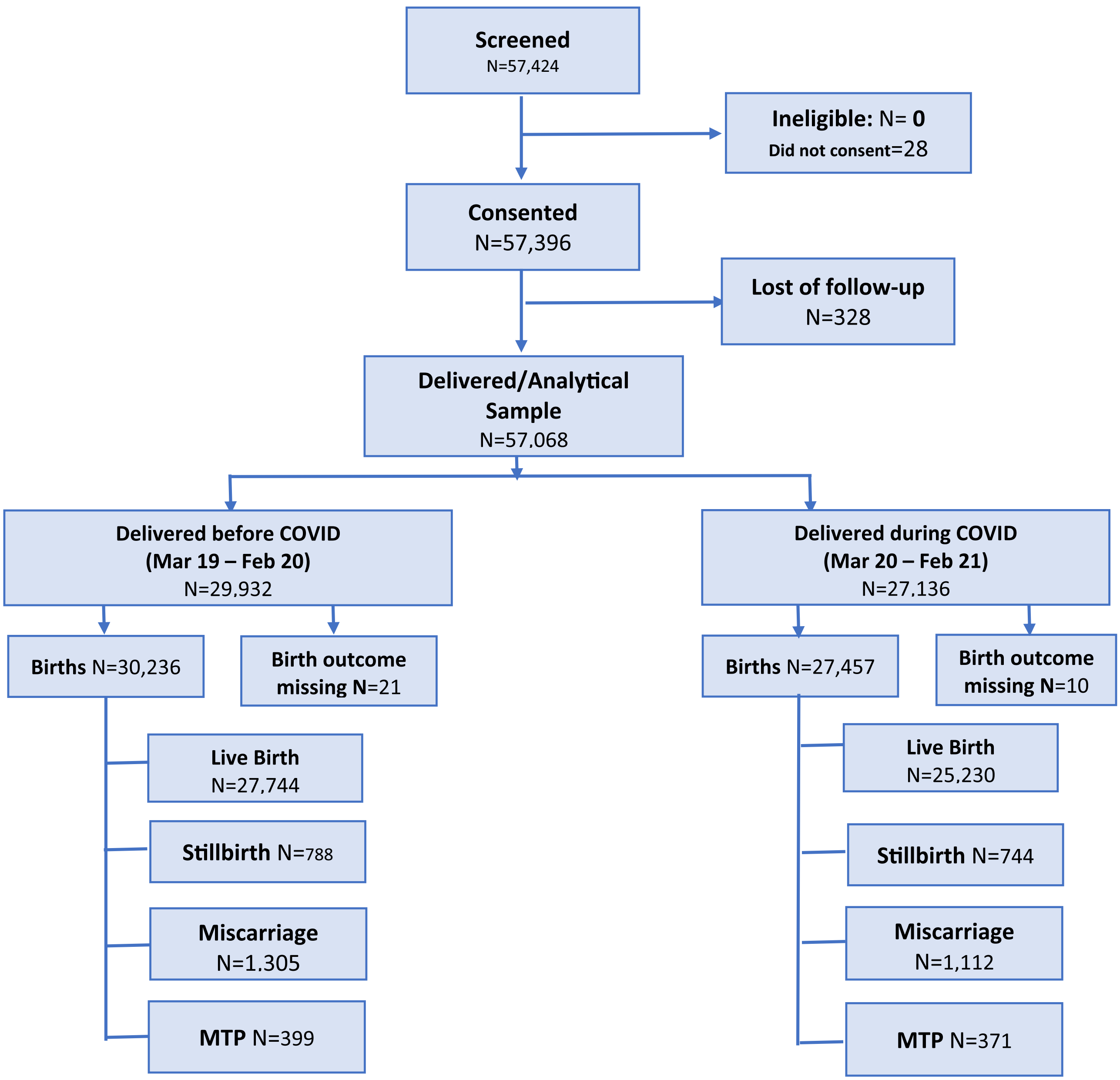

FIGURE 1 Consort diagram. Note: The Maternal and Newborn Health Registry geographic clusters included in this analysis were ongoing from 2019 to 2021. However, the Guatemalan clusters were reduced in size after 2019. Abbreviation: MTP, medical termination of pregnancy

TABLE 1 Maternal demographics pre-COVID-19 and during COVID-19 by location

	Total		Africa		Guatemala		India		Pakistan	
in	Pre-COVID	During COVID	Pre-COVID	During COVID	Pre-COVID	During COVID	Pre-COVID	During COVID	Pre-COVID	During COVID
N	29 932	27 136	14 104	13 669	4747	3180	6701	6342	4380	3945
Maternal age (years)	29 930	27 133	14 102	13 667	4747	3180	6701	6341	4380	3945
<20	4597 (15.4)	3996 (14.7)	3149 (22.3)	2932 (21.5)	818 (17.2)	540 (17.0)	483 (7.2)	410 (6.5)	147 (3.4)	114 (2.9)
20–35	23 538 (78.6)	21 518 (79.3)	9884 (70.1)	9727 (71.2)	3477 (73.2)	2324 (73.1)	6176 (92.2)	5877 (92.7)	4001 (91.3)	3590 (91.0)
>35	1795 (6.0)	1619 (6.0)	1069 (7.6)	1008 (7.4)	452 (9.5)	316 (9.9)	42 (0.6)	54 (0.9)	232 (5.3)	241 (6.1)
Parity	29 931	27 134	14 104	13 669	4747	3180	6700	6340	4380	3945
0	9290 (31.0)	8512 (31.4)	3882 (27.5)	3796 (27.8)	1508 (31.8)	1082 (34.0)	2825 (42.2)	2790 (44.0)	1075 (24.5)	844 (21.4)
1–2	12 300 (41.1)	11 066 (40.8)	5124 (36.3)	4974 (36.4)	2041 (43.0)	1347 (42.4)	3595 (53.7)	3297 (52.0)	1540 (35.2)	1448 (36.7)
≥3	8341 (27.9)	7556 (27.8)	5098 (36.1)	4899 (35.8)	1198 (25.2)	751 (23.6)	280 (4.2)	253 (4.0)	1765 (40.3)	1653 (41.9)
Maternal level of education	29 931	27 132	14 103	13 668	4747	3180	6701	6340	4380	3944
No formal schooling (0 years)	6587 (22.0)	5808 (21.4)	2337 (16.6)	2106 (15.4)	386 (8.1)	260 (8.2)	271 (4.0)	207 (3.3)	3593 (82.0)	3235 (82.0)
Primary (1–6 years)	5881 (19.6)	4961 (18.3)	3261 (23.1)	3176 (23.2)	1938 (40.8)	1233 (38.8)	357 (5.3)	263 (4.1)	325 (7.4)	289 (7.3)
Secondary (7–12 years)	15 195 (50.8)	14 274 (52.6)	7864 (55.8)	7788 (57.0)	1941 (40.9)	1401 (44.1)	5003 (74.7)	4723 (74.5)	387 (8.8)	362 (9.2)
University + (>12 years)	2268 (7.6)	2089 (7.7)	641 (4.5)	598 (4.4)	482 (10.2)	286 (9.0)	1070 (16.0)	1147 (18.1)	75 (1.7)	58 (1.5)

2.2 | Ethical considerations

This study was reviewed and approved by the ethics committees of participating research sites (INCAP, Guatemala; University of Zambia, Zambia; Moi University, Kenya; Aga Khan University, Pakistan; Kinshasa School of Public Health, Kinshasa, Democratic Republic of the Congo), KLE University's Jawaharlal Nehru Medical College, Belagavi, India; Lata Medical Research Foundation, Nagpur, India), the institutional review boards at each US partner university and the data coordinating centre (RTI International). All women provided informed consent for participation in the study, including data collection and the follow-up visits.

3 | RESULTS

Altogether, a total of 57424 women were enrolled in the MNHR during the study periods. Of these, 57396 consented to participate and birth outcome data were collected for 57068 (99.4%) women (Figure 1). Of these women, 29932 (52.4%) delivered during the pre-COVID-19 period resulting in 27744 (91.8%) live births, 788 (2.6%) stillbirths, 1305 (4.3%) had a miscarriage and 399 (1.3%) reported a medical termination of pregnancy. During the COVID-19 period, a total of 27136 women delivered. Of these, 25230 (91.9%) had a live birth, 744 (2.7%) had a stillbirth, 1112 (4.0%) had a miscarriage and 371 (1.4%) had a medical termination.

Table 1 presents the number of women in total and per region and their maternal characteristics during the pre-COVID-19 and COVID-19 periods. Most women enrolled in the pre-COVID-19 and during COVID-19 periods were 20–35 years of age (78.6% and 79.3%, respectively). Overall, the proportion of pregnant women with a primary or secondary education was similar in both periods (70.4% during pre-COVID-19 period and 70.9% during COVID-19 period). The proportions of women with a parity of 1–2 were 41.1% and 40.8% during the pre-COVID-19 and COVID-19 periods, respectively.

We next evaluated the provision of obstetric care and maternal health outcomes overall by region, comparing the pre-COVID-19 period with the COVID-19 period (Table 2). The proportion of women receiving four or more ANC visits was similar overall (63.2% in the pre-COVID-19 period versus 62.4% in the COVID-19 period, RR 0.98, 95% CI 0.96–1.01), with similar findings across regions. We also evaluated the mean number of ANC visits in each period (4.1 in the pre-COVID-19 period versus 4.0 during the COVID-19 period, p = <0.0001) (data not shown). Next, we assessed the proportion of women who delivered at home in the pre-COVID-19 period and the COVID-19 period, overall and by region. Every site had an increase in the percentage of home births during the COVID-19 period. Overall, 18.9% of the women delivered at home in the pre-COVID-19 period versus 20.3% in the COVID-19 period (adjusted RR [aRR] 1.12, 95% CI 1.05, 1.19). Finally, we found that the type of delivery attendant did not differ substantially between the two periods overall. However, we observed increased physician-attended deliveries in the African sites and a decrease in the percentage of physician-attended deliveries in Guatemala, changes that were statistically significant. There was also a slight increase in caesarean births in the COVID-19 period, which was significant overall (aRR 1.11, 95% CI 1.03–1.19) and in Guatemala and India. In terms of measures of maternal health, we observed no statistically significant differences in the pre-COVID-19 to during the COVID-19 period. The maternal death ratio was 127/100000 compared with 122/100000 in the pre-COVID-19 versus COVID-19 periods, respectively (RR 1.02, 95% CI 0.66–1.59). Similarly, rates of antepartum and postpartum haemorrhage as well as reported hypertensive disorders were not significantly different in the two periods overall or by site.

We next evaluated the fetal and neonatal outcomes by period (Table 3). The stillbirth rate was 27.6 per 1000 versus 28.6 per 1000 births in the pre-COVID-19 versus COVID-19 periods, respectively (aRR 0.99, 95% CI 0.86–1.14), and 28-day neonatal mortality was 22.7 versus 22.3 per 1000 live births (aRR 0.95, 95% CI 0.82–1.08). The low birthweight rate was 15.7% versus 14.6% (aRR 0.94, 95% CI 0.89–0.99) and the preterm birth rate was 15.8% versus 16.1% (aRR 0.98, 95% CI 0.92–1.04).

Finally, because rates of home birth represented the most substantial difference among the measures of health care, we first explored when during the COVID-19 period the increase occurred by site (Figure S1) evaluating the delivery trends by month during the pre-COVID-19 and the COVID-19 time-periods. In the African sites, the increase appeared to have occurred consistently across the year, whereas in Guatemala, a notable increase in home births appeared to have occurred early during the COVID-19 period. The changes observed in the percentage of home births in India and Pakistan were smaller and inconsistent and were not statistically significant. Figure S2 presents the absolute difference in the proportion of women attended by a physician at delivery. Although the annual differences were not statistically significant, it appears that in the early months of the pandemic, there were decreases in physician-attended deliveries in the Guatemalan, Indian and Pakistan sites.

4 | DISCUSSION

4.1 | Main findings

Our results, comparing data from the pre-COVID-19 period of March 2019 to February 2020 with the early COVID-19 pandemic period of March 2020 to February 2021, suggest that in most Global Network sites, there were small but significant increases in home births and small decreases in ANC use, and fewer deliveries (but not significantly fewer) attended by physicians. Importantly, there were no increases in the neonatal mortality, maternal mortality and stillbirth rates across the Global Network during the pandemic period compared with the previous year.

TABLE 2 Pregnancy care and maternal outcomes in the pre-COVID-19 period and during the COVID-19 period overall and by location

	Total			Africa		
	Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]
N	29 932	27 136		14 104	13 669	
Four or more ANC visits, %	63.2	62.4	0.98 (0.96–1.01)	61.6	60.6	0.98 (0.93–1.03)
Home birth, %	18.9	20.3	1.12 (1.05–1.19)	13.7	17.4	1.27 (1.07–1.52)
Physician delivery, %	30.9	28.6	1.05 (0.99–1.10)	4.3	6.1	1.41 (1.18–1.69)
Nurse/nurse midwife/health worker delivery, %	47.9	51.5	0.98 (0.83–1.15)	81.7	80.2	0.98 (0.93–1.03)
Traditional birth attendant/ family/self delivery, %	21.2	19.9	1.02 (0.93–1.12)	14.0	13.8	0.99 (0.78–1.25)
Caesarean birth, %	16.3	16.7	1.11 (1.03–1.19)	2.4	3.0	1.25 (0.99–1.58)
Maternal deaths per 100 000	127	122	1.02 (0.66–1.59)	99	73	0.74 (0.25–2.17)
Antepartum haemorrhage, %	1.0	1.1	1.11 (0.79–1.55)	1.2	1.3	1.04 (0.75–1.44)
Postpartum haemorrhage, %	1.4	1.1	0.73 (0.61–0.87)	1.6	1.4	0.87 (0.74–1.03)
Hypertensive disorders, %	2.4	1.9	0.89 (0.75–1.06)	0.7	0.8	1.24 (0.97–1.60)

[a]Adjusted Relative risk (aRR) and corresponding 95% CI account for the correlation of outcomes within community. Models are adjusted for maternal age, education and parity.

TABLE 3 Fetal and neonatal outcomes in the pre-COVID-19 period and during the COVID-19 period overall and by location

	Total			Africa		
	Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]
N	30 236	27 457		14 295	13 886	
Stillbirth, rate per 1000 SB + LB	27.6	28.6	0.99 (0.86–1.14)	29.0	32.6	1.12 (0.97–1.30)
Early-ND, rate per 1000 LB	18.5	18.6	0.92 (0.80–1.06)	16.5	19.0	1.16 (0.94–1.42)
28-day ND, rate per 1000 LB	22.7	22.3	0.95 (0.82–1.08)	18.3	19.9	1.09 (0.91–1.30)
Perinatal mortality, rate per 1000 SB + LB	45.6	46.8	0.97 (0.88–1.06)	45.0	51.0	1.13 (1.00–1.29)
LBW, %	15.7	14.6	0.94 (0.89–0.99)	9.9	9.8	1.00 (0.91–1.10)
PTB, %	15.8	16.1	0.98 (0.92–1.04)	14.5	15.6	1.08 (0.97–1.20)

Abbreviations: LB, live birth; LBW, low birthweight; ND, neonatal death; PTB, preterm birth; SB, stillbirth;

[a]Adjusted Relative risk (aRR) and corresponding 95% CI accounting for site and the interaction of pre-COVID-19 or during COVID-19 and site. Models are adjusted for maternal age, education and parity.

4.2 | Interpretation

We have considered why, across the Global Network sites, we did not observe increases in stillbirths or neonatal deaths with the onset of the pandemic associated with the increase in home deliveries or the changes in ANC or physician attendance. First, the changes observed in ANC and care at delivery were all small. Second, we have previously explored the relationship between institutional delivery and stillbirth and neonatal mortality rates and did not find a consistent relationship across the Global Network sites.[25] We believe that the number of visits or the site of delivery alone is not sufficient to establish a measure of obstetric or neonatal care quality. If high-quality obstetric and neonatal care are not provided, delivering in a facility is unlikely to be associated with decreased fetal or newborn mortality.

We have also thought about why some other studies seemed to find large increases in certain poor outcomes associated with the COVID-19 pandemic, but this Global Network study did not. Most importantly, this was a population-based study of pregnancy outcomes over a time-period and did not evaluate the difference in outcomes between those women who tested positive for COVID-19 or were symptomatic and those women who tested negative. We were interested in whether changes in medical services for pregnant women occurred from before the pandemic to the early part of the pandemic and whether these changes were related to changes in outcome. We did not evaluate whether if a woman was infected with COVID-19 or if she was symptomatic, there were worse outcomes. We were especially interested in whether the very large increases in adverse outcomes associated with predictions of decreased services could be verified with actual data. Compared with some of the other studies evaluating care indices, our study included a large number of pregnancies from defined populations that were routinely monitored using standardised methods, and

Guatemala			India			Pakistan		
Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]
4747	3180		6701	6342		4380	3945	
62.7	64.5	1.01 (0.98–1.04)	78.4	76.8	0.96 (0.91–1.02)	45.4	43.7	0.99 (0.96–1.01)
39.8	44.3	1.13 (1.06–1.20)	9.7	10.3	1.09 (0.98–1.22)	26.8	27.2	1.00 (0.93–1.07)
63.5	61.3	0.95 (0.91–0.98)	65.8	62.3	0.93 (0.85–1.01)	27.4	25.8	0.97 (0.93–1.01)
0.3	0.2	0.69 (0.39–1.25)	24.6	27.5	1.12 (0.96–1.30)	26.5	32.2	1.21 (0.98–1.48)
36.2	38.5	1.08 (1.03–1.13)	9.6	10.2	1.14 (0.90–1.44)	46.2	42.0	0.89 (0.76–1.05)
35.4	38.5	1.06 (1.01–1.12)	33.4	36.7	1.07 (1.00–1.14)	18.0	18.7	1.06 (0.94–1.19)
84	220	2.57 (0.98–6.71)	134	63	0.48 (0.20–1.16)	251	305	1.20 (0.72–2.02)
0.3	0.3	1.25 (0.38–4.17)	0.5	0.7	1.42 (0.87–2.33)	1.8	1.5	0.81 (0.69–0.96)
1.0	1.0	0.96 (0.66–1.40)	0.8	0.5	0.60 (0.37–0.97)	2.0	1.2	0.56 (0.44–0.73)
4.5	4.5	0.96 (0.79–1.17)	3.4	2.5	0.72 (0.55–0.93)	4.0	2.9	0.74 (0.42–1.30)

Guatemala			India			Pakistan		
Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]	Pre- COVID	During COVID	aRR (95% CI)[a]
4783	3203		6743	6378		4415	3990	
19.1	21.6	1.14 (0.76–1.71)	18.9	17.6	0.93 (0.70–1.26)	45.5	36.7	0.81 (0.67–0.98)
15.8	10.7	0.68 (0.51–0.91)	12.1	12.6	1.05 (0.71–1.56)	38.6	33.5	0.88 (0.70–1.10)
23.4	18.5	0.79 (0.57–1.08)	14.9	14.1	0.95 (0.67–1.35)	49.5	47.9	0.98 (0.79–1.20)
34.6	32.1	0.93 (0.71–1.22)	30.8	30.0	0.98 (0.83–1.16)	82.3	69.0	0.84 (0.73–0.97)
19.2	16.9	0.88 (0.80–0.96)	20.9	20.4	0.98 (0.89–1.08)	24.8	22.2	0.90 (0.80–1.01)
12.9	10.9	0.84 (0.73–0.97)	11.4	11.6	1.02 (0.92–1.13)	30.7	29.7	0.97 (0.86–1.10)

the results were less likely to be influenced by selection bias in outcomes or time-periods.

Although maternal death and other adverse outcomes are increased with severe maternal COVID-19, as evidenced by the study of Villar et al.,[1] most maternal infections are mild and severe illness and death are rare. Occasional adverse outcomes occur, especially in populations with high rates of COVID-19, but for the most part, based on available evidence, we would not expect COVID-19 to have a substantial impact on stillbirths, neonatal deaths or maternal deaths at the population level. We recognise that the impact of COVID-19 on pregnancy and child outcomes is an ongoing area of active research.[20,26,27]

Another potential explanation for the absence of change in stillbirth or neonatal mortality during the pandemic in our sites is that at least some pregnant women may have adopted behaviours that were protective against COVID-19, including fewer social interactions and more mask wearing, which may have reduced their exposure to COVID-19.[28] The decreases in observed stillbirth rates in Guatemala and Pakistan may be actual, but also may have occurred because of decreased reporting of adverse outcomes as the result of reduced care seeking in those sites, especially early in pregnancy when most stillbirths occur.[29] The increases in stillbirths reported in the Vaccaro et al. and the Chmielewska et al. studies of about 30%, using methodologies different from this study, was not consistent with our findings and this difference requires further investigation.[11,16]

4.3 | Strengths and limitations

Among the strengths of this study were the large sample size, population-based data from three regions, multiple sites and the prospective, on-going data collection with standardised data collection protocols across the sites. A limitation was the potential for decreased quality and completeness of data collection during the COVID-19 pandemic. However, extensive efforts were made to capture all pregnancy outcomes in Global Network geographic areas. We also had limited, objective assessment of the visibility of the COVID-19 pandemic at the onset for each community, and thus the time-periods when communities perceived the pandemic may have varied from the declaration by the World Health Organization of the COVID-19 pandemic. Most important, the pandemic is still ongoing and probably increasing in severity and visibility in low- and middle-income countries. Further evaluations will be required over time to determine whether the observations made related to care seeking and pregnancy outcomes in the early stages of the pandemic hold through the remainder of the pandemic.

5 | CONCLUSIONS

In summary, we emphasise the difference in some outcomes projected by some modelling exercises and the results of actual population-based data. Models, at times, can be useful in helping researchers consider the potential ranges in outcomes associated with potential changes in practice, especially if the estimates are reasonable. Estimates of very high rates of adverse outcomes based on extreme assumptions of decreased availability of medical care may, or may not, motivate the responsible governmental agencies or public health community into taking some action. However, when the population-based data fail to support the model's assumptions, credibility related to modelling may be lost.

In the Global Network sites, there was an increase in home births, and perhaps small decreases in ANC use and deliveries attended by a physician during the early COVID-19 period. Despite the differences in these measures of health care, we did not observe any mortality increases in the COVID-19 period. Continuing to follow the healthcare use and maternal and newborn health outcomes on a population basis will be important to better understand the indirect impact of the COVID-19 pandemic on the population as the pandemic continues.

ACKNOWLEDGEMENTS

This study was funded through grants from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

CONFLICT OF INTERESTS

None declared. Completed disclosure of interests form available to view online as supporting information.

AUTHOR CONTRIBUTIONS

SN, FN, SS, EMM and RLG drafted the manuscript with input from VRT, MM, CLB, MB and SMB. SN, FN, SS, LF, AG, AP, SSG, FE, MM, EC, AL, AT, MB, CLB, EAL, NFK, RJD, WAC, PLH, SMB, RH, NP WAP, MKT, TN, EMM and RLG conceived the study and developed the protocol and procedures. LF, MM, AP, PD, AK, SSG, FE, MM, EC, AL, AT and SY carried out the study. VRT, TN and EMM conducted the analyses. All authors reviewed and approved the final manuscript.

DETAILS OF ETHICS APPROVAL

This study was approved by ethics review committees and institutional review boards at the participating institutions as follows: University of North Carolina at Chapel Hill (FWA 00004801) 7 January 2021; Kinshasa School of Public Health, Kinshasa, Democratic Republic of the Congo (FWA 00003581); 5 August 2021; University of Alabama at Birmingham, USA (FWA 00005960) 16 June 2021; University of Colorado Health Sciences Center (FWA 00005070) 18 May 2021; Institute for Nutrition in Central America and Panama (INCAP), Guatemala City, Guatemala (FWA 00000742) 11 August 2021; University of Virginia (FWA 00014631) 12 September 2019; ICDDR,B (Bangladesh) (FWA 00001468) 23 January 2021; Thomas Jefferson University (FWA 00002109) 10 March 2021; JN Medical College, Belagavi India (FWA 00024127) 15 January 2021; Columbia University School of Medicine (FWA 00000636) 21 May 2021; Aga Khan University, Karachi, Pakistan (FWA 00001177) 1 July 2021; Boston University School of Medicine (FWA IORG0000222) 27 July 2021; Lata Medical Research Foundation, Nagpur, India (FWA 00012971) 14 December 2020; Indiana University School of Medicine, Indianapolis, Indiana (FWA 00003544) 20 March 2020; Moi University, Eldoret, Kenya (FWA 000031280) 23 January 2020.

DATA AVAILABILITY STATEMENT

All data presented in the manuscript will be available through the NICHD Data and Specimen Hub (N-DASH).

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Naqvi S, Naqvi F, Saleem S, Thorsten VR, Figueroa L, Mazariegos M, et al. Health care in pregnancy during the COVID-19 pandemic and pregnancy outcomes in six low- and-middle-income countries: Evidence from a prospective, observational registry of the Global Network for Women's and Children's Health. BJOG. 2022;129:1298–1307. https://doi.org/10.1111/1471-0528.17175