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RESEARCH ARTICLE

Knowledge, attitudes, and practices of pregnant women regarding COVID-19 vaccination in pregnancy in 7 low- and middle-income countries: An observational trial from the Global Network for Women and Children's Health Research

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Abstract

Objectives: We sought to determine the knowledge, attitudes and practices of pregnant women regarding COVID-19 vaccination in pregnancy in seven low- and middle-income countries (LMIC).

Design: Prospective, observational, population-based study.

Settings: Study areas in seven LMICs: Bangladesh, India, Pakistan, Guatemala, Democratic Republic of the Congo (DRC), Kenya and Zambia.

Population: Pregnant women in an ongoing registry.

Methods: COVID-19 vaccine questionnaires were administered to pregnant women in the Global Network's Maternal Newborn Health Registry from February 2021 through November 2021 in face-to-face interviews.

Main outcome measures: Knowledge, attitude and practice regarding vaccination during pregnancy; vaccination status.

Results: No women were vaccinated except for small proportions in India (12.9%) and Guatemala (5.5%). Overall, nearly half the women believed the COVID-19 vaccine is very/somewhat effective and a similar proportion believed that the COVID-19 vaccine is safe for pregnant women. With availability of vaccines, about 56.7% said they would get the vaccine and a 34.8% would refuse. Of those who would not get vaccinated, safety, fear of adverse effects, and lack of trust predicted vaccine refusal. Those with lower educational status were less willing to be vaccinated. Family members and health professionals were the most trusted source of information for vaccination.

Conclusions: This COVID-19 vaccine survey in seven LMICs found that knowledge about the effectiveness and safety of the vaccine was generally low but varied. Concerns about vaccine safety and effectiveness among pregnant women is an important target for educational efforts to increase vaccination rates.

KEYWORDS
COVID-19, low- and middle-income countries, pregnancy, vaccination

Tweetable abstract: The COVID-19 vaccine survey in seven LMIC indicates that the knowledge of pregnant women about the effectiveness and safety of the vaccine was generally low and a third of the women did not plan to be vaccinated.

1 | INTRODUCTION

COVID-19 infection, a severe acute respiratory syndrome, was declared a global pandemic by the World Health Organization (WHO) in March 2020.[1] The pandemic has resulted in severe illness and death among millions of people globally.[1,2] Various COVID-19 vaccination trials have shown greater than 90% effectiveness in preventing severe COVID-19 disease and death.[3–5] World-wide, 66% of the population have received at least one dose of the COVID-19 vaccine and widespread vaccination programmes are in progress.[1] Nevertheless, vaccination rates, especially in some low- and middle-income countries (LMIC), are low, with the Africa region having the lowest vaccination rates globally. Several challenges to vaccination are present, one of which is vaccine refusal, defined as an individual or group decision to refuse vaccination, given an opportunity for vaccination.[6] Understanding the influences behind vaccine refusal is critical, as low vaccine coverage will likely result in increased illness, death and the emergence of new variants threatening immunity conferred by vaccines.

In a systematic review, vaccine acceptance in the general population was significantly higher in some LMICs (80.3%) compared with higher income countries (HICs) such as the USA (64.6%) and Russia (30.4%).[7] In another survey of 16 HIC and LMICs, the strongest predictors of vaccine acceptance in pregnant women included confidence in vaccine safety, perception of low risk, general compliance with preventive measures, monitoring of COVID-19 news, and trust in public health agencies.[8] However, most studies performed to date have disproportionately represented HIC and higher-educated participants, and data for women in lower socioeconomic settings remain limited. The lack of knowledge and low level of acceptance for COVID-19 vaccination remains a major concern to achieve herd immunity.

Vaccination during pregnancy is an important opportunity when women generally enter the health system and can improve vaccine coverage in the population. In August 2021, the U.S. Centers for Disease Control and Prevention (CDC) released data on the safety of COVID-19 vaccines in pregnant women and encouraged vaccination among women planning for pregnancy, during breastfeeding and during pregnancy.[9] Data suggest that the benefits of COVID-19 vaccination outweigh any known or potential risks during pregnancy.[10] According to the CDC, no evidence suggests that vaccination would cause harm during pregnancy or

that there are any safety concerns regarding pregnancy or newborn outcomes.[9–11] The World Health Organization authorized COVID-19 vaccination for pregnant women soon after this. Despite the availability of COVID-19 vaccines, limited information is available about knowledge, attitudes and practices of pregnant women related to COVID-19 vaccines in LMIC.[12]

To date, there have been few, if any, population-based studies of pregnant women regarding COVID-19 vaccine from LMICs based on prospectively collected data.[13–17] This study presents results of a survey on pregnant women's knowledge, attitudes and practices related to COVID-19 vaccine effectiveness, safety and willingness to be vaccinated. The study findings should help public health authorities to identify and mitigate potential obstacles for having a successful COVID-19 vaccination programme in women intending to become pregnant and among pregnant women.

2 | METHODS

This study was undertaken as an initiative of the Global Network for Women and Children's Health Research (Global Network), a multi-country research network funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD).[18] The COVID-19 vaccine study was nested within the Global Network's Maternal and Neonatal Health Registry (MNHR). The MNHR is a prospective, population-based observational study that includes all pregnant women, their newborns and their outcomes in defined geographic communities (clusters).[19] Each cluster includes approximately 500 births annually, with 8–10 clusters available at each of the Global Network sites in western Kenya, Zambia (Kafue and Chongwe), the Democratic Republic of the Congo (DRC) (North and South Ubangi Province), Pakistan (Thatta in Sindh Provence), India (Belagavi and Nagpur), Guatemala (Chimaltenango) and Bangladesh (District Tangail). The MNHR has been ongoing in all sites since 2009, except for the DRC, which joined in 2014, and the Bangladesh site, which joined in 2018.

The COVID-19 vaccine survey was initiated as part of the MNHR in February 2021, as COVID-19 vaccination was initially approved, and is ongoing. The initiation dates of the KAP vaccination survey varied among the sites. All women who were enrolled within the MNHR sampling frame were eligible to be approached to participate in the vaccine survey, and of the 45.6% (n = 13 105) approached, 98% provided consent. For this analysis, we used vaccine-related survey data collected at the first prenatal visit from February 2021 through November 2021. Data from the two Indian sites were similar and were combined. The questionnaire asked about women's beliefs regarding vaccine effectiveness and safety. We also asked about willingness to receive the COVID-19 vaccine and, for those not willing to receive the vaccine, the reasons for their refusal.

We used a separate questionnaire to ascertain vaccination status at delivery. The vaccination status questions were collected starting at different times across the sites beginning in early 2021. Data in the system as of 11 November 2021 are included in this report.

2.1 | Statistical analysis

The analysis population includes women screened for the MNHR who were eligible, consented and had completed the COVID-19 vaccine KAP questionnaire. Data analyses were done using SAS ENTERPRISE GUIDE version 9.4 (SAS Institute Inc.). We present results in frequencies and percentages. Simple statistics were used to determine significant differences in the distribution of knowledge, attitudes and practices related to the COVID-19 vaccine. To assess the factors associated with being unwilling to be vaccinated for COVID-19, we evaluated relative risks (RR) and 95% confidence intervals (95% CI) using log-binomial models with generalised estimating equations to account for the correlation of outcomes within cluster. Unwillingness to receive a COVID-19 vaccination is modelled for each factor independently, accounting for site and the interaction of factor and site.

2.2 | Ethical considerations

This study was reviewed and approved by ethics review committees of all participating sites: INCAP, Guatemala; University of Zambia, Zambia; Moi University, Kenya; Aga Khan University, Pakistan; KLE University's Jawaharlal Nehru Medical College, Belagavi, India; Lata Medical Research Foundation, Nagpur, India, Kinshasa School of Public Health, Democratic Republic of the Congo, and the International Centre for Diarrhoeal Disease Research, Bangladesh. The Institutional Review Boards at each US partner university and the Data Coordinating Center (RTI International) also approved the protocol. All women provided informed consent for participation in the study and data collection.

3 | RESULTS

From February through November 2021, the COVID-19 vaccine questionnaires were completed for 13 105 pregnant women. The number of surveys completed at each site ranged from 368 in the DRC to 2316 in Pakistan. Table 1 presents the maternal demographic characteristics by site. Most of the women across all the sites were in the age group 20–35 years and were educated at the primary and secondary level, except for Pakistan, where 81% of women were illiterate. Slightly more than 40% (41.8%) of the women at all sites were ≤13 weeks pregnant at the time of enrolment in the MNHR; 33.7% had a parity of 0, 45.4% had a parity of 1 to 2, and 20.9% had a parity of ≥3.

TABLE 1 Maternal enrolment in the COVID-19 vaccine study and demographic characteristics by site

	Overall	DRC	Zambia	Kenya	Guatemala	India	Pakistan	Bangladesh
Women, *n*	13 105	368	2205	2133	987	2821	2316	2275
Age (years)								
<20 (%)	15.6	20.4	21.8	19.5	18.3	7.6	4.3	25.3
20–35 (%)	79.0	68.4	70.3	74.9	72.4	91.7	88.6	70.4
≥36 (%)	5.4	11.2	7.9	5.6	9.2	0.7	7.0	4.3
Maternal level of education								
No formal schooling, illiterate (%)	19.6	33.2	8.3	1.2	8.1	3.9	81.2	7.3
Primary/secondary (%)	72.4	66.3	88.7	88.8	84.0	78.6	17.3	85.8
University+ (%)	8.0	0.5	3.0	10.0	7.9	17.5	1.5	7.0
GA at enrolment (weeks)								
≤13 (%)	41.8	23.5	13.3	25.1	51.8	74.6	45.2	38.1
14–28 (%)	38.6	58.5	44.7	55.2	37.0	9.5	36.5	54.1
≥29 (%)	19.6	18.1	42.0	19.7	11.2	15.8	18.2	7.7
Parity								
0 (%)	33.7	20.7	31.4	32.9	35.5	40.6	3.8	39.7
1–2 (%)	45.4	29.6	43.5	42.1	44.4	54.0	33.5	54.6
≥3 (%)	20.9	49.7	25.1	25.1	20.2	5.4	42.7	5.7

TABLE 2 Women vaccinated and not vaccinated for COVID-19 prior to delivery by site

Characteristic	Overall, *n* (%)	DRC	Zambia	Kenya	Guatemala	India	Pakistan	Bangladesh
Vaccination status reported prior to delivery	6175	209	831	434	1277	1307	168	1949
Vaccinated (%)	3.9	0.0	0.0	0.0	5.5	12.9	0.0	0.0
Not vaccinated (%)	96.1	100.0	100.0	100.0	94.5	87.1	100.0	100.0

TABLE 3 Beliefs about COVID-19 vaccine effectiveness and safety by site

Characteristic	Overall	DRC	Zambia	Kenya	Guatemala	India	Pakistan
Women, *n*	13 105	368	2205	2133	987	2821	2316
Knowledge about COVID-19 vaccination							
Effectiveness, *n*							
Very effective (%)	29.2	29.6	48.1	17.4	35.9	48.8	17.4
Somewhat effective (%)	21.7	4.3	27.4	20.0	22.2	23.2	24.3
Not very effective (%)	12.5	2.7	8.3	16.5	19.3	2.6	33.2
Do not know (%)	36.6	63.3	16.2	46.1	22.6	25.5	25.1
Safe for pregnant women (%)	22.8	30.7	36.9	11.8	28.8	35.5	16.2
Safe for a woman trying to get pregnant (%)	31.4	53.5	52.6	23.9	35.8	44.4	17.3

Using a separate questionnaire administered at delivery, with data collection starting variably from February to June 2021, we collected data by site on the vaccination status of 6175 women at the time of the delivery. For this study component, the last date of data collection was 11 November 2021. Up to that date, the only sites in which any women had received COVID-19 vaccinations were in India (12.9%) and Guatemala (5.5%) (Table 2).

Table 3 describes the knowledge and attitudes of the women towards COVID-19 vaccination. Overall, 29.2% of pregnant women considered the COVID-19 vaccine to be very effective and 21.7% believed the vaccine to be somewhat effective in preventing COVID-19 infection. The belief about the effectiveness of the COVID-19 vaccine varied widely across the sites, with a high of about 48.8% of the women in India and 48.1% in Zambia to a low of 6.9% of the women in Bangladesh believing the vaccine to be very effective. Overall, more than a third of women (36.6%) described having no information on the effectiveness of the COVID-19 vaccine for prevention of COVID-19 infection. Of the

women from Bangladesh, 74.6% claimed not to know about vaccine effectiveness, as did 63.3% from the DRC, and 46.1% from Kenya, compared with 25% or fewer of the women from the other sites. Overall, 22.8% of women perceived that the vaccine was safe for pregnant women, whereas 31.4% considered the vaccine safe for women who were trying to get pregnant. As with beliefs about effectiveness, there was a wide range in beliefs about safety, with only 6.4% of the women in Bangladesh believing it safe to be vaccinated in pregnancy compared with about 35% of those surveyed in India and Zambia.

Table 4 presents data about practice including the willingness of the women in the various sites to be vaccinated with the COVID-19 vaccine. Overall, 56.7% of women stated that they would get the vaccine if available, with wide variations among the sites; in Pakistan, only 30.0% of the women surveyed would get the vaccine, compared with 71.2% in Zambia and 80.4% in India. Overall, 8.7% of those surveyed were unsure about whether or not they would get vaccinated. Nearly 75% of the women were willing to pay for the vaccine if not available free of cost. However, more than one-third of the women (34.8%) said they would not get the vaccine, again with wide variation among the sites. Reasons given for not wanting to be vaccinated included not being sure of the safety (30.6%), fear of adverse effects (25.1%), not being sure of effectiveness (16.3%) and lack of trust (25.0%). Of the women who were unsure whether they would get the vaccine (8.5%), most stated they would like to discuss the issue with family members (58.7%) and health professionals (42.7%) to make the final decision (data not shown).

Table 5 presents the relative risks and 95% confidence intervals for unwillingness to be vaccinated from log-binomial models with generalised estimating equations to account for the correlation of outcomes within clusters. Among the sites, compared with India, women in Pakistan were nearly 50% more unwilling to be vaccinated, whereas the women in Guatemala were less unwilling (RR 0.31, 95% CI 0.17–0.55) to be vaccinated. Compared with women 20–35 years of age, women <20 years of age in the DRC and Kenya were more unwilling to be vaccinated. Compared with women with a university education, women with no formal education or who were illiterate in the DRC, Guatemala, India, Pakistan and Bangladesh were more unwilling to be vaccinated. Compared with women of parity 1–2, nulliparous women in Zambia and Kenya were more unwilling to be vaccinated, as were women of parity ≥3 in India.

4 | DISCUSSION

This study is among the first comprehensive analysis of COVID-19 vaccine knowledge, attitude and practice surveys on pregnant women in multiple LMICs.[20] Overall, knowledge regarding safety and effectiveness related to the COVID-19 vaccine was low and, at the time of the survey, many women planned not to be vaccinated even if vaccines were available to them. To understand some of the context in which the vaccine survey was performed, we also evaluated the proportion of women at each site who were vaccinated at delivery. In our sites, at delivery, only the pregnant women in India (12.9%) and Guatemala (5.5%) had received any COVID-19 vaccinations and the proportion of women vaccinated in those sites was small.

4.1 | Main findings

Of the 13 105 women in the seven countries who were surveyed, 29.2% believed the vaccine to be very effective in preventing a COVID-19 infection and another 21.7% believed the vaccine to be somewhat effective. Importantly, 36.6% of the women claimed not to have any information about whether the COVID-19 vaccine was effective. There was wide variation among the sites in women's belief

TABLE 4 Willingness or unwillingness of pregnant women to receive the COVID-19 vaccination by site and the reasons for not wanting to be vaccinated

Characteristics	Overall	DRC	Zambia	Kenya	Guatemala	India	Pakistan	Bangladesh
Women, *n*	13 105	368	2205	2133	987	2821	2316	2275
Will get vaccinated if available and eligible (%)	56.7	53.3	71.2	49.2	49.9	80.4	30.0	50.9
Will not get vaccinated (%)	34.8	39.0	28.4	40.6	37.3	12.1	68.7	27.5
Do not know if will get vaccinated, *n* (%)	8.5	7.7	0.4	10.2	12.8	7.5	1.3	21.6
Willing to pay fee if vaccination not free (%)	74.9	63.1	84.6	68.5	66.3	87.1	36.1	72.7
Reasons to not get vaccinated								
Not sure of safety (%)	30.6	4.2	28.1	36.3	25.5	25.1	22.8	57.5
Not sure of effectiveness (%)	16.3	8.4	28.0	23.1	13.0	12.6	10.8	14.9
Fear of adverse effects (%)	25.1	11.9	13.1	29.7	49.5	48.2	19.3	21.4
Lack of trust in vaccine (%)	25.0	8.4	29.2	12.3	6.0	2.3	47.4	8.8
Religious belief (%)	1.7	1.4	0.5	0.0	2.4	2.6	0.1	8.5
Other	3.2	64.3	1.1	0.5	2.7	9.1	0.0	0.5

TABLE 5 Relative risk and 95% confidence intervals for being unwilling to be vaccinated by site and maternal characteristics[a]

	DRC	Zambia	Kenya	Guatemala	India	Pakistan	Bangladesh
Site	1.02 (0.70–1.48)	0.91 (0.50– 1.66)	1.01 (0.79– 1.29)	0.31 (0.17–0.55)	Ref	1.47 (1.10–1.96)	0.58 (0.32–1.07)
Age (years)							
<20	1.11 (1.02–1.21)	1.21 (0.94–1.56)	1.13 (1.03–1.25)	1.05 (0.73–1.51)	0.94 (0.83–1.06)	0.91 (0.81–1.01)	1.04 (0.90–1.19)
20–35	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥36	1.10 (0.92–1.33)	1.11 (0.84–1.48)	0.98 (0.76–1.26)	0.77 (0.30–1.99)	0.99 (0.94–1.05)	0.99 (0.95–1.05)	1.00 (0.87–1.15)
Maternal level of education							
No formal schooling—illiterate	1.37 (1.03–1.82)	0.72 (0.25–2.08)	1.22 (0.76–1.96)	3.23 (1.79–5.84)	1.42 (1.17–1.73)	1.81 (1.04–3.15)	1.72 (1.11–2.67)
Primary/secondary	1.21 (0.96–1.53)	0.60 (0.19–1.87)	1.16 (0.81–1.66)	1.38 (0.94–2.02)	1.18 (1.05–1.33)	1.65 (1.00–2.74)	1.44 (0.87–2.37)
University+	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Parity							
0	1.05 (0.99–1.11)	1.33 (1.01–1.74)	1.26 (1.05–1.52)	0.95 (0.68–1.32)	1.00 (0.89–1.12)	0.97 (0.91–1.04)	1.07 (0.98–1.18)
1–2	Ref	Ref	Ref	Ref	Ref	Ref	Ref
≥3	1.10 (0.98–1.24)	1.16 (0.94–1.44)	1.09 (0.86–1.38)	1.36 (0.87–2.11)	1.10 (1.01–1.21)	1.02 (0.99–1.06)	1.04 (0.97–1.11)

[a]Relative risks and 95% confidence intervals from log-binomial models with generalised estimating equations to account for the correlation of outcomes within cluster. Unwillingness to receive a COVID-19 vaccination is modelled for each factor independently, accounting for site and the interaction of factor and site. Presented RR (95% CI) are for the interaction of factor and site to capture site-specific RRs.

regarding vaccine effectiveness, with only 6.9% of the women in Bangladesh believing the vaccine to be very effective compared with about 48% in India and Zambia. In Bangladesh, 74.5% of the women claimed not to know about vaccine effectiveness compared with 16.2% in Zambia. Overall, 31.4% of the women believed the vaccine was safe for a woman trying to get pregnant, and 22.8% believed vaccination was safe during pregnancy. As with beliefs about effectiveness, there was a wide range in beliefs about safety, with only 6.4% of the women in Bangladesh believing it safe to be vaccinated in pregnancy compared with about 35% of those surveyed in India and Zambia.

Overall, 56.7% of the women stated they would get the vaccine if available and they were eligible, again with a wide range among the sites; in Pakistan, only 30.0% of the women surveyed would get the vaccine compared with 71.2% in Zambia and 80.4% in India. Among the 34.8% of women who would not get vaccinated, reasons for not getting vaccinated included concerns about safety, lack of trust in the vaccine, fear of adverse effects and concerns about effectiveness.

The association of maternal characteristics to being unwilling to be vaccinated varied among the sites. Among the sites, women in Pakistan were the most unwilling to be vaccinated, whereas the women in Guatemala were the least unwilling to be vaccinated. Women of low educational status were generally more unwilling to be vaccinated.

4.2 | Interpretation

The findings of our study are generally consistent with a study conducted in pregnant women in 16 countries with a high incidence of COVID-19 cases, which found that the strongest predictors related to vaccine acceptance were lack of confidence in vaccine safety, effectiveness, and trust of public health authorities.[13] Our vaccine survey suggests that family members and health professionals are those to whom the women would turn to for advice related to COVID-19 vaccination. A Jordanian survey found a similar percentage of women who consulted health professionals about getting vaccinated.[16] However, in a similar study, only a small percentage (3.1%) of women believed that they would consult a family member. Considering all available data, a major educational effort will likely be needed in most sites to achieve high rates of vaccination.

We have considered why, across the Global Network sites, only a small percentage of women were vaccinated. First, as pregnant women were not initially included in the vaccine development trials, they were also not included in the government awareness initiatives. The introduction of the vaccine generally followed a phased approach. For example, in the first phase, the COVID-19 vaccine was usually offered to healthcare workers, and then to the elderly population. Just as pregnant women were not included in the initial COVID-19 vaccination trials, they were also not included in the public health awareness campaigns. The late inclusion of pregnant women in the awareness agenda and lack of guidance from public health officials and providers also likely led to a lack of trust and low level of knowledge around vaccine effectiveness and safety during pregnancy. To increase pregnant women's confidence in COVID-19 vaccine safety and to accelerate the vaccine uptake, we believe that educational campaigns focusing on pregnant women are needed.

In summary, the COVID-19 vaccination survey documented that pregnant woman from seven participating

LMIC had variable knowledge related to the COVID-19 vaccine. A low percentage of pregnant women across all participating sites were vaccinated. Nearly half the women surveyed believe the COVID-19 vaccine is very or somewhat effective and a similar proportion of the women believe that the COVID-19 vaccine is safe for pregnant women and women trying to conceive. With the availability of vaccines, about 50% of women believe they would get the vaccine. Of those who would not get the vaccine, vaccine safety, adverse effects and lack of confidence are the important predictors for refusal of vaccine. Family members and health professionals were identified by the pregnant women as the most trusted source of information about the COVID-19 vaccine.

4.3 | Strengths and limitations

Our paper has some limitations and some strengths. Among the strengths are the large sample size, population-based data from seven LMICs, multiple sites, and prospective on-going data collection with standard data collection protocols used across the sites. One of the weaknesses is the variation in the start of data collection among the sites, which may have been associated with perceptions of COVID-19 vaccination. Another limitation was the lack of available data about the status of the pandemic in each site, the ongoing educational efforts in each site and our limited knowledge of how each of these factors influences women's knowledge, attitudes and practices related to COVID-19 vaccination acceptance.

5 | CONCLUSIONS

Knowledge about COVID-19 vaccination is limited and highly variable among pregnant women in the Global Network sites. It appears that a major educational effort may be needed to help achieve high rates of vaccination. To improve coverage of the COVID-19 vaccine, it is critical that pregnant women have sufficient knowledge about effectiveness and safety.

AUTHOR CONTRIBUTIONS

FN, SN, SS and RLG wrote the first draft of the paper. FN, SN, SS, ALG, NP and EMM developed the protocol. EF, EN and VT conducted study analyses. FN, SN, SS, NP, LF, MM, ALG, AP, PD, AK, SSG, FE, EC, AL, AT, RH, SSi, SY, MB, EAL, NFK, RJD, WAC, WAP, PLH, MK-T, EMM and RLG oversaw study implementation and monitoring. All authors reviewed and approved the manuscript.

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CONFLICT OF INTEREST

Authors declare no conflicts of interest.

ETHICS STATEMENT

This study was approved by ethical 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 DRC (FWA 00003581); 5 August 2021; University of Alabama at Birmingham, US (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

The study data will be publicly 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.

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