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# Cesarean section rate and outcomes during and before the first wave of COVID-19 pandemic

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## Abstract

**Objectives:** The objective of the study was to assess how the current COVID-19 pandemic has affected cesarean section (C-section) rates, indications, and peripartum outcomes.

**Methods:** This was a retrospective cross-sectional study that compared a 3-month rates of and indications for C-sections at three tertiary health care institutions in Nigeria before (October 2019–December 2019) and during the first wave of COVID-19 pandemic (March 2020–May 2020). Primary outcomes were C-section rate and indications between the two

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periods. Data were analyzed using SPSS 26.0 IBM Corporation. Rates and odds ratios with 95% confidence intervals were used to quantify indications and peripartum outcomes and statistical significance was accepted when p value was $<0.05$.
**Results:** The baseline characteristics of the two groups were similar. The C-section rate during the COVID-19 period was significantly less than the period prior to the pandemic (237/580, 40.0% vs 390/833, 46.8%; p = 0.027). The rates of postdatism (odds ratio = 1.47, 95% confidence interval = 1.05–2.05, p = 0.022), fetal distress (odds ratio = 3.06, 95% confidence interval = 1.55–6.06, p = 0.017), emergency C-section (odds ratio = 1.43, 95% confidence interval = 1.01–2.05, p = 0.042), and anemia (odds ratio = 1.84, 95% confidence interval = 1.12–3.03, p = 0.016) were significantly higher during the pandemic than prepandemic.
**Conclusion:** The overall C-section rate during the first wave of COVID-19 was significantly lower than the prepandemic period. There were higher rates of postdatism, fetal distress, emergency C-section, and postpartum anemia. Further studies on this changing C-section trend during the pandemic are needed.

**Keywords**
Cesarean section rate, COVID-19, lockdown, pregnant women, SARS-CoV2

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## Introduction

A number of pneumonia cases of unknown causes were noticed in Wuhan, Hubei province, China, in December 2019.[1] This was later isolated as a novel coronavirus that was identified as severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) that is different from other common respiratory viruses.[2,3] It was later named COVID-19 (coronavirus disease of 2019) by the World Health Organization (WHO) in February 2020.[4] This virus rapidly spread throughout the world and was declared a pandemic in March 2020 by the WHO.[3,5–7] On 27 February 2020, Nigeria recorded its first case of COVID-19 in an Italian national who flew to Nigeria through Milan, Italy, and the disease has spread to all the states of Nigeria causing many deaths.[7] It has also put pressure on the scarce health care resources in Nigeria.

Its mode of transmission is known to be through contact in the form of respiratory droplets, though airborne transmission has not been totally ruled out.[1,8] The Nigerian Centre for Disease Control recommended handwashing, social distancing of at least 2 m apart, and the use of face masks as means of reducing the spread of the disease. There were also restrictions to performing elective surgical procedures. This has negatively affected the quality of health delivery as the majority of scarce resources are channeled toward controlling and containing the spread of COVID-19. This led to cancelation of procedures with its emotional and psychological effects on the patients.

Labor presents a unique scenario in the COVID-19 pandemic, as most hospital admissions are anticipated and the timing of many admissions to the hospital is planned.[9] In anticipation of likely hospital admission at time and to limit the risk of exposure, pregnant women are often instructed to discontinue work or begin working from home a minimum of 2 weeks before the anticipated date of delivery and to practice strict social isolation during this time, especially for those who can or where it is permissible. For most women, this is initiated at about 37 weeks of gestation.[9]

Pregnant women with COVID-19 who deliver by cesarean section (C-section) may be at greater risk of complications that affect them and their babies.[10] C-section should be done only when there is an indication for it outside COVID-19.[9,10] The coronavirus crisis is throwing many pregnant women's birth plans up in the air and leading some health trusts to increase home births in high-income countries.[10] Previous evidence has been conflicting regarding the effect of COVID-19 pandemic lockdowns on obstetric intervention[7,9,10] and a recent Spanish study by Mariño-Narvaez et al. recommended more novel studies on the impact of the pandemic on C-sections.[11]

To the best of our knowledge, data on the impact of COVID-19 pandemic on C-section rates, indications, and perinatal outcomes are scarce globally and none currently in Nigeria. Such study is important in the global understanding and reporting of the impact of COVID-19 pandemic on cesarean births. This study was aimed at assessing how COVID-19 pandemic has affected the rates, indications, and outcomes of C-section before and during COVID-19 pandemic.

## Methods

### Study design

This is a retrospective cross-sectional comparative study.

### Study population

The study was conducted among pregnant women who had deliveries prior to and during the first wave of COVID-19 pandemic.

### Study site

Study sites were Obstetrics and Labor ward of Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria;

University of Nigeria Teaching Hospital, Ituku Ozalla, Nigeria; and Enugu State University Teaching Hospital, Parklane, Enugu, Nigeria. These hospitals have many consultant obstetricians, trainee doctors (registrars and senior registrars), and ancillary medical staff. They are training centers for medical postgraduate studies and they have isolation centers for the treatment of COVID-19-positive patients in Nigeria. These hospitals have between 5000 and 10,000 deliveries per year and are government-funded referral centers for maternal and newborn care. They provide comprehensive emergency obstetric care and serve as major referral centers for maternal and childcare services in south-eastern Nigeria. Surgical attendants were protected with surgical masks, caps, gowns, sterile gloves, and face shields during surgery. The choice of surgical mask type and face shield was subject to the availability of equipment and discretion of the medical staff and surgeons. Only essential personnel remained in the operating room during patient intubation/extubation procedure. These hospitals do not have a negative-pressure operating theater and high-efficiency particulate air filter was not available in the operating rooms. Since none of the women presented with COVID-19 symptoms, reverse transcriptase-polymerase chain reaction (RT-PCR) and antibody testing had not been performed preoperatively in the study centers at the time of the study. According to the hospitals' protocol, PCR test was not performed on all elective and emergency pregnant women to be taken for cesarean section. Only patients who were symptomatic or clinically suspected were tested for COVID-19. Samples of such tests were collected and sent to the Testing Hospital which was more than 400 km away from the study hospitals.

### *Eligibility criteria*

*Inclusion criteria.* This included women who underwent C-section 3 months before the COVID-19 pandemic (from 1 October 2019 to 31 December 2019) and 3 months during the first wave of COVID-19 pandemic (1 March 2020–30 May 2020).

*Exclusion criteria.* Pregnant women who had uterine rupture or ectopic pregnancy or molar pregnancy were excluded from the study. The cases of missing or incomplete data were also excluded from the study.

*Sample size determination.* The sample size was obtained using the formula $N = Z^2 \alpha PQ / d^2$, where Z = standard normal deviation at 95% confidence interval, P = proportion in the target population = 0.188 (based on prevalence of C-section in a previous study in Nnewi, Nigeria),[12] $Q = 1 - p$, and $d = 0.05$. The ultimate was adjusted to allow a noninferiority sample size of 234 obtained and rounded up to 258 to cater for 10% attrition. Therefore, a minimum of 627 women who had C-section were seen for both of pre- and intra-COVID-19 era.

*Sample technique.* It was a non-random sampling approach. All available case files were examined.

*Study outcome measures.* Study outcome measures were C-section rates, indications for C-sections, maternal outcomes of C-section, and perinatal outcomes of C-section.

*Procedures involved.* The main theater, labor ward, and obstetrics theater records were reviewed to identify women who underwent C-section during the study period. The patients' case records were then retrieved from the hospitals' medical record department. For the obstetric variables, data were extracted from the Maternity Registers and medical records by trained data collectors using a data retrieval form. The patients' sociodemographic, booking status, indication for the C-section, birth weight, perinatal outcome, and operative/postoperative complications were retrieved from the patients' case notes and analyzed. If more than one indication or complication was found for the cases that had C-section, the main indication or worst outcome was used for analysis. Completed forms were then assessed by a data coordinator at the hospital for completeness and accuracy before being entered digitally into the Excel spreadsheet by the data entry and management team.

*Statistical analysis.* The gleaned data were exported to Statistical Package for Social Sciences (SPSS) version 26 (IBM Corp.) for analysis. We used descriptive statistics to compare the socioeconomic and obstetric characteristics of women pre- and during COVID-19 era, and applied the Pearson chi-squared test for categorical variables to determine statistically significant differences between the groups. Rates and odds ratios (ORs) with 95% confidence intervals (CIs) were used to quantify indications and peripartum outcomes and statistical significance was accepted when p value was less than 0.05. All significance tests were two sided.

### *Ethical approval*

Informed consent was not sought for the present study because it was a retrospective study of cases. The study was approved by the ethics review board of NAUTH, Nnewi, Nigeria (Reference No. NAUTH/CS/66/VOL.13/VER III/46/2020/038 26-2017; date of approval: 31 July 2020) and the other two hospitals (Reference Nos. UNTH/CSA/329/VOL.5; ESUTHP/C-MAC/RA/034/VOL.1/293). The study was conducted according to the Helsinki declarations on ethical principles for medical research involving human subjects.

## Results

In total, 1413 deliveries and 627 C-sections met the eligibility criteria for the study. Segmentally, prior to COVID-19,

**Table 1.** The deliveries according to study sites.

| Center | During COVID-19 (N = 580) | | Pre-COVID-19 (N = 833) | | OR (95% CI) | p value |
|---|---|---|---|---|---|---|
| | Vaginal (%) | CS (%) | Vaginal (%) | CS (%) | | |
| 1. ESUT | 211 (58.9) | 147 (41.1) | 272 (52.6) | 245 (47.4) | 0.78 (0.59–1.02) | 0.064 |
| 2. NAUTH | 79 (59.8) | 53 (40.2) | 101 (53.4) | 88 (46.6) | 0.77 (0.49–1.20) | 0.255 |
| 3. UNTH | 53 (58.9) | 37 (41.1) | 70 (55.1) | 57 (44.9) | 0.86 (0.50–1.48) | 0.581 |
| Total | 343 | 237 | 443 | 390 | 0.79 (0.63–0.97) | 0.027* |

Values are expressed as number (percentage) of women. CS: cesarean section; ESUT: Enugu State University of Science and Technology; NAUTH: Nnamdi Azikiwe University Teaching Hospital; UNTH: University of Nigeria Teaching Hospital.
*Statistically significant.

there were 833 deliveries, 390 of which were delivered by C-section, giving a C-section rate of 46.8%. By contrast, during the COVID-19 period, there were 580 deliveries and 237 women had C-section, giving a C-section rate of 40.0%. This is illustrated in Table 1. The observed difference was statistically significant (p = 0.027).

Twenty cases of C-section (3.2%) were excluded because their case files did not have complete information for the study. Overall, only 379 and 228 case files were available with complete information for the study in the pre-COVID-19 and during the COVID-19 period, giving a full information retrieval rate of 97.2% and 96.2%, respectively. The flow chart of the women is shown in Figure 1. None of the women studied was tested for COVID-19.

Table 2 shows the baseline demographic and clinical characteristics of the participants. The baseline characteristics of the two groups were similar. The indications for the C-section that occurred during the COVID-19 period, compared with pre-COVID-19 period, are reported in Table 3. Fetal distress (OR = 3.06, 95% CI = 1.55–6.06, p = 0.017) was significantly higher during COVID-19 period. There was no difference in the rate of failed induction of labor (1.3% vs 1.3%; OR = 0.99, 95% CI = 0.24–4.21, p = 0.997).

Peripartum and puerperal outcomes of C-sections that occurred during the COVID-19 period, compared with pre-COVID-19 period, are presented in Table 4. Postdatism (OR = 1.47, 95% CI = 1.05–2.05, p = 0.022) and anemia (OR = 1.84, 95% CI = 1.12–3.03, p = 0.016) were significantly higher during the COVID-19.. On the contrary, the differences in the rates of other peripartum and puerperal outcomes, including wound infection, puerperal sepsis, emergency C-section, newborn special care admission, absence of 6 weeks postnatal visit, and use of spinal anesthesia, did not reach any statistical significance ($p > 0.05$).

## Discussion

In this study, we assessed how COVID-19 pandemic has affected the rates, indications, and outcomes of C-section when compared with periods before the COVID-19 pandemic. Our study indicates that there were significant differences in C-section rates, some indications, outcomes, and complications between women who were managed during the first wave of COVID-19 pandemic and pre-COVID-19 period. Although Enugu State University of Science and Technology (ESUT) Teaching Hospital had the highest number of deliveries in both years, there were no significance differences in cesarean section rates facility-wise during the two periods of study. However, during the first wave of COVID-19, there were significantly more women delivering at a later gestational age (⩾40 weeks).

There was an overall significant decline in C-section rates from 46.8% in the pre-COVID-19 period to 40.0% during the COVID-19 period (p = 0.027). Similar finding was observed in a recent study by Einarsdóttir et al. on Icelandic obstetric population.[13] On the contrary, a recent analysis of women delivering at New York City hospitals during the first wave of COVID-19 found C-section rates not significantly different compared with the pre-pandemic period.[14] Previous study has speculated that C-section rates are reduced in low- and middle-income countries due to indirect impacts of the COVID-19 pandemic on the healthcare system, although there is no evidence to support this speculation exists.[15] Expectedly, given the documented benefits of labor support, reducing access to labor care may increase the incidence of C-section rates.[16] Regarding the perspectives on surgery during the COVID-19 pandemic, Cohen et al.[17] and Coccolini et al.[18] suggested that each patient should be evaluated individually with added measures for dual protection of the patient and healthcare professionals.

In addition, one potential explanation for the decrease in C-section rate during the COVID-19 first wave period might be related to the restriction of movement and public transport during the pandemic. During the first wave, there were lockdown impositions and also reduction in earlier presentation for delivery during the period as majority presented at postdate period for delivery. However, presenting at postdate period could have allowed the majority of women to spontaneously go into labor during the waiting lockdown period. A majority of women in the country of study pay for health bills entirely from their pocket, and so lack of adequate funding support may have contributed.[19] Again, a majority of the

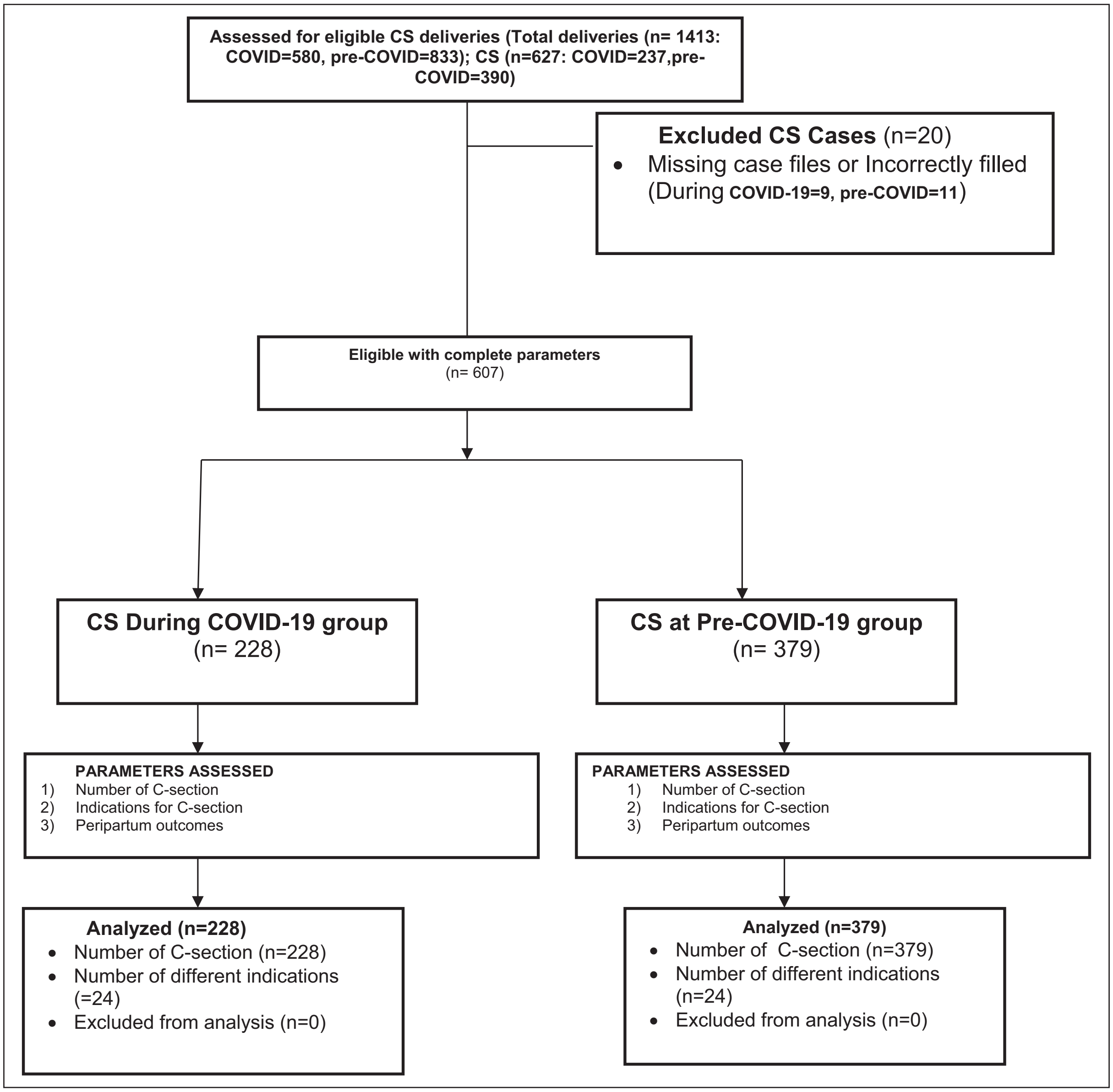


**Figure 1.** Flow chart of the participants.
CS: cesarean section.

population that depended on daily menial jobs for survival really suffered as the lockdown did not permit them to go out to do their jobs.

This foregoing explanation is also in line with a Brazilian study.[20] During the beginning of the COVID-19 quarantine in São Paulo, Brazil, it was observed that some hospitals noticed that some pregnant women, particularly those who were recommended to undergo elective C-sections for reasons such as repeated cesarean deliveries or abnormal fetal presentation, were admitted in the second stage of labor and then subsequently went on to have vaginal deliveries.[20] They further evaluated to know whether the quarantine period led to pregnant women with spontaneous labor arriving at the hospital in a more advanced phase of labor and concluded that their obstetrics population feared COVID-19 infection. As a result, the women underwent initial labor at home until their concerns about exposure were outweighed by their concerns regarding the well-being of their babies.[20]

Moreover, pregnant women may be reluctant to attend treatment at hospitals due to fear of exposure to COVID-19. In one study, it was reported that one-third of pregnant women started working from home due to fear of being infected with COVID-19.[21] This often led to delays in assessing health care. Previous reports revealed that delayed care in 12 children in Italy resulted in four deaths and outbreak on ST-segment-elevation myocardial infarction care in Hong Kong.[22–24]

Although the health personnel factors was not assessed in the present study, the reduction could be attributable to

**Table 2.** Baseline demographic and clinical characteristics of the participants.

| Parameter | During COVID-19 (N = 228) Frequency (%) | Pre-COVID-19 (N = 379) Frequency (%) | p value[a] |
|---|---|---|---|
| Age (years) | | | |
| 16–25 | 32 (14.0) | 58 (15.3) | |
| 26–30 | 64 (28.0) | 99 (26.1) | |
| 31–35 | 68 (29.8) | 112 (29.6) | 0.964 |
| 36–40 | 46 (20.2) | 75 (19.8) | |
| 41–45 | 15 (6.6) | 29 (7.7) | |
| 46–50 | 3 (1.3) | 6 (1.6) | |
| Educational level | | | |
| 1. None | 7 (3.1) | 11 (2.9) | |
| 2. Primary | 23 (10.1) | 40 (10.6) | |
| 3. Secondary | 120 (52.6) | 213 (56.2) | 0.626 |
| 4. Tertiary | 78 (34.2) | 116 (30.6) | |
| Booking status | | | |
| 1. Booked | 159 (69.7) | 265 (69.9) | |
| 2. Unbooked | 69 (30.3) | 114 (30.1) | 0.962 |
| Booking gestational age (weeks) | | | |
| 1. $<13$ | 22 (9.6) | 31 (8.2) | |
| 2. 13–28 | 105 (46.1) | 149 (39.3) | |
| 3. $>28$ | 101 (44.3) | 199 (52.5) | 0.147 |
| Parity | | | |
| 1. 1 | 57 (25.0) | 88 (23.2) | |
| 2. 2–4 | 149 (65.4) | 255 (67.3) | |
| 3. $\geqslant 5$ | 22 (9.6) | 36 (9.5) | 0.873 |
| HIV status | | | |
| 1. Positive | 12 (5.3) | 21 (5.5) | |
| 2. Negative | 216 (94.7) | 358 (94.5) | 0.884 |

Values are expressed as number (percentage) of women. CS: cesarean section; HIV: human immunodeficiency virus.
[a]By $\chi^2$ test.

**Table 3.** The indications for the cesarean section in the participants.

| Parameter | During COVID-19 (N = 228) Frequency (%) | Pre-COVID-19 (N = 379) Frequency (%) | OR (95% CI) | p value |
|---|---|---|---|---|
| 4. Two or more previous CS | 54 (23.7) | 84 (22.2) | 1.09 (0.74–1.61) | 0.665 |
| 5. Cephalopelvic disproportion | 18 (7.9) | 34 (9.0) | 0.87 (0.48–1.58) | 0.647 |
| 6. Failed VBAC | 14 (6.1) | 26 (6.9) | 0.89 (0.45–1.74) | 0.729 |
| 7. Severe preeclampsia/eclampsia | 39 (17.1) | 58 (15.3) | 1.14 (0.73–1.78) | 0.558 |
| 8. Fetal distress | 24 (10.5) | 14 (3.7) | 3.06 (1.55–6.06) | 0.001* |
| 9. Obstructed labor | 13 (5.7) | 24 (6.3) | 0.89 (0.45–1.79) | 0.753 |
| 10. Antepartum hemorrhage | 10 (4.4) | 26 (6.9) | 0.62 (0.29–1.32) | 0.215 |
| 11. Breech presentation | 5 (2.2) | 10 (2.6) | 0.83 (0.28–2.45) | 0.732 |
| 12. Failed induction | 3 (1.3) | 5 (1.3) | 0.99 (0.24–4.21) | 0.997 |
| 13. Multiple gestation | 10 (4.4) | 29 (7.7) | 0.55 (0.26–1.16) | 0.116 |
| 14. Prolonged PROM | 3 (1.3) | 7 (1.8) | 0.71 (0.18–2.77) | 0.620 |
| 15. Social reasons | 5 (2.2) | 5 (1.3) | 1.68 (0.48–5.86) | 0.418 |
| 16. Fetal macrosomia | 3 (1.3) | 12 (3.2) | 0.41 (0.11–1.46) | 0.168 |
| 17. Previous uterine rupture | 1 (0.4) | 3 (0.8) | 0.55 (0.06–5.34) | 0.608 |

*(Continued)*

**Table 3.** (Continued)

| Parameter | During COVID-19 (N = 228) Frequency (%) | Pre-COVID-19 (N = 379) Frequency (%) | OR (95% CI) | p value |
|---|---|---|---|---|
| 18. Sickle cell in primigravida | 2 (0.9) | 4 (1.1) | 0.83 (0.15–4.57) | 0.830 |
| 19. Fibroids in pregnancy | 2 (0.9) | 7 (1.1) | 0.47 (0.09–2.28) | 0.349 |
| 20. Poor biophysical profile | 2 (0.9) | 5 (1.3) | 0.66 (0.13–3.44) | 0.624 |
| 21. Malpresentation | 5 (2.2) | 7 (1.8) | 1.19 (0.37–3.79) | 0.767 |
| 22. Severe hypertension | 1 (0.4) | 2 (0.5) | 0.83 (0.08–9.21) | 0.880 |
| 23. RVD non-compliant on HAART | 3 (1.3) | 3 (0.8) | 1.67 (0.33–8.35) | 0.532 |
| 24. Persistent OPP | 4 (1.8) | 5 (1.3) | 1.33 (0.36–5.03) | 0.669 |
| 25. Uterine dehiscence | 1 (0.4) | 4 (1.1) | 0.41 (0.05–3.72) | 0.430 |
| 26. Hip dislocation | 0 (0.0) | 2 (0.5) | 0.33 (0.02–6.91) | 0.475 |
| 27. Others | 6 (2.2) | 3 (0.8) | 3.36 (0.83–13.57) | 0.089 |

Values are expressed as number (percentage) of women.
CS: cesarean section; VBAC: vaginal birth after CS; PROM: premature rupture of membranes; RVD: retroviral disease; HAART: highly active antiretroviral therapy; OPP: occipito-posterior position; 95% CI: 95% confidence interval; others: advanced breast cancer in pregnancy.
*Statistically significant.

**Table 4.** The perinatal and puerperal outcomes of the participants.

| Parameter | During COVID-19 (N = 228) Frequency (%) | Pre-COVID-19 (N = 379) Frequency (%) | OR (95% CI) | p value |
|---|---|---|---|---|
| Maternal complications | | | | |
| 1. Wound infection | 15 (6.6) | 22 (5.8) | 1.14 (0.58–2.25) | 0.699 |
| 2. Anemia | 36 (15.8) | 35 (9.2) | 1.84 (1.12–3.03) | 0.016* |
| 3. PPH | 7 (3.1) | 15 (4.0) | 0.77 (0.31–1.91) | 0.572 |
| 4. Puerperal sepsis | 6 (1.6) | 4 (1.1) | 2.53 (0.71–9.08) | 0.153 |
| 5. Hospital acquired pneumonia | 2# (0.9) | 3 (0.8) | 1.11 (0.18–6.69) | 0.910 |
| 6. None | 162 (71.1) | 300 (79.2) | 0.65 (0.44–0.94) | 0.024* |
| Gestational age at delivery (weeks) | | | | |
| 1. 28–34 | 24 (10.5) | 69 (18.2) | 0.53 (0.32–0.87) | 0.012* |
| 2. 35–39 | 72 (31.6) | 127 (33.5) | 0.92 (0.64–1.30) | 0.624 |
| 3. ⩾40 | 132 (57.9) | 183 (48.3) | 1.47 (1.05–2.05) | 0.022* |
| Type of CS | | | | |
| 1. Emergency | 161 (70.6) | 237 (62.5) | | |
| 2. Elective | 67 (29.4) | 142 (37.5) | 1.43 (1.01–2.05) | 0.042* |
| Type of anesthesia | | | | |
| 1. Spinal | 160 (70.2) | 238 (62.8) | | |
| 2. General | 68 (29.8) | 141 (37.2) | 1.39 (0.98–1.98) | 0.064 |
| APGAR Score in 1 min | | | | |
| 1. 0–3 | 14 (6.1) | 39 (10.3) | 0.57 (0.30–1.08) | 0.083 |
| 2. 4–6 | 22 (9.7) | 29 (7.7) | 1.29 (0.72–2.30) | 0.391 |
| 3. 7–10 | 192 (84.2) | 311 (82.0) | 1.17 (0.75–1.81) | 0.491 |
| APGAR Score in 5 min | | | | |
| 1. 0–3 | 9 (3.9) | 37 (9.8) | 0.38 (0.18–0.80) | 0.011* |
| 2. 4–6 | 8 (3.5) | 11 (2.9) | 1.22 (0.48–3.07) | 0.678 |
| 3. 7–10 | 211 (92.5) | 331 (87.3) | 1.78 (1.00–3.21) | 0.047* |
| Birth weight (kg) | | | | |
| 1. <1 | 6 (2.6) | 3 (0.8) | 3.39 (0.84–13.68) | 0.087 |
| 2. 1.0–1.49 | 11 (4.8) | 24 (6.3) | 0.75 (0.36–1.56) | 0.442 |
| 3. 1.5–2.49 | 41 (18.0) | 78 (20.6) | 0.85 (0.56–1.29) | 0.435 |

*(Continued)*

**Table 4.** (Continued)

| Parameter | During COVID-19 (N=228) | Pre-COVID-19 (N=379) | OR (95% CI) | p value |
|---|---|---|---|---|
| | Frequency (%) | Frequency (%) | | |
| 4. 2.5–3.49 | 115 (50.4) | 171 (45.1) | 1.24 (0.89–1.72) | 0.204 |
| 5. 3.5–4.0 | 45 (19.7) | 86 (22.7) | 0.84 (0.56–1.26) | 0.392 |
| 6 >4.0 | 10 (4.4) | 17 (4.5) | 0.98 (0.44–2.17) | 0.954 |
| SCBU admission: | | | | |
| 1. Yes | 65 (28.5) | 84 (22.2) | | |
| 2. No | 163 (71.5) | 295 (77.8) | 1.40 (0.96–2.02) | 0.079 |
| Indication for SCBU admission | (n=65) | (n=84) | | |
| 1. Low birth weight | 22 (33.8) | 30 (35.7) | 1.40 (0.96–2.02) | 0.079 |
| 2. Prematurity | 9 (13.8) | 12 (14.3) | 1.24 (0.69–2.21) | 0.461 |
| 3. Neonatal jaundice | 7 (10.8) | 7 (8.3) | 1.68 (0.58–4.86) | 0.336 |
| 4. Perinatal asphyxia | 17 (26.2) | 21 (25.0) | 1.37 (0.71–2.66) | 0.347 |
| 5. HIV exposed | 10 (15.4) | 15 (17.9) | 1.11 (0.49–2.52) | 0.797 |
| 6 weeks postnatal visit: | | | | |
| 1. Yes | 111 (48.7) | 210 (55.4) | | |
| 2. No | 117 (51.3) | 169 (44.6) | 0.76 (0.55–1.06) | 0.108 |

Values are expressed as number (percentage) of women. OR: odds ratio; CI: confidence interval; PPH: postpartum hemorrhage; SCBU: special care baby unit.
#The two women were COVID-19 negative.
*Statistically significant.

organizational changes during the pandemic, including increased consultant obstetrician gynecologist presence on the labor ward, and as increasing number of obstetrician gynecologist may hesitate in performing C-section because of continued adequate monitoring with C-section only performed for absolute or definite indications. This may offer a possible explanation to the significantly improved neonatal outcomes since there was significant reduction in APGAR score less than 4 from 9.8% pre-COVID-19 to 3.9% during the COVID-19 era and significant increase in APGAR score of ⩾7 from 87.3% pre-COVID-19 to 92.5% during the COVID-19 era (p=0.047).

During the first wave of COVID-19 pandemic, there were significantly more women delivering at gestational age ⩾40 weeks (57.9% vs 48.3%, OR=1.47, 95% CI=1.05–2.05, p=0.022), compared with earlier gestation. The decline in obstetric intervention in earlier gestation was similar to a recent study in Canada by Liu et al. that examined obstetric intervention, preterm birth, and stillbirth rates from March to August 2020.[25] Recently, the COVID-19 pandemic has affected patient management through rescheduling of elective surgeries, including C-section.

Of all the indications for C-section observed during the two study periods, fetal heart rate abnormality was significant and 3 times higher during the COVID-19 period (OR=3.06, 95% CI=1.55–6.06, p=0.001) than the pre-COVID-19 era. The explanation may be because the majority of the women were significantly delivered at postdate gestation and via emergency C-section. The women may have labored to an advanced stage of labor while at home before presentation to hospital because of COVID-19 scare and or aversion for C-section as previously reported in Nigeria.[20]

Lockdown is an effective public health measure to eliminate the coronavirus infection or flatten the outbreak curve, and many countries significantly affected by the pandemic have issued stay-at-home orders and requested self-restraint to ensure reduced social interaction. At the time of the study, preoperative COVID-19 testing for both pregnant women and health professionals was lacking in study hospitals due to the fact that regular screening of preoperative pregnant women and healthcare professionals for COVID-19 was restricted to those with symptoms in the study hospitals. In addition, testing also was restricted to patients and pregnant women with the presence of suggestive symptoms. In addition, surgical procedures performed within the aforementioned time were all captured and we specifically performed C-section for indications other than due to COVID-19.

Although there was a reduction in the general anesthesia rate (37.2% to 29.8%) during the COVID-19 pandemic, it did not reach a significance level (OR=1.39, 95% CI=0.98–1.98, p=0.064). On the contrary, there was a significant reduction in the general anesthesia rate during the COVID-19 period from a previous study in United Kingdom by Bhatia et al. that revealed a significant reduction (7.7% to 3.7%, p<0.001; risk ratio (95% CI) = 0.50 (0.39–0.93)) in general anesthetic rates was noted across hospitals during the pandemic.[26] This difference may be due to the fact that Bhatia et al study was on COVID-19-positive population. Nevertheless, due to the feared but rare complications of general anesthesia, including failed tracheal intubation, pulmonary aspiration of gastric contents, and accidental intraoperative awareness, strategies to reduce general anesthesia rates have remained a focus for obstetric anesthetists.[27,28]

Many countries are now experiencing the fourth wave of the COVID-19 epidemic with the emergent of delta and omicron variants; the battle against COVID-19 seems unlikely to end soon. Therefore, preventing the transmission of COVID-19 and preparing to deal with the fourth wave are very important. Based on these findings, we can deduce a number of clinical implications of this study. Our pilot perception is that our pregnant women population could have feared COVID-19 infection. As a result, these women underwent initial labor at home until their concerns about exposure were outweighed by their concerns regarding the well-being of their babies.

In addition, the fact that majority of pregnant women arrived at labor at postdate gestation with majority needing emergency C-section as well as that majority arrived at the hospital in advanced stage of labor with no adverse maternal and neonatal outcome leads us to consider that pregnant women could be encouraged to go to the hospital at the early part of their active stage under a shared decision model. There is therefore an urgent need for organizational changes to healthcare delivery so as to protect those vulnerable to the virus (staff and patients) and to protect them from potentially harmful consequences.[29] Pregnant individuals in particular are encouraged to take all available precautions to optimize health and avoid exposure to COVID-19.[30]

### *Strengths and limitations*

The main strength of our study was the large sample size collected in multicenter public hospitals distributed over the south-east part of Nigeria, which makes our results generalizable and applicable to many other health care settings in Nigeria. The data collection teams were organized to secure quality data and repeated validity checks were undertaken. First, although every effort was made to eliminate sources of bias, including balanced baseline characteristics, the retrospective nature of the study and lack of randomization do leave the opportunity for unknown causes of bias, which could not be adjusted for. Second, few rates of incomplete data capture very likely have not affected our findings. These seem to be missing at random. Yet, inevitably, we cannot confirm this with certainty, nor determine how these pregnant women would have affected the detailed findings of the study. Although no data on decision-to-delivery intervals were presented in this article, however, neonatal outcomes were discussed. The issue of complications and peripartum outcomes may not be generalizable to the situation of birth by C-section as it is more prone to the issue of confounding by indication, where adverse outcomes are related to the medical reasons that led to the C-section.[30,31] Therefore, the outcomes are not causal due to the cross-sectional nature of the study. Our report was only for the first wave and further study could target the effects of the second, third, and fourth waves of the pandemic on C-section rates. The lack of testing ability at the period of interest also constituted a limitation. Finally, based on the months (October–December 2019 vs March–May 2020) chosen for the study, we did not allow us to control the seasons in maternity care service variations.

## Conclusion

The overall C-section rate during the first wave of COVID-19 was significantly lower compared with the pre-COVID era, with fetal distress, emergency cases, postdates delivery and postpartum anemia being significantly higher compared with pre-COVID era. Further studies on this changing C-section trend during the other waves of the pandemic are needed.

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### Author contributions

G.U.E., E.O.U., J.T.E., L.I.E., and J.I.I. were involved in the overall conceptual design and implementation of the project, and overall revision of the manuscript. C.C.O., B.C.O., C.G.O., N.C.E., E.I.I., O.P.A., H.I.N., C.C.N., C.P.N., O.Z.I., and T.B.E. contributed to data collection, analysis, and manuscript writing. P.C.A., I.D.A., K.E.E., A.A.O., E.P.I., G.C.I., D.C.I., E.A.E., C.C.A., O.S.U., C.I.O., E.O.N., S.G.M., L.N.O., C.O.O., E.P.E., U.E.O., A.O.U., G.O.U., and K.M.A. were involved in the writing of this manuscript and overall revision. The authors read, approved the final manuscript, and agreed to be accountable for all aspects of the work.

### Disclosure statement for publication

All authors have made substantial contributions to conception and design of the study, or acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and final approval of the version submitted. This manuscript has not been submitted for publication in another journal.

### Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Ethical approval and consent to participate

The study was approved by the Ethics Review Board of NAUTH, Nnewi, Nigeria (Reference No. NAUTH/CS/66/VOL.13/VER III/46/2020/038 26-2017; date of approval: 31 July 2020) and other hospitals (Reference Nos. UNTH/CSA/329/VOL.5; ESUTHP/C-MAC/RA/034/VOL.1/293). Informed consent was not sought for the present study because it was a retrospective study of cases. The waiver for the consent was taken from the Institutional Review Board/Ethics Committee.

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## Data availability

The data used to support the findings of this study are available from the site publicly.

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