BMJ Open

Obstetric referrals, complications and health outcomes in maternity wards of large hospitals during the COVID-19 pandemic: a mixed methods study of six hospitals in Guinea, Nigeria, Uganda and Tanzania

Lenka Beňová [1], Aline Semaan [1], Bosede Bukola Afolabi,[2]
Dinah Amongin [3,4] Ochuwa Adiketu Babah,[2] Nafissatou Dioubate,[5]
Niane Harissatou,[6] Amani Idris Kikula [7] Sarah Nakubulwa,[4,8] Olubunmi Ogein,[9]
Moses Adroma,[4] William Anzo Adiga,[10] Abdourahmane Diallo,[11]
Ibrahima Sory Diallo,[6] Lamine Diallo,[12] Mamadou Cellou Diallo,[11] Cécé Maomou,[12]
Nathanael Mtinangi,[13] Telly Sy,[11] Thérèse Delvaux [1] Alexandre Delamou,[5]
Annettee Nakimuli,[4] Andrea Barnabas Pembe,[7]
Aduragbemi Oluwabusayo Banke-Thomas [14]

ABSTRACT

Objectives The COVID-19 pandemic affected provision and use of maternal health services. This study describes changes in obstetric complications, referrals, stillbirths and maternal deaths during the first year of the pandemic and elucidates pathways to these changes.

Design Prospective observational mixed-methods study, combining monthly routine data (March 2019–February 2021) and qualitative data from prospective semi-structured interviews. Data were analysed separately, triangulated during synthesis and presented along three country-specific pandemic periods: first wave, slow period and second wave.

Setting Six referral maternities in four sub-Saharan African countries: Guinea, Nigeria, Tanzania and Uganda.

Participants 22 skilled health personnel (SHP) working in the maternity wards of various cadres and seniority levels.

Results Percentages of obstetric complications were constant in four of the six hospitals. The percentage of obstetric referrals received was stable in Guinea and increased at various times in other hospitals. SHP reported unpredictability in the number of referrals due to changing referral networks. All six hospitals registered a slight increase in stillbirths during the study period, the highest increase (by 30%–40%) was observed in Uganda. Four hospitals registered increases in facility maternal mortality ratio; the highest increase was in Guinea (by 158%), which had a relatively mild COVID-19 epidemic. These increases were not due to mortality among women with COVID-19. The main pathways leading to these trends were delayed care utilisation and disruptions in accessing care, including sub-optimal referral linkages and health service closures.

Conclusions Maternal and perinatal survival was negatively affected in referral hospitals in sub-Saharan

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The prospective design is a strength of this study as it documents evolutions in maternal and perinatal health indicators, and health system-level and hospital-level events over the first year of the COVID-19 pandemic.

⇒ The study was conducted in four countries with extremely different experiences and responses to the pandemic, which allowed us to employ a comparative analysis lens to enhance our understanding of the pathways at hand.

⇒ Limitations were related to the completeness and quality of routine data across the referral hospitals. This was mitigated by conducting an extensive validation and verification exercise and by triangulating qualitative and quantitative findings.

Africa during COVID-19. Routine data systems in referral hospitals must be fully used as they hold potential in informing adaptations of maternal care services. If combined with information on women's and care providers' needs, this can contribute to ensuring continuation of essential care provision during emergency.

BACKGROUND

The COVID-19 pandemic has caused widespread disruption within health systems across the globe. As of 2 April 2022, there have been more than 490 million cases and over 6 million deaths reported worldwide.[1] Though Africa has reported the lowest burden of the

disease with cumulative confirmed COVID-19 cases per million people (8,377 in Africa compared with 61,583 across the entire world) and confirmed COVID-19 deaths per million people (183 in Africa compared with 778 across the entire world).[2 3] Although this relatively low direct impact of COVID-19 might be explained by demographic characteristics of the population, whereby the median age in the region was 18.6 years in 2020,[4] African health systems were not spared the disruptions of the COVID-19 pandemic.[5] Early on in the pandemic, there was global concern regarding the potential direct effect that COVID-19 could pose on vulnerable populations such as pregnant women. The direct effects that drew greatest concern included higher risk of maternal death, vertical transmission of the virus from pregnant women to their unborn babies leading to stillbirths, prematurity and congenital birth defects.[6–8] As per predictions made early in the pandemic, it was estimated that an 8.3%–38.6% increase in maternal deaths per month could occur across 118 low- and middle-income countries (LMIC).[9] Evidence, mostly from high income countries, later showed that COVID-19 was associated with an increase in maternal and neonatal morbidity and mortality as well as stillbirths.[10 11] The pandemic has negatively influenced access to and utilisation of maternity care, with significant declines in institutional deliveries, antenatal and postnatal care visits reported in eight countries in sub-Saharan Africa (SSA).[12] Additionally, declines in use of first antenatal care (ANC) visit and facility-based deliveries have been documented in Lesotho, Liberia and Sierra Leone during the COVID-19 pandemic.[13] Subsequently, indirect effects on the quality of care and health outcomes for pregnant women were predicted, mainly as a result of COVID-19 mitigation measures such as lockdowns and travel bans.[14 15] A meta-analysis of 14 studies showed that lockdowns during the pandemic were significantly associated with a higher risk of stillbirths.[16] A systematic review documented an excess of maternal mortality during the COVID-19 pandemic, ranging from 8.5% in Kenya to 61.5% in Uganda.[17]

Tertiary referral hospitals are at the apex of health systems in SSA and are designed to manage complicated cases and provide essential training function. Pregnant women typically visit these referral hospitals with obstetric complications, in addition to the routine outpatient and inpatient care these facilities provide to thousands of women and newborns per annum. Most of these hospitals are designated to provide care across large catchment areas, many of which are urban areas. These areas were the most affected in SSA when the COVID-19 pandemic first hit in many countries, with cities like Kampala, Lagos, Nairobi and Johannesburg being the epicentres of their respective countries.[10] These referral hospitals gained greater significance during the pandemic, as they were designated points of care for pregnant women with suspected or confirmed COVID-19 infection. In many instances, these facilities led the development of protocols and training of skilled health personnel (SHP).[18]

In a previous in-depth study conducted in six tertiary referral hospitals in SSA, we showed that potential negative impacts on providing quality maternity care exist both at the meso-level and macro-level of the healthcare system. These range from lack of rapid testing of pregnant/labouring women suspected with COVID-19 and severe pre-existing shortage in staffing, to wider health systems' decisions on the location of COVID-19 treatment centres and reallocation of maternity care staff away from their jobs.[19] Although no changes were reported to indications for caesarean sections and labour inductions, the study showed that caesarean section rates increased slightly in Tanzania and Uganda, and small increases in the percentage of labour inductions were noted in five of the six hospitals.[19]

From the utilisation side, we documented lower levels of utilisation in outpatient ANC, childbirth care and postnatal care during the first wave of the COVID-19 pandemic, mainly attributed to restrictive measures and closure of some health facilities, and community fear of seeking care in hospitals.[20] The study noted that the delays and disruptions in accessing routine and emergency obstetric care at the referral hospital level are likely to have affected the number of complications seen in the six hospitals and consequently maternal and perinatal health outcomes.[20] The objective of this paper is to extend the frame further by describing trends in referrals, obstetric complications, maternal and perinatal health outcomes in the six SSA referral hospital maternity wards during the first year of the COVID-19 pandemic, using routine data and qualitative interviews with SHP.

METHODS
Study design
We used a mixed-methods study design to analyse and synthesise data from two sources: (1) routine data recorded in study hospitals on the periods before and during the COVID-19 pandemic and (2) semi-structured key-informant interviews with SHP in hospital maternity wards. Data were collected prospectively, in parallel, analysed separately and triangulated at the synthesis stage with the full study team including senior and junior clinician-researchers from the six hospitals. The study included a small number of stakeholders in order to be able to capture rich in-depth information. This approach was highly suitable for prospective tracking such as the one we conducted and provided an opportunity to capture snapshots within the rapidly changing contexts of both internal (within-hospital) and external (national and global level) events.

Study context
The six public hospitals with large referral maternity wards in urban areas are located in four countries, which were selected purposively to enable cross-country comparisons within SSA. In light of the high degree of sensitivity and trust required to produce accurate and rich observations[21]

and to begin data collection as soon as feasible, the study included hospitals with which the Institute of Tropical Medicine or the country principal investigators (PIs) had pre-established collaborative relationships. The participating hospitals were: Hôpital National Ignace Deen/Ignace Deen National Hospital (HNID) and Hôpital Regional de Mamou/Mamou Regional Hospital (HRM) in Guinea, Lagos University Teaching Hospital (LUTH) in Nigeria, Muhimbili National Hospital (MNH) in Tanzania, Kawempe National Referral Hospital (KNRH) and Mulago Specialised Women's and Neonatal Hospital (MSWNH) in Uganda (online additional file 1).

COVID-19 timeline

Time series data on national key events that could influence maternal care provision and utilisation during the study period were extracted from the Oxford COVID-19 Government Response Tracker (e.g., lockdowns, night-time curfews, domestic travel bans, etc).[22] Relevant hospital-level events, including maternity service closure and modifications in service organisation and provision, were captured prospectively during bi-weekly team meetings with PIs. These data, triangulated with epidemiological

data from the WHO COVID-19 dashboard[1] and Salyer et al[23] allowed us to identify three distinct periods: first wave, slow period and second wave. The exact dates of these periods differed between the four countries. However, the first wave was characterised by the initiation of strict national restriction measures in all four countries. The slow period involved an easing of restriction measures in Guinea and Nigeria and lifting restrictions in Tanzania. The second wave was characterised by an increase in the number of COVID-19 cases nationally without the (re)introduction of restriction measures. Events occurring during each period are described in detail by country in table 1.

Data

Routine data

Monthly aggregate routine data for the period from 1 January 2019 to 28 February 2021 were extracted from each hospital's maternity ward records by local clinical researchers and data clerks under the supervision of the hospital PIs. We calculated and analysed four indicators capturing case-mix and maternal and perinatal health outcomes: (1) monthly number and percentage of

Table 1 Characteristics of the identified three periods during the first year of the COVID-19 pandemic in Guinea, Nigeria, Tanzania and Uganda

	Guinea	Nigeria	Tanzania	Uganda
First wave	March–August 2020 Travel restrictions, night-time curfew, domestic travel ban and bans on mass gatherings. Staff reorganised into 24-hour teams and interns were put on mandatory leave. Communications moved to WhatsApp (HNID), a COVID-19 response committee was established (HRM).	March–June 2020 Night-time curfew, domestic travel ban, school closures, mandate on face masks in public and ban gatherings of >50 people. Society of Gynaecology and Obstetrics of Nigeria issues Guidelines for service provision. Hybrid ANC (face to face and telemedicine). Maternity service closed between 6 May and 1 June 2020 due to shortage in maternity SHP following diagnosis with COVID-19. Isolation centre in LUTH. First obstetric case with COVID-19 in LUTH.	March–June 2020 Schools closed, ban on mass gatherings, travel restrictions. No lockdown. ANC spaced for low-risk women. Isolation centre at MNH. Limit number of allowed visitors to women. First obstetric COVID-19 case at MNH.	March–June 2020 Night-time curfew, school closure, mask wearing mandate, travel restrictions, ban on mass gatherings, domestic travel bans. Limit number of relatives allowed to visit. Outpatient clinics closed in KNRH. Elective surgeries were limited or stopped. First obstetric COVID-19 case at MSWNH.
Slow period	September 2020–January 2021 COVID-19 treatment centre opened in Mamou. First obstetric case with COVID-19 at HNID. Interns returned from the mandatory leave.	July–October 2020 Night-time curfew and mask mandate.	July–November 2020 Government declared that the pandemic was over. Lifting of all restrictions.	July–September 2020 Continued implementation of restriction measures. Local movement permits were issued to pregnant women.
Second wave	No second wave.	November 2020–January 2021 Sharp rise in the number of COVID-19 cases. No movement restrictions.	December 2020–January 2021 Increase in the spread of the virus with no national restriction measures.	October 2020–January 2021 Rise in the number of COVID-19 cases. Continued restriction measures. Two floors at MSWNH dedicated to COVID-19 treatment.

ANC, Antenatal care; HNID, Hôpital National Ignace Deen/Ignace Deen National Hospital; HRM, Hôpital Regional de Mamou/Mamou Regional Hospital; KNRH, Kawempe National Referral Hospital; LUTH, Lagos University Teaching Hospital; MNH, Muhimbili National Hospital; MSWNH, Mulago Specialised Women's and Neonatal Hospital; SHP, Skilled health personnel.

obstetric referrals among all deliveries, including antepartum and intrapartum women coming to the referral hospital from home (giving birth with a traditional birth attendant) or from private clinics, or women referred from lower-level facilities. For MSWNH in Uganda, KNRH was among the referring facilities. The number of referrals in MNH included postpartum women who gave birth before arrival (and it was not possible to disaggregate the referrals); (2) monthly number of intrapartum complications and percentage of complications among all deliveries. The definitions of recorded complications differed between hospitals, and included varied combinations of uterine rupture, laparotomy, eclampsia, haemorrhage or blood transfusions, preterm labour, premature rupture of membranes, gestational diabetes and transfer to intensive care unit; more details are available in online additional file 2; (3) annual number of stillbirths and stillbirth rate (stillbirths per 1,000 deliveries due to the lack of data on the total number of births), including a combination of fresh and macerated stillbirths at or after 28 weeks of gestation; and (4) annual number of maternal deaths and maternal deaths per 100,000 deliveries, otherwise referred to as in-hospital maternal mortality ratio (MMR). The data used for calculation of these indicators were extracted from multiple sources within each hospital (online additional file 2). For several indicators, particularly for maternal deaths, the data were available from multiple sources in each hospital, reaching up to five sources for maternal deaths in LUTH (Nigeria). In this case, values were collected from all available sources and validated against each other. In case of discrepancies between the sources, clinical researchers consulted with the hospital data clerks and the local PIs and recorded values from the source deemed most reliable.

Interviews

We conducted three rounds of semi-structured interviews with two to six maternity SHP in each hospital, including respondents of various seniority levels (junior and senior staff) and cadres (medical doctors, midwives and nurses). Interviews were conducted on the online video and audio conferencing platform Zoom by LB in Tanzania, Uganda and Nigeria and in English language, which is widely spoken and used by care providers in the three countries. Interviews were conducted in person by ND in Guinea, in the French language which is adopted as an official language in the country, between July 2020 and February 2021. In total, 22 providers were interviewed and 50 interviews took place. We used a semi-structured interview guide to capture changes in the provision and utilisation of maternal care and understand perceptions of respondents on any changes in maternity volumes and case-mix (online additional file 3). All interviews were audio recorded, transcribed, de-identified and imported into qualitative data analysis software Dedoose.

Analysis

We conducted descriptive analysis of each routine data indicator for a period of 24 months, divided into two 12-month time periods representing a year before the pandemic was declared (from March 2019 to February 2020 labelled as *pre-COVID-19*) and a year afterwards (from March 2020 to February 2021 labelled as *during COVID-19*). Frequencies were displayed in bar charts and percentages/rates in line charts. Indicator values were compared and presented.

Qualitative data from interviews was analysed in an iterative approach using the framework method.[24] The details of the analysis are described elsewhere.[19 20] For this analysis, we relied on an explanatory approach for triangulation, as we explored themes and quotes from the interviews that provide information on explanations and perceptions on the levels and trends seen in routine data from the perspective of SHP. Identified themes were further summarised to capture similarities and differences across the six hospitals and to identify relationships between the main themes in the data. Additionally, we interpreted changes over the study period by taking into consideration the three identified periods in the COVID-19 timeline analysis. Throughout the analysis and synthesis phase, efforts were made to validate the findings though regular bi-weekly discussions with the full team, including local PIs and junior and clinical researchers (online supplemental file 4).

Patient and public involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS
Routine data

The six hospitals received a variable number of obstetric referrals, from fewer than five in any month (HRM in Guinea) to more than 1,000 in KNRH (figure 1). With the exception of HRM, in all the hospitals, the percentage of deliveries arriving as referrals from other health facilities ranged from 30% (HNID Guinea) to nearly 100% (MNH Tanzania). During the COVID-19 pandemic, the number and percentage of deliveries which were referred from other health facilities remained stable in HRM and HNID (Guinea), except for a 17% increase in HNID starting in January 2021 coinciding with the first serious increase in COVID-19 infections in the country. In LUTH (Nigeria), the percentage of referrals received was mostly lower during the pandemic compared with the previous year, except in December 2020 when it nearly doubled. In MNH (Tanzania), there was an 18% decrease in the number of referrals received between April and July 2020, followed by a 7% increase between August and November 2020, compared with the previous year. In KNRH (Uganda), the percentage of referrals received was lower during most months of the pandemic compared with the previous
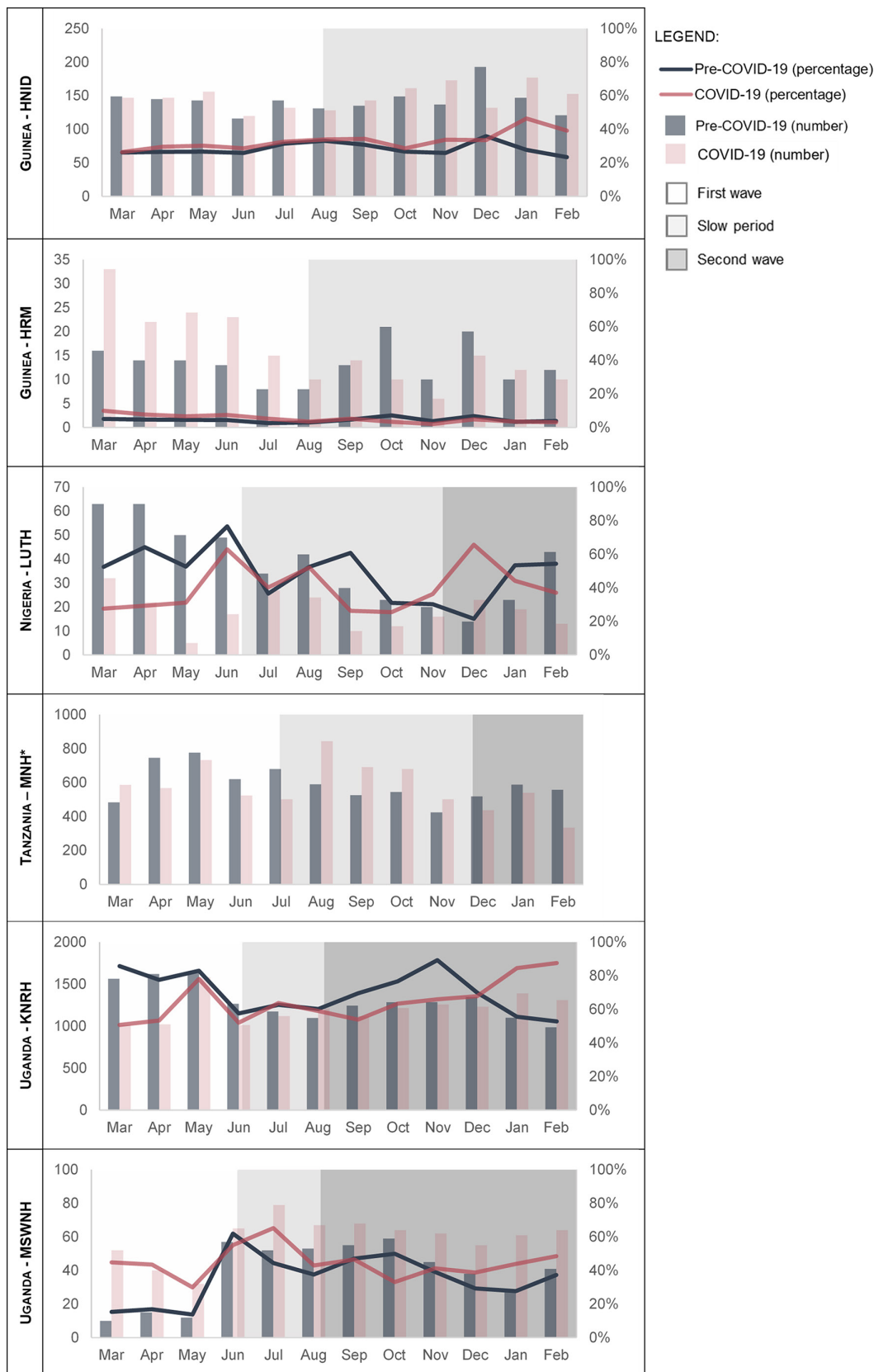
Figure 1 Number (left y axis—bars) and percentage (right y axis—lines) of received obstetric referrals out of all deliveries by month in each referral hospital before and during the COVID-19 pandemic. *Obstetric referrals in Muhimbili National Hospital (MNH) include births before arrival. Dividing them by the total number of deliveries exceeds 100% and was not included. HNID, Hôpital National Ignace Deen/Ignace Deen National Hospital; HRM, Hôpital Regional de Mamou/Mamou Regional Hospital; KNRH, Kawempe National Referral Hospital; LUTH, Lagos University Teaching Hospital; MNH, Muhimbili National Hospital; MSWNH, Mulago Specialised Women's and Neonatal Hospital.

year, then it increased by 32% in January and February 2021 compared with 2020. In MSWNH (Uganda), the number and percentage of referrals during the first pandemic year were higher compared with the previous year; in the period March–May 2020 more than triple the numbers were received.

The five hospitals from which data on obstetric complications were available experienced substantial month-to-month variability in the number of obstetric complications (figure 2). In Guinea (HNID and HRM), the percentage of obstetric complications among all deliveries was comparable during and before the pandemic. In HNID, the monthly number of complications varied considerably as a result of variability in the number of deliveries. In HRM during COVID-19, the number of obstetrics complications was relatively stable month-to-month, with a maximum of 60 complications recorded in May 2020. In LUTH (Nigeria), the percentage of complications was 12% higher between June and September 2020, and 10% higher during November 2020, compared with the same month in 2019. In MNH (Tanzania), the percentage of obstetric complications among all deliveries was relatively similar (around 10% a month) during and before the pandemic, with the exception of August 2020 when a notable 70% reduction was observed. KNRH (Uganda) reported the highest numbers and percentages of obstetric complications among the five hospitals, reaching up to 57% of deliveries in February 2021; the number and percentage of complications were somewhat lower between March and October 2020 compared with the previous year. This trend reversed starting in November 2020, when the proportion of complications increased by 15% compared with the same months pre-COVID-19. Further analysis of the data by complication type shows that this increase is attributable to the complication labelled 'blood transfusions'. In MSWNH (Uganda), the number of monthly complications was relatively low, ranging between 1 and 15 per month. In April and May 2020, the number and percentage of complications exceed the values in 2019.

The detailed quarterly numbers and rates of stillbirths and maternal deaths are shown in online additional file 5. Stillbirth rates varied widely between the six hospitals over the 24-month period and ranged from 25/1,000 births in MSWNH to above 85/1,000 in both Guinean hospitals (HNID and HRM) during the 12 months before COVID-19 (figure 3A). We noted a variability in the numbers of stillbirths by quarter within the hospitals included. However, the overall stillbirth rate before COVID-19 was relatively stable. It increased in all hospitals during the first year of the pandemic, except in HRM (Guinea). The most dramatic increase in stillbirth rates (by 30%–40%) was seen in the two Ugandan hospitals.

The in-hospital MMR ranged from 340 per 100,000 deliveries at HRM (Guinea) to nearly 2,500 per 100,000 deliveries at LUTH (Nigeria) in the 12 months before COVID-19. The number of maternal deaths per quarter and maternal deaths per 100,000 deliveries in each

hospital is shown in online additional file 5. All six hospitals experienced an increase in the number of maternal deaths registered in the first 3 months of the pandemic compared with the same time in 2019. However, taken over the first year of the pandemic, only four of the six hospitals registered an increase in the MMR (figure 3B), with HNID in Guinea reporting the highest relative increase of 158%. On the other hand, in MNH (Tanzania) the MMR did not change and in MSWNH (Uganda) it declined by 24%.

Interviews

During the first wave of COVID-19 in Uganda, Tanzania and Nigeria, SHP reported that the number of women arriving with obstetric complications increased. In Guinea, SHP perceived that the numbers of referrals to HNID increased and that most women arriving to HRM were either in advanced labour or showed signs of complications. Respondents reported that the main reasons for this were that women avoided using large hospitals and sought antenatal and childbirth care elsewhere including in lower-level and private sector facilities, which are not equipped to manage obstetric complications to the same extent as referral hospitals. This bypassing of hospitals due to fear of infection, maternity service closures (LUTH) and difficulties with transport due to lockdown restrictions (Uganda) meant that healthcare-seeking to the adequately equipped facilities may have been delayed, which could have contributed to higher severity of complications. SHP reported that the numbers of referrals depended on the structures of referral networks and current functionality of other health facilities in that network. This was perceived as resulting in unpredictable numbers of obstetric referrals. Respondents linked the delays and increased severity of obstetric complications to poor maternal and perinatal outcomes (table 2).

SHP in Tanzania and Uganda reported that the slow period following the first wave of COVID-19 coincided with a 'low season' which they defined as a time of the year when relatively fewer births happen. All six hospitals were providing maternal health services during this time, including non-urgent care. Respondents perceived that the number of obstetric referrals and complications declined to pre-COVID-19 levels. However, SHP reported longer-term consequences of disruptions to care provision during the first wave: for example, higher number of oncological patients in gynaecological clinics presenting with untreatable cancers (LUTH) and complications in labour due to closures in ANC clinics durinh the first period (KNRH).

The second wave, which affected three of the four countries in our analysis in late 2020, saw variable perceptions of case-mix among SHP both within and across hospitals in Nigeria, Tanzania and Uganda. This period coincided with a 'high season' or 'boom months' when SHP in Uganda and Tanzania expected to see a rise in numbers of births. In Uganda, this increased demand for childbirth care was perceived
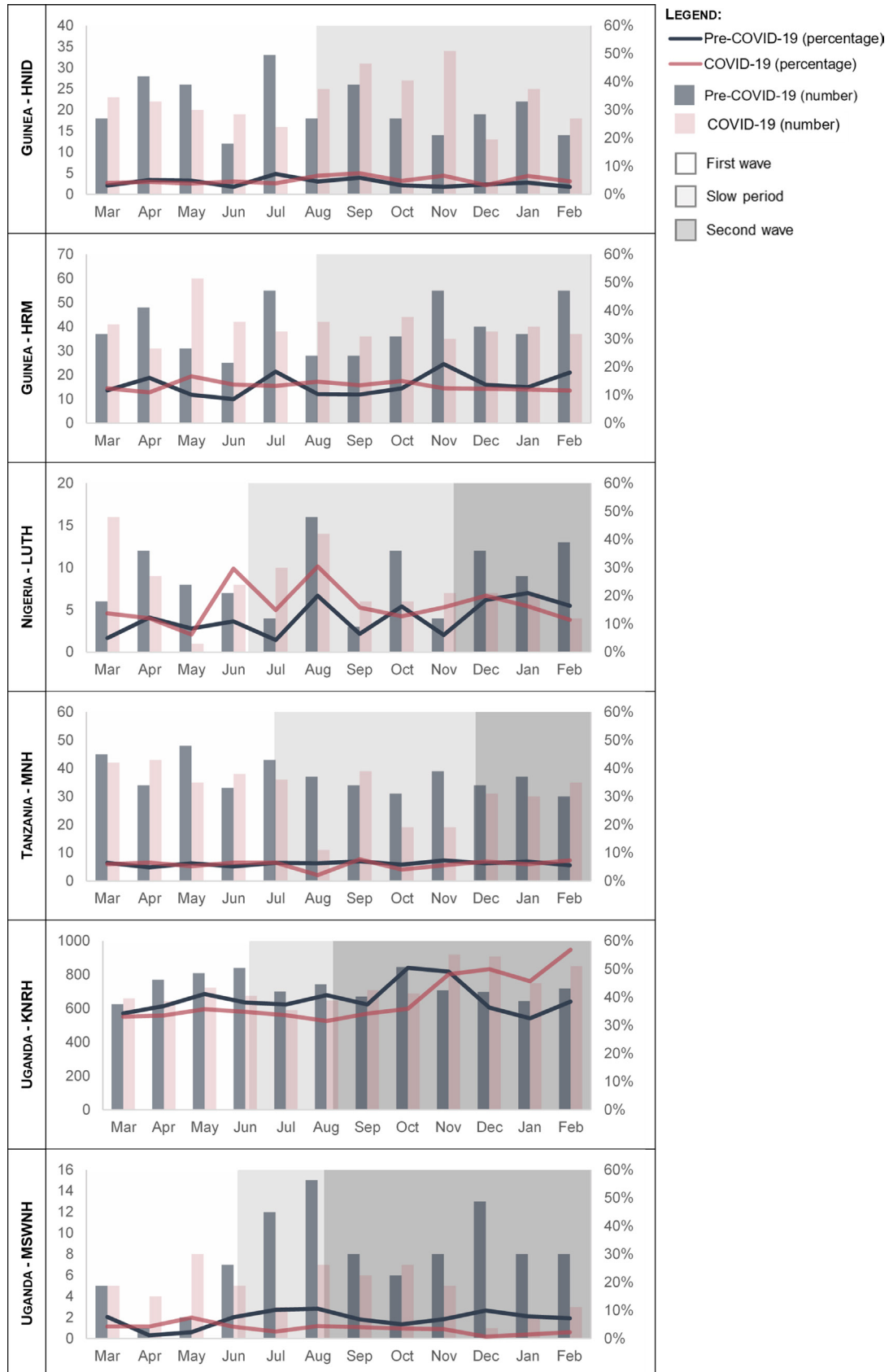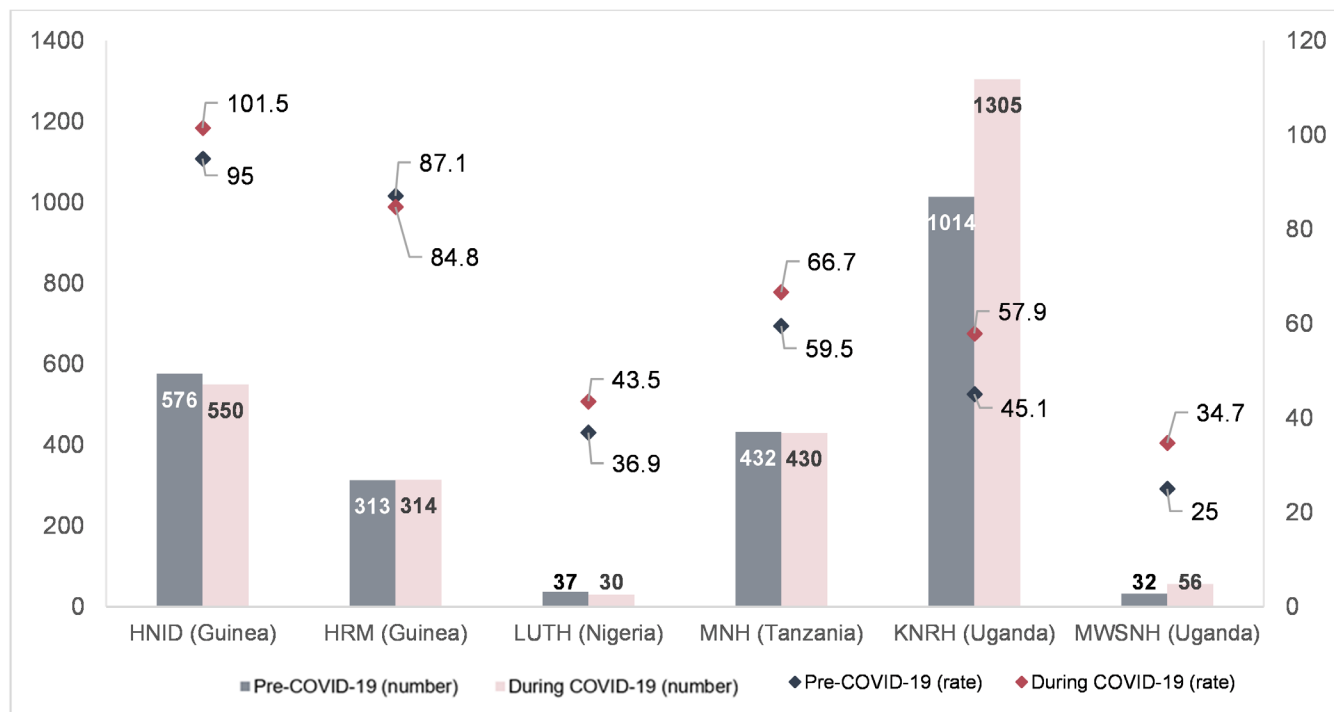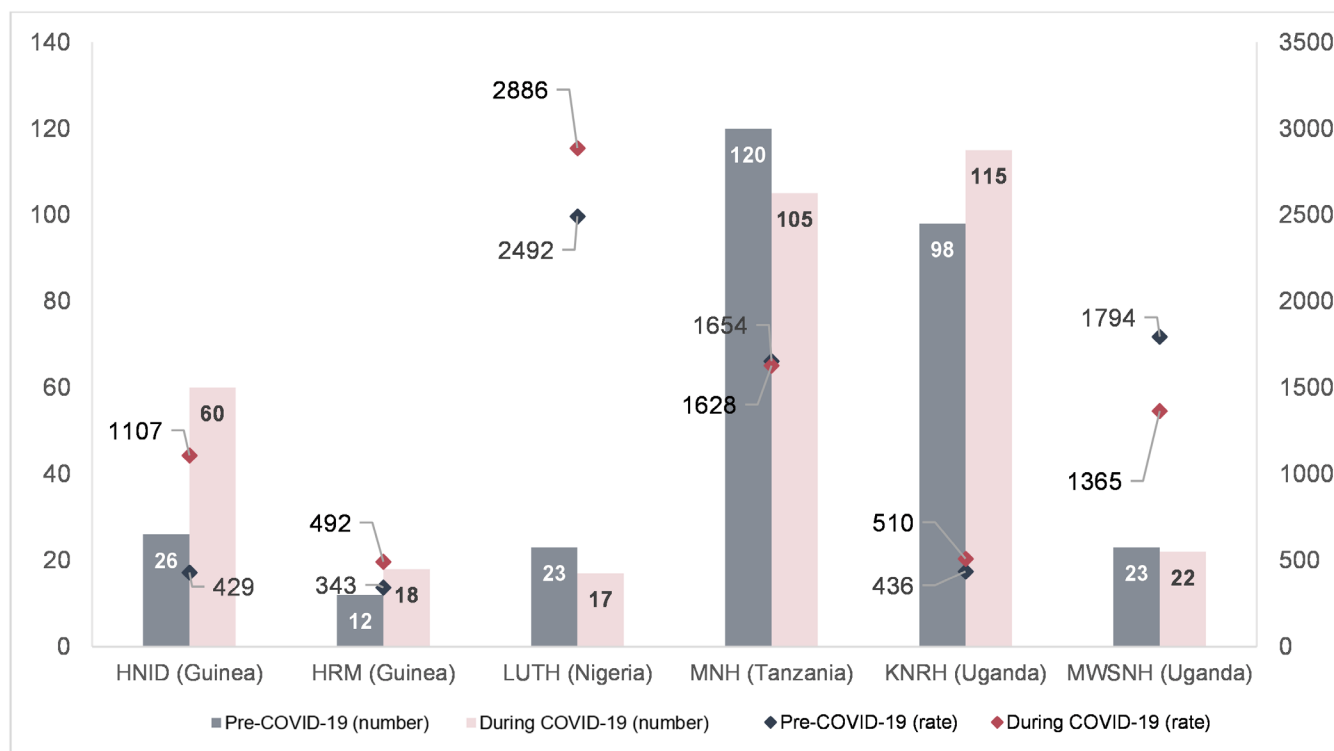
Figure 2 Number (left y axis—bars) and percentage (right y axis—lines) of obstetric complications out of all deliveries by month in each referral hospital before and during the COVID-19 pandemic. HNID, Hôpital National Ignace Deen/Ignace Deen National Hospital; HRM, Hôpital Regional de Mamou/Mamou Regional Hospital; KNRH, Kawempe National Referral Hospital; LUTH, Lagos University Teaching Hospital; MNH, Muhimbili National Hospital; MSWNH, Mulago Specialised Women's and Neonatal Hospital.

A

B

Figure 3 Number (left y axis—bars) and rate (right y axis—lines) per 1000 births** of annual* stillbirths (A) and per 100,000 deliveries of annual* maternal deaths (B) in each referral hospital before and during the COVID-19 pandemic. *12 months period between March and February of each of 2019 and 2020. **For MNH (Tanzania), KNRH (Uganda) and MWSNH (Uganda) the number of deliveries was used as a denominator, proxy for the number of births which was not available. HNID, Hôpital National Ignace Deen/Ignace Deen National Hospital; HRM, Hôpital Regional de Mamou/Mamou Regional Hospital; KNRH, Kawempe National Referral Hospital; LUTH, Lagos University Teaching Hospital; MNH, Muhimbili National Hospital; MSWNH, Mulago Specialised Women's and Neonatal Hospital.

Table 2 Illustrative quotes by period

First wave	▶ "We ended up receiving patients with worse comorbidities. Some of them who are supposed to be in normal labour probably, or those who were supposed to be delivered by elective surgery… most of those came in the late hours of the night requiring more longer hours to try and solve the comorbidities that had arisen. For example, that night I remember the 1st of April in the night I dealt with more than 3 emergency caesarean hysterectomies, ruptured uteri, we had very terrible obstructed labour, coming… raising out of these sorts of delays in accessing service deliveries." (Respondent B, KNRH Uganda)
	▶ "I know most of the women were afraid of big hospitals. Like I even had a patient of mine who has delivered 4 children at Muhimbili and then she was so scared of COVID, and she asked me if I attend any other private clinic and I said yes, she came (to the SHP's private practice)… and then she had an…. she was post-date and had the cord around the neck…. I told her she should come to Muhimbili when labour starts and we put a CTG so that we can monitor and if anything goes wrong then that's when do a caesarean, but she was afraid of Muhimbili so much, so then she went to another small private clinic, and then they told her no, cord around the neck is not good for you and then they did a caesarean at that small clinic, and then I don't know what she got, was it an embolism or general haemorrhage, she passed away, 18 hours after the caesarean section. So, yea… to be… I can say that that COVID killed that woman indirectly, because they ran away and then just to find that they are running away from… maybe had they come… (to MNH)" (Respondent C, MNH Tanzania)
	▶ "They were coming more. We did not get time to go back to the community to find out why women were running to Kawempe. It seemed as though they were not getting treatment where they were getting it before (before COVID-19) and also transport to take them to those other places it was unavailable for them. Some of them were taken here so they had to come to Kawempe as it is near for them. Why they were coming in late? They came late because transport was limited at that time." (Respondent A, KNRH Uganda)
	▶ "Those who came to our hospital, a national hospital, were the most complicated cases and they were accepted and managed. The government instructed that almost all women go to Amana regional hospital, but sometimes Amana was full and overcrowded. Patients then came again to our hospital to ease the overcrowding of Amana." (Respondent A, MNH Tanzania)
	▶ "Number of patients, it depends because as maternity… we normally depend on the peripheral hospital. Sometimes they refer a lot of patients and sometimes few. But, during my night shift two days ago, we didn't get the time to rest, there were a lot of patients." (Respondent B, MNH Tanzania)
	▶ "I remember when in March (2020) and then it was so bad in April and we ended up having so many mothers and babies around that time and so many losses, because of that they came in very late. By the time we tried to intervene, things were so bad, and we had a big influx of pregnant women coming to Kawempe. I think (other health facilities) in the community were not working then. They almost all came here to Kawempe." (Respondent A, KNRH Uganda)
	▶ "The patients do not use our hospital very much, they prefer to go to the (private) clinics, or to do self-medication at home. So most often, the patients who do come, we receive them late. Either it is a (case of) anaemia during pregnancy who is also diagnosed with malaria and in turn develops complications, or it is a case of stillbirth, or a patient who had a haemorrhage and remained at home until it is too late… So simple things that we can diagnose in time and manage the illness, but the delays happen either at home or at the referring facility" (Respondent B, HRM Guinea).
Slow period	▶ "The second bit I think we did not do well, which really at the end of the day suffered from was closing off the antenatal clinic. In here, most of those that would have planned or scheduled their elective surgery, because we had paralyzed the clinics for about 1.5 months, we ended up having many of them coming, appearing in the labour ward adding to the already huge number of patients coming in with comorbidities like uterine rupture or labour obstruction. So, we should have scheduled for elective surgery or planned interventions in antenatal care… we ended up not doing that and it costs us, it ended up leaving those appearing in the ward surviving with comorbidities." (Respondent B, KNRH Uganda)
	▶ "No, we don't have more complicated cases since we are working normally. We are running our clinics, we have been seeing our patients, so they have less reasons to go to other facilities for care. Compared to when we came back initially, it's better now, so the complicated cases are much reduced not like just immediately after COVID started. It's better now, we are seeing them, and we can plan their deliveries, we are running almost back to normal, like before COVID. The numbers are not yet back but structure-wise we are better now than initially." (Respondent A, LUTH Nigeria)

Continued

Table 2 Continued

Second wave	► "To a large extent, some of them presented late because of fear of COVID. Some of them came early but the unit had problems, there was a period that we had to shut down because more than 2/3 of the unit had contracted the virus. So, we had to shut the unit down and were not operating for some time. All that put together, yes, so the long and short of it is that we could not meet the demand at that time. Whether they did not come early or they came early but because we could not operate. Now they are coming back with advanced disease." (Respondent C, LUTH Nigeria) ► "The number of women is higher right now, so we are quite busy, we are delivering average of 30 c-sections in 24 hours, up from the usual 18–25… giving us a caesarean section rate between 39 and 45 percent of the deliveries, just have that in the back of your mind. So, the numbers are huge, they are calling on a huge input of human resource, ok?" (Respondent B, KNRH Uganda) ► "It (HNID) is a referral service, and the cases that cannot be delivered there (in lower-level facilities) are those who come here… (the number of complications did) not (increase) so much, you know the emergency service doesn't know COVID or else." (Respondent D, HNID Guinea) ► "Yes, (we received more complications) until now, especially during the elections, there have been many problems, that is, patients coming to the hospital with obstetrical complications. These patients come late (to the hospital) and tire us enormously. Even us doctors, we have had problems moving from home to the hospital, one day I myself was obliged to stay here until midnight, so that (the difficulty of transportation during the election campaigns) tired us enormously." (Respondent B, HRM Guinea)

Three time periods during COVID-19: care provision to women with suspected or confirmed COVID-19

► "In the beginning (first wave of COVID-19), most of the people were worried and when a person came sneezing or coughing, difficulty breathing, they were sent immediately to us [MNH referral hospital]. The system is just to refer, so they were directed to a hospital. Some were tested there and were referred tested, already some protection and then they came to our hospital, and we were informed that the sample was taken, and we were waiting for the results." (Respondent A, MNH Tanzania)

► "I would say more complications. Over the last 2–3 weeks we've had a series of not so good… well, complicated cases, I would say. Some were seen because of COVID, some people might say, this woman is ill, we might not be able to test, move on, move forward, and sent to a tertiary hospital and they believe that probably by the time she gets there… that they should find the way around on whatever she has. Most patients are coming in from outside facilities, are quite ill, just like we had then." (Respondent A, LUTH Nigeria)

► "In the past two… three weeks, we had three (maternal) deaths, but the babies are there yeah (…). they (women who had COVID-19 but were not officially diagnosed) were very ill. You know, they come to our hospital after the other referring hospitals fail to take care, so they come really sick." (Respondent C, MNH Tanzania)

HNID, Hôpital National Ignace Deen/Ignace Deen National Hospital; HRM, Hôpital Regional de Mamou/Mamou Regional Hospital; KNRH, Kawempe National Referral Hospital; LUTH, Lagos University Teaching Hospital; MNH, Muhimbili National Hospital; MSWNH, Mulago Specialised Women's and Neonatal Hospital.

to have been further exacerbated by additional pregnancies conceived during the first lockdown. On the other hand, respondents reported that the number of women seeking care had not completely recovered to pre-COVID-19 levels, and this was ascribed to the increasing cost of transport (Uganda) and rising poverty as a consequence of the earlier lockdown (Nigeria). In Guinea, where no second wave was identified, SHP did not perceive substantial changes to the case-mix and referrals due to COVID-19 but reported that fewer women might be seeking care during the election campaigns in the summer of 2020 (HNID, HRM).

In regard to the care of women with suspected or confirmed COVID-19, respondents in all hospitals noted that a lack of rapid testing for COVID-19 during the entire study period (average 24–48 hour waiting times for test results were reported) caused critical delays in providing care to women and their babies. As a result, SHP felt that their hospitals were providing suboptimal care for these women. In Guinea, the COVID-19 treatment centre included a team of obstetricians and gynaecologists to provide care to women diagnosed with COVID-19 during pregnancy or labour. Overall, the treatment centre managed women with no complications, and referred emergency cases to be treated at HNID. Additionally, SHP perceived that lack of clarity in the process of referring patients to a facility capable of providing obstetric care to women with COVID-19 contributed to the number of obstetric complications seen in their hospital and ultimately caused avoidable poor outcomes among women with symptoms of COVID-19.

DISCUSSION

The aim of this mixed-methods study was to present and compare referrals, obstetric complications and stillbirths and maternal deaths in six referral hospital maternity wards in SSA before and during the first year of the COVID-19 pandemic, and to elucidate pathways leading to patterns observed in these outcomes. Five of

the six hospitals registered a slight increase in stillbirth rates during the first year of COVID-19 compared with the year before. Four of the six hospitals had an increase in in-hospital MMR, with the highest increase noted in Guinea (158% in HNID and 44% in HRM). Obstetric referrals and complications as a percentage of in-hospital deliveries fluctuated across the three time periods, mostly increasing during the first and/or second waves of the pandemic in each country. The unique incorporation of prospective qualitative interviews with SHP contributed more in-depth understanding of the pathways leading to the trends observed in routine data. These pathways are represented by interactions between several factors at various levels, including factors external to the hospitals, such as transportation bans restricting women's access to hospitals, increasing poverty levels following lockdowns, ongoing election campaigns and seasonal trends in numbers of births. SHP noted that women delaying or avoiding hospital-based care because of fear of infection, closure of some maternity wards included in our study or delayed ANC consultations may contribute to an increased severity of complications and higher numbers of referrals received at the hospitals.

In our study, trends in numbers and percentages of referrals received in maternity wards during the COVID-19 pandemic varied between hospitals and countries. During the first wave, the number of referrals was lower than or similar to the previous year in five of the six maternity wards. A potential explanation for the decline could be transportation bans and lockdowns disrupting referral channels. In KNRH (Uganda), the lockdown interrupted and delayed referrals, leading to referred patients arriving with more severe complications. However, four of the six maternity wards had an increase in the number and percentage of referrals documented as the pandemic progressed: MNH (Tanzania) during the slow period; LUTH (Nigeria) and KNRH (Uganda) during the second wave; and HNID (Guinea) coinciding with the first real increase in the number of cases in Guinea. Various health system-level factors could explain this variability, including the functioning and capacity of lower-level facilities, and women's healthcare-seeking behaviour (preference to seek care in lower-level or private facilities, which end-up referring complications to referral hospitals).[25] In MSWNH in Uganda, increments in referrals started from June 2019 before the pandemic, probably because the hospital had just been commissioned and quickly established its role within the health system. The COVID-19 pandemic had little (if any) impact on this hospital's growth trajectory, suggesting that trends observed in routine data indicators are not solely attributable to COVID-19.

Similarly, the percentage of obstetric complications out of deliveries, stillbirth rates and MMRs was affected very differently in the six maternity wards during the COVID-19 pandemic. This variability was grounded in the varied COVID-19 developments at the country level, such as the diverse epidemiological evolution of the disease and varied extent of mitigation measures. Previously, we documented in detail how COVID-19 developments influenced care provision and utilisation.[19 20] Changes in provision and use could be reflected in changes in health outcomes and obstetric complications in these hospitals. During the Ebola virus disease outbreak in West Africa, provision and utilisation of maternity care declined, and higher MMRs were reported in the affected countries.[26] In the two hospitals in Guinea included in our study, the provision of childbirth care was stable throughout the first 10 months of the COVID-19 pandemic, which did not reach epidemic levels in the country. Similarly, percentage of complications and the stillbirth rate remained stable, with the exception of an increase in in-hospital MMR in HNID. In one hospital in Uganda (MSWNH), the use of some maternal care services increased[20] and was paralleled by a decline in percentage of complications and in-hospital MMR during the first year of the pandemic. Conversely, LUTH (Nigeria), MNH (Tanzania) and KNRH (Uganda) experienced interrupted provision and decreased use of maternal services during the pandemic compared with the year before. In these hospitals, patterns of complications fluctuated between the three pandemic periods and stillbirth rates and MMRs increased. Previous research documented that COVID-19 response and mitigation measures are linked to an increase in preventable maternal mortality and deteriorations in perinatal health outcomes in LMICs, and this increase is mediated by declines in essential service use and exacerbated delays in access to and provision of quality care.[27–31] Aside from provision and use affecting health outcomes, studies in Uganda and Nigeria documented that stressful working conditions for SHP which were exacerbated during the pandemic could have contributed to delays in care provision, declines in quality of care and subsequently adverse health outcomes for women and newborns.[32 33]

In the Guinean hospitals, which had the lowest MMRs before COVID-19, we noted the largest increases in MMR, predominantly driven by trends in the first 3 months of the pandemic. Notably, among the four countries, Guinea had the mildest COVID-19 epidemic and mitigation measures, and a small number of women with confirmed COVID-19 in the hospitals. Therefore, it is unlikely that this increase in MMR was driven by COVID-19 mortality among women. During the pandemic, some of these referral hospitals were designated the role of responders and care providers to women with confirmed COVID-19. Interestingly, in these hospitals the increases in mortality were not attributable to COVID-19 related causes of death. Interactions between complicated factors at different levels could be behind the observed increases in in-facility maternal mortality. More research exploring these dynamic interactions is recommended to better understand their impact on health outcomes, particularly to draw lessons from referral hospitals on adaptions and response to health system shocks.

Strengths and limitations

The strengths of our study lie in the prospective mixed-methods approach to data collection which allowed us to document evolutions in health outcomes, complications and referrals over the first year of the COVID-19 pandemic. The study sites being four countries with extremely different experiences and responses to the pandemic and having two hospitals in two countries allowed us to employ a comparative analysis lens (between and within countries) to enhance our understanding of the pathways at hand. The variability captured across the six hospitals can inform hospital selection for further in-depth analysis. The prospective approach allowed us to collect key events on hospital/maternity ward levels, which do not seem to be reported or collated, unlike national events for which a number of databases were set-up immediately. These events, such as service closures and new guidelines, are important for patients and for national coordination of provision of essential healthcare services. Last, the mixed-methods approach, particularly conducting interviews with SHP, allowed us to deduce potential explanations for trends observed in the routine data.

On the other hand, there are some limitations related to the completeness and quality of routine data collected for this study, which need consideration in interpreting our findings. There were instances of missing data for certain months or indicators. Across the different sites, this limitation was explained by the lack of centralisation of data on all relevant indicators in one place, the inability to retrieve some data points because record staff were on leave (no back-up staff) or illegible information or missing data ('torn sheets'). Regarding data quality, we noted some discrepancies with some indicators which were reported across multiple sources within the same health facilities. Another limitation is the inconsistency of definitions/recording of referrals (eg, in MNH referrals include births before arrival) and complications (different lists of complications collected in hospitals), which makes it difficult to compare trends between hospitals. These challenges were mitigated by conducting an extensive exercise of validating and verifying the data, which was achieved given the close collaboration and communication between members of the research team and the strong relationships that the researchers had with the hospital data clerks. However, routine data from referral hospitals can be challenging to interpret because their main function of managing referred cases suggests that the data reflect both in-hospital and external health system issues.[34] For example, changes in stillbirth rates and MMR could be further explored by disaggregating the cases by referral status to better understand whether delays in referral/arrival could have been exacerbated during the COVID-19 pandemic as a result of bypassing tertiary hospitals or because of travel bans and lockdowns. Additionally, rare outcomes, such as maternal mortality, are difficult to sensibly compare month to month, as such, we were only able to make annual comparisons. Nonetheless, any potential indirect impacts of the pandemic on these outcomes, particularly in the context of referral hospitals, would be difficult to measure within the short period of one year.[17] Other limitations include a delay in receiving ethical approval in Uganda, which delayed conducting interviews and the early period of the pandemic was covered retrospectively. In addition, the inability of the research team to travel and conduct in-person data collection due to international travel bans meant that most interviews were conducted via online conferencing platforms. This limitation was mitigated by training on best practices for remote interviewing and conducting bi-weekly meetings with country PIs and junior researchers for regular sharing of information and validation of research findings.

Implications for research, practice and policy

This study has clear implications for policy, practice and research, particularly as health systems continue to respond to COVID-19 and prepare for future shocks. There is an imperative need to prioritise providing essential maternal care services when planning and responding to health system shocks, such as the COVID-19 pandemic, including making special considerations to ensure the well-being of maternal and newborn healthcare providers. This warrants the importance of relying on quality routine data to rapidly learn from the negative impacts of care interruptions and adapt service provision accordingly.[35 36] In our study, when asked about trends in health outcomes, SHP rarely responded by referring to numbers from the routine data system. This reflects the lost potential of leveraging these information systems by not communicating them to care providers. SHP can use this information efficiently to help in planning and inform hospital-level management, especially during a pandemic.

Nonetheless, routine data systems have limitations which should be overcome to uncover their full potential. In our study, we document how routine data systems lack the agility to record and report the impact of shocks to the health system. The number of women with confirmed diagnosis of COVID-19 in each maternity ward, while one of the most important indicators of expertise and functionality, was available only informally from PIs or department heads. The rigidity and inflexibility of record forms make it difficult to add new indicators to routine data collection and analysis, and therefore reduce the value of these systems in informing future decisions and lessons from such disruptions. We advocate for integrating flexibility in routine systems for a more efficient response to future shocks. For better surveillance and monitoring, we recommend expanding the range of indicators routinely collected in referral hospitals to include maternal near-misses, which could provide a more sensitive signal of the influence of a pandemic on women's health while reflecting the level of readiness and adequacy of the response of the health system.

From a research perspective, understanding the true impact of the pandemic on health outcomes, such as

maternal mortality, requires population-level indicators since in-facility data does not represent the community.[37] Future research on the impact of the COVID-19 pandemic on maternal health outcomes at the community level is recommended, including community surveys using the sisterhood method.[38]

CONCLUSIONS

In conclusion, obstetric complications and referrals from other facilities fluctuated significantly and were varied across hospitals and countries during the first year of the COVID-19 pandemic. Poor maternal and perinatal outcomes increased across studied referral hospitals, especially during the first wave of the pandemic in early 2020. Consistently across the various contexts, the main pathways leading to this deterioration were linked to delays in care utilisation, disruptions in access to care including sub-optimal referral linkages and health service closures, translating into higher levels of complications and deaths occurring in maternity wards. However, the COVID-19 pandemic and the mitigating actions do not explain all the observed patterns and trends; referral hospitals were affected very differently based on various country-level COVID-19 developments (epidemiological and political), and the roles of maternity wards in caring for women—all women and women with confirmed COVID-19 in particular. Referral hospitals represent the last stage of care for many complicated pregnancy and childbirth cases, and thus offer a unique reflection of the functionality of the whole health system. At a time when countries are realising that health systems need to learn how to '*live with COVID-19*', it is essential that routine data systems in these hospitals are optimised and fully used to urgently advocate to national and regional authorities what measures need to be adapted for maternal care services to continue uninterrupted.

Author affiliations

[1]Department of Public Health, Institute of Tropical Medicine, Antwerpen, Belgium
[2]Department of Obstetrics and Gynaecology, University of Lagos, Idi-Araba, Lagos, Nigeria
[3]Department of Health Policy Planning and Management, Makerere University, Kampala, Uganda
[4]Department of Obstetrics and Gynaecology, School of Medicine, College of Health Sciences, Makerere University, Kampala, Uganda
[5]Département de santé publique, Centre National de Formation et de Recherche en Santé Rurale, Maférinyah, Forécariah, Guinea
[6]Institut de Nutrition et de Santé pour Enfants, Conakry, Guinea
[7]Department of Obstetrics and Gynaecology, School of Medicine, Muhimbili University of Health and Allied Sciences, Dar es Salaam, United Republic of Tanzania
[8]Department of Obstetrics and Gynaecology, Kawempe National Referral Hospital, Kampala, Uganda
[9]College of Medicine, University of Lagos, Lagos, Nigeria
[10]Department of Obstetrics and Gynaecology, Mulago Specialized Women and Neonatal Hospital, Kampala, Uganda
[11]Service de la maternité, Hôpital National Ignace Deen, Conakry, Guinea
[12]Service de la maternité, Hôpital Régional de Mamou, Mamou, Guinea
[13]Department of Obstetrics and Gynaecology, Muhimbili National Hospital, Dar es Salaam, United Republic of Tanzania
[14]Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, UK

Author note The reflexivity statement for this paper is linked as an online supplemental file 4.

ORCID iDs
Lenka Beňová http://orcid.org/0000-0001-8595-365X
Aline Semaan http://orcid.org/0000-0001-8348-1206
Dinah Amongin http://orcid.org/0000-0002-1420-005X
Amani Idris Kikula http://orcid.org/0000-0002-1130-9279
Thérèse Delvaux http://orcid.org/0000-0001-6299-2648
Aduragbemi Oluwabusayo Banke-Thomas http://orcid.org/0000-0002-4449-0131

REFERENCES

1 World Health Organization. WHO Coronavirus disease (COVID-19) dashboard. 2021. Available: https://covid19.who.int/
2 Global Change Data Lab. Cumulative confirmed COVID-19 deaths per million People547 [Internet]. Our world in data. 2022. Available: https://ourworldindata.org/explorers/coronavirus-data-explorer?facet=none&uniformYAxis=0&Metric=Confirmed+deaths&Interval=Cumulative&Relative+to+Population=true&Color+by+test+positivity=false&country=Africa~Europe~North+America~South+America~OWID_WRL
3 Global Change Data Lab. Cumulative confirmed COVID-19 cases per million people. 2022. Available: https://ourworldindata.org/explorers/coronavirus-data-explorer?facet=none&Metric=Confirmed+cases&Interval=Cumulative&Relative+to+Population=true&Color+by+test+positivity=false&country=Africa~Europe~North+America~South+America~OWID_WRL
4 United Nations Department of Economic and Social Affairs - Population Division. World population prospects: the 2022 revision. 2022. Available: https://population.un.org/dataportal/data/indicators/67/locations/903/start/2020/end/2023/table/pivotbylocation
5 Tessema GA, Kinfu Y, Dachew BA, *et al*. The COVID-19 pandemic and Healthcare systems in Africa: a Scoping review of preparedness, impact and response. *BMJ Glob Health* 2021;6:e007179.
6 Khan MSI, Nabeka H, Akbar SMF, *et al*. Risk of congenital birth defects during COVID-19 pandemic: draw attention to the physicians and policymakers. *J Glob Health* 2020;10:020378.
7 Khalil A, Kalafat E, Benlioglu C, *et al*. SARS-Cov-2 infection in pregnancy: A systematic review and meta-analysis of clinical features and pregnancy outcomes. *EClinicalMedicine* 2020;25:100446.
8 McClure EM, Kinney MV, Leisher SH, *et al*. Impact of COVID-19 on maternal and child health. *Lancet Glob Health* 2020;8:e1258.
9 Roberton T, Carter ED, Chou VB, *et al*. Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a Modelling study. *Lancet Glob Health* 2020;8:e901–8.
10 Chmielewska B, Barratt I, Townsend R, *et al*. Effects of the COVID-19 pandemic on maternal and perinatal outcomes: a systematic review and meta-analysis. *Lancet Glob Health* 2021;9:e759–72.
11 Villar J, Ariff S, Gunier RB, *et al*. Maternal and neonatal morbidity and mortality among pregnant women with and without COVID-19 infection: the INTERCOVID multinational cohort study. *JAMA Pediatr* 2021;175:817–26.
12 Shapira G, Ahmed T, Drouard SHP, *et al*. Disruptions in maternal and child health service utilization during COVID-19: analysis from eight sub-Saharan African countries. *Health Policy Plan* 2021;36:1140–51.
13 Aranda Z, Binde T, Tashman K, *et al*. Disruptions in maternal health service use during the COVID-19 pandemic in 2020: experiences from 37 health facilities in low-income and middle-income countries. *BMJ Glob Health* 2022;7:e007247.
14 Semaan A, Audet C, Huysmans E, *et al*. Voices from the frontline: findings from a thematic analysis of a rapid online global survey of maternal and newborn health professionals facing the COVID-19 pandemic. *BMJ Glob Health* 2020;5:e002967.
15 Kotlar B, Gerson EM, Petrillo S, *et al*. The impact of the COVID-19 pandemic on maternal and perinatal health: a Scoping review. *Reprod Health* 2021;18:10.
16 Vaccaro C, Mahmoud F, Aboulatta L, *et al*. The impact of COVID-19 first wave national Lockdowns on perinatal outcomes: a rapid review and meta-analysis. *BMC Pregnancy Childbirth* 2021;21:676.
17 Calvert C, John J, Nzvere FP, *et al*. Maternal mortality in the COVID-19 pandemic: findings from a rapid systematic review. *Glob Health Action* 2021;14:1974677.
18 Ezenwa BN, Fajolu IB, Akinajo OR, *et al*. Management of COVID-19: a practical guideline for maternal and newborn health care providers in sub-Saharan Africa. *J Matern Fetal Neonatal Med* 2022;35:1789–95.
19 Semaan A, Banke-Thomas A, Amongin D, *et al*. We are not going to shut down, because we cannot postpone pregnancy': a mixed-methods study of the provision of maternal Healthcare in six referral maternity wards in four sub-Saharan African countries during the COVID-19 pandemic. *BMJ Glob Health* 2022;7:e008063.
20 Banke-Thomas A, Semaan A, Amongin D, *et al*. A mixed-methods study of maternal health care utilisation in six referral hospitals in four sub-Saharan African countries before and during the COVID-19 pandemic. *BMJ Glob Health* 2022;7:e008064.
21 Barasa EW, Molyneux S, English M, *et al*. Hospitals as complex adaptive systems: a case study of factors influencing priority setting practices at the hospital level in Kenya. *Soc Sci Med* 2017;174:104–12.
22 Hale T, Angrist N, Goldszmidt R, *et al*. A global panel database of pandemic policies (Oxford COVID-19 government response Tracker). *Nat Hum Behav* 2021;5:529–38.
23 Salyer SJ, Maeda J, Sembuche S, *et al*. The first and second waves of the COVID-19 pandemic in Africa: a cross-sectional study. *The Lancet* 2021;397:1265–75.
24 Gale NK, Heath G, Cameron E, *et al*. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol* 2013;13:117.
25 Goyal M, Singh P, Singh K, *et al*. The effect of the COVID-19 pandemic on maternal health due to delay in seeking health care: experience from a tertiary center. *Intl J Gynecol Obs* 2021;152:231–5. 10.1002/ijgo.13457 Available: https://obgyn.onlinelibrary.wiley.com/toc/18793479/152/2
26 Kassa ZY, Scarf V, Fox D. The effect of Ebola virus disease on maternal health service utilisation and perinatal outcomes in West Africa: a systematic review. *Reprod Health* 2022;19:35.
27 Kumar M, Puri M, Yadav R, *et al*. Stillbirths and the COVID-19 pandemic: looking beyond SARS-Cov-2 infection. *Intl J Gynecology & Obste* 2021;153:76–82. 10.1002/ijgo.13564 Available: https://obgyn.onlinelibrary.wiley.com/toc/18793479/153/1
28 Nair M. Reproductive health crisis during waves one and two of the COVID-19 pandemic in India: incidence and deaths from severe maternal complications in more than 202,000 hospital births. *EClinicalMedicine* 2021;39:101063.
29 Weissman E, Buchner D, Hemachandra N, *et al*. Benefit-risk analysis of maintaining essential reproductive, maternal, newborn, and child health (RMNCH) services against risk of COVID-19 infection. *PLOS Glob Public Health* 2022;2:e0000176.
30 Ahmed T, Roberton T, Team M of EHS, *et al*. Indirect effects on maternal and child mortality from the COVID-19 pandemic: evidence from disruptions in Healthcare utilization in 18 low-and middle-income countries. *SSRN J* 2021.
31 Andreucci CB, Knobel R. Social determinants of COVID-19-related maternal deaths in Brazil]. *Lancet Reg Health Am* 2021;3:100104.
32 Kayiga H, Genevive DA, Amuge PM, *et al*. Lived experiences of frontline Healthcare providers offering maternal and newborn services amidst the novel Corona virus disease 19 pandemic in Uganda: A qualitative study. *PLOS ONE* 2021;16:e0259835.
33 Ameh C, Banke-Thomas A, Balogun M, *et al*. Reproductive maternal and newborn health providers' assessment of facility preparedness and its determinants during the COVID-19 pandemic in Lagos, Nigeria. *Am J Trop Med Hyg* 2021;104:1495–506.
34 Radovich E, Banke-Thomas A, Campbell OMR, *et al*. Critical comparative analysis of data sources toward understanding referral during pregnancy and childbirth: three perspectives from Nigeria. *BMC Health Serv Res* 2021;21:927.
35 World Health Organization. Flagship report of the Alliance for health policy and systems research. In: Sheikh K, Abimbola S, eds. *Learning health systems: pathways to progress*. 2021.
36 World Health Organization. Scoping review of interventions to maintain essential services for maternal, newborn, child and adolescent health and older people during disruptive events. 2021.
37 Calvert C, John J, Nzvere FP, *et al*. COVID-19 and maternal and perinatal outcomes. *Lancet Glob Health* 2021;9:e1062.
38 Merdad L, Hill K, Graham W. Improving the measurement of maternal mortality: the Sisterhood method Revisited. *PLOS ONE* 2013;8:e59834.