The use of a mobile obstetric emergency system (MORES) to improve obstetric referrals in Bong County, Liberia: a pre/post-intervention descriptive study

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Abstract

Objective: The purpose of this study was to examine the association between the implementation of a mobile obstetric emergency system (MORES) and referral time for obstetric emergencies as well as maternal/newborn outcomes. Design: Pre/post intervention descriptive study. Setting: Liberia's caesarean section (CS) coverage is about 5%, lower than 9-19% coverage associated with decreased maternal mortality. Delays in the referral process from a rural health facility (RHF) to a district hospital for comprehensive emergency obstetric and newborn care (CEmONC) services such as CS contribute to the high maternal mortality. Sample: Women with referral data from both RHFs (n=20) and hospitals (n=2) within Bong County, Liberia. Methods: A pre/post descriptive analysis was conducted on data collected from RHFs and two hospitals in Bong County, Liberia. Descriptive analysis and logistic regression models examined the relationship between the intervention's implementation and mode of delivery, maternal outcome, newborn outcome, and transfer time from RHF to district hospital. Main outcome measures: Mode of delivery, maternal outcome, newborn outcome, and transfer time. Results: Women had higher odds of undergoing a CS at endline (OR: 1.86 95%; CI: 0.99- 3.46) compared to baseline. Additionally, newborns had lower odds of showing depressive symptoms (OR: 0.31; 95%CI: 0.14-0.68), defined as a non-vigorous newborn with poor respiratory effort, muscle tone or heart rate <100 beats per minute. Conclusion: MORES is a promising means to increase timely care seeking along the referral pathway which may enhance access to caesarean section as well as improved newborn outcomes in low- and middle-income countries.

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Running title:

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Conclusion : MORES is a promising means to increase timely care seeking along the referral pathway which may enhance access to caesarean section as well as improved newborn outcomes in low- and middle-income countries.

Introduction

Low-and middle-income countries (LMICs) have long suffered disproportionately high preventable maternal mortality and morbidity rates compared to high-income countries (1). Countries in sub-Saharan Africa (SSA) specifically, account for 2/3 of the world's maternal deaths (2). Delays that contribute to these maternal death and injuries are often categorized using the "three delays" framework (3). The first delay refers to the delay in deciding to seek care; the second to the delay in presenting to the health center; and the third delay refers to the delay in receiving care once the woman arrives at the health facility(3). However, additional delays can further occur when a woman needs to be referred from a rural health facility (RHF) to a district hospital for emergency obstetric care services such as blood transfusion and caesarean section (CS) (4) (5).

Rural Health Facilities (RHF) in LMICs often have the capacity to perform basic emergency obstetric and newborn care (BEmONC), which includes parenteral antibiotics, parenteral uterotonic, and parenteral anticonvulsants administration, manual removal of retained placenta, vacuum aspiration, assisted vaginal delivery, and basic neonatal resuscitation (6). Alternatively, district hospitals typically offer comprehensive emergency obstetric and newborn care (CEmONC), which includes blood transfusion and CS in addition to the seven BEmONC functions (6). Hence, if a woman shows indications for a blood transfusion or a CS, healthcare providers at the RHF should refer the woman to a district hospital for additional care (4)(5). In the process of a referral, the same three delays can occur.

According to recent verbal autopsies conducted in Bong County Liberia, ineffective communication between RHFs and hospitals is a contextual cause contributing to preventable maternal deaths (7). Specifically, having no standardized referral process for communication of important information as well as the lack of feedback once the patient is referred to the hospital were identified as communication challenges (7). A study conducted in Nigeria found that women who were referred from a RHF were three times more likely to travel longer than 60 minutes to get to a hospital compared to women who went directly to a hospital bypassing the RHF (5). Furthermore, a study conducted in Rwanda found that longer travel time from RHF to a hospital was significantly associated with adverse neonatal outcome, emphasizing the need for strategies to reduce the transfer delay from health centers to district hospitals (4). Despite this need, only 40% of RHFs in Liberia were ready to make an emergency referral, defined as having access to a functional ambulance or other vehicle stationed at the facility or access to an ambulance and a functioning telephone, either a landline or a mobile phone(8). Hence, there is a great need to implement efficient and effective

communication mechanisms between RHFs and hospitals to improve the referral process and ultimately maternal and newborn outcomes.

WhatsApp, one of the most popular communication platforms worldwide has been examined as a potential means to streamline the obstetric referral process between communities, RHFs, and hospitals (9)(10)(11). Several feasibility and acceptability studies conducted in Ghana and Liberia found that the use of WhatsApp as a communication platform for obstetric referral is feasible and acceptable among community health workers, nurses, and midwives with a few addressable potential challenges such as data coverage and smartphone accessibility (9)(10)(11). Building upon these studies, this study piloted a mobile obstetric emergency system (MORES) using the free WhatsApp platform as an obstetric referral intervention in Bong County, Liberia. The purpose of this study was to examine the association between the implementation of the MORES intervention and transfer times, maternal outcome, and newborn outcomes.

Methods

Design :

This study was a pre/post descriptive study. We collected data from 20 RHFs and two district hospitals. We then merged the two data sets to examine the number of obstetric referrals from RHF to hospitals to identify common reasons for referrals, maternal and newborn outcomes, and time from RHF referral to hospital arrival. Inclusion criteria for RHFs included: staffed by providers who owned a smartphone capable of downloading WhatsApp and facility located two hours or less from the district hospital. The two district hospitals included in the study provide the vast majority of CEmONC services to residents of the county. Baseline data were collected six months prior to implementation of the MORES intervention (November 1, 2020 to April 30, 2021) and endline data were collected during the last six months of the intervention (August 1, 2022 to January 31, 2023).

Study setting :

Liberia is a West African country with a maternal mortality ratio of 661 deaths per 100,000 live births, ninth highest globally (2). Bong County is the third most populous county in Liberia, with a population of approximately 329,000 (12). To reduce maternal deaths, efforts have been made to increase facility delivery with skilled providers instead of home births, particularly in rural areas. The most recent Demographic and Health Survey of Liberia revealed 84% of women delivered with a skilled provider, up from 61% in 2013 (13). Bong County reports 88% of pregnant women receiving four or more antenatal care visits and 86.8% delivering with a skilled provider. In 2019, there were 15,231 facility births attended by a skilled provider in Bong County (13). Of these, 12,362 (81%) were delivered at a RHF with a midwife or nurse.

MORES Intervention:

Following baseline collection of referral data, a two-day interactive obstetric triage and MORES referral training was conducted with the nurses and midwives at 20 RHFs and two district hospitals in Bong County, Liberia. The training focused on recognition and management of acutely ill pregnant woman, managing obstetric emergencies, and prioritization of care. The healthcare providers were provided with an overview of MORES, assigned unique ID, and messaging templates for RHF referrals to the district hospitals (Figure 1) and templates for received hospital referrals back to the RHF provider were designed to ensure bi-directional communication (Figure 2). Templates for referrals from providers at RHFs included information such as patient initials, reasons for referral, time of referral, and type of transportation. Templates for providers at the district hospitals to communicate back to RHFs providers included information such as unique ID, patient initials, referral received confirmation, patient's arrival time and maternal and newborn outcomes. Prior to the implementation of the MORES intervention, referrals were handwritten at the RHF and carried by the women's family to the district hospital. Furthermore, these handwritten referrals would often get misplaced and forgotten, causing the necessary information to never reach the hospital.

Data collection and procedures :

Research assistants (RAs) from the Bong County health team obtained permission from the RHFs and district hospitals to conduct chart reviews and collect transfer data. A retrospective review of the hospital labor and delivery logs for baseline referrals sent from the 20 RHFs to the two district hospitals was conducted prior to implementation of the MORES intervention. Data collection was repeated at endline, during the final six months of the study. Identifying data was collected to link data from hospital labor and delivery log and patient charts to data from RHF logs. The linking document, and identifiable data, were destroyed after clinical data were collected. Deidentified data collected and used for analysis included date and time of departure from RHF and hospital arrival, type of delivery, and maternal and newborn outcomes. The hospital logs contained more referral records than those recorded in the RHF logs, as not all women referred arrived at the district hospital. Thus, data were sorted as complete (hospital data linked to RHF data) or incomplete (hospital records only).

Data management and analysis :

Referral data were collected via paper and pen, entered into Excel and exported into Stata 17 (StataCorp, College Station, TX, USA) for analysis. All paper copies were stored in a locked cabinet at the county health office in Bong County. All digital data were stored in an encrypted DropBox folder only accessible to the research team.

Descriptive analyses were conducted for all baseline and endline data and analyzed as separate cohorts (complete and incomplete). Frequency and percentage were tabulated for RHFs, referrals to district hospitals, reasons for referral, and outcome variables including mode of delivery, maternal outcome, newborn outcome, and transfer time from RHF to district hospital. Transfer time was further presented as mean with (SD), as well as the median time, and categorized into two hours or less, between two hours and twelve hours, and more than 12 hours. The two hours or less category was included per *The Lancet's*definition of geographic accessibility, with access to a health facility with the capacity to provide essential surgical and anesthesia services, including CS, within two hours (14). Furthermore, the 12 hours or less and more than 12 hours were included because despite a referral from a RHF, woman often go back home before going to the referred hospital.

Binary logistic regression models and linear regression models were fit to assess the relationship between the timepoint of the data (baseline, endline), mode of delivery, maternal outcome, newborn outcome, and transfer time. All models accounted for the clustering of individuals within hospital and RHF. All logistic regression models provided odds ratios (ORs) and 95% confidence intervals (95% CIs) and linear regression models provided coefficient and standard error (SE).

Ethics :

Ethical approval for the study was obtained from the Institutional Review Boards of the University of Michigan and University of Liberia. The study used retrospective medical records, the data were fully anonymized before analysis, and the ethics committee waived the requirement for the informed consent.

Results

Table 1 presents descriptive statistics for the baseline sample of 225 women referred from 20 RHFs to the two districts hospitals, CB Dunbar (75.1%) and Phebe (24.8%). Of the 225, 93 (41.3%) women had complete records and 132 (58.6%) women had records only from the hospital. The most common reasons for referrals were obstructed labor (33.3%), other (12%) which included premature rupture of membranes, anemia, and previous CS (8%). Most women delivered via spontaneous vaginal delivery (56.8%), with 18 women (8%) and 92 babies (40.8%) experiencing complications. On average, women took 23 hours to get to the hospital, after the referral was initiated at the RHF, with the median being 5.8 hours and only 12.9% of the women arriving at the hospital within two hours of less.

Endline data included 287 women with 159 (55.4%) complete records (*Table 2*). Of the total sample, 155 (54%) women were referred to CB Dunbar and 132 (46%) referred to Phebe. Similar to the baseline sample, the most common reasons for referral among the endline sample were obstructed labor (22.6%), previous

CS (15.6%), and other (12.8%). Less than half of the women delivered via spontaneous vaginal delivery (41.4%), with 13 women (4.5%) and 67 babies (23.3%) experiencing complications. The average time it took for women to arrive at the district hospital following referral from the RHF was 32 hours, with the median of 7.2 hours and 18 (11.3%) women arriving at the hospital in 2 hours or less from time of referral.

Table 3 shows the association between timepoints, mode of delivery, maternal outcome, newborn outcome, and transfer time. The unadjusted model showed that women at endline were more likely to undergo a CS (OR: 1.86; 95%CI: 0.99-3.46) compared to women at baseline. There was no statistically significant association between timepoints and maternal outcomes. Newborns at endline were significantly less likely to be depressed (OR: 0.31; 95%CI: 0.14-0.68) compared to newborns at baseline. Lastly, there was no statistical significance in transfer time from RHF to hospital between baseline and endline.

Discussion

Main Findings

This study examined the association between a MORES intervention implementation and mode of delivery, maternal outcome, newborn outcome, and transfer time from 20 RHFs to two district hospitals in rural Liberia. Following implementation of MORES, women had higher odds to undergo a CS and newborns had lower odds of being depressed, defined as a non-vigorous infant with presence of poor respiratory effort, poor muscle tone, or heart rate < 100 beats per minute during the delivery room provider's initial assessment. No statistically significant association was observed between the intervention and maternal outcomes and transfer time.

Interpretation

It is well established that prompt and high-quality CS can significantly improve maternal and newborn outcomes(15). A study of all 194 WHO member states to examine the relationship between CS rate and maternal and newborn mortality, found a CS rate of 9-19% of the population coverage was associated with decreased maternal and neonatal mortality (8) (16) (17). While the global CS rate continues to rise with current estimates at 21.1%, the CS rate in sub-Saharan Africa is only 5% (18)(8).

Liberia's facility-based deliveries significantly increased between 2004 and 2017, from 37% to 80% (8). Most of the increase occurred in rural areas, closing the gap between urban and rural areas. However, the CS rate did not reflect that improvement, with 6.1% born via CS in urban areas compared to 3.7% in rural areas, far below the 9-19% of the population coverage associated with a decrease in mortality(8) (16) (17). Furthermore, in 2019, about 84% of deliveries in Bong County occurred in a health facility, with 81% taking place within RHFs (13). This study found that the MORES intervention was associated with approximately 1.8 times higher CS rate, indicating that the intervention may be improving the unmet need of CS.

Relatedly, this study found that newborns were significantly less likely to exhibit poor respiratory effort and muscle tone after the intervention implementation. This may further indicate preparations to receive women being referred from RHFs due to improved communication with the MORES intervention, led to more timely care with improved newborn outcome. While the stillbirth rates were not shown to be statistically significant, a downward trend from 20.4% to 13.8% was noted.

The transfer time from RHF to district hospitals was not significantly associated with the intervention. In fact, the median time increased from 5.87 hours to 7.2 hour and no significant percentage changes were observed when time was examined as 2 hours or less versus longer than two hours. However, after the intervention, the percentage of women arriving to the hospital within 12 hours more than doubled, compared to before the intervention.

Although all RHFs in this study were located less than two hours from a CEmONC facility, it is worth noting that even post intervention close to 30% of the women took more than 12 hours to reach the district hospital following a referral. This may be due to the seasonal differences in the road conditions affecting travel time (rainy and dry season) (4). Additionally, previous literature notes that families often delay or refuse referral

when recommended due to concerns about the quality of care in hospital, fear of disrespected and abusive care, financial constraints, and lack of transportation means (19)(15). Hence, future studies need to further investigate the reasons behind the delay, specifically those between 2 to 12 hours and beyond 12 hours.

Limitations

This study has several limitations. First, because we extracted referral data from routinely collected data at the RHFs and district hospitals through admission logs, additional demographic data such as women's age, marital status, education level, and reproductive history that could have functioned as a confounding factor are lacking. Furthermore, reasons for referral could not be adjusted for because we could not collapse the variables in a scientifically meaningful way to include in the adjusted model. Second, additional time points were not captured to examine where specifically the delays in travel time occurred. For example, capturing dispatch time (between call for referral, dispatch ambulance), response time (dispatch time plus arrival of ambulance on scene), travel time (depart scene to arrive hospital), prehospital time (from making referral call to the woman arriving at the hospital) could have been additional time related variables that could have enhanced the results (Caviglia et al., 2021). Due to these limitations, the result of this study needs to be interpreted carefully.

Conclusion

Timely and high-quality obstetric emergency care such as caesarean section significantly reduces maternal mortality and morbidity. While Liberia has experienced increased facility-based deliveries in the past decade, it has not been accompanied by timely referral to hospitals capable of performing emergency obstetric services. Prior to implementation of the MORES intervention, unidirectional communication from RHFs to district hospitals prevented feedback to providers making the referral. While the focus of this study was not to examine quality improvement at RHFs, providing feedback to healthcare providers has the potential to examine clinical decision-making in real time and increase connectedness for providers working in rural settings. Given that the MORES intervention was associated with a significant increase in CS and a reduction in depressed newborns at birth, it may be an innovative solution to communicate emergency referral information, improve treatment upon arrival at the hospital, and improve bi-directional communication to ultimately reduce maternal and newborn morbidity and mortality. Future studies should examine the reasons for delays after referral has been made as well as interventions to overcome these challenges.

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Ethics approval

All ethical approvals were obtained from the University of Michigan (Ref No.UM HSBS – HUM0019544) and University of Liberia (Date of approval Feb 5, 2021). The study used retrospective medical record, the data were fully anonymized before analysis, and the ethics committee waived the requirement for the informed consent.

Author contributions

HL and CE managed and conducted data analysis, BD, HS, AN, and CR collected data. NL and JL designed the study and BD, HS, AN, JL, and NL designed data collection instruments. HL, CR, CE, NL, JL contributed to the development of the manuscript and all authors reviewed and approved the final version of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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