Simulation-based low-dose, high-frequency plus mobile mentoring versus traditional group-based trainings among health workers in Nigeria; a cluster randomized controlled trial

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Abstract

Background: The aim of this study was to compare health workers knowledge and skills competencies between those trained using the onsite simulation-based, low-dose, high frequency (LDHF) training plus mobile (m) mentoring and the ones trained using the traditional offsite, group-based training (TRAD) approach in Kogi and Ebonyi states, Nigeria, over a 12-month period.

Methods: A prospective cluster randomized controlled trial was conducted by enrolling 299 health workers in 60 health facilities in Kogi and Ebonyi states, randomized to either LDHF/m-mentoring (intervention, n=30 facilities) or traditional group-based training (TRAD, n=30 facilities) control arm. These health workers in both arms received basic emergency obstetric and newborn care training with simulated practice using anatomic models and role-plays. The control arm was trained offsite while the intervention arm was trained onsite where they worked. Mentorship was done through telephone calls and reminder text messages. The multiple choice questions and objective structured clinical examinations mean scores were compared; p-value <0.05 was considered statistically significant. Qualitative data were collected and content analysis was done.

Results: The mean knowledge scores between the two arms at months 3 and 12 post-training were equally high; no statistically significant differences. Both arms showed improvements in composite scores for assessed BEmONC clinical skills from around 30% at baseline to 75% and above at endline (p <0.05). Overall, the observed improvement and retention of skills was higher in intervention arm compared to the control arm at 12 months post-training, (p<0.05). Some LDHF/m-mentoring approach trainees reported that mentors' support improved their acquisition and maintenance of knowledge and skills, which may have led to reductions in maternal and newborn deaths in their facilities.

Conclusion: The LDHF/m-mentoring intervention is more effective than TRAD approach in improcquisition and retention. Health care managers should have the option to select the LDHF/m-mentoring learning approach, depending on their country's priorities or context, as it ensures health workers remain in their place of work during training events thus less disruption to service delivery.

Background

As there is limited quantity and quality of skilled birth attendants in Nigeria, evidence-based approach is needed to train health workers to improve competencies and maternal/newborn outcomes [1,2]. Doctors, nurses and community health extension workers (CHEWs) are commonly trained on *day of birth* care. Considering the high maternal and newborn mortality and morbidity figures in Nigeria, there is need to train birth attendants on high-impact interventions using competency-based approaches to improve the quality of maternal and newborn care and reduce maternal and perinatal/neonatal mortality [3–6]. It's expected that all health workers have the necessary level of competency to perform life-saving procedures if appropriately trained on basic emergency obstetric and newborn care (BEmONC) functions, including newborn resuscitation and management of bleeding after birth.

Health workers in Nigeria are usually trained using traditional lecture-based, offsite approach in which a limited number of persons from any health facility can be trained at one time. This approach to training is known to be expensive [7-10]. Maternal and newborn health outcomes have remained suboptimal despite continuous training of health workers [8]. Health workers absenteeism from work to attend offsite training is also a concern for health facility managers [9, 10]. Moreover, since only a few health workers are trained each time through the current offsite workshop approach, the quality of care may not be improved to the desired level [3]. Health workers also find it difficult to practice new or updated skills because the entire team members have not been trained on the relevant skills and approaches. In addition, step-down training by those that have been trained most often does not happen as intended due to lack of will and management support among other factors. Health worker turnover and attrition negatively affects the quality of care provided if those leaving are the only ones who received training.

Similar studies done in Ghana and Uganda (7,8) showed promising results with the onsite simulation-based low-dose, high-frequency (LDHF) plus mobile (m)-mentoring training approach. In these studies health workers competencies were better with the LDHF+mMentoring approach compared with the TRAD approach although limited skills were assessed such as newborn resuscitation and postpartum haemorrhage (PPH). The present study however assessed other skills such as active management of labour, management of eclampsia, etc and utilized a more rigorous methodology in order to improve the strength of evidence. There is limited evidence from developing countries including Nigeria on facilitators, barriers, and effectiveness of simulation-based LDHF/m-mentoring learning approaches in improving maternal and newborn health, including day of birth care. In the few studies where the LDHF/m-mentoring approach has been tested, there sample sizes have been limited and methodological approaches have not been standardized [2]. The studies should be adequately powered and use rigorous designs to answer the research questions [2].

The LDHF approach uses in-service learning updates to deliver information based on local needs during short, structured, onsite, interactive learning activities that involve the entire team and are spaced over time to optimize learning. It also involves brief, ongoing activities (e.g., skills practice, team drills, games, and quality improvement activities) at the work place to sustain learning and support clinical decision-making [11]. The approach also uses mobile phone mentorship calls and reminder text messages to the trainees to reinforce gains made from training and resolve emerging issues at the workplaces.

As described by the authors in a previous study [11], the principles of the LDHF approach include:

1. Competency-focused learning activities concentrates on what providers “need to know”—eliminating what is “nice to know.”
2. Simulation- and case-based learning focuses on skills practice, problem-solving, role-play, and other interactive exercises. Dosing and frequency depend on topic, extent of the learning gaps, and learner characteristics.
3. Appropriately spaced, brief periods of learning deliver targeted information in 1 day or over several days.

4. Team-focused training ensures that all providers have updated clinical practice and can work together to implement improvements in care.
5. Facility-based training decreases absenteeism, improves teamwork, addresses onsite barriers, and promotes changes to provider performance.
6. Ongoing practice and quality improvement activities reinforce learning and transfer to clinical practice.
7. Facility-based peer staff, coaches others as they practice or engage in interactive exercises after learning to increase compliance and improve performance and outcomes.

Methods

Study Objectives

This study aimed to compare the knowledge and skills competencies of health workers in improving maternal and newborn *day of birth care* after the LDHF/m-mentoring versus the TRAD training approaches in Ebonyi and Kogi states, Nigeria. The primary outcomes were increase in knowledge, clinical skills, and retention of clinical competency at 3- and 12-months post-training. The secondary outcomes measured were facilitators of and barriers to the LDHF/m-mentoring training approach at individual and institutional levels.

Our hypothesis was that LDHF/m-mentoring results in better knowledge and skills outcomes compared to the TRAD approach.

Study setting

The study was conducted in Ebonyi and Kogi States, in Nigeria. Ebonyi State has a population of 2.8 million and is in the South-East zone. Kogi state has a population of 4.3 million and is in the North-Central zone. At the time of the study, the Maternal and Child Survival Program (MCSP), in partnership with the Federal Ministry of Health, Ebonyi and Kogi States Ministries of Health and Professional Associations supported 120 health facilities across the two states, of which 60 were selected to be part of the study, 30 in each state. The MCSP was a global, $560 million, 5-year cooperative agreement funded by the United States Agency for International Development (USAID) to introduce and support scale-up of high-impact health interventions among USAID’s 25 maternal and child health priority countries, as well as other countries.

Study design

This was a prospective cluster randomized controlled trial. It was a mixed- method study. Informed consent and ethical approval were obtained. The study was conducted between October 2016 and November 2017 in sixty health facilities that were randomly selected and assigned to either the intervention arm or the control arm. The authors have attempted a brief description of the methodology. The training approaches, eligibility criteria and randomization have been described in the published study protocol [11].

Training approach 1 and data collection: Simulation based LDHF/m-mentoring training of participants – group 1 or intervention group

The training for the LDHF arm was for the entire team of service providers available at the health facility, but only those who met the study inclusion criteria were assessed. The training was divided into two “low-dose” training courses of 4 days each, with additional time for assessment as needed and was conducted at the health facilities using the basic emergency obstetrics and newborn care (BEmONC) package. The BEmONC package include training on (i) administering parenteral antibiotics, (ii) administering uterogenic drugs for active management of the third stage of labour and prevention of postpartum haemorrhage, (iii) use of parenteral anticonvulsants for the management of pre-eclampsia/eclampsia, (iv) manual removal of placenta, (v) removal of retained products (e.g. manual vacuum extraction, dilatation, and curettage), (vi) performing assisted vaginal delivery (vii) performing basic neonatal resuscitation [12]. This was for an initial 4days with emphasis on normal uncomplicated cases and repeated after 1 month to emphasize more complicated skills (figure 1). The training techniques were modified to shift the emphasis to practice. This was a competency-based training that has been used in Jhpiego’s (affiliate of Johns Hopkins University) training with the aim of improving and retaining the skills of the health worker. The trainer practices the skills while the trainee observes. The trainee then practices using the anatomical models (manikins) while the trainer observes. At the end, the trainer debriefs and provides feedback to the trainee. The trainee repeats the practice until competency is achieved. The Peer Practice Coordinators (PPCs) received technical update in LDHF including the use of session plans, case scenario and MamaNatalie/NeoNatalie models to conduct simulation practices. During the one-month interval between training courses, health care workers had opportunity to practice what they learned and reinforce their competencies through high-frequency simulation-based practices of 2–3 times weekly. The time spent on lectures was reduced and time spent on hands-on practice was increased. The PPCs completed the practice log. In addition to the simulation exercises, all the trained health workers in the LDHF arm participated in mobile Mentoring (mMentoring), which consisted of receiving weekly reminder messages and quiz questions on the topics reviewed via SMS messaging. Also the PPCs received structured, monthly half-hour mentoring calls from a trainer/master mentor that provided remote support, answering questions, providing guidance and reinforcing key messages.

After oral consent was obtained, the participants took a pre-training assessment consisting of MCQs and OSCEs to assess their baseline knowledge and skills on BeMONC. The MCQ contained a set of multiple

choice questions to test trainees' knowledge. OSCE involved the use of checklists to evaluate trainees' demonstration of clinical skills to ensure that each step is correctly and completely carried out. These tools were adapted from previous studies and validated by the researchers and trainers [6,7,12]. The assessments tested their knowledge and skills on conduct of normal delivery, active management of the third stage of labor (AMTSL), neonatal resuscitation, case management of pre-eclampsia and eclampsia (PEE) and management of PPH (e.g. manual removal of placenta, internal bimanual uterine compression and compression of the abdominal aorta). They also had an immediate post-training assessment which included MCQs and OSCEs. The questions answered correctly and procedure done competently was scored over a total of 100%. A test score of ≥80% was accepted as level of competence. The pre-training and immediate post-training assessments results were compared. Skills and knowledge assessments were done at three time points post-training (immediate post training day, at 3 months 12 months). Trainees' satisfaction with the simulation-based LDHF/m-Mentoring training approach was determined using satisfaction (quantitative) survey. The scores at each assessment were collected using validated tools and recorded in real-time on android devises and sent to a central server after verification.

Qualitative data were collected through six focus group discussions (FGD) comprising 8-10 participants per group purposively selected from LDHF arm at 12 months. The participants were greeted and invited via telephone and given full study information including the aims of the study. All the invited respondents gave consent to participate in the study. The FGDs were used to collect data on experiences and satisfaction of trainees with the LDHF/m-mentoring training approach. The enquiry was based on the high-frequency practice sessions with simulators, mobile mentoring through short messages and quizzes, overall impressions of the LDHF/m-mentoring approach, and how it could be improved. The IDIs with PPCs collected data on their experience managing simulator practice sessions, interactions with trainers/master mentors, m-Mentoring, changes made in clinical practice after the training, success, challenges and their overall impression about LDHF/m-mentoring training approach. With regard to trainers, data were collected about their experiences with the LDHF/m-mentoring training approach, successes and challenges with mobile mentoring to support the PPCs, and the effectiveness of approach in building the capacity of the health workers. The data was collected at their workplaces. Only the interviewer and the respondents were present at a private place where the interviews were conducted. Interview guides were adapted from previous work and pretested. Repeated interviews were not carried out. Audio-recorders were used during interviews to help during recall. Each interview lasted for 45-60minutes. The qualitative data was collected until data saturation was reached. The interviews were transcribed. The Transcripts were not returned to participants for comments.

Training approach 2 and data collection: Traditional group training of participants – Group 2 or control group

The traditional training approach consisted of 8 days of lectures with practice sessions on simulators, outside the participants' workplace, usually in a hotel (figure 2). The group had lectures and practice

sessions on conduct of normal delivery, AMTSL, neonatal resuscitation, case management of PEE and management of PPH. The BEMONC package and clinical observation checklists were used during the training sessions as was done for the intervention arm. The group-based training approach involved training sessions consisting of 8 days of lectures and fewer practice sessions using manikins (MamaNatalie/NeoNatalie) offsite and not at the trainees' place of work. Emphasis was not made on practice sessions at the health facilities when they returned. They did not have mMentoring.

Oral consent was obtained. The participants/trainees took pre-training assessments consisting of MCQs and OSCEs through use of manikins to assess their baseline knowledge and skills respectively. The assessments tested their knowledge and skills on conduct of normal delivery, AMTSL, neonatal resuscitation, case management of PEE and management of PPH (e.g. manual removal of placenta, internal bimanual uterine compression and compression of the abdominal aorta). At the end of the eight-day training, the participants had an immediate post-training assessment which included MCQs and OSCEs. As described for the intervention arm, the questions answered correctly and procedure done competently were scored out of a total of 100%. These were recorded in real-time on android devises and sent to a central server after verification. The assessments results were compared. Trainees' satisfaction survey was also conducted.

Both study arms were trained and assessed by senior clinicians (mainly obstetricians, pediatricians and midwives) whose knowledge and skills were standardized. The tools were pre-tested among 25 health workers from health facilities that were not part of the study. Before being used, checklists for the assessed clinical skills were modified in accordance with the Nigeria context by the research team and data collectors. At the time of the training, MCSP did not support any interventions in these facilities that are likely to cause contamination. Other quality improvement interventions only happened at the non-study facilities at the time of the study.

The assessors were blinded to the groups the participants were assigned to as they conducted the assessments.

Eligibility criteria

The sixty health facilities were selected from a sampling frame of the 120 MCSP-supported health facilities in the two states located in three geopolitical zones where the project support. They represented all three levels of the healthcare system in Nigeria (Primary health care or PHC, secondary, tertiary). The health workers were drawn from among those working in labor and delivery sections of the participating health facilities in the two states. In addition, the health workers had spent at least six months in the health facility working in either maternal or newborn care section.

Randomization

The unit of randomization in this study was the health facility. The 60 facilities were matched based on locations and level in the health care system, then divided into nine strata taking into consideration the three geopolitical zones as well as the three levels of the health care system in Nigeria. Thereafter, each stratum was randomized to either intervention or control arm using randomly permuted blocks in a ratio of 1:1 so as to achieve balance in geographical location and types of health facilities in the two study arms. Randomization was done by a study team member. Those assessing outcomes were blinded to the training methodology used for the health facilities. Since there were at times less than three skilled birth attendants in some health facilities, all health workers employed in the maternity or newborn units in such facilities who met the inclusion criteria were selected from the randomized health care facilities.[5]

Sample size

The details on the computation of the sample size, including the assumptions are provided in the study protocol manuscript. [5]. Briefly, the required number of participants was computed as the average number of health workers to be included from each of the 60 facilities (30 per arm) using a test of two proportions. The percent of competent health workers was estimated at 50% in the control group. Study power was set at 80% to reject a null hypothesis that the proportions of competent health workers are equal in the two study arms against the alternative hypothesis of 20 percentage point difference in proportions of competent health workers between the two study arms - effect size. The significance level was set at 0.05. Sample size computation was done using PASS statistical software. The correlation of health workers competency in each health facility was assumed to be 0.05 given that some facility-level factors are shared by the health workers working together and influence how they perform certain tasks. We assumed there are about four health workers selected per facility, thus 240 health workers sampled across the two groups. An adjusted sample size of 300 participants (150 per study arm) was arrived at after factoring in potential 20% drop-out during follow up period after baseline. More health workers were recruited from Kogi State since it had a larger population than Ebonyi. Study participants recruited from each facility included the maternity unit head, wherever possible, and two others to ensure that the other team members received the necessary support to practice.

Data analysis

The primary outcome was health workers clinical competency in BEmONC skills at three months post-training assessed through simulation. The secondary outcome was retention in clinical competency level in BEmONC skills as determined through MCQs and OSCEs assessments at 12 months post-training. The results on assessments at three and 12 months after training were presented. For both arms, composite scores were computed for the infection prevention and the BEmONC functions, namely; skills in conducting normal delivery, active management of the third stage of labor (AMTSL), neonatal resuscitation, case management of pre-eclampsia and eclampsia with magnesium sulphate ($MgSO_4$),

and the management of primary postpartum hemorrhage. Percent scores were computed per participant based on either questions answered correctly or procedures done competently depending on the assessment tool used.

To describe categorical variables, counts and simple proportions were used. Mean and standard deviations as well as median and interquartile range were used to summarize data on continuous variables. Percentage of those achieving the required competency level of ≥80% post-training scores in MCQs and OSCEs were computed and compared across the two study arms. A generalized linear model was used to test the differences between arms on MCQ and OSCE scores at 12 months using a group indicator as the main predictor in the model. Furthermore, adjustments were made to account for facility-level and health worker characteristics that might have influenced the two study arms at baseline and could be strongly correlated with the outcome scores. A significance level of <0.05 was set for statistical significance. A longitudinal model that accounts for intra-provider correlations over time as well as within-facility correlations was developed. This model assessed the change in scores over time post-training. The model is appropriate, since it estimated using generalized estimating equations (GEE) with working exchangeable correlation structure.

In regards to the qualitative data, transcripts in Microsoft Word were imported into ATLAS.ti software (version 8.0) for content analysis. The codebook was developed by the two (2) qualitative researchers, the data analyst and a second coder, using a priori codes developed from the research aims and questions, and the interview guides adopted from previous studies. In order to enhance validity, we adopted a 1st tier triangulation (of researchers) and ensured a well-documented audit trail of materials and processes. To ensure reliability, refutational analysis, constant data comparison, comprehensive data use was done. Reliability checks were performed by each coder independently re-coding documents already coded by the other.

Results

Two hundred and ninety-nine (299) participants completed the study out of the original 323 providers who were randomized to different study arms; LDHF arm=172; TRAD arm=127 (Table 1 and Figure 3). Both arms had similar socio-demographic characteristics, but statistical significant difference between the arms was found in Median Time to Training (minutes) and Cadre/Job (Table 1).

Table 2 shows that the TRAD arm had better knowledge test scores compared to the LDHF/m-mentoring arm at baseline and immediately after the training intervention in some thematic areas, such as AMTSL, essential newborn care, and neonatal resuscitation ($p < 0.05$). However, at 3 and 12 months after training assessment, both arms were equal in knowledge acquisition and retention; no statistically significant differences were noted.

Health workers in both arms showed improvement in overall pass rates in clinical skills competency, improving from around 30% at baseline to 75% and above at end line; difference-in-differences were statistically significant ($p < 0.05$); TRAD (from 27.4% to 74.8%) and LDHF/m-mentoring (from 30.1% to

81.1%). Overall, the observed improvement and retention of BEmONC skills was higher in LDHF/m-mentoring study arm participants (81.1%) compared to the TRAD arm participants (74.8%) at 12 months post-training ($p<0.05$). The LDHF/m-mentoring study arm showed better skills assessment results (Figure 4). There was a dip in both arms at the three-month assessment. (Figure 5).

Figure 3 shows that overall for BEmONC skills, the LDHF/m-mentoring arms had better post-training assessment scores at 12 months post-training for assisting normal birth (including care of the newborn), AMTSL, manual removal of placenta, bimanual compression of the uterus, abdominal aortic compression, pre-eclampsia/eclampsia management ($p<0.05$).

Analysis codes were grouped into four thematic categories, guided by both the specific objectives, research questions and those that emerged from the data. These thematic categories were: 1) knowledge and skills learning outcomes of birth attendants trained through the simulation-based LDHF/m-Mentoring; 2) successful outcomes following simulation-based LDHF/m-Mentoring; 3) data use; 4) challenges and overall impression about LDHF/m-mentoring approach

The analytic process proceeded in two basic steps: Using the thematic groups, emerging themes were summarized related to relevant specific objectives, while analyzing content to compare the three, different respondent groups across the two states. Illustrative quotes were selected to provide examples of evidence supporting the themes both within and across groups and states.

The results of the qualitative study are presented in four sections. The first section addressed knowledge and skill learning outcomes of birth attendants following simulation-based LDHF/m-Mentoring, the second section addressed trainees' satisfaction with successful outcomes following simulation-based LDHF/m-Mentoring approach, third section addressed facilitators of LDHF/m-Mentoring approach and the fourth section addressed the barriers to LDHF/m-Mentoring approach (Table 3).

Excerpts from respondents are presented in italics. Each quote in the text is labeled by type of interview and State.

Theme 1: Knowledge and skill learning outcomes of birth attendants

In both states, all the FDG participants opined that the simulation-based/m-Mentoring training approach enabled them gain improvement in skills/knowledge involving correct application of drugs such as use of magnesium sulphate in the management of pre-eclampsia/eclampsia, oxytocin to manage post-partum haemorrhage, use of misoprostol now used only when it is indicated rather than being used routinely for all clients during labour as was the case prior to the training. The use of magnesium sulphate was said to be the most valuable information or skill learnt during the training.

A respondent said,

'Also the application of magnesium sulphate in pre-eclampsia and eclampsia. Before I didn't understand it but now even if am sleeping, and woken up, I can perfectly handle it. It has helped me to realize that misoprostol is not a must for every patient. Prior to the training, I could not use magnesium sulphate but now I can. I can now make use of magnesium sulphate in handling bleeding in women the way they taught us. The training equipped us on how to manage bleeding with Oxytocin' (FGD, Ebonyi).

Theme 2: Trainees' satisfaction with successful outcomes following the simulation-based LDHF/m-Mentoring approach

The respondents reported reduction in maternal and neonatal morbidity and mortality were common theme across states and respondents. In Ebonyi state, a respondent said since after the simulation-based training commenced, they have not had any maternal or neonatal deaths in their facility. In Kogi state, a participant stated a reduced mortality from pre-ecclampsia and ecclampsia because of improved skills among the peer practice coordinators.

There is clearly noticeable improved new born care and reduced complications and mortalities among new born and their mothers' (IDI, Kogi)

Theme 3: Facilitators of LDHF/m-Mentoring approach

Respondents identified facilitators of LDHF/m-Mentoring approach as support provided by the implementing partners through availability of equipment/supplies, use of telephone for communication, expert knowledge/skill and support from master mentors, incentives/welfare such as transport reimbursement and meals during training, support from management of facilities such as arrangement of duty rosters to enable trainees attend practice sessions and assessments through text messages and quizzes.

The support I provided on phone depended on what they ask. Sometimes while taking delivery, they may ask questions through phone on areas where they needed assistance. They will tell me what they are doing while I seized that opportunity to correct them when I realized they were not doing it right. I had taught about manual removal of retained placenta, pre-ecclampsia and ecclampsia through telephone (IDI, Kogi).

Theme 4: Barriers to LDHF/m-Mentoring approach

The barriers mentioned included lack of funding/equipment/supplies and incessant strikes actions. The cost of obtaining or providing training and guidance from the master mentors was one of the most important barriers identified across the two states. In both Ebonyi and Kogi states lack of finance for the

various costs involved in the LDHR/m-Mentoring-related activities was mentioned more frequently and consistently than any other barrier. Different work schedules prevented some trainees from attending some practice sessions and unavailability of equipment hindered some from translating what they learnt into practice.

The research subjects said that:

The use of the phone which requires recharge card purchases, the internet cost. Cost, initially, I was making frequent calls but later it was reduced to twice every month. I have not been paid for what I have spent so far in making calls to PPC (IDI, Ebonyi).

'I find it difficult bringing everybody together at the same time because we run different shifts. It was very difficult to get members of the group to come together and practice due to our work schedule' (IDI, Ebonyi).

Discussion

In this cluster randomized control trial, the knowledge assessment scores increase from baseline to end line at 12 months among the study arms. The acquisition and retention of BEmONC skills was different at 12 months with the LDHF/m-mentoring arm demonstrating better performance than the TRAD arm. This study contributes to the much needed evidence base for LDHF/m-mentoring training approach in LMICs, adding on the finding of related studies done in Uganda [7] and Ghana [8]. As part of the intervention package, LDHF/m-mentoring study arm participants received weekly SMS reminders and quizzes along with continuous skills practice on anatomical models, which helped, reinforce knowledge on specific clinical areas over time. In contrast, the TRAD arm participants, which represented the *status-quo,* did not have the extra support, which might explain the differences in skills performance at 12 months. Furthermore, information gathered qualitatively suggests that a key benefit of m-mentoring is the ability of trainees to call their mentors at the point of care to address complications such as placenta praevia or birth asphyxia. This close mentor-mentee relationship might also have helped the mentees to develop confidence in these crucial skills, which demonstrates a great potential of the LDHF/m-mentoring approach.

Overall, the LDHF arm had better skills performance at all the assessment points compared to the TRAD arm. The qualitative data also support this improvement in knowledge and skills related to maternal and newborn care. Of note, there was an observed drop in skills competency at three months in both arms from the immediate post-training assessment. Some of the possible explanation for the drop in skills competency is that it took time following intense training, before a practice was established as routine. Another possible cause for the drop may have been that there was a health workers' strike that was ongoing just before the post-training assessments in the two states. Despite these factors, the LDHF/m-mentoring arm still performed better in all competencies at 3- and 12- months post-training. It's

encouraging to note that this observed better performance was in competences that are very crucial for the survival of the mother and the baby on the *day of birth*; these include, AMTSL, manual removal of placenta, neonatal resuscitation, loading dose of magnesium sulphate, and pre-eclampsia/eclampsia. The continued simulation practice may have helped in building and retaining these competencies.

Studies on BEmONC in-service training have demonstrated the value of simulation and continuous practice in improving knowledge and skills competency [2, 7, 8]. This has led to adaptation of various approaches to determine which ones led to the greatest returns on investment [3–10]. Our findings are consistent with those of previous studies that reported that TRAD offsite training may improve the trainees' competencies, but knowledge and skills may not be transferred to other co-workers at the facility, nor translated into practice or performance [13-14]. On the other hand, methods that involve repetitive, mentor-supported learning and regularly coordinated practice sessions, such as the onsite LDHF/m-mentoring training, resulted in better skills acquisition and retention over time [1,7-8,11-17]. This claim has been supported by other well-designed studies that showed that onsite LDHF/m-mentoring training approach, coupled with an efficient mentorship program, resulted in improved provider preparedness to deal with complications [7- 8, 15].

Findings from the Ghana study that measured patient-level outcomes showed that the LDHF/m-mentoring training approach was associated with a sustained decrease in facility-based newborn mortality and intrapartum stillbirths [7]. The limitations acknowledged by Gomez and colleagues in the Ghana study, such as the lack of a randomized control trial design and lack of concealment/information bias, have been addressed in our study using a cluster randomized controlled trial in a similar low-resource setting. Although our study did not measure patient-level outcomes, we assessed a crucial component of the *day of birth*, namely the competency of the service providers. Our study was adequately powered to produce generalizable conclusions on the comparative effectiveness of the LDHF/m-mentoring and TRAD approaches in the study setting and possibly in similar environments especially in LMICs. As reported by other studies, to be effective, training programs should be conducted as close as possible to the workplace and be competency-based [16-18].

The present study also adds to the growing yet still insufficient body of evidence in LMICs supporting the use of simulation, specifically for training in the management of obstetrics and newborn emergencies [19-21]. Skills that are not used very frequently in management of obstetric and newborn complications are likely to be non-existent or lost due to a lack of use, and therefore the need to practice often. The appropriate dose or frequency of practice in order to reach competency level depends on many factors, which include the personal attributes of service health worker among other things. Simulation-based trainings provide participants with the opportunity to repeat practice sessions in a safe environment

where they will not harm patients [7, 8, 18, 21]. Using the workplace to practice skills is beneficial. The availability of the anatomical models for continuous onsite simulation practice sessions also helps to organize emergency drills to test the health systems response to life-threatening complications.

Another important finding is that some of the facilitators for the LDHF/m-mentoring approach are related to successful outcomes that were reported as health workers improved their skills, which motivated the participants to practice more and seek support from master mentors. Inadequate mentorship should be addressed to improve quality of BEmONC [22]. On the other hand, some of the barriers to this approach included lack of funding, logistics, medical equipment and supplies, . Labor strikes by health workers also limited peer practice sessions. To function maximally, health workers need to improve their competency and they need an enabling environment, including availability of supplies, equipment, appropriate guidelines and policies, and timely remuneration [23, 24]. Our study findings corroborated those of previous studies in LMICs on the effectiveness of the LDHF training approach compared to the offsite traditional training approach to build health workers capacity [7,8].

This study had some limitations. These include some operational-level logistic challenges in ensuring that the mentors always had the airtime in a timely manner in order to maintain seamless communication with the mentees. This was mitigated by the mentors being very understanding by using their resources as they awaited support provided through the study. Another limitation was the health workers' strike which occurred around three months post-training, which potentially affected the findings negatively at that assessment period. Finally, although the study team appealed to MOH not to transfer the study participants to other non-study facilities for duration of the study, some staff were transferred. However, the proportion was very low; they were not included in the analysis.

Conclusion

This is one of the few studies from a middle-income country that has used a pragmatic design—a cluster randomized controlled trial and qualitative methods—to generate much needed information on learning outcomes of two approaches to health worker capacity building. Our study findings corroborated those of similar studies to support the proposition to a shift from traditional offsite group-based training to low-dose, high-frequency and onsite training as an effective way to build the capacity of maternal and newborn care providers. This shift can be explored in other clinical settings to improve the quality of care. The findings suggest that a low-dose, high frequency and simulation- and practice-based training approach, including mobile mentoring is likely to result in better skills competency outcomes and higher skills retention among health workers. This study has shown promising results that can address health worker absenteeism due to frequent offsite trainings, which are a major concern for health facility managers in LMICs. Training staff onsite without taking them away from service delivery points is a strong reason for adoption of the LDHF/m-mentoring approach.

The findings are expected to provide health facility managers and other decision makers with valuable information to guide resource allocation for maximum benefit and effectiveness in building the capacity of frontline health workers. The authors recommend that capacity building among healthcare workers, to the extent possible, should utilize the onsite LDHF/m-mentoring learning approach. Further evidence is needed to determine the value of m-mentoring in influencing learning outcomes and the cost-effectiveness of both training approaches as these were not explored in our study.

List Of Abbreviations

AMTSL: Active management of third stage of labor

BEmONC: basic emergency obstetric and newborn care

FGDs: Focused Group Discussions.

IDI: In-depth Interviews

IQR: interquartile range

LDHF: low-dose, high-frequency; m-mentoring: mobile mentoring

LMICs: Low and Middle Income Countries.

MCQ: Multiple Choice Questionnaire

MOH; Ministry of Health

OSCE: objective structured clinical examination

PE/E: Pre-eclampsia/Eclampsia

PPH: Postpartum Haemorrhage

SD: standard deviation

TRAD: traditional group-based training.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from Nigerian Health Research Ethics Committee with approval number NHREC/ 01/01/2007 November 2015 and the Johns Hopkins School of Public Health, Institutional Review Board #000007196, on August 23rd, 2016. The trial was retrospectively registered with the NIH-Sponsored ClinicalTrials.Gov registry on 24th August, 2017: NCT03269240. Verbal informed consent was

obtained from study participants and confidentiality was assured. Verbal informed consent was used because the authors thought that asking health providers to review and sign forms might be considered risky because of the fear that if they performed poorly their supervisors may see their scores and trace it back to them.

Consent for publication

Not applicable

Availability of data and material

The datasets generated and/or analyzed during the current study are available in the figshare repository, https://doi.org/10.6084/m9.figshare.9955133

Competing interests

The authors declare that they have no competing interest.

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Authors' contributions

EU, MK, EO, GY, AO, BO1, UO, JE, GI, GA, GO, OA, CO, AA and BO2 contributed to the data collection, analysis and development of the manuscript. EU, MK, EO and GY conceived the idea of the manuscript and wrote the initial draft. All other authors contributed significantly to the research project and manuscript development. All authors read and approved the final manuscript.

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Tables

Table 1: Baseline characteristics of study sample of providers by study arm

Characteristic of Health Workers	LDHF/m-mentoring	TRAD	
	N=172, Percent	N=127, Percent	**p value**
State or Location			
Ebonyi	36.6	26.011	*0.05*[a]
Kogi	63.4	74.0	
Type of Facility			
Primary health center	38.4	47.2	*0.05*[a]
General/Mission hospital	52.3	38.6	
Tertiary hospital	9.3	14.2	
Mean (SD) Age: years	41.0 (10.3)	40.6 (8.8)	0.78[b]
Sex			
Male	15.7	22.0	0.16[a]
Female	84.3	78.0	
Marital Status			
Married	84.3	89.0	0.60[c]
Single	10.4	8.6	
Divorced	0.6	0.0	
Widowed	4.7	2.4	
Religion			
Christian	79.7	74.8	0.33[a]
Islam	18.6	22.8	
Other	0.0	0.8	
Missing	1.7	1.6	
Duration Since Graduation: years	12.0 (6.0–23.0)	14.0 (8.0–21.0)	0.54[d]
Cadre/Job Title			
Community health extension worker	34.3	43.3	***0.03***[+c]
Doctor	3.5	8.7	
Nurse	57.0	46.4	
Other	5.2	1.6	
Median (IQR) Duration Working at Facility since Employment: years	6.0 (3.0–10.0)	6.0 (3.0–10.0)	0.84[d]
Median (IQR)* Time to Training: minutes	60.0 (60.0–90.0)	60.0 (60.0–120.0)	***<0.001***[+d]
Duration at current position: median (IQR) years	8.0 (4.0–18.0)	9.0 (4.0–15.0)	0.76[d]

*Types of tests: a=Pearson's chi-squared; b=Two sample t test; c=Fisher's exact; d=Wilcoxon rank-sum. SD, standard deviation; IQR, interquartile range. *TRAD participants residing within 5 km of the training sites were not accommodated in a hotel; they travelled daily to the training site; +, statistical significance*

Table: 2: Comparison of levels of knowledge between study arms across four assessment periods

Thematic Area #	Thematic Area	Total number of items	Assessment 1—Baseline					
					Unadjusted analysis		Adjusted analysis*	
			Mean # correct, LDHF	Mean # correct, TRAD	IRR (95%CI)	p value	IRR (95%CI)	p value
1	Infection prevention	6	3.17	2.67	1.19 (1.07, 1.32)	**0.001**[+]	1.17 (1.06, 1.30)	**0.002**[+]
2	Normal birth	8	4.17	4.01	1.04 (0.96, 1.13)	0.349	1.03 (0.95, 1.12)	0.498
3	AMTSL	4	1.79	1.73	1.03 (0.88, 1.21)	0.682	1.02 (0.88, 1.18)	0.822
4	Management of eclampsia	2	1.13	1.11	1.02 (0.89, 1.18)	0.754	1.02 (0.88, 1.17)	0.805
5	Essential newborn care	2	0.94	1.03	.92 (0.77, 1.09)	0.318	0.91 (0.76, 1.08)	0.270
6	Neonatal resuscitation	20	8.55	11.15	0.77 (0.70, 0.84)	**<0.001**[+]	0.75 (0.68, 0.82)	**<0.001**[+]
	Overall score	42	17.62	19.71	0.89 (0.83, 0.96)	**0.002**[+]	0.88 (0.82, 0.94)	**<0.001**[+]
Thematic Area #		**Total number of items**	**Assessment 2—Immediate post-training**					
					Unadjusted analysis		**Adjusted analysis***	
	Thematic Area		**Mean # correct, LDHF**	**Mean # correct, TRAD**	**IRR (95%CI)**	**p value**	**IRR (95%CI)**	**p value**
1	Infection prevention	6	5.01	5.04	1.00 (0.94, 1.06)	0.888	0.98 (0.92, 1.04)	0.470
2	Normal birth	8	6.51	6.76	0.96 (0.92, 1.01)	0.134	0.95 (0.90, 1.00)	**0.040**[+]
3	AMTSL	4	3.2	3.49	.92 (0.86, 0.98)	**0.009**[+]	0.90 (0.84, 0.96)	**0.002**[+]
4	Management of eclampsia	2	1.72	1.8	0.95 (0.89, 1.02)	0.138	0.95 (0.89, 1.01)	0.116
5	Essential newborn care	2	1.34	1.65	0.81 (0.74, 0.89)	**<0.001**[+]	0.80 (0.72, 0.88)	**<0.001**[+]

6	Neonatal resuscitation	20	11.29	16.21	0.7 (0.63, 0.77)	**<0.001⁺**	0.68 (0.61, 0.75)	**<0.001⁺**
	Overall score	42	24.21	30.57	0.79 (0.75, 0.84)	**<0.001⁺**	0.77 (0.73, 0.82)	**<0.001⁺**
Thematic Area #		**Total number of items**	**Assessment 3—3 months post-training**					
					Unadjusted analysis		**Adjusted analysis***	
	Thematic Area		**Mean # correct, LDHF**	**Mean # correct, TRAD**	**IRR (95%CI)**	**p value**	**IRR (95%CI)**	**p value**
1	Infection prevention	6	4.54	4.24	1.07 (0.99, 1.16)	0.086	1.04 (0.96, 1.12)	0.348
2	Normal Birth	8	5.9	5.7	1.04 (0.96, 1.11)	0.342	1.01 (0.94, 1.08)	0.760
3	AMTSL	4	3.07	3.04	1.01 (0.92, 1.10)	0.853	0.97 (0.89, 1.06)	0.569
4	Management of Eclampsia	2	1.69	1.7	1.00 (0.92, 1.08)	0.932	0.99 (0.91, 1.07)	0.741
5	Essential Newborn Care	2	1.55	1.52	1.02 (0.91, 1.14)	0.781	1.00 (0.89, 1.12)	0.964
6	Neonatal Resuscitation	20	14.45	13.98	1.03 (0.96, 1.11)	0.372	1.00 (0.93, 1.08)	0.978
	Overall score	42	27.41	26.37	1.04 (0.98, 1.10)	0.200	1.01 (0.95, 1.06)	0.796
Thematic Area #		**Total number of items**	**Assessment 4—12 months post-training**					
					Unadjusted analysis		**Adjusted analysis***	
	Thematic Area		**Mean # correct, LDHF**	**Mean # correct, TRAD**	**IRR (95%CI)**	**p value**	**IRR (95%CI)**	**p value**
1	Infection prevention	6	4.15	3.99	1.04 (0.95, 1.14)	0.380	1.01 (0.93, 1.10)	0.795
2	Normal birth	8	5.59	5.32	1.05 (0.97, 1.14)	0.213	1.03 (.95, 1.11)	0.470
3	AMTSL	4	2.88	2.89	1.00 (0.90, 1.10)	0.944	0.96 (0.88, 1.06)	0.426

4	Management of eclampsia	2	1.61	1.59	1.02 (0.93, 1.11)	0.730	1.00 (0.92, 1.10)	0.920
5	Essential newborn care	2	1.51	1.46	1.04 (0.93, 1.16)	0.544	1.01 (0.90, 1.13)	0.867
6	Neonatal resuscitation	20	13.83	14.02	0.99 (0.94, 1.04)	0.588	0.95 (0.91, 1.00)	**0.036**[+]
	Overall score	42	26.47	26.16	1.01 (0.96, 1.06)	0.642	0.98 (0.94, 1.02)	0.340

IRR, incidence rate ratio; CI, Confidence interval; +, statistical significance

Table 3: Key findings by themes and supporting quotations

Key Findings	Supporting quotation
Theme 1: Knowledge and skill learning outcomes of birth attendants	
1. Knowledge on hygiene refers to improved skill or knowledge in hygienic practices e.g hand washing, proper cord care.	A discussant in Ebonyi said: *'Before we normally use glove as a protective device but now we wash our hands before wearing the gloves (FGD, Ebonyi).* Another respondent in Kogi said: *' At my facility I re-oriented the people that work with me what standard practice is all about. Example, hand washing was not practiced in our labour ward'. We used improvised water system in order to still be able to comply with this standard practice of hand washing even though there are no running tap (FGD, Kogi).*
1. Proper documentation refers to improved skill/knowledge in documentation e.g use of partograph	An FGD participant in Ebonyi said: *'The training was different to me by emphasizing that the partograph is a medico-legal document* *The training endeared me to the use of partograph to monitor labour and the importance of documentation. We have started using partograph. Before now, we were not using partograph' (FGD, Ebonyi)* Also, in Kogi state, a discussant said: *I was not used to making use of partograph before this training. But now, we routinely use partograph to monitor the progress of labour (FGD, Kogi).*
1. Respectful maternity care refers to improved skill/knowledge in patientmidwife relationship, asking patients for their opinion/choices during service delivery, speaking nicely to clients/patients instead of shouting, explaining procedures to patients/clients and asking for consent. Also allowing relatives into delivery/treatment suite if patient wishes so.	In Ebonyi, a discussant said: *'The respectful maternity care involves asking and telling the patient what you want to do and how you are going to do it and the effect. Now when a woman is coming for antenatal or maternity, we ask them to come with their husbands. There were some words that we never thought were abusive but after the training, I cannot tolerate anybody abusing my patient. We now ask for patient's opinion on how she is to be taken care of like lying down or sitting up. Unlike before you just keep commanding the patient on what to do. The training was good (FGD, Ebonyi)* Another in Kogi said: *Yes, it had made me to reemphasize rights of patience and give them utmost respect. Value their opinion more(FGD, Kogi).*
1. Resuscitation includes improved/newly acquired skill/knowledge in neonatal care immediately after delivery.	*Respondents in Ebonyi said:*

	1) 'Mine is in neo-natal resuscitation, before if a baby is presented to me; after like I minute I will dump the baby and call another for help. But after the training, I can now resuscitate a baby no matter how bad. 2) 'I so much value neo-natal resuscitation, now we keep the place warm and resuscitate. The Neonatalie (anatomical model) is very helpful in the area of resuscitation. Before I don't know about the breathing of the baby, but the NeoNatalie taught me'. *In Kogi, respondents said:* *1) "In the aspect of child resuscitation. It teaches how to resuscitate the child* *2) "Now we do newborn resuscitation*
1. Disease management is improved: skills/knowledge in managing morbid conditions, including providing initial primary care before the arrival of the doctor or referral.	*1. It has provided us with options and confidence to face women with PPH unlike previously that this condition scares us a lot and usually ended in referrals.* "Before we did not know how to treat eclampsia, PE, we used to refer always' *(FGD, Ebonyi)*. 2. *What we don't know how to handle, since we were trained we now know how to handle them.. We now know hypertension, PE, E. Also bleeding (haemorrhage), before we don't know, the training is an eye opener to us (FGD, Kogi).* *3. We learnt many methods of preventing PPH. PPH is minimized here. Before I didn't know management of PE/E. But the training helped me to improve my knowledge in PPH, PE, E (FGD, Kogi).*
1. Coaching/mentoring pertains to improved skill/knowledge which has led to training other colleague or students	A respondent in Ebonyi opined: *'The use of MamaNatalia (anatomical model) also helps us to even teach the student nurses before using the real scenario.* Another said: *I've been able to coach a colleague that didn't partake in the training. Also students that come, I coach them.* In Kogi, the participants said: *1) I like the confidence resulting from the knowledge the training has helped me to gain which also made it possible for me to train others.* *2) They have made me a better trainer and have taught me how to train a small group.* *3) We now render correct health education in addition to in-house training sessions for staff using the*

1. Drug usage pertaining to gained improvement in skills/knowledge involving correct application of drugs for conditions identified.	*guidelines, which has now been introduced.* *1. 'Also the application of magnesium sulphat in preeclampsia and eclamsia. Before I didn't understand it but now even if I am sleeping, and woken up, I can perfectly handle it. It has helped to realize that misoprostol is not a must for every patient. Prior to the training, I could not use magnesium sulphate but now I can. I can now make use of oxytocin in handling bleeding in women the way they taught us. The training equipped us on how to manage bleeding with Oxytocin' (FGD, Ebonyi).* *2. 'Has made a very significant difference" like there are some areas which we don't know before e.g. we didn't know that this oxytocin has to be given before delivery of the placenta* *Ten years ago only 3 centres used magnesium sulphate and partograph in Kogi state. Presently, several facilities are making use of these' (FGD, Kogi).*
Theme 2: Trainees' satisfaction with successful outcomes following the simulation-based LDHF/m-Mentoring approach *A.* Successful outcome on maternal survival refers to numerical gains achieved following training in service delivery pertaining to reduced maternal mortality/better maternal survival following trainings and application of skills. *B.* Successful outcome on newborn/neonatal survival refers to successes gained as numerical improvement neonatal/infant survival, reduced neonatal/infant mortality following trainings and application of skills.	*Post-partum haemorrhage and ruptured uterus are no longer occurring in the supported facilities (IDI-Kogi).* *'There are less maternal and newborn complications in the supported facilities. There is clearly noticeable improved newborn care and reduced complications and mortalities among newborn and their mothers' (IDI, Kogi),* *It has helped in reducing maternal mortality very much thus reduce the death that are related to these conditions. (IDI, Ebonyi).* *'Firstly, since the training, we have not had maternal or neonatal deaths in our facility. One of the babies is my greatest success (There is one case in which a participant called me from a facility very late at night. They were having issues and she called me to clarify, it had to do with augmentation of labour. I had to put her through and by morning, she gave me the good news that all went well and the woman put to birth' (IDI, Ebonyi)'.* *"Especially in newborn resuscitation. We have saved babies that would have died". Now babies can be resuscitated so more babies are surviving and we are having more successful deliveries. Before, they used to deliver people*

C. Successful outcome on patient trust/satisfaction include any mention of gains achieved following training in service delivery involving patients/clients being happier, more co-operative, feeling safer with health workers and more trusting of health workers.	*and some of the babies end up being asphyxiated. So the way the resuscitate babies has greatly improved. Those problems are no more. Knowledge in method and skills of resuscitation has increased and delivery outcome improved greatly (IDI, Kogi).* *The training has made our clients to become confident in our ability and services as health workers, especially, after the application of respectful maternal care (IDI, Ebonyi)*
Theme 3: Facilitators of LDHF/m-Mentoring approach 1. Support from implementing partner refers to support or motivation for the training or practice emanating from the provision and availability of equipment, drugs or supplies from MCSP. 1. Expert knowledge/skill and support from master mentors through telephone pertaining to support for training and practice through the provision of expert knowledge and skills.	A respondent in Ebonyi state said: *'Our implementing partners are the biggest supporter of this program, they trained us.'* From Kogi, respondents said: 1. *'They brought the training close to us. Also the knowledge they are providing me with. They trained us as consultants with them'.* 2. *'They have been supporting us through training and helping us to improve our skills'.* From Kogi: 1. *Through phone calls, I discussed topics on maternal and child health, real life experience and situation they have for example PPH. I advise them to refer cases they cannot handle.* 2. *The support I provided on phone depended on what they ask. Sometimes while taking delivery, they may ask questions through phone on areas where they needed assistance. They will tell me what they are doing while I seized that opportunity to correct them when I realized they were not doing it right. I had taught about manual removal of retained placenta, pre-ecclampsia and ecclampsia.* 3. *There was once they took the picture of a baby during weighing and sent to me. I noticed the baby had cap on while weighing. I then took advantage of this to teach them how to properly take the weight measurement.* From Ebonyi a mentor commented that:

1. Incentives/welfare refers to support received from MCSP, master mentors or peer practice coordinators involving the provision of transport fare, lunch during practice sessions to encourage trainings/practice or reimbursement for LDHF/m-Mentoring-related phone calls. 1. Support from management of facilities has to do with support provided by management involving 1. the arrangement of duty rosters to 2. enable trainees attends practices sessions, permission for retraining/stepping down, provision of venues/keys for practice. 1. Assessments through text messages and quizzes refers to support from the mentors or coordinators which includes following up of trainees actively to ensure skills/knowledge are acquired, identifying problematic areas with correction provided.	*Usually all the topics but mainly newborn resuscitation; that was the area they are not finding funny. Occasionally they call me when they have difficulty in the hospital, I also assist them. On phone, I discussed topics such as normal delivery, administration of magnesium sulphate and Manual removal of placenta.* Another mentor said, *'I also call during their practice session since I know the time they usually have their practice session at 1.30pm. I sometimes travel to the facilities when phone calls cannot completely address their challenges. I remind them to go back to their manual where explanation through phone is not sufficient to address their challenges' (IDI, Kogi).* *'Salaries have not been paid for several months. So I support them financially… The master mentor supports through giving general encouragement on the need to comply with the guidelines and to reach him for clarification when the need arises. He also assist through training us to acquire more skills related to patient care' (FGD, Kogi)* *'I motivate them by giving them little things (launch) just to encourage them. Yes, light refreshment during practice' (IDI, Ebonyi).* *'The management allows us to go for training' (IDI, Ebonyi).* *'The management support by providing a training ground and allowing us to go for the practice' (FGD, Ebonyi).* *They have been supportive. At least I am here for this training because my facility management permitted me. So, they created a conducive atmosphere that permitted the project to go on successfully. (IDI, Kogi)* *'The short messages reminders and quiz made us to practice. For any quiz we did not get the right answers we were corrected immediately' (IDI, Kogi).*
Theme 4: Barriers to LDHF/m-Mentoring approach A. Funding/equipment/supplies pertaining to mention of problems	*The use of the phone which requires recharge card purchases and internet cost were challenging. I was making frequent calls but later it was reduced to twice every month*

involving inadequate funding, equipment, drugs, supplies, or electricity.	*due to cost. I have not been paid for what I have spent so far in making calls to PPC (IDI, Ebonyi).* *My major challenge is the cost of maintaining the registers/records because if MCSP closes, we are most likely to revert to old practice of not keeping records (IDI, Ebonyi)* *'I find it difficult bringing everybody together at the same time because we run different shifts. It was very difficult to get members of the group to come together and practice due to our work schedule' (IDI, Ebonyi).* *'There was the problem of so much distraction because the people were busy in the ward. You keep starting afresh when they go out and come back. So it took time to complete the tools' (IDI, Ebonyi).*
B. Logistics and incessant strikes refers to problems encountered during project or use of skills in service areas pertaining to late/untimely dissemination of information, fixing of trainings while trainees are working on shift, training staff and transferring them to areas where skills are not utilized , time constraint, hectic schedule, poor/no transport, poor/wrong choice of meeting venue.	*'The mentees having to gather from different places where they live to enable them practice is challenging' (IDI, Kogi).* *'Frequent labour strikes seriously hindered our being able to translate knowledge to practice and bad roads for those living in hard-to-reach localities' (IDI, Kogi).* '

Figures

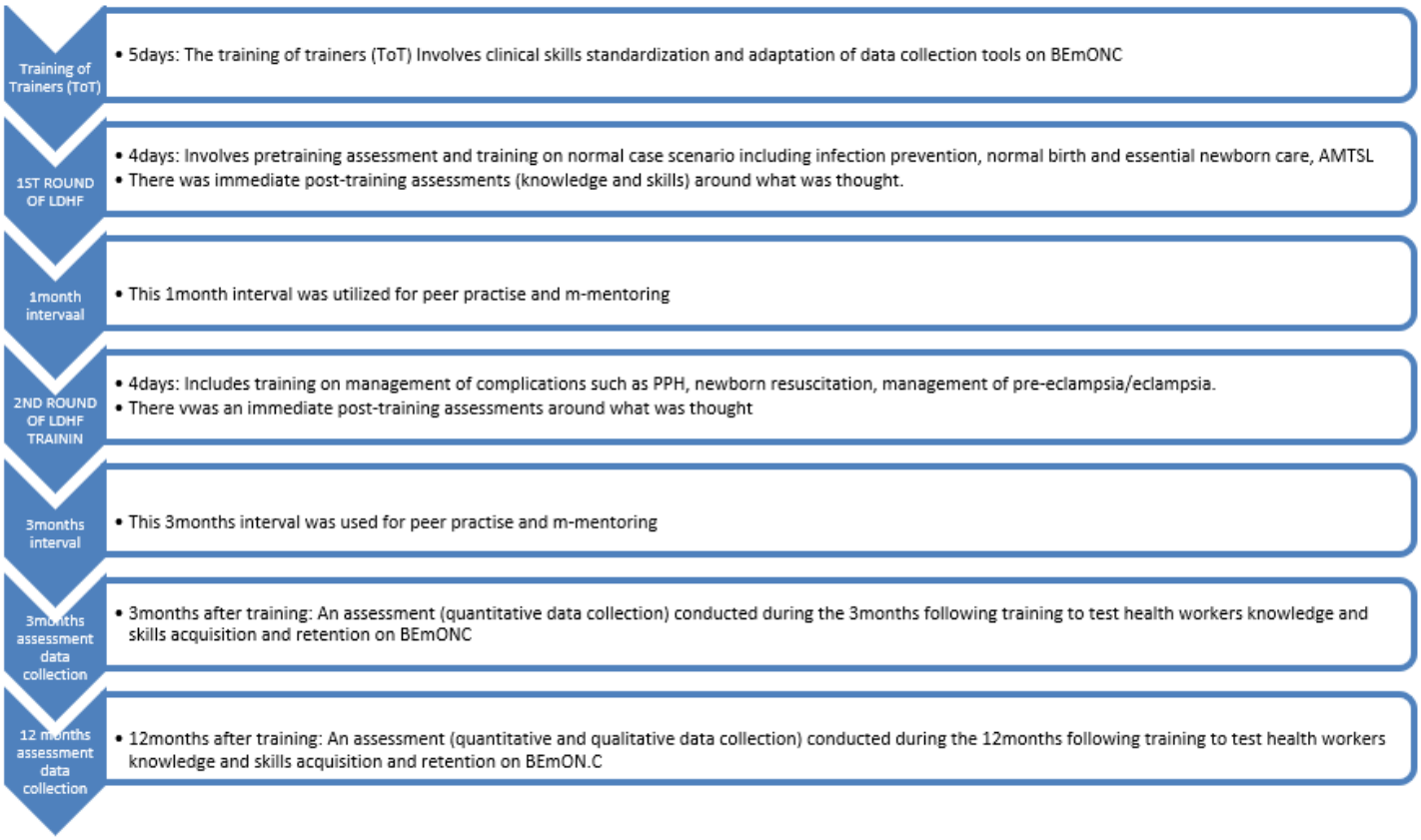


Figure 1

Training approach 1 and data collection: Simulation based LDHF/m-mentoring training of participants – group 1 or intervention group

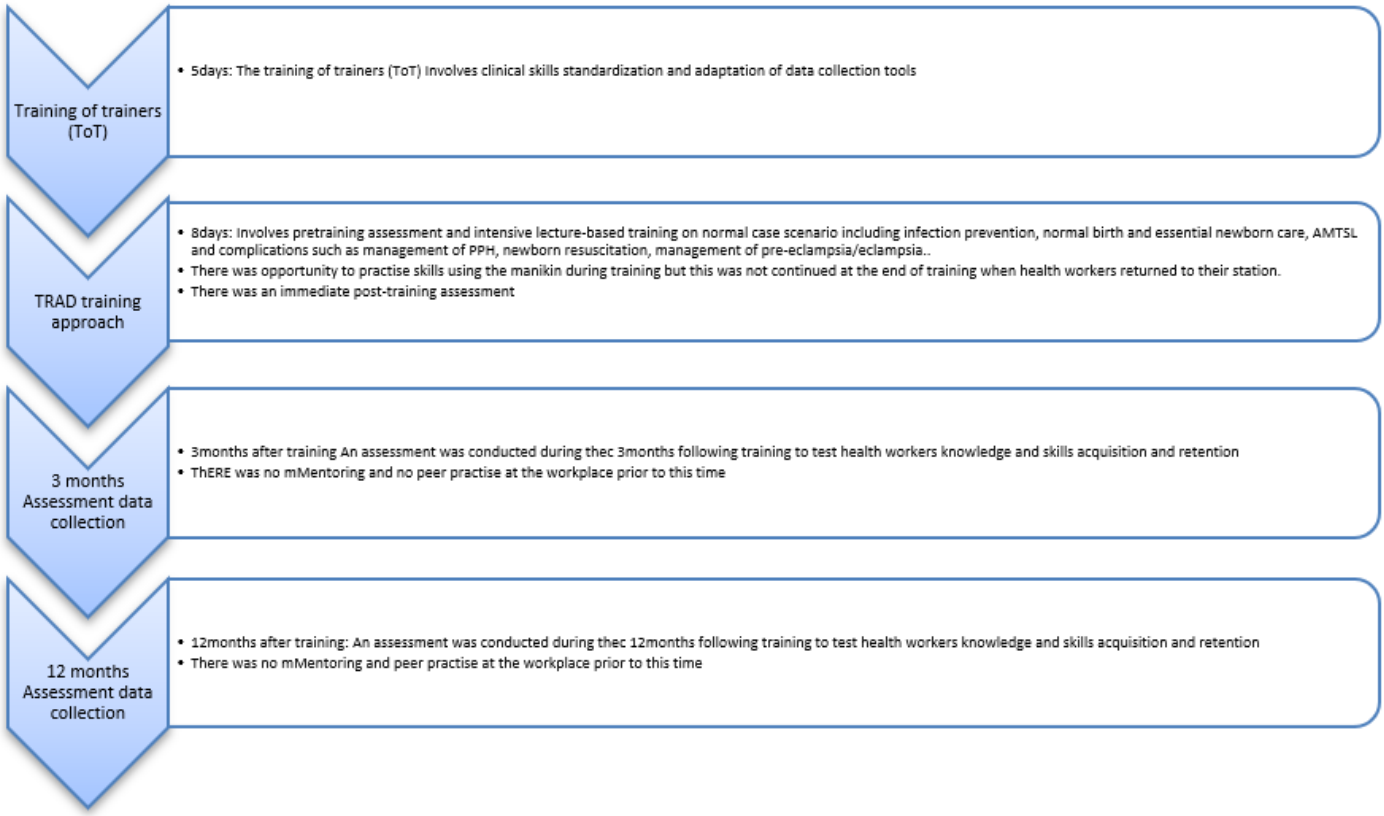


Figure 2

Training approach 2 and data collection: Traditional off-site training of participants – group 2 or control group

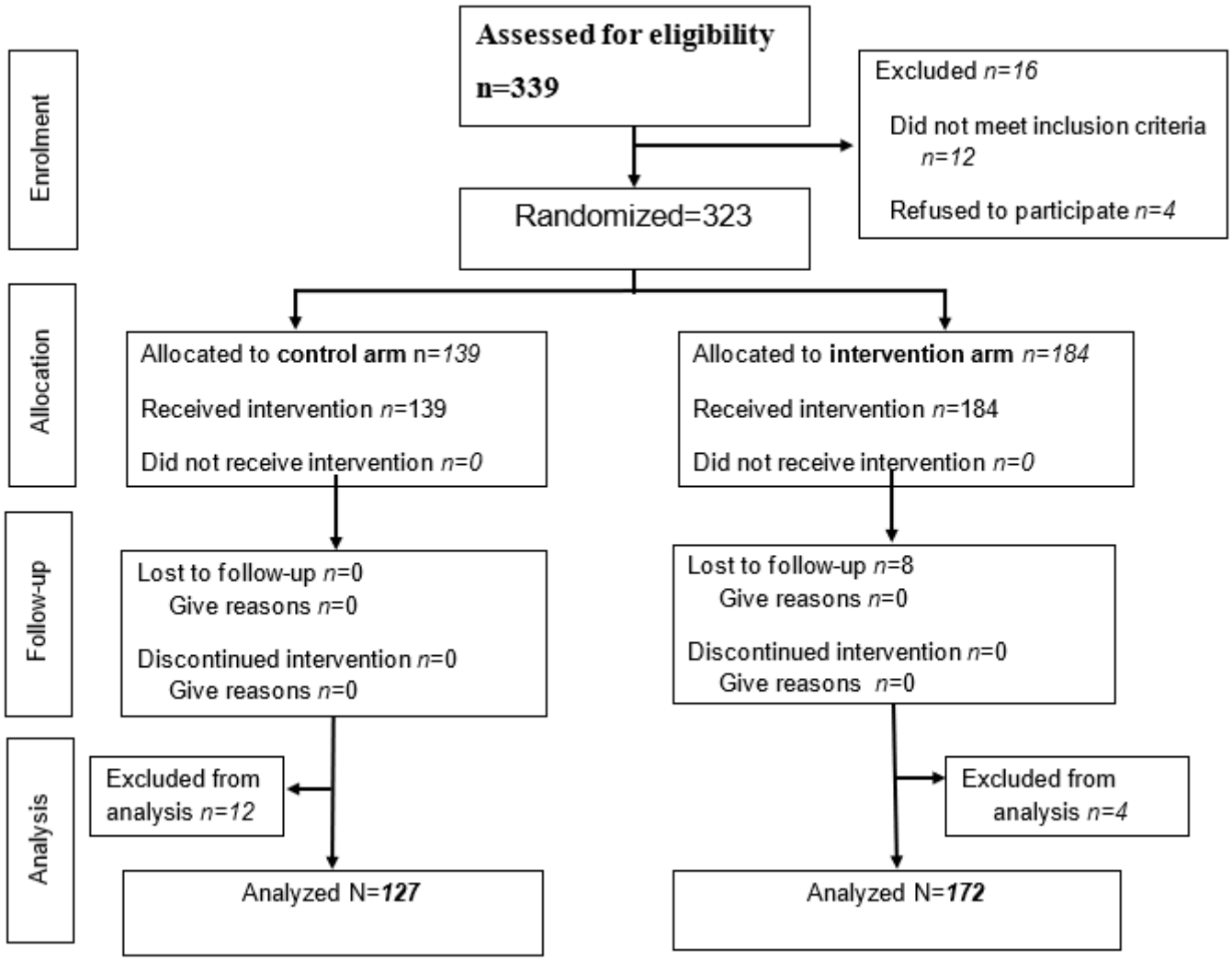
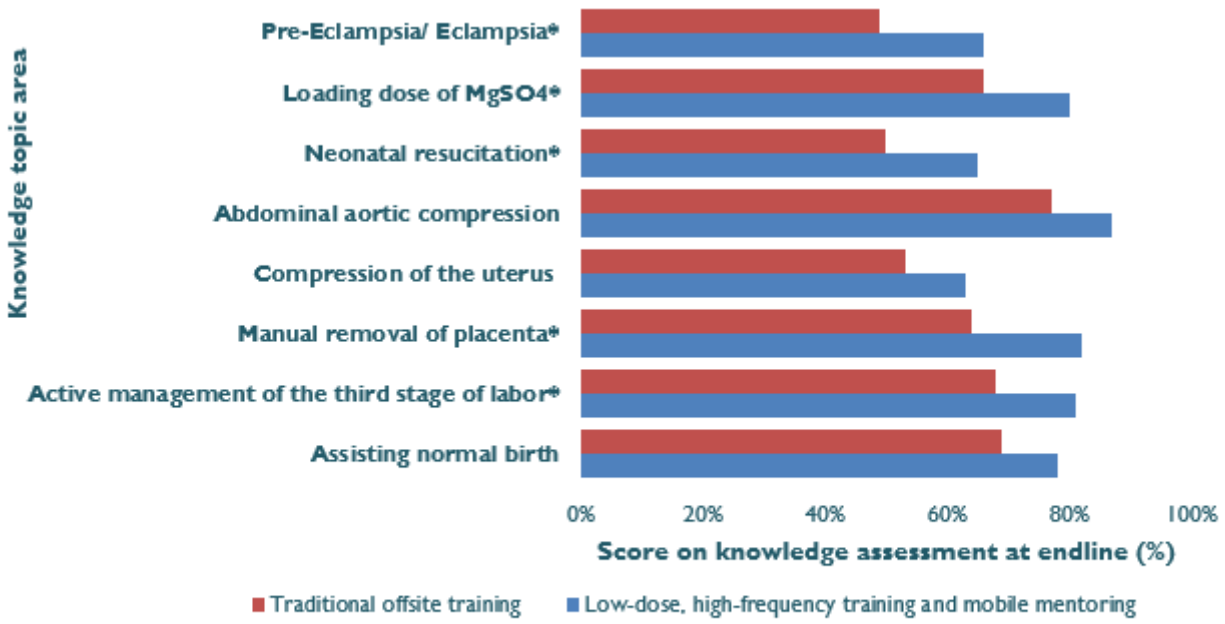


Figure 3

Consort flowchart of enrolment of study participants and data analysis



**denotes p value <0.05*

Figure 4

Assessment of providers' BEmONC skills at 12 months post-training

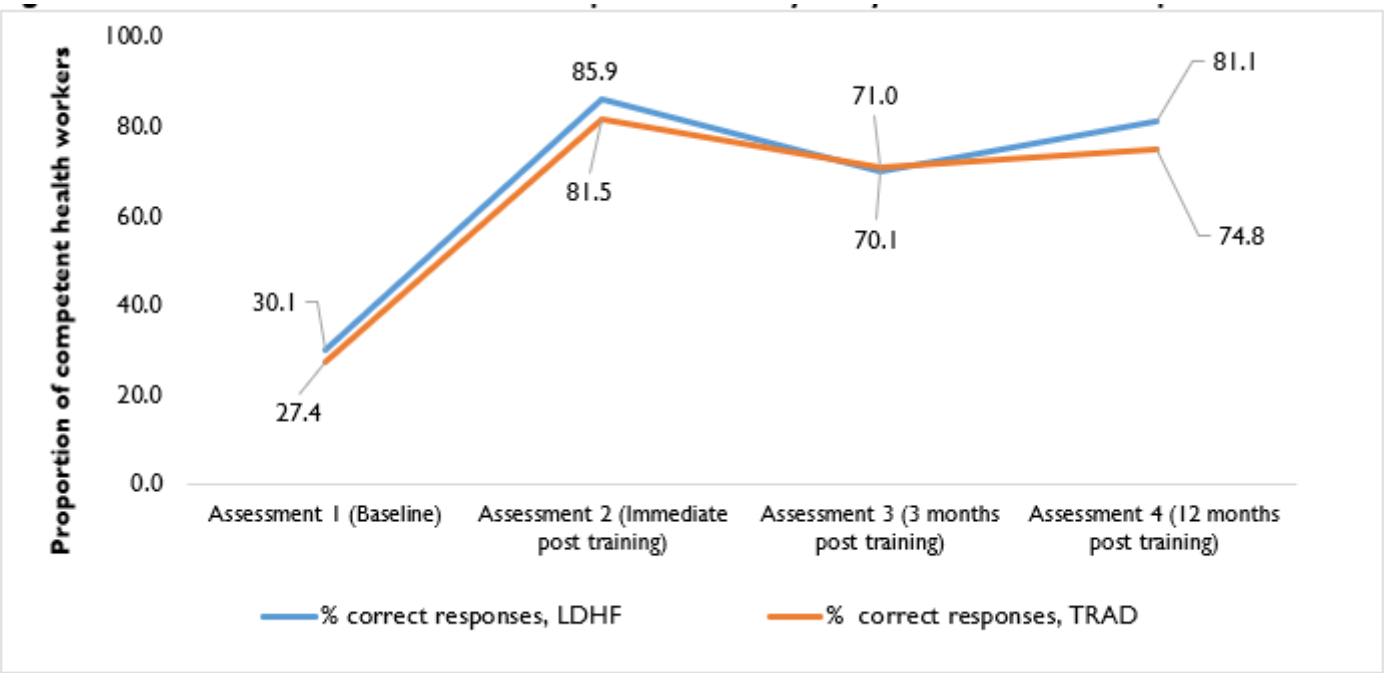


Figure 5

Trends in BEmONC skills mean composite scores by study arm over 12-month period

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Jan18CONSORT2010Checklist121420191.doc
- coreqchecklist.pdf