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RESEARCH ARTICLE

Evaluation of retention of knowledge, skill and competency of health workers one year after completion of the Helping Babies Breathe training program in South Sudan [version 1; peer review: 1 approved with reservations, 1 not approved]

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Abstract

Introduction: The aim of the study is to evaluate the long-term retention of knowledge, skill and competency of health workers who completed Helping Babies Breathe (HBB) training and effect on newborn mortality

Methods: The study employed pre-post-interventions study and participants were selected based on their previous training on HBB protocols. Health workers were assessed for knowledge, skill and competency pre, post training in March, and 3months in June 2017 and 1-year post implementation in September 2018. Health workers were scored on knowledge, skill and competency. The mean score was obtained and repeated ANOVA, chi-squared test and Pearson's test was used to compare pre- and post-intervention and one-year implementation. Retention of health worker's knowledge, skill and competency was assessed using the HBB questionnaires, checklist, practical skill and drills, and were scored on knowledge, skill and competency. The scores were computed into percentages, mean scores and mean differences, and compared against scores at 3 months and 1 year. Impact on management of newborn asphyxia was conducted using a review of delivery registry at maternity and children ward scores were group into percentages, averages means, computed using the Chi-square test.

Results: There were 53 health workers evaluated; 29 were in the intervention and 24 in the control hospital. There was marked decline in the knowledge (84% to 69.4% $p=0.001$), skills, (94.6% to 77%, $p=0.001$), competency for simple resuscitation (88.5% to 76.4%, $p=0.36$) and complex resuscitation (83.3% to 76.9%, $p=0.001$) in intervention hospitals. Health workers in the control had good retention and improvement of knowledge (50.6% to 61.2%, $p=0.004$), skills (40.3% to 56.5% $p=0.004$), competency for simple resuscitation

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(38.0% to 53.1% $p=0.001$) and complex resuscitation (33.1% to 53.4% $p=0.001$).

Conclusions: Health workers in the control hospital had improvement in retention of their knowledge, skill and competency. Newborn mortality decreased in both hospitals.

Keywords

Knowledge, skill, competency, retention, neonatal resuscitation, Education

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Introduction

Of the 200,000 children born annually in South Sudan, an estimated 40% die in the first month of life¹. Newborn mortality contributes to 39% of all deaths of under-fives in South Sudan. The decline of newborn mortality rate in South Sudan has remained slower than the global average rate for the last decade^{2,3}. The highest risk to newborn life is within the first day of life. Death within this period accounts for almost 5% of newborn deaths^{4,5}. Globally and in South Sudan, the main direct causes of newborn deaths are usually infection-related complications (26%), intrapartum complications (24%) including birth asphyxia, preterm delivery (34%), and congenital abnormalities (9%). In South Sudan, 20% of newborn deaths are associated with birth asphyxia^{6,7}.

The transition from intrauterine to extrauterine life requires initiation of breathing which is critical physiological changes required for newborn survival. Research indicates that the majority of newborns initiate breathing within 30 minutes and an estimated 10% breathe when they receive drying and stimulations from health workers, 3% of newborns require positive pressure (PPV), while another 2% need ventilation and intubation offered by knowledgeable and skilled health workers^{8,9}. Training of health workers on newborn resuscitation and provision of effective and timely resuscitation could prevent a good number of newborn with asphyxia and subsequently improve their survival rate.

Various studies on the effectiveness of newborn resuscitation training programs such as HBB showed increased knowledge, skill and competency after training which was sometimes retained for 1 year. Evaluation of newborn resuscitation training has shown an immediate increased in knowledge, practical skills and competency with improved newborn outcome^{10,11}. Although training has been carried out, there has been limited rigorous evaluation of retention of knowledge, skill, competency and newborn outcome in low-resource and post-conflict settings like South Sudan.

The outcome of training depends on the extent to which knowledge, skill and competency of health workers is retained, alongside the ability to use the learned skills, knowledge and application at appropriate time. However, the retention of knowledge and skills, and their application to improve newborn outcomes depends on several factors, such as conditions at the clinical environment, regular supervision, settings, opportunity to practice, availability of supplies and appropriate equipment⁹.

Training of health workers appropriately, provision of refresher training and support and ensuring good training environment facilitates the long-term retention of knowledge, skill and competency among health workers in low resource settings^{12,13}. In South Sudan, nurses and midwives manage normal delivery and birth asphyxia is not recognized early enough. Medical doctors are often involved in the late stages of the management of birth asphyxia due to critical shortages, even in a major hospital setting. The objective of study is to evaluate retention of knowledge, skill and competency of the health workers and the impacts on newborn mortality after one year of implementation.

Methods

Trial background

The trial has been registered with Pan African Clinical Registry with registration number [PACTR201708002469225](#)¹⁴. The study TREND statement is available as supporting document. The original aim of the study was intended to measure only effectiveness of improving health workers, knowledge, skill and competency. The measurement of newborn mortality was conceived later leading to late registration.

Sample size

Calculation of sample size was based on the ability to detect a 20% increase in knowledge, practical skill and competency and 20% reduction in newborn mortality with an error of 0.05, 20% and dropout rate of 50%. The study used this value as our references for the sample size calculation. Using [G*Power](#) version 3.1, we determined a sample size of 74 participants in each arm to account for losses, but due to the ongoing conflict the actual participate for both arms was less than estimated sample size

Selection criteria

The following selection criteria were applied. Medical officers/doctors, nurses, midwives, maternal child health officers, community health workers and clinical officers working and practicing in maternity, operating theater and children ward; health providers self-reporting that they provide routine care services at delivery and neonatal unit or departments; and Health workers willing to be available for data collection and during the period of study.

Recruitment setting

The health workers were identified and recruited from maternity wards, newborn operating theater and children ward of Juba Training Hospital (intervention site) and Wau Teaching Hospital (control). After the completion of the recruitment process, an invitation was sent to those health workers who met the inclusion criteria to participate in the study. Written informed consent was obtained from the health workers. All newborn delivered in maternity, newborn unit and operating theatre who met the inclusion criteria were included in the study.

Location of data collection

Data on the pre and post training on knowledge, practical skills of the health workers and records of newborn asphyxia and deaths both in intervention and control group was collected from the area of practice, maternity ward, operating theatre and newborn unit.

Period of recruitment

Health workers recruitment commenced on February 1st and ended in 25th February 2017. Training intervention was 27th–28th February 2017. The intervention commenced in March and follow-up started on June 1st and ended on 30th June 2017. The 1-year evaluation was conducted in August 2018.

Specific objectives and hypotheses

Our study objectives were as follows. To assess change in health worker knowledge, psychomotor skills, competency of the health

workers regarding managing neonates with birth asphyxia after training intervention, and the ratio of perinatal mortality due to asphyxia of hospital admission within 24 hours of birth after training interventions. Meanwhile we hypothesized that HBB training would result in 20% increase in knowledge, skill and subsequent reduction of early newborn mortality among newborn born with asphyxia.

Primary and secondary outcome measures

The main primary outcome was any improved knowledge, skill and competency of the health workers on HBB protocol. The secondary outcome was the ratio of early newborn reduction with asphyxia within 24 hours.

Data collection method and instruments

Data was collected by use of a questionnaire with 17 multiple choice questions to assess the knowledge of health workers on the HBB protocol, a seven-step checklist for bag-and-mask skill assessment, a five-step checklist for preparation at birth skill checks, a 13-step checklist with simulation for the first Objective Structural Clinical Examination (OSCE), a self-observation questionnaires consisting of a 25-step checklist maternity and newborn register for recording delivery, and neonatal a registration form¹⁵.

Validity of HBB instruments

The validity of the **HBB instruments** was determined by expert reviews and opinions from Chulalongkorn University, college of Public Health Sciences. The study used HBB instruments for assessing the knowledge, practical skill and competency of the health workers was a standard HBB instrument tool which has been validated and used in other low setting countries where HBB and skills evaluation have been conducted¹¹.

Retention evaluation

The retention evaluation of skill was conducted following, pre- and post-test study design conducted in Juba and Wau Teaching hospitals in Republic of South Sudan. The pre- and post-training assessment was completed in March 2017 and the 3-month assessment was done on knowledge, skill competency and newborn mortality in June 2017. Assessment at 1 year post-intervention to determine retention of knowledge skill, competency and review of neonatal mortality was conducted in September 2018. During evaluation, health workers who were available and received previous HBB training in both hospitals were approached and interviewed according to the set exclusion and inclusion criteria. The Study was approved by South Sudan Ethical Committee, Ministry of Health in Juba, South Sudan and reviewed by Chulalongkorn University, College of Public Health Sciences Bangkok, and Ethics Review committees of Juba Teaching Hospital and Wau Teaching Hospital. Informed consent, both written and verbal, was obtained from the health workers before the training intervention. Informed consent was sought from each of the health workers available at the time of evaluation. Additionally, verbal approval was sought from the mothers with newborn asphyxia by the health worker.

Training of trainers of trainers

In December 2016, four midwives went through the HBB trainers of trainer's (TOT) workshop and become research assistants and facilitators. Training of midwives as TOTs covered teaching methodology, neonatal resuscitation using HBB model, evaluation skills and practical skill training. The second part of TOT involved conducting HBB simulation drills, preparation of births, newborn routine care, the golden minute and ventilation of newborn. The last component of TOT program was facilitation and coaching skills using American Pediatric Association model for HBB.

Selection and training of health workers

Completion of TOT course for facilitators was followed by recruitment of health workers in the Juba Teaching Hospital (intervention) and Wau Teaching hospitals (Control) to participate in the HBB study. The health workers in the control hospital were not trained on HBB protocol during the implementation period. However, plans are underway to provide training after final evaluation. The two hospitals were located 300 km apart and in different regions. Both are national teaching hospitals that train health workers. Health workers were selected from maternity and newborn wards and the antenatal clinic (ANC). All health workers working in maternity, neonatal ward and the ANC were approached to participate in the study. Informed consent written in Arabic and English were read and explained to the health workers, who signed a copy before their full participations.

Pre-training assessment was conducted before the commencement of training on demographics, previous knowledge and exposure to HBB training, knowledge, skill and competency, and also review the birth registry for number of births, neonatal asphyxia and mortality for the past year. The survey used a multiple-choice questionnaire¹⁵ and simulated environment using Bag and Mask checklist for psychomotor skill and OSCE&B^{11,15} for competency at pre-intervention, immediately after intervention, 3 months post-intervention and 1 year post-intervention.

The initial training program covered preparation for birth, routine care, the golden minute and ventilation of newborn using bag and mask techniques. Individual training involved conducting simulation drills on mannequins (mama and baby NeoNatalie). Immediate feedback on performance of the health workers and lectures by the facilitators. The health workers were allowed to practice a number of drills, demonstration and return demonstration using mannequins. The demonstration was accompanied with an explanation on how to perform tasks to help newborn breath at birth during the study, individual health workers were assessed on their knowledge, skills and competency on neonatal resuscitation using HBB protocol, pre-training, immediately after training, at 3 months and at 1 year to determine short- and long-term retention of knowledge, skill and competency. A 20-minute written multiple-choice test was administered to the participants before and after the training to evaluate knowledge. Skills and competency assessment for the health workers were evaluated through clinical simulation using the NeoNatalie newborn simulator. The trainees were directed and observed as they

perform the task on the mannequin. OSCE A&B were administered to test the performance and competency of the trainee health workers on HBB. OSCE A consists of 13 items while OSCE B consist of 18 items indicating the key component of what the trainee must learn and practice. Each item in objective OSCE A and B were scored 1 when correctly done and score 0 for not correctly done. A passing score of 80% was required to complete the course successfully. In each training session, health workers were asked to evaluate the training using a questionnaire with a five-point Likert scale¹⁵.

The HBB training included trainers and trainees reviewing training modules and practical sessions on newborn asphyxia, routine care and ventilation. Health workers practiced on the mannequin and were provided with equipment, and each of the practice sessions on the mannequin was rated by the facilitators, who were senior midwives and trained as master trainers. The mannequin which presented mother and newborn was placed on the resuscitation table and each situation presenting the condition of the baby and mother is controlled with the health workers present caring for the mother and newborn. The facilitator (rater) was responsible to ensure participants completed the skill-based checklist for assessing the performance of the health workers during the practical drill. The participant performed the drills in either Arabic or English, communication channels commonly used in South Sudan. The task performed by the health workers were explained and verbalized to the midwife rater as the health workers conducted the newborn resuscitation drill.

Content of training

Each topic was introduced by the main facilitators followed by demonstration and return demonstration by the participants. This was followed by self-directed and self-assessment exercise using the learner work book. The training comprised of six classroom hours and two hours for practical. A series of procedures surrounding births were reviewed through practical exercises under the supervision of the trainers. Scenarios reproducing routine care and neonatal resuscitation at birth were performed on a NeoNatalie new born simulator. During the training, one simulator, a stethoscope, resuscitator and suction device were made available for every two trainees. The intervention was delivered to a group 20 health workers each. Training was provided to the intervention group in Juba Teaching hospital. The HBB training intervention course was facilitated by two senior midwives who were trained as research assistants (master trainer) and assisted by the principal investigator and the research assistants. The newborn resuscitation was conducted by the health workers in various unit selected. The intervention was delivered at the main hospital training hall and the observation was at maternity, newborn unit and operating theatre. Two training session was conducted to allow adequate time for facilitators and participants to learn and practice. The ratio of one facilitator and six participants was maintained to support participants to learn in pairs as standard protocol indicated in the training. The duration lasted for 2 days. The training intervention was delivered in 6 hours each for two days and practical sessions was 20 minutes. Observation of health workers practicing resuscitation was

observed throughout the 3 month period by the research assistants. Bag and mask drill was delivered every morning 5 days a week for 3 months. Health workers were provided breakfast and lunch during the two days training interventions and support supervision during morning drill of mask and bags.

Health worker assessment

Completing tasks such as preparation for ventilation, assessing the newborn, conducting ventilation using bag and mask, conducting stimulations and referral of the newborn was directly performed on the mannequin and scored by the experienced rater. Raters score health workers one on skill and competency when the task is correctly completed and zero when not correctly completed. Health workers must have obtained 80% or above to be considered competent in all the three aspect of knowledge, skill and competency to help newborns breathe.

Post-training and intervention assessment was done immediately, and at 3 months using the simulated HBB knowledge-, skill- and competency-based checklist. Assessment were categorized into knowledge, practical skills and competency. The sum of the scores were calculated by determining the degree of completion of each task in knowledge, skill and competency, the total score for each task was 80% for knowledge, skill and competency respectively.

All health workers who completed the initial HBB training and were present 1 year later were asked to participate in HBB knowledge, skill drills and competency assessment to determine long term retention of their knowledge, skill and competency. The retention of knowledge, skill and competency assessment used the same check list for assessment and scoring at the initial training. During 1-year evaluation, each individual health workers was assigned knowledge, skill and competency score presented as percentage of correctly performed items at 1-year evaluation. Health workers were asked to complete the same five-point Likert scale survey as well their confidence in HBB practice.

Assessment for simple newborn resuscitation

During the interventions, health workers were assessed for simple resuscitation using Objective Structural Clinical Examination (OSCE A) which was made up of 13 observation steps consisting of scripted information on preparation for birth, drying the baby thoroughly, ability to recognize the baby is not breathing, positioning of the head and clearing the airway, evaluation of the breathing, clamping or tying and cutting the cord, position skin to skin and communication with mother. The successful completion requires a total score of 10 correct of 13 steps and the health worker being observed must include the Dries thoroughly, Recognizes Baby is not crying and positioning and clearing the airway. OSCE A is a performance assessment of preparation for birth and routine newborn care, and a learner must perform = 80% (10 of 13 steps) correctly to pass, including three essential steps. OSCE A is a performance assessment of preparation for birth and routine newborn care, and a learner must perform = 80% (10 of 13 steps) correctly to pass, including three essential steps.

Assessment for complex newborn resuscitation

We conducted assessment of health workers for complex neonatal resuscitation using Objective Structural Clinical Examination (OSCE B) was made up of 18 scripted scenario on preparation for birth, drying of the baby, recognize the baby is not breathing, ventilation at 40 breathes per minutes (30–50) acceptable, looking for chest movement, evaluate breathing, call for help, improve ventilation thorough, repositioning the head, reapplication of mask, clear secretion, open mouth slightly and squeezing the bag hardly. The 18 items reflects the key components of the training course for newborn survival. Each item was scored 1 if carried out correctly and any partial or incorrect action was scored zero. Similar to OSCE A, OSCE B was a performance assessment of a complex resuscitation scenario that requires bag-mask ventilation, and a learner must perform 14 of the 18 steps correctly to be evaluated to have the competency to help newborn with asphyxia to breathe.

Hospital registry and forms

Data on neonatal mortality was collected from the hospital register at the delivery room, operating theater and neonatal unit admission book pre- and post-implementation for June 2017–June 2018. In the pre-implementation phase, hospital monthly record was used to collect the number of deliveries, neonates with breathing problems; neonates resuscitated using HBB protocols and the perinatal mortality due to asphyxia outcome immediately post-training and end of intervention. For easy follow-up, a simple form was designed by the research team to track deliveries, use of HBB protocol for newborn with birth asphyxia and the outcome of the resuscitation within 24 hours. The mean ratio of the perinatal death was used to determine the outcome/changes of the intervention within the period of four months. The review of hospital registry and form was approved by the South Sudan ethical review board and the hospital ethics committee.

Statistical analysis

The mean score and the significant level within and between groups were tested using repeated ANOVA and Chi squared test in the three performance areas of knowledge, skill and competency. Newborn mortality was determined and tested with Pearson chi squared test. The statistical analyses were performed using SPSS version 20 and $p < 0.05$ was considered statistically significant.

Results

Characteristics of health workers

In total, 70 health workers completed pre-training course and 67 were evaluated at 3 months. Of the health workers who original completed the training and were evaluated at 3 months, 53 were available for the one year were evaluated for HBB knowledge, skill and competency. A total of 58.6% of the health workers in intervention and 66.7% in the control spent their full time working in maternity (delivery unit). The health worker in average attends 115 deliveries and managed 7.7 asphyxia cases in 1 year. The [Table 1](#) shows demographic characteristics of the health workers after 1 year of implementation.

Status of retention of knowledge

As shown in the [Figure 2](#), the status of knowledge scores among the health workers in the intervention group declined from 84.5% at 3 months to 69.4%, with a mean difference of $69.4 \pm 18.8 (-15.0 (-22.7-7.4))$ in the 17 domains that was assessed after 3 months and at one year after training. The changes in scores of knowledge measure at 1 year was statistically significant ($p < 0.05$) ([Table 2](#)). Meanwhile the assessment established that knowledge scores increased for health workers in the control group from 50% to 61%, with a mean difference of $61.2 \pm 20.3 (10.5 (0.54-20.6))$. The changes in the knowledge among the control were significant ([Table 2](#)).

Status of retention of skill among the health workers

Skills retention among the health workers were assessed using the seven domains of determining skill applied at pre-training, immediately post-training and at 3 months post-training assessment for both groups. The 1-year mean skill scores declined from 94.5% to 77% from 3 months' assessment. The decline is visible across all the seven domains: i) Check equipment; ii) select the correct mask; iii) apply the mask to make a firm seal; iv) ventilate at 40 breaths; v) Look at chest movement; vi) improve ventilation if the chest does not move; vii) reapply mask and reposition, clear secretions and squeeze the bag. Mean differences of $77.0 \pm 21.8 (-17.5 (-27.2-7.8))$ were found. the result showed a marked increase in the mean scores among the control group ([Table 2](#)). The mean skill score increased from 40.3% to 56.5%. The mean differences in skills was $56.5 \pm 25 (16.2 (1.2-31.2))$ which was statically significant ($p < 0.05$).

Status of health worker's competency for simple resuscitation

The competency of the health workers declined among the intervention (Juba Teaching Hospital) and greatly increased in the control (Wau Teaching Hospital) after one-year evaluation when compared with the 3 months' post implementation. There was significant decrease in competency between the 3 months and 1 year of training (88.6 ± 8.6 to 76.4 ± 13.6) (mean difference decline of $-12.2 (-18.3-6.1)$ $p < 0.001$). The mean decreased between 3-months and 1-year after training evaluation for the retention of was significant. The status of retention of competency among the health workers in control showed significant increase from 38.0 ± 9.1 to 53.9 ± 11.8 (mean difference $15.1 (8.7-21.4)$ $p < 0.001$) ([Table 2](#)).

Status of health worker's competency for complex resuscitation

Evaluation of retention status of health worker's competency in both groups after one year of post implementation assessment has shown that there was marked decreased among the intervention while control has shown significant increased. In the intervention, the mean competency score decreased from 90.4 ± 8.6 to 76.9 ± 11.6 (mean difference $-13.6 (-19.8-7.4)$; $p < 0.001$) whilst the control had significant increase in their competency for complex from 32.4 ± 8.3 to 53.4 ± 21.7 (mean difference $21.0 (10.9-31.0)$; $p < 0.01$).

Table 1. Demographic characteristics.

Demographic characteristics		Intervention		Control	
		n (N=29)	%	n (N=24)	(%)
Age, years	25–35	17	58.6	15	62.5
	36 above	12	41.4	9	37.5
	Totals	29		24	
Gender	Male	4	13.8	3	12.5
	Female	25	86.2	21	87.5
	Total	29		24	
Education level	Primary eight	4	13.3	3	12.5
	Secondary	3	10	4	16.7
	College/ tertiary	19	63.3	17	70.8
	Diploma in Midwifery	1	3.3	0	0
	Community H.W Training	2	7.0	0	0
	Total	29		24	
Professional qualification	Nurse	9	31.0	10	41.7
	Midwives	10	34.5	9	37.5
	Maternal Child health officer	3	10.3	0	0.0
	Nurse practitioner	1	3.4	0	1.0
	Clinical officer	2	6.9	2	8.3
	Community Health workers	4	13.8	2	8.3
	Skilled birth attendants	0	0.0	0	0.0
	Intern Doctor	0	0.0	1	4.2
	Total	29		24	
Primary area	Newborn care	8	27.5	11	26.7
	Sick children ward	3	10.3	1	4.2
	Maternal and newborn care	18	62.1	15	62.5
	Obstetrics/Obstetrician			1	4.2
	Total	29		24	
Current place of work	Maternity ward	17	58.6	16	66.7
	Children ward	11	37.9	4	16.7
	Operating theater (OT)	1	3.4	4	16.7
	Total	29		24	
Monthly income	300- 1000 SSP	10	34.5	7	29.2
	1001- 2,000 SSP	11	37.9	12	50.0
	2,001 SSP and above	8	28	5	21
	Total	29		24	
Duration of practice	≤ 1 year	7	24.1	4	16.7
	2–3 years	7	24.1	7	29.2
	4–5 years	5	17.2	4	16.7
	>5 years	10	34.5	9	37.5
	Total	29		24	

Enrollment

Figure 1. Flow chart for recruitment and allocation health workers.

Status of early newborn mortality

A review of records in the hospital registry and forms from June 2017 to June 2018 found out that 6,072 live births were registered in the maternity and newborn wards and ANC. A total of 4,887 of the total live birth were recorded in the intervention hospital and 1,210 in the control hospital. All births were reported to be assisted by health workers trained in the HBB. A 1-year post-training evaluation found that there was a significant increase in the number of newborns with asphyxia being resuscitated in both hospitals. More newborns in intervention hospital received neonatal support (resuscitation). 98.4% of the newborn received support compared to 1.6% in control group at 3 months. Meanwhile

(86.7%) compared to the control (48.4%) newborn received neonatal resuscitation support from health workers at assessment after 1 year. The support given to newborn by health workers was statically significant ($p < 0.050$; Table 3). Review of data on early mortality due to asphyxia shows that mortality decreased from 30.7% at 3 months to 17.9% at 1 year in the intervention hospital which is significant ($p < 0.05$). There was also significant reduction of early newborn mortality in the control hospital. Mortality reduced from 69.2% at 3 months to 49.4% at 1 year after implementation ($p < 0.05$). The result showed that more newborn deaths occurred within 24 hours of birth in both hospitals in comparison to deaths that occurred after 24 hours up to 1 year (Table 3).

Figure 2. Flow chart for birth registry pre- and post-implementation.

Discussion

This study attempted to evaluate the retention of knowledge, skills, competency and impact of modified HBB at Public Tertiary Hospital in South Sudan. The status of knowledge, skill and competency among the health workers in the intervention and control was evaluated after 1 year and compared with the status at 3 months. The objective of the training was to build the knowledge, skills and competency of health workers. More focus was placed on enhancing skill and competency through hands on practice and avenue for continued peer-to-peer simulation refresher training, supervision and mentoring. The evaluation at 1-year post-training showed a significant decline in the retention of knowledge, skills and competency among the health workers. The causes of considerable decline in the retention of knowledge, skill and competency were not clear among the health workers

and this was consistent in all the domains evaluated and further evaluation is needed to further determine causes for the decline.

Our assumption was that training in the modified HBB could lead to longer retention of the acquired knowledge, skill and competency. Review on the general status of the implementation of HBB protocol conducted through review of newborn records, conducting drills and observing health workers resuscitate newborn with asphyxia and interactions with health workers in the intervention hospital revealed that the setup of HBB simulation corners at the hospital that provides opportunity for the health workers to have peer-to-peer clinical practice using mannequins, bag and mask was not available, and space was limited by the ongoing major hospital renovation. Furthermore, health workers reported a lack of support from experienced mentors assigned during training, as

Table 2. Retention of HBB-trained health worker's knowledge, psychomotor skills and competency one year after training.

	Intervention		P value ^a	Control		P-Value
Variables	Mean	Mean df. (CI)		Mean	Mean df. (CI)	
HBB Knowledge						
Pre-test	42.5±17.3			48.0±13.9		
Post-test	97.8±3.4	55.2 (50.9-59.6)	<0.001	51.2±11.2	3.1 (−3.0–9.4)	0.9
3 months follow-up	84.5±7.4	−13.3 (−17.7–8.87)	<0.001	50.6±16.9	−0.3 (−0.1–6.0)	0.9
1 year follow-up	69.4±18.8	−15.0 (−22.7–7.4)	<0.001	61.2±20.3	10.5 (0.54-20.6)	0.04
HBB Psychomotor skills (Bag and Mask)						
Pre Test	26.1±19.9			- [*]	-	-
Post test	94.4±8.5	69.2 (62.8-75.7)	<0.001	43.8±16.7		
3 months follow-up	94.5±8.2	0.1 (−0.3–0.8)	<0.001	40.3±20.5	3.4 (11.0–4.10)	0.37
1 year follow-up	77.0±21.8	−17.5 (−27.2—7.8)	0.001	56.5±25.5	16.2 (1.2–31.2)	0.04
HBB Competency for simple neonatal resuscitation (OSECE A)						
Pre test	26.9±14.6			- [*]	-	-
Post test	88.8±8.5	61.2 (57.0–66.7)	<0.001	38.9±8.5	-	-
3 months follow-up	88.6±8.6	03.1 (−4.6–532)	0.9	38.0±9.1	2.65 (−8.42–3.1)	0.36
1 year follow-up	76.4±13.6	−12.2 (−18.3—6.1)	<0.001	53.9±11.8	15.1 (8.7–21.4)	<0.001
HBB competency for complex neonatal resuscitation (OSECE B)						
Pre test	17.5±8.9			^{**}	-	-
Post test	90.9±7.1	73.47 (69.5–77.36)	<0.001	36.5±13.0	-	-
3 months follow-up	88.3±10.8	−274 (6.71–1.22)	0.17	33.1±8.7	−3.63 (−8.2–0.93)	0.12
1 year follow-up	76.9±11.6	−13.6 (−19.8—7.4)	<0.001	53.4±21.7	21.0 (10.9–31.0)	<0.001

Scores expressed as mean difference. *Significant level at 0.005 at 3 months and one year after training. Pa-Value within intervention group tested by repeated ANOVA, 0.001 and 0.001 between immediate post intervention and 3 months follow up
 **No baseline conducted for control group for bag and mask, OSCEA&B.

Table 3. Early newborn mortality due to asphyxia 1 year after HBB training.

Variable	Intervention/Control	Before intervention		After intervention (3 months)			1 year after Intervention		
		Freq	Percent (%)	Freq	Percent (%)	P. Value	Freq.	Percent (%)	P. Value
Total live births	Intervention	1116	52.40	1112	53.9	-	4,887	80.2	0.000
	Control	1011	47.50	950	46	-	1,210	19.8	0.000
Newborn birth asphyxia	Intervention	88	55.7	125	57.1	0.18	312	75.9	<0.001
	Control	70	44.3	94	42.9	-	99	24.1	<0.001
Newborn resuscitated using HBB	Intervention	0	00	124	98.4	0.001*	270	86.7	0.001
	Control	0	00	2	1.6	0.114	48	48.4	0.001
Asphyxia deaths	Intervention	26	50.9	4	30.7	0.001*	57	17.9	0.001
	Control	25	49	9	69.2	0.110	49	49.4	0.001
Death within 24 hours	Intervention	14	51.9	4	23.5	0.001*	41	71.9	0.001
	Control	13	48.1	13	48.1	0.110	33	67.3	0.001
Death after 24 hours	Intervention	12	50.0	9	33.3	0.000*	16	28.0	0.001
	Control	12	50.0	18	66.7	0.112	32.7	32.7	0.001

Tested by Pearson Chi square test 2x2 sided significance for birth asphyxia, newborn death within and after 24 hours before and after implementation.

most of them move out of the hospital for better-paying jobs, probably contributing to low retention of knowledge, skill and competency. More feedback from health workers suggested that they had little time to link theory to practice due to the high work load resulting from high staff attrition. The intervention hospital was purely supported by government, such that it lacks most of the necessities for practical applications of the HBB interventions.

Surprisingly, evaluation of Health worker's knowledge, skill and competency in the control hospital showed a significant increase after 1 year despite having considerable gap in all the domains of knowledge, skill and competency during the pre, post and 3 months assessment. We undertook extensive review to understand activities leading to increased knowledge after 1 year of training. Our review and interaction with health workers indicated that, health workers were supported and the hospital maternity, newborn and ANC unit is entirely managed by non-governmental organizations (NGOs). Health workers were provided opportunity to learn through the introduction of online HBB models. Although practical training has not yet been conducted, emphasis was placed on HBB as one of the key actions to reduce newborn mortality. Health workers had better opportunity to learn and understand the concepts and rationale from the mentors who were placed in the hospital by the NGO. The good environment could have contributed to increased knowledge after 1 year.

Our evaluation documented the challenges of resuscitation in developing countries with high newborn mortality. The decline in performance in retention of knowledge, skill and competency of the health workers trained in HBB brings in issues to what requires to be done to ensure health workers retention of acquired knowledge, skills and competency in HBB in tertiary hospitals and other local primary health care centers. The majority of the health workers in the intervention facilities had limited opportunity to perform appropriate interventions to resuscitate a newborn with asphyxia in comparison with the control hospital that could have resulted in significant changes observed in the results.

Our study is relevant as it documented what happens to knowledge, skills and competency in terms of retention by the health workers trained and provided a chance to practice in the hospital. This study demonstrated that knowledge, skill and competency tends to disappear with time and refresher training is necessary for the health workers to keep abreast with skills and knowledge.

There are few evaluation reports that document the retention of knowledge, skill and competency after training for a period of 1–2 years. In Tanzania, report indicates significant improvement in knowledge. However, retention of skills remained poor in comparison to the knowledge¹⁶. In similar evaluation of the retention of knowledge and skill among the Canadian Doctors and Nurses, there was better retention of knowledge than skills. The skills of nurses and doctors dropped upon evaluation at 6 months after training.

In terms of the long-term effect of HBB training on reduction of newborn mortality, our study documented a significant increase in

the number of newborns assisted to breathe by the health workers in both hospitals. The rate of neonatal mortality due to asphyxia reduced from 30.7% to 17.9% in the intervention hospital, and from 69.2% to 49.4% at the same period. It is interesting to document a significant reduction in the number of newborns in the control hospital although no formal training was known to have been provided. The results documented pointed out that reduction of mortality does not only depend on learned skill and developed competency, but also on the availability of resources. However, the relationship between mortality and resources was not evaluated. Despite the small sample size, our evaluation showed a similar result to a large randomized study conducted in Tanzania to determine neonatal outcome after health worker receiving HBB training where newborn mortality within 24 hours and still-birth reduced significantly¹⁷. Although, evaluation studies were conducted at global level, still few evaluation studies focused on determining impact of modified resuscitation training on newborn outcomes. Therefore, more evaluation is recommended particularly, in post-conflict settings.

The strength of the study is that the majority of the health workers were nurses and midwives who had training on newborns and spent their full time in the maternity and children ward; therefore, they represented a population that typically encounters and manages birth asphyxia as they occur in hospital setting. The documentation of knowledge, skill, competency and birth asphyxia during the pre-training, immediately post-training and at 3 months post-training provided an opportunity to evaluate the same health workers available at the hospital at the time of assessment.

The result of the study could have limited by relying on the documentation of newborns in maternity and children ward of both hospitals to determine newborn outcome after pre-training, immediately post-training and at 3 months post-training where trained staff were available to help with documentation. There still exists a large gap in the documentation of medical records and keeping and data use among the health workers, clerks and managers in the hospitals and health facilities in South Sudan.

Conclusion

The evaluation of retention of knowledge, skill and competency and its impact on newborn mortality at 1-year after HBB training could be first in South Sudan, a country emerging from war that has low-skilled health workers. The evaluation has shown mixed results, with health workers in the intervention hospital showing marked decline in knowledge, skills and competency, while encouraging increase in the level of knowledge, skill and competency in the control group. The decline in knowledge, skill and competency scores and the level of increase among the groups were consistent. Although the reason for the observed gap is not clear, it could be attributed to limited opportunity to practice, lack of support and high attrition rate among the health workers in interventions and whereas, the control group had opportunity to learn from mentors, participate in online studies and availability of resources for practicing their skills. A further review is recommended to understand the various factors that affects

acquisition and retention of knowledge, skill and competency on newborn resuscitation in developing countries. Despite the changes in level of retention of knowledge, skills and competency, there has been significant decrease in newborn mortality in both intervention and control groups.

Data availability

Underlying data

Data concerning newborn mortality and the performance of health workers are available on OSF. DOI: <https://doi.org/10.17605/OSF.IO/3NTJB>¹⁵.

Extended data

Consent forms and assessment tools used in this study are available on OSF. DOI: <https://doi.org/10.17605/OSF.IO/3NTJB>¹⁵.

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

Reporting guidelines

A completed TREND statement is available on OSF¹⁵.

Grant information

The authors declare that no grants were involved in supporting this work.

Acknowledgements

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Beena D. Kamath-Rayne

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Long term retention of neonatal resuscitation skills is an important concept that must be studied as there are many unknown factors that could potentially affect competency and skills retention. Educational efficiency is an important component of the Formula for Survival, which denotes potential survival being a product of medical science x educational efficiency x local implementation. The authors are to be commended to undertaking a study that specifically evaluates retention of skills in this population in South Sudan. However, while the topic is important, the way in which these authors have presented their data and results needs to be improved.

My interpretation of the study design is that in the intervention hospital, HBB training occurred, and then workshop participants were evaluated pre/post and then at 3 and 12 months with the knowledge and skills-based assessments associated with HBB. In the control hospital, no HBB training was offered. Furthermore, in the intervention hospital, bag-mask ventilation drills were used to augment retention of skills over time.

The manuscript could use some copyediting to fix basic grammatical, spelling and word choice mistakes. There is also some confusion about the secondary outcome of neonatal mortality, which the authors refer to as neonatal mortality due to birth asphyxia. In the abstract, for example, this is only called neonatal mortality. If this is asphyxia-related mortality only the authors could do a better job of determining how this specifically was assessed as the cause of death rather than something else. Also, some babies, like premature babies, can have both asphyxia and prematurity as contributors to their deaths. How was this sorted out?

Further detail on the methods/results would be helpful to improve the readers' interpretation of the investigators' findings. With the delivery room observations and calculation of neonatal mortality, was it known whether the individual leading the resuscitation had been trained in HBB? Given the frequent turnover in such settings, it would be important to know whether the resuscitator was in the study protocol or not. It would also be helpful to know how many individuals in each hospital did not consent to the study; what proportion of health providers

potentially eligible for the study in each hospital who take care of newborns were in the study?

What types of health workers were included in the study, and did they have any previous exposure to neonatal resuscitation or simulation? What individuals refused to be in the study or were lost to follow-up? Were they predominantly one type of health provider? Tabangin et al.¹ showed that doctors performed better in simulated evaluations (OSCE B) due to having had previous experience with neonatal resuscitation and simulation training, which allowed their performance to improve at a greater level than nurses, who had not had prior experience.

How was it known that the daily bag-mask ventilation drills were performed, and that the intervention group received the intervention? The CONSORT diagram was difficult to follow as the numbers did not appear to add up correctly.

The authors could be much more rigorous in their literature search to support their arguments. Because of their lack of a complete literature review, the study is not able to fully analyze their results within the context of the previously studies and their nuances. I believe the study was done with HBB 1st Edition materials, however, the correct citation was not reported; there is a publication date of 2014 which would be incorrect for either the 1st or 2nd Edition. This is important to distinguish because the 2nd Edition has greater emphasis about an ongoing system for practice, an improved OSCE, and more standardization about giving feedback and debriefing after the OSCEs. References 10 and 11 do not support their points regarding an immediate increase in knowledge and skills showing improvements in neonatal outcome. Some of the most important papers regarding retention of skills both in the short and long term after HBB training are not cited. These are referenced below.

The findings that the skills declined in the intervention group does not fit with what would be expected nor with what has been seen in previous studies. It also does not fit with neonatal mortality decreasing if the skills are not being performed as well. It would be helpful for the authors to hypothesize why they had such markedly different findings from all the other studies that have been published. It also underscores the importance of knowing whether the intervention such as the ongoing practice and drills were being completed as desired.

In regards to the greater numbers of babies being "assisted to breathe" during the study period - which the authors also referred to as "resuscitation" - could they be more specific about what this resuscitation entailed? Some studies have shown that fewer babies require bag-mask ventilation after HBB because more babies are being stimulated appropriately and respond to that alone. If they are referring to bag-mask ventilation, can they comment on whether the preceding steps to bag-mask ventilation were appropriately performed or not, or the health providers just went right to bag-mask ventilation?

While the authors are to be applauded for their efforts on this study, major revisions are required before this study can be considered worthy for indexing. I am concerned that their studies are framed in a dangerous way, to suggest that ongoing practice is not beneficial for retention of skills, that goes against both common sense and what has been shown in other studies. The authors need to provide some justification for these findings.

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Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

No

Are all the source data underlying the results available to ensure full reproducibility?

No

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: I am the associate editor for the second edition of Helping Babies Breathe.

Reviewer Expertise: neonatal resuscitation, Helping Babies Breathe, educational outcomes

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Report 22 February 2019

<https://doi.org/10.5256/f1000research.19204.r44166>

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Brett D. Nelson

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I congratulate and thank the authors for their important work on newborn health in South Sudan. Having worked on various HBB projects, and having worked for a couple of years in South Sudan, I really enjoyed reading your article.

The paper is great. However, I would like to humbly provide a strong recommendation that the current abstract please be updated by the authors. The abstract's Results and Conclusion sections currently seem to suggest that the Control group fared better than the Intervention group and had better retention than the Intervention group. (E.g., "Conclusions: Health workers in the control hospital had improvement in retention of their knowledge, skill and competency. Newborn mortality decreased in both hospitals.")

Respectfully, I think this could be inadvertently misleading to many readers. While the Control group's scores did increase slightly (and statistically significantly, for the possible reasons discussed in the paper), the Control group's scores were always much lower than the Intervention group's scores (since the Controls didn't receive the training yet). So I would argue that the Control group never showed any significant knowledge or skills in HBB and, therefore, never "retained" this knowledge and skills. Because they hadn't yet been formally taught the knowledge and skills (again, because they were Controls), they never had the knowledge and skills to lose and never had the ability to "retain" the HBB skills.

Meanwhile, the Intervention group did acquire substantial knowledge and skills following the successful training and lost some knowledge and skills over time, which we've seen in other HBB studies -- unless active measures are taken to retain knowledge and skills via on-the-job training, daily practice, refresher training, supervisory visits, etc. In short, I think the small improvement in the Control group's comparatively low scores should not be the primary focus of the abstract's

Results and Conclusion sections, and I think it may be inadvertently misleading to readers to simply conclude that "Health workers in the control hospital had improvement in RETENTION of their knowledge, skill and competency" (my emphasis added). This could give the mis-perception that the Controls did better than the Intervention group.

I hope you don't mind the suggestion, and hopefully this might be some helpful feedback to further strengthen your paper. And again, I congratulate and thank the authors for their important work.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Newborn medicine, Helping Babies Breathe, global health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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