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Simulation and education

A one-day "Helping Babies Breathe" course improves simulated performance but not clinical management of neonates☆

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ABSTRACT

Objective: "Helping Babies Breathe" (HBB) is a simulation-based one-day course developed to help reduce neonatal mortality globally. The study objectives were to (1) determine the effect on practical skills and management strategies among providers using simulations seven months after HBB training, and (2) describe neonatal management in the delivery room during the corresponding time period before/after a one-day HBB training in a rural Tanzanian hospital.
Methods: The one-day HBB training was conducted by Tanzanian master instructors in April 2010. Two simulation scenarios; "routine care" and "neonatal resuscitation" were performed by 39 providers before (September 2009) and 27 providers after (November 2010) the HBB training. Two independent raters scored the videotaped scenarios. Overall "pass/fail" performance and different skills were assessed. During the study time period (September 2009–November 2010) no HBB re-trainings were conducted, no local ownership was established, and no HBB action plans were implemented in the labor ward to facilitate transfer and sustainability of performance in the delivery room at birth. Observational data on neonatal management before ($n = 2745$) and after ($n = 3116$) the HBB training was collected in the delivery room by observing all births at the hospital during the same time period.
Results: The proportion of providers who "passed" the simulated "routine care" and "neonatal resuscitation" scenarios increased after HBB training; from 41 to 74% ($p = 0.016$) and from 18 to 74% ($p \leq 0.0001$) respectively. However, the number of babies being suctioned and/or ventilated at birth did not change, and the use of stimulation in the delivery room decreased after HBB training.
Conclusion: Birth attendants in a rural hospital in Tanzania performed significantly better in simulated neonatal care and resuscitation seven months after one day of HBB training. This improvement did not transfer into clinical practice.

1. Introduction

Neonatal mortality is defined as death before one month of age and recent global estimates range from 2.9 to 3.6 million deaths per year.[1–4] Of these, 50–70 percent may occur within the first day of life.[1,5–8] Almost 99% of all deaths take place in resource-poor settings.[1,9–12] A major factor contributing to the high mortality is a global lack of trained providers in neonatal stabilization and/or resuscitation which is most acute in Sub-Saharan Africa with the highest neonatal mortality.[13] "Helping Babies Breathe" (HBB) is an evidence-based curriculum in basic neonatal care and resuscitation, utilizing simulation-based training to educate large numbers of birth attendants in low-resource countries.[14] HBB was developed by the Global Implementation Task Force of the American Academy of Pediatrics, and a formative evaluation of the course has been conducted in Pakistan and Kenya.[15] This evaluation indicates high satisfaction and self-efficacy rating among participants and significantly improved theoretical knowledge after the course, assessed by multiple choice questions. By contrast, post-training mastery of a practical task, i.e. face mask ventilation, as assessed by an objective structured clinical evaluation, did not increase.[15]

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The effect of HBB training on management strategies of different simulated scenarios has not been evaluated.

Simulation-based training engages health care workers (HCW) to synthesize and apply knowledge and tasks according to a scenario, thereby combining theoretical, cognitive, technical, and behavioral skills in a dynamic situation.[16,17] Simulation-based training is a growing method of teaching, learning, and performance evaluation in high-income countries, and several studies demonstrate sustained improvement in management of simulated medical emergencies after this type of education.[18–21] However, very little is known about the transfer of skills into clinical practice. Further, HCW in low-resource countries, with different socio-cultural background, may not be familiar with simulation-based training, or the training might not be adjusted to the providers' needs and retentiveness. Therefore, performance evaluation of providers in such settings is necessary.

The objectives of this study were to (1) determine the effect on practical skills and management strategies among providers using simulations seven months after HBB training, and (2) describe neonatal management in the delivery room during the corresponding time period before/after the one-day HBB training in a rural Tanzanian hospital. The Kirkpatrick model of evaluation was used to assess the impact of simulation-based training.[21]

2. Methods

2.1. Implementation of HBB

National implementation of HBB in Tanzania began in 2009 and has been led by the Ministry of Health and Social Welfare (MOHSW). Haydom Lutheran Hospital (HLH) in Northern Tanzania is one of eight sites in a multicenter study to evaluate implementation and impact of the program. HLH is a rural referral hospital with an immediate catchment area including about 500,000 people. The greater reference area covers about 2 million people. The hospital provides comprehensive emergency obstetric, and basic emergency newborn care. Midwives largely conduct deliveries and newborn resuscitation if indicated. Occasionally, anesthetic nurses, operating nurses, student nurses, and ward attendants with no formal education have to manage deliveries and non-breathing newborns due to lack of midwives. The equipment is basic, containing two towels, clamps or strings to tie the cord before cutting, scissors, a mechanical suction device, and a neonatal resuscitator. After birth, infants requiring more than routine care are triaged to an adjacent neonatal area. This is a 10-m^2 room with one long bench, with the capability of providing oxygen, intravenous fluids, and antibiotics. The neonates are intermittently cared for by family members and the labor staff.

The first HBB training at HLH was conducted by Tanzanian Master Instructors in April 2010. The course methodology focuses on hands-on practice using a simulator mannequin, emphasizing the very first basic steps; drying, stimulation, suction, warmth, and initiation of face mask ventilation within the "Golden Minute®" after birth. The teaching tools are developed for efficient dissemination, and the educational kit contents a set of flip-over illustrations, an action plan, a neonatal simulator (NeoNatalie, Laerdal Medical), a student handbook, a manual resuscitator (Laerdal Medical), and a suction device (Pinguin, Laerdal Medical). The materials and equipment were left behind to facilitate re-training and dissemination.

2.2. Data collection

A time line of the data collection and the HBB training is provided in Box 2 and is as well outlined next. In August 2009, closely linked to the national HBB program, a descriptive observational open cohort study was initiated in the delivery room at HLH.[22,23] Sixteen research assistants/observers were trained to observe the birth attendants' performances related to delivery and newborns by measuring time intervals to important key events using a stop watch, and to record the findings on a data collection form following every delivery. The observers work in three shifts over 24 h. Three observers cover each shift; two are always located in the labor ward or in the theater; one in the adjacent neonatal area.

In September 2009, 39 providers from the Maternity Ward (approximately 70% of the entire staff) were invited to perform two simulation scenarios using the HBB equipment. Participants were recruited among available birth attendants and represented five professional categories: midwives, anesthetic, operating, or student nurses, and ward attendants (assistants without any formal medical education). The study was conducted in a separate room where confidentiality was assured. The purpose of the study and the working mode of the mannequin were explained to each participant and written informed consent was obtained before start. Demographic data (gender, age, profession, frequency of attended deliveries, newborn care and resuscitations, and newborn resuscitation trainings) was noted. The participants were asked whether they felt confident caring for and resuscitating a newborn, ranging from "Not confident at all" to "Not very confident", "Confident", "Very confident", and "Always confident". Finally, they were asked to name eight key points of preparing for a delivery, caring for a healthy newborn, and for a newborn not breathing spontaneously. Two simulation scenarios were performed and videotaped; "Routine Care" and "Neonatal Resuscitation".

In November 2010, seven months after the HBB training, the goal was to re-test the same 39 individuals. However, due to high employee turnover, working schedules, and time constraint in the field, only 13 (33%) participants were available for re-testing. Therefore, all accessible birth attendants who had completed HBB training at HLH in April 2010 were traced and an additional 14 participants were recruited to be evaluated, even if they had not been tested before. In total, 27 providers were interviewed and videotaped post HBB, and repeated the same simulated scenarios.

Altogether, there were 66 videos of "routine care" and 66 videos of "neonatal resuscitation". One research assistant (EB) operated all the scenarios and functioned as an interpreter during both pre and post HBB testing. HLE and CV conducted the interviews and introduced the provider to simulation and the scenario before and after HBB, respectively.

2.3. Video assessments of provider performance and inter-rater agreement

The videos were assessed separately by two independent raters with a vast experience in simulation-based education. The raters did not know whether the video performance was pre or post HBB training. Prior to the individual evaluation of the videos, a common observation of two dummy videos for each scenario and agreement about scoring criteria was conducted. Key points of care were scored as "right", "wrong", or "unsure" (e.g. insufficient video quality) by each rater. In the "Neonatal Resuscitation" scenario, time to first ventilation attempt was recorded. In order to assess the overall performance of the participant, summarizing scores were given. A score between 1 and 3 (Very good, Good, Adequate) is indicative of "a performance that would enhance survival of the infant", i.e. equal to a "pass", while a score of 4 or 5 (Inadequate, Incorrect) is indicative of "a performance that places the infant at risk of adverse outcome including death", i.e. equal to "fail". Inter-rater agreement in "pass/fail" was 100% for both scenarios. Overall agreement in the "Routine Care" scenario was 71% with Cohen's kappa 0.64, while the agreement was 86% and Cohen's kappa 0.83 in the

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Box 1: The Kirkpatrick model for evaluating effects of educational courses.[21]

Level 1: *Reaction.* Participants perception of the course
Level 2: *Learning.* Acquired knowledge, improved skills, or changes in self-confidence and attitudes because of the training
Level 3: *Behavior.* Translation of the newly acquired knowledge and skills into daily practice
Level 4: *Results.* The ultimate goal; patient outcome

Box 2: Time line of the data collection and the HBB training

- **August 2009** Start of observational open cohort study in the delivery room
- **September 2009** Pre HBB simulation testing: 39 health care workers at the maternity ward observed in (i) routine care and (ii) neonatal resuscitation
- **1 September 2009–14 April 2010** Continuous observations of neonatal care in the delivery room before the HBB simulation training ($n = 2745$)
- **15–16 April 2010**: HBB simulation training
- **17 April 2010–30 November 2010** Continuous observations of neonatal care in the delivery room after HBB simulation training ($n = 3116$)
- **November 2010** After-HBB simulation testing: 27 health care workers at the maternity ward that had completed the HBB-training in April 2010 observed in (i) routine care and (ii) neonatal resuscitation

"Neonatal Resuscitation" scenario. The difference in the assessed "Time to ventilation" varied from 0 to 13 s between the raters ($p = 0.16$).

2.4. The Kirkpatrick model for evaluation

The Kirkpatrick model for evaluation of training courses was first developed by Donald Kirkpatrick in 1959 and later updated several times, latest in 2006.[21] It describes four levels of evaluation (Box 1) that provide a thorough understanding of the effectiveness of a training program and potential needs for improvement.

2.5. Statistical analysis

The software program PASW 20.0 (SPSS Inc; Chicago, USA) was used for statistical analysis. Independent-samples *t*-test was used to compare means of continuous parametric variables.

The relation between categorical variables was explored by Chi-square tests when all expected cell frequencies were equal or greater than five, otherwise Fischer's Exact Probability Test was applied. The McNemara and Wilcoxon signed-rank test was used for paired analysis. The relation between unpaired ordinal data and between continuous and categorical variables was explored by Mann–Whitney *U* test. Two-sided *p*-values lower than 0.05 were considered statistically significant. The changes between pre and after HBB training were analyzed on two levels: The first analysis was for the entire cohort of 39 providers tested prior to and for the 27 tested post HBB training. A second analysis was performed of the 13 providers that were tested both pre and post training.

2.6. Ethical considerations

The study was approved by the management at HLH and the National Institute for Medical Research in Tanzania.

3. Results

3.1. Study population

There were no significant differences regarding age, gender, and education between the two cohorts of providers tested pre and post HBB training (Table 1). The entire study population consisted of 53 participants: 39 tested before and 27 tested after HBB training; 13 providers were evaluated both pre and post HBB training.

3.2. Performance of "Routine Care" simulation before and after HBB training

Before HBB training, 16/39 (41%) providers passed the "Routine Care" scenario as compared to 20/27 (74%) providers seven months after HBB training ($p = 0.016$). The total score improved from a median 4 (Interquartile range (IQR) 3.4) to a median 2 (IQR 1.4; Rater A, $p = 0.002$) and 3 (IQR 2.4; Rater B, $p = 0.002$). Table 2 presents the results of "Routine Care" assessments by the two raters with corresponding Cohen's Kappa and mean changes in the total score and in the different single items. The highest potential of improvement was seen in "Dries baby". However, the low Kappa value indicates, that this item was at the same time especially difficult to score on the simulation video.

3.3. Performance of "Neonatal Resuscitation" simulation before and after HBB training

Before HBB training, 7/39 (18%) providers passed the "Neonatal Resuscitation" scenario as compared to 20/27 (74%) providers post HBB training ($p \leq 0.001$). The total score improved from median 4 (IQR 4.5) to 3 (IQR 2.4, $p < 0.001$) as assessed by both raters. Table 3 presents the results of the "neonatal resuscitation" assessments by the two raters. The number of providers who managed to successfully apply the face mask increased from 12/39 (31%), Rater A, 14/39 (36%), Rater B before HBB to 20/27 (74%, Rater A and B, $p \leq 0.001$ and $p = 0.002$ respectively) after HBB training, with a mean increase of 41%. Mean time to recognition of a "no breathing" mannequin and start of ventilation did not change and the majority of providers initiated face mask ventilation within the "Golden Minute®" (Table 3). The proportion of providers who managed to

Table 1
Study population.[a]

	Total cohort	Pre HBB	Post HBB	Providers that were re-tested
Number	53	39	27	13
Age (±SD)	38.1 (±10.3)	38.5 (±11.2)	39.6 (±9.5)	42.6 (10.9)
Male/female (%)	12/41 (23/77)	8/31 (21/79)	7/21 (26/74)	3/10 (23/77)
Profession (%)				
Midwife	20 (38)	14 (36)	11 (41)	5 (39)
Other nurse	11 (21)	7 (18)	7 (26)	3 (23)
Ward attendant	17 (32)	13 (33)	7 (26)	3 (23)
Nurse student	5 (9)	5 (13)	2 (7)	2 (15)

[a] No significant difference between the cohorts as tested by Student's *t*-test (age) and Chi-square test or Fisher's exact probability test (gender and profession).

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Table 2
Assessed performance of "Routine care" before and after HBB training.

All participants	Pre HBB $n = 39$	Post HBB $n = 27$	p-Value[a]	Cohen's kappa
Pass (%)	16 (41)	20 (74)	0.016	1.0
Total score, Rater A median (IQR)	4 (3,4)	2 (1,4)	0.002	
Total score, Rater B median (IQR)	4 (3,4)	3 (2,4)	0.002	
Total score, mean change in %[b]				0.64
1. Very good		+18.2		
2. Good		+15.5		
3. Adequate		−0.3		
4. Inadequate		−28.4		
5. Incorrect		−4.7		
Single items, mean change in %[b]				
1. Dries baby		+29.8		0.34
2. Cuts cord		+13.0		0.82
3. Keeps warm		+24.6		0.48
4. Give to mother		+12.0		0.68
Participants tested before and after HBB-training	***n* = 13**	***n* = 13**		
Pass (%)	2 (15)	10 (77)	0.002	1
Total score, Rater A median (IQR)	4 (4/4)	2 (2/3)	0.024	
Total score, Rater B Median (IQR)	4 (4/4)	3 (2/3)	0.024	
Single items, mean change in %[b]				
1. Dries baby		+23.1		0.60
2. Cuts cord		+19.3		0.77
3. Keeps warm		+15.4		0.42
4. Give to mother		+11.5		0.77

[a] Chi-square test or Fishers exact probability test for categorical data and Mann–Whitney U test for ordinal data.
[b] Percentages calculated as (change Rater A + change Rater B)/2.

suction correctly increased from 3/39 (8%, Rater A) and 5/39 (13%, Rater B) before HBB to 15/27 (56%, Rater A, $p < 0.001$) and 13/27 (48%, Rater B, $p = 0.001$). The number of providers who stimulated correctly increased as well, however, only one rater found that this improvement was significant, with 3/39 (8%, Rater A and B) before HBB to 4/27 (15%, Rater A, $p = 0.43$) and 9/27 (33%, Rater B, $p = 0.01$) after HBB.

3.4. Performance of the 13 providers tested before and after HBB training

Before the HBB training 2/13 (15%) passed the "Routine Care" scenario compared to 10/13 (77%) after training ($p = 0.002$), and 5/13 (39%) versus 9/13 (69%) passed the "Neonatal Resuscitation" scenario ($p = 0.219$) (Tables 2 and 3).

Table 3
Assessed performance of "Neonatal Resuscitation" before and after HBB training.

All participants	Pre HBB n = **39**	Post HBB n = **27**	p-Value[a]	Cohen's kappa
Pass (%)	7 (18)	20 (74)	<0.001	1
Total score, Rater A median (IQR)	4 (4,5)	3 (2,4)	<0.001	
Total score, Rater B median (IQR)	4 (4,5)	3 (2,4)	<0.001	
Total score, mean change in %[b]				0.83
1. Very good		+11.1		
2. Good		+28.9		
3. Adequate		+16.1		
4. Inadequate		−8.7		
5. Incorrect		−47.5		
Single items, Mean Change in %[b]				
1. Stimulates correctly		+16.4		0.77
2. Suctions correctly		+42.7		0.61
3. FMV successfully at first try		+40.3		0.59
4. FMV successfully during scenario		+40.8		0.86
Mean time to FMV in seconds (±SD)	40 ± 26	42 ± 16	0.672	67%[c]
Starts FMV within 60 s (%)	27/39 (69)	25/27 (93)	0.022	1
Participants tested before and after HBB-training	***n* = 13**	***n* = 13**		
Pass (%)	5 (39)	9 (69)	0.219	
Total score, Rater A median (IQR)	4 (3,5)	3 (2,4)	0.16	
Total score, Rater B Median (IQR)	4 (3,5)	3 (2,4)	0.16	
Single items, mean change in %**				
1. Stimulates correctly		+11.6		0.83
2. Suctions correctly		+46.2		0.66
3. FMV successfully at first try		+34.6		0.48
4. FMV successfully during scenario		+15.4		0.89
Mean time to FMV in seconds (±SD)	35.6 (19.7)	44.6 (19.8)	0.56	
Starts FMV within 60 s (%)	10 (77)	11 (85)	1.0	

FMV, face mask ventilation.
[a] Chi-square test or Fishers exact probability test (two-tailed) for categorical variables, Student's t-test for continuous variables, and Mann–Whitney U test for ordinal data.
[b] Percentages calculated as (Change Rater A + change Rater B)/2.
[c] Inter-rater agreement ±5 s.

Table 4
Observed performance of stimulation, suction, and face mask ventilation (FMV) in the delivery room of all births occurring in the respective observation periods at HLH.

	Pre HBB training	Post HBB training	*p*-Value
Time period	01.09.2009–16.04.2010	17.04.2010–30.11.2010	
Total n of infants born	2745	3116	
Perinatal management			
Stimulation (%)	485 (17.7)	438 (14.1)	≤ 0.0001[a]
Suction (%)	344 (12.5)	398 (12.8)	=0.782[a]
FMV (%)	231 (8.4)	233 (7.5)	=0.185[a]
Mean time to start FMV	76 ± 54 s	89 ± 76 s	=0.028[b]

[a] Chi-square test.
[b] Student's *t*-test.

3.5. Correlations

There were no correlations between frequency of attended deliveries, frequency of newborn care and resuscitations, theoretical knowledge and "pass/fail" performance. High self-confidence in neonatal resuscitation ("Confident", "Very confident" or "Always confident") was related to reduced performance ($p = 0.01$), and the number of providers who reported themselves as "always confident in resuscitating babies" decreased from 29/39 (74%) to 5/27 (19%) after HBB training ($p \leq 0.001$).

3.6. Neonatal management in the delivery room

Neonatal management in the delivery room is presented in Table 4. The number of newborn infants stimulated at birth decreased after HBB training, whereas the frequency of suction and face mask ventilation remained stable. Mean time from birth to initiation of face mask ventilation also increased in the period after HBB training.

4. Discussion

This report documents the long-term impact of a one-day HBB training on practical skills and management strategies among providers in a rural Tanzanian hospital. When providers simulated "Routine Care" and "Neonatal Resuscitation" (Kirkpatrick level 2) seven months after HBB training, skills and performance were significantly better. By contrast, neonatal management in the delivery room during the corresponding time period did not improve and in fact was worse (Kirkpatrick level 3). Thus, less newborn infants were stimulated and the time to initiate face mask ventilation was longer.

To our knowledge, this is the first study evaluating the impact of a simulation-based training course as it relates to the acquisition of knowledge and skills of providers and subsequent translation into clinical practice in a rural hospital in Africa. The Kirkpatrick model has been used to assess the impact of educational courses as it relates to learning and reaction (levels 1 and 2) but rarely as it relates to the transfer of acquired knowledge, skills and management strategies into clinical practice and the impact on patient outcome (levels 3 and 4).[24] The findings in this study suggest that while one-day HBB training is adequate in improving long-term performance in a simulated setting, it is insufficient to integrate and translate those skills into clinical practice as in the delivery room. These sobering findings likely reflect the reality of clinical practice where resources are limited, and there is a high staff turnover. Specifically at HLH approximately 25 midwives and 60 additional providers with varying educational backgrounds might be called upon to deliver newborn infants. This points to the critical need for a consistent program targeted at ongoing training and local mentoring which was not present during the study period. An additional and unanticipated observation was that related to provider self-confidence, as those with high self-confidence performed worse when tested. Following the training this degree of self-confidence decreased significantly which we interpret as a significant benefit of simulation based training.

The clinical observations in the delivery room in this report indicate an increase in mean time to initiation of face mask ventilation, in the period after HBB training. This is in contrast to testing on the simulator where the majority of providers initiated face mask ventilation within the "Golden Minute®". The reasons behind this conflicting observation are unclear but important to delineate. We have previously demonstrated the critical importance of early initiation of face mask ventilation to prevent morbidity and mortality among those who do not start breathing spontaneously after stimulation.[23] This critical observation stresses the importance of repeated trainings but in addition perhaps a focus on time management strategies, which is much easier to recognize in the safe confines of a simulated environment, as opposed to the hectic situation with a non-breathing wet baby in the delivery room.

A major limitation to this report includes the before and after design which restricts the ability to isolate the effect of the one-day HBB training from potential other changes at HLH during the time period. Importantly the number of deliveries at HLH has been increasing consistently during the study period without a corresponding increase in staff. These factors may have influenced the behavioral findings, i.e. the inability to translate the newly acquired knowledge and skills into daily practice (Kirkpatrick level 3). Second we were only able to re-test one third of the cohort of providers previously tested. Thus, while the two cohorts represent the same maternity ward they do not represent the same participants which might have influenced the findings. We therefore analyzed the 13 participants that were re-tested separately with comparable findings to the entire cohort. Notably however, the improvement in "Neonatal resuscitation" was not statistically significant, but we assume that this is due to a small sample size. Potential limitations related to simulation-based testing (Kirkpatrick level 2) include the unfamiliarity of many providers with the concept of simulation during the pre HBB testing that might have influenced their performance. Further, the scenarios were videotaped for subsequent scoring by two raters who represent a completely different clinical and cultural background, and neither were familiar with conditions encountered in low-resource limited settings. This is probably reflected in "unnecessary" uncertainty (scoring "unsure") and a low Cohen's kappa of several items. Therefore, to achieve sufficient inter-rater agreement some of the videos had to be re-rated.

5. Conclusion

A one-day simulation-based HBB training conducted in a rural Tanzanian hospital resulted in improved provider performance seven months later when tested in a simulated setting. However, this improvement was not translated into delivery room management. Subsequently, measures were taken (short HBB re-trainings delivered regularly and frequently with local mentoring) to improve the transfer of acquired knowledge and skills into

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clinical practice. Further research is necessary to explore the impact of these measures on performance and patient outcome. More focus on early stimulation and discussions around local implementation should be prioritized during HBB training.

Conflict of interest statement

Hege L. Ersdal and Corinna Vossius have recieved financial support from Lærdal Foundation for Acute Medicine. Eliwaza Bayo, Estomih Mduma, Jeff Perlman, Anne Lippert and Eldar Søreide have no conflict of interest.

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