Newborn Resuscitation Training in Resource-Limited Settings: A Systematic Literature Review

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abstract

CONTEXT: Birth asphyxia contributes substantially to neonatal mortality in low- and middle-income countries (LMICs). The effects of training birth attendants in neonatal resuscitation (NR) on mortality are limited by falloff of skills and knowledge over time and transference of learned skills into clinical practice.

OBJECTIVE: This review examined acquisition and retention of NR knowledge and skills by birth attendants in LMICs and the effectiveness of interventions to improve them.

DATA SOURCES: Medline, Cochrane, Embase, CINAHL, Bireme, and African Index Medicus databases were searched. We reviewed Web pages and reports from non–peer-reviewed (or "gray") literature sources addressing NR training in LMICs.

STUDY SELECTION: Articles on acquisition and retention of NR knowledge and skills, and interventions to improve them, were limited to LMICs.

RESULTS: The initial search identified 767 articles, of which 45 met all inclusion criteria. Of these, 31 articles analyzed acquisition of knowledge and skills, and 19 analyzed retention. Most studies found high acquisition rates, although birth attendants struggled to learn bag-mask ventilation. Although significant falloff of knowledge and skills occurred after training, refresher training seemed to improve retention. Results of the gray literature analysis suggest that formal, structured practice sessions improve retention.

LIMITATIONS: This review did not analyze training's direct impact on mortality.

CONCLUSIONS: Knowledge and skills falloff is a significant barrier to the success of NR training programs and possibly to reducing newborn mortality in LMICs. Refresher training and structured practice show significant promise. Additional research is needed to implement and assess retention improvement strategies in classroom and clinical settings.

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REVIEW ARTICLE

Approximately 2.7 million newborns die every year worldwide, the overwhelming majority of them in low- and middle-income countries (LMICs).[1–4] Birth asphyxia, defined as a newborn's failure to initiate and/or sustain normal breathing and oxygenation, accounts for roughly one-quarter (21%–28%) of all neonatal deaths, many of which are misclassified as stillbirths.[3–10] Despite significant progress in reducing global mortality in children aged <5 years as called for in the United Nations' Millennium Development Goal 4, neonatal mortality rates and deaths due to birth asphyxia in particular have failed to improve at the same rate as other child health indicators and, in some areas, have remained stagnant.[1,10–13]

Neonatal resuscitation (NR) is a simple, inexpensive intervention that has been shown to reduce neonatal mortality.[9,14–19] In high-income countries, the introduction of training programs such as the Neonatal Resuscitation Program in the United States and Newborn Life Support in the United Kingdom was associated with a reduction in neonatal morbidity and mortality.[20,21] These programs offer standardized training, knowledge, and skills in essential newborn resuscitation to providers. Similar training programs for birth attendants in LMICs have the potential to significantly reduce global neonatal mortality.[19,22,23] Helping Babies Breathe (HBB) is a global newborn resuscitation training initiative developed by the American Academy of Pediatrics (AAP) and its partners that is tailored for low-resource settings.[24–27] HBB uses picture-based training and low-cost inflatable mannequins (NeoNatalie; Laerdal Global Health, Stavanger, Norway) for simulation and emphasizes establishing ventilation in newborns within the first 60 seconds of life. Since its introduction in 2010, HBB has been taught in 77 countries to ∼300 000 birth attendants and is currently being implemented throughout sub-Saharan Africa, Asia, and Latin America.[28] Data on its effectiveness at reducing neonatal mortality are mixed, however.[29–31]

Falloff of skills and knowledge after training in newborn resuscitation has been well documented in high-income countries.[32–34] There are few data on this phenomenon from LMICs. However, poor retention of knowledge and skills after training courses likely represents a significant barrier to improving neonatal mortality worldwide.[35] The present systematic literature review examines acquisition and retention of newborn resuscitation knowledge and skills among birth attendants in LMICs, and identifies and characterizes effective strategies for improving skill and knowledge acquisition and retention.

METHODS

A peer-reviewed literature search was conducted between June and July 2015 in the following 6 databases: Medline, Cochrane, Embase, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Bireme, and African Index Medicus. The following search terms and Medical Subject Headings were used: ((((newborn OR neonatal) AND resuscitation) OR (helping babies breathe)) AND (education OR training OR skills OR knowledge OR birth attendant OR retention OR acquisition) AND (developing countries OR low income countries OR middle income countries OR resource-limited setting OR global health)). Results from all available publication years were limited to articles written in English and published in peer-reviewed publications. Articles were screened for relevance first by title, then by abstract, and finally by full text.

The results were manually sorted to include only studies analyzing newborn resuscitation training programs in LMICs that measured the acquisition and/or retention of knowledge and skills. We included articles assessing training programs taking place in either classrooms or clinical settings and those involving providers working either in health care facilities or in the community. We excluded articles describing studies in high-income countries and those focused only on measuring the impact of training on neonatal mortality unless they also measured birth attendant knowledge and skills either in the classroom or clinical setting. Articles assessing baseline birth attendant knowledge and skills were excluded if no training or educational intervention was performed. The bibliographies of all pertinent articles were manually reviewed to obtain additional articles.

In addition, the "gray" literature (ie, non–peer-reviewed) was searched for efforts to improve birth attendant knowledge and skills acquisition and retention by reviewing records, Web pages, and reports from various sources addressing newborn resuscitation training in LMICs over the past decade. Sources included reports and presentations generated by members of the HBB Global Developmental Alliance, which includes the United States Agency for International Development, the AAP, Latter-day Saints Charities, and Save the Children. Furthermore, Web sites of the AAP's Neonatal Resuscitation Program and HBB programs were reviewed. Gray literature findings were manually sorted to only include reports and documents pertaining to the knowledge acquisition and/or retention of newborn resuscitation knowledge or skills.

RESULTS

Description of Articles

The initial literature search identified 767 articles (Fig 1). Many of these

articles were excluded because they concerned high-income countries or reported training's impact on mortality without discussing acquisition and/or retention of skills. Article abstracts were reviewed based on title relevance, and the list was narrowed to 86 articles. Manual review of full-text articles identified 45 that met all inclusion criteria.

Training programs evaluated by these articles varied. Of 45 articles, 17 (37.8%) analyzed educational interventions based on the Neonatal Resuscitation Program, 9 (20%) described HBB programs,[25,26,30,31,36–40] and the remaining 19 (42.2%) analyzed a variety of other newborn resuscitation training programs. Course content varied as well, ranging from focusing solely on basic newborn resuscitation to including bag-mask ventilation (BMV), while relatively few also included chest compressions, administering medications, and endotracheal intubation. Training courses for birth attendants ranged from a 1-time session lasting 3 hours,[41] to intensive courses lasting 4 months,[42] to self-study courses lasting 5 weeks.[43] The articles included in the literature review evaluated birth attendants with all levels of education and training, ranging from traditional birth attendants to physicians (Table 1).

Methods for measuring acquisition and retention of knowledge and/or skills varied. Twenty-six studies (57.8%) evaluated knowledge levels by using written examinations. Thirty-eight studies (8.4%) attempted to measure birth attendant skills; of these, 24 (63.2%) required birth attendants to perform a particular skill while being graded by examiners. Thirteen studies (28.9%) had participants run through simulated scenarios, with 10 studies (22.2%) specifically mentioning formal objective structured clinical examinations (OSCEs).[25,26,37–40,42,44,50,63] Thirteen articles (28.9%) specifically
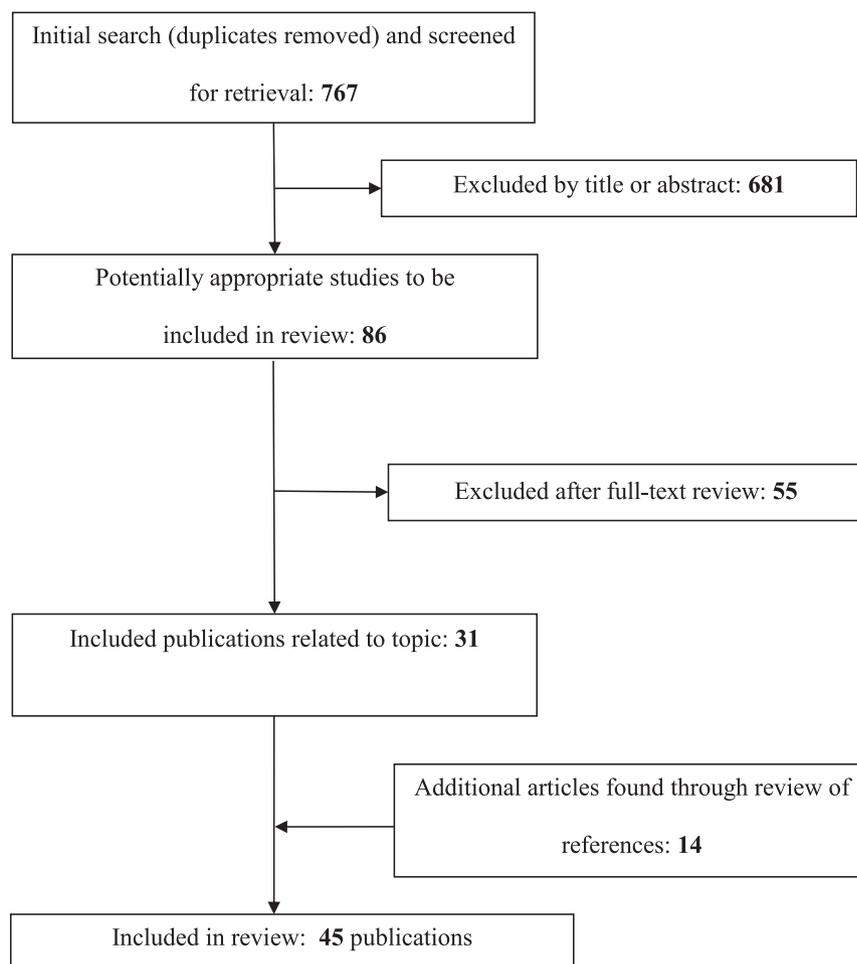
Initial search (duplicates removed) and screened for retrieval: **767**

Excluded by title or abstract: **681**

Potentially appropriate studies to be included in review: **86**

Excluded after full-text review: **55**

Included publications related to topic: **31**

Additional articles found through review of references: **14**

Included in review: **45** publications

FIGURE 1
Peer-reviewed articles screened and reviewed.

mentioned use of a mannequin in simulation.[25,36,38,39,48,49,59,61,62,71,73–75] Sixteen studies (35.6%) evaluated clinical behavior in the delivery room in addition to, or instead of, testing birth attendants in simulated scenarios. In 10 (62.5%) of these studies, examiners directly observed birth attendants,[18,30,31,36,43,44,59,64,65] whereas in 7 studies (43.8%), scores were based on chart review or recall by birth attendants and/or the newborn's mother.[37,43,47,50,57,60,62] One study both directly observed birth attendants and surveyed community women cared for by these attendants.[43]

Acquisition of Knowledge and Skills

Twenty-nine studies (64.4%) examined the acquisition of

knowledge and skills by testing birth attendants immediately after training. Of these, 26 studies (90.0%) demonstrated a majority (>50%) of birth attendants achieving passing scores on posttraining examinations. Twenty-three studies tested birth attendants both before and immediately after training, and all exhibited significant improvement in knowledge and/ or skills. Improvement in scores ranged from 7% to 89%. Although improvement in knowledge and skills was universal, training did not universally achieve high levels of acquisition. A study of Iraqi obstetrics and pediatric residents found that only 14% passed a Mega Code examination after training,[75] whereas a study in rural Nepal

TABLE 1 Articles Included in the Literature Review

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Allen and Jeffery[44]	Journal of Tropical Pediatrics, 2006	Implementation and evaluation of a neonatal educational program in rural Nepal	Nepal	Before-and-after cohort study	Physicians, nurses, community nurses	Written knowledge test before and after training; simulation skills test after training	Knowledge and skills significantly improved after training
Berglund et al[45]	Acta Obstetricia et Gynecologica, 2010	Successful implementation of evidence-based routines in Ukrainian maternities	Ukraine	Before-and-after cohort study	Physicians, nurses, midwives	Used delivery room documentation to evaluate newborn management	Clinical management of newborns significantly improved after training
Bhatia et al[46]	Indian Pediatrics, 1993	Training of final year MBBS students in neonatal resuscitation	India	Before-and-after cohort study	Medical students	Written knowledge skills before and after training; simulated skills assessment immediately after training	Knowledge and skills significantly improved after training
Bhuiyan et al[47]	Int J Gynaecol Obstet, 2005	Evaluation of a skilled birth attendant pilot training program in Bangladesh	Bangladesh	Controlled trial; before-and-after cohort study	Skilled birth attendants	Skills evaluated by interviewing newborns' mothers 6 mo after training	Performance was higher among birth attendants who underwent training
Bookman et al[41]	Resuscitation, 2010	Educational impact of a hospital-based neonatal resuscitation program in Ghana	Ghana	Before-and-after cohort study	Midwives	Written and skills test before and after training, and 9–12 mo after training	Knowledge and skills significantly improved after training; no falloff of knowledge and skills 9–12 mo after training
Carlo et al[48]	J Pediatr, 2009	Educational impact of the neonatal resuscitation program in low-risk delivery centers in a developing country	Zambia	Before-and-after cohort study	Midwives	Written and skills test before and after training, and 6 mo after training	Knowledge and skills significantly improved after training; significant falloff of knowledge and skills after training
Couper et al[49]	Rural and Remote Health, 2005	The neonatal resuscitation training project in rural South Africa	South Africa	Before-and-after cohort study	Physicians, nurses, paramedics	Written and skills test before and after training	Knowledge and skills significantly improved after training
Deorari et al[18]	Ann Trop Paediatr, 2001	Impact of education and training on neonatal resuscitation practices in 14 teaching hospitals in India	India	Before-and-after cohort study	Physicians, nurses	Observed clinical behaviors in the delivery room before and for 12 mo after training; analyzed changes in birth asphyxia	Use of BMV increased, while use of medications and chest compression declined, after training
Disu et al[50]	Nigerian Journal of Clinical Practice, 2015	National neonatal resuscitation training program in Nigeria (2008-2012): a preliminary report	Nigeria	Before-and-after cohort study	Physicians, nurses, midwives	Written test before and after training; telephone survey with birth attendants 8 mo after training to measure clinical behavior in delivery room	Knowledge significantly improved after training; found high levels of BMV use at 8 mo
Dynes et al[51]	Midwifery, 2013	Strengthening maternal and newborn health in rural Ethiopia: early results from frontline health worker community maternal and newborn health training	Ethiopia	Before-and-after cohort study	TBAs, HEWs, community health promoters	Performance testing before and after training	Performance significantly improved after training
Dynes et al[52]	Midwifery, 2011	Home-based life saving skills in Matlab, Bangladesh: a process evaluation of a community-based maternal child health program	Bangladesh	Before-and-after cohort study	Community health research workers	Performance testing before, immediately after, and 1 y after training	Performance significantly improved after training; skills improved further from immediately after training to 1 y later

TABLE 1 Continued

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Enweronu-Laryea et al[53]	*Resuscitation*, 2009	Evaluating the effectiveness of a strategy for teaching neonatal resuscitation in West Africa	Ghana	Before-and-after cohort study	Midwives, nurses, obstetrics residents, pediatrics residents, medical officers, nurse anesthetists	Written knowledge tests only	Knowledge significantly improved after training; lower cadre birth attendants improved more than higher cadre birth attendants; birth attendants working in higher volume birth facilities performed significantly better than those working in lower volume birth facilities
Ergenekon et al[54]	*Resuscitation*, 2000	Neonatal resuscitation course experience in Turkey	Turkey	Before-and-after cohort study	Physicians, nurses	Written knowledge tests only	Knowledge significantly improved after training
Ersdal et al[36]	*Resuscitation*, 2013	A one-day Helping Babies Breathe course improves simulated performance but not clinical management of neonates	Tanzania	HBB, before-and-after cohort study	Midwives, student nurses, ward attendants	Simulated skills test and observed clinical behaviors in the delivery room before training and 7 mo after HBB training	Test performance significantly improved after training, but this improvement did not correlate with improved newborn management in the delivery room
Gobezayehu et al[55]	*Journal of Midwifery & Women's Health*, 2014	Knowledge and skills retention among frontline health workers: community maternal and newborn health training in rural Ethiopia	Ethiopia	Before-and-after cohort study	TBAs, HEWs, community health workers	Simulated skills test immediately after training and 18 mo after training	Measures of retention were mixed, with some birth attendant groups showing no falloff; falloff of knowledge and skills was significantly associated with lower cadres; program featured refresher training
Goudar et al[37]	*Pediatrics*, 2013	Stillbirth and newborn mortality in India after Helping Babies Breathe training	India	HBB, before-and-after cohort study	Physicians, nurses, auxiliary nurse midwives	Written knowledge tests and OSCE before and after initial HBB training and refresher session	Knowledge and skills significantly improved after training
Hoban et al[26]	*Journal of Tropical Pediatrics*, 2013	Helping Babies Breathe training in sub-Saharan Africa: educational impact and learner impressions	Ethiopia	HBB, before-and-after cohort study	Physicians, nurses, nurse midwives	Written knowledge tests before and immediately after HBB training; simulated BMV skills test after training	Knowledge significantly improved after training; scores improved more dramatically for lower cadre birth attendants
Hosokawa[56]	*International Medical Journal*, 2011	Impact of neonatal resuscitation training workshop in Mongolia	Mongolia	Before-and-after cohort study	Physicians, midwives	Written tests and simulated skills evaluation before and after training	Knowledge and skills significantly improved after training; scores improved more dramatically for lower cadre birth attendants
Jabir et al[48]	*Acta Pediatrica*, 2009	Knowledge and practical performance gained by Iraqi residents after participation to a neonatal resuscitation program course	Iraq	Before-and-after cohort study	Pediatrics and obstetrics residents	Written knowledge tests before and immediately after training; simulated Mega Code skills test after training	Knowledge significantly improved after training; only 14% received a passing score on the Mega Code skills test

TABLE 1 Continued

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Jeffery et al[42]	Medical Education, 2004	The impact of evidence-based education on a perinatal capacity-building initiative in Macedonia	Macedonia	Before-and-after cohort study	Physicians, nurses	Written tests and simulated skills evaluation after training; evaluated delivery room documentation to measure clinical behaviors; measured neonatal mortality rate before and after training	All trainees passed the knowledge/skills test after training; clinical behaviors became more evidence-based after training; neonatal mortality rate improved after training
Kumar[57]	Transactions of the Royal Society of Tropical Medicine and Hygiene, 1994	Effect of training on the resuscitation practices of traditional birth attendants	India	Posttraining skills assessment	TBAs	Used delivery room documentation and interviews with TBAs and newborns' family members to evaluate newborn management; compared results versus those of historical control subjects	Newborn management significantly improved after training compared with historical control subjects
Lai et al[58]	Education for Health, 2012	Teaching medical students neonatal resuscitation: knowledge gained and retained from a brief simulation-based training workshop	Malaysia	Before-and-after cohort study	Medical students	Written knowledge tests before, immediately after, and 2–10 mo after training	Knowledge significantly improved after training, although only 30.4% received passing scores; there was significant falloff
Makene et al[59]	BMC Pregnancy and Childbirth, 2014	Improvements in newborn care and newborn resuscitation after a quality improvement program at scale: results from a before and after study in Tanzania	Tanzania	Before-and-after cohort study	Physicians, nurses, nurse midwives	Evaluated written knowledge tests, simulated skills tests, and direct observation of birth attendant management in the delivery room before and 2 y after training	Knowledge and clinical management significantly improved, although resuscitation skills were persistently low
Malhotra et al[60]	National Medical Journal of India, 2011	Can traditional birth attendants be trained to reduce neonatal mortality rate? Lessons from Lufwanyama Neonatal Survival Project	Zambia	Controlled trial; evaluated delivery room management by interviewing TBAs 1 mo after training; program featured refresher training	TBAs	Evaluated delivery room management by conducting interviews with TBAs 1 mo after training; neonatal mortality rate measured in experimental and control groups	Management skills and neonatal mortality rate significantly improved in newborns managed by TBAs who underwent training
McClure et al[61]	Acta Pediatrica, 2007	Evaluation of the educational impact of the WHO Essential Newborn Care course in Zambia	Zambia	Before-and-after cohort study	Midwives	Written tests and simulated skills evaluation before and after training	Knowledge and skills significantly improved after training
Mduma et al[31]	Resuscitation, 2015	Frequent brief on-site simulation training and reduction in 24-h neonatal mortality—an educational intervention study	Tanzania	HBB, before-and-after cohort study	Midwives, nurse students, nurses, Physicians	Evaluated skills by directly observing delivery room management; measured 24-h neonatal mortality before and after training	Use of stimulation and suction increased after training, while use of BMV decreased; neonatal deaths decreased after training

TABLE 1 Continued

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Msemo et al[30]	Pediatrics, 2013	Newborn mortality and fresh stillbirth rates in Tanzania after Helping Babies Breathe training	Tanzania	HBB, before-and-after cohort study	Midwives	Evaluated skills by directly observing delivery room management; measured neonatal mortality rate before and after training	Use of stimulation and suction increased after training, while use of BMV decreased; neonatal deaths decreased after training
Musafili et al[38]	Acta Pediatrica, 2013	Evaluating Helping Babies Breathe: training for healthcare workers at hospitals in Rwanda	Rwanda	HBB, before-and-after cohort study	Physicians, midwives, nurse anesthetists	Written knowledge tests before, immediately after, and 3 mo after HBB training; skills evaluated by OSCE conducted immediately after and 3 mo after training	Knowledge significantly improved after training; there was significant falloff
Olson et al[62]	Int J Gynaecol Obstet, 2012	Community-based newborn resuscitation among frontline providers in a low-resource country	Indonesia	Controlled trial; before-and-after cohort study	Midwives	Evaluated knowledge by interviewing midwives before and 1 y after training; measured survival of newborns cared for by experimental and control groups	Knowledge significantly improved after training; there was no difference in 1-d survival between midwife groups
Olson et al[63]	Resuscitation, 2015	Assessing self-efficacy of frontline providers to perform newborn resuscitation in a low-resource setting	Indonesia	Controlled trial; retrospective cohort analysis	Midwives	Path analysis conducted to evaluate relative determinants of resuscitation attempts	Training affected resuscitation attempts indirectly; only self-efficacy demonstrated a significant effect on actual resuscitation attempts
Opiyo et al[64]	PLoS One, 2008	Effect of newborn resuscitation training on health worker practices in Pumwani Hospital, Kenya	Kenya	Controlled trial; posttraining skills assessment	Nurses, midwives	Evaluated skills by directly observing delivery room management; measured neonatal mortality	Delivery room performance significantly improved after training, and inappropriate measures were reduced in birth attendants who underwent training
Reisman et al[39]	Int J Gynaecol Obstet, 2015	Validation of a novel tool for assessing newborn resuscitation skills among birth attendants trained by the Helping Babies Breathe program	Tanzania	HBB, posttraining knowledge and skills assessment	Physicians, nurses, public health nurses, medical attendants	Evaluated birth attendant knowledge and skills by conducting OSCEs in the weeks after HBB training	Skills performance was higher in nurses than other cadres and in those birth attendants working in high-volume birth centers; BMV scores were low
Senarath et al[65]	Journal of Obstetrics, Gynecologic, and Neonatal Nursing, 2007	Effect of training for care providers on practice of essential newborn care in hospitals in Sri Lanka	Sri Lanka	Controlled trial; before-and-after cohort study	Physicians, nurses, midwives	Used direct observation and delivery room documentation to evaluate newborn management in both groups of birth attendants	Clinical skills improved more significantly in birth attendants who underwent training
Seto et al[40]	Perspect Med Educ, 2015	Educational outcomes of Helping Babies Breathe: training at a community hospital in Honduras	Honduras	HBB, before-and-after cohort study	Physicians, nurses	Written tests, simulated skills evaluation, and OSCE before and immediately after training	Knowledge and skills significantly improved after training; only 42% of birth attendants initiated BMV within 1 min of birth

TABLE 1 Continued

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Shrestha et al[66]	*International Nursing Review*, 2013	Newborn care in Nepal: the effects of an educational intervention on nurses' knowledge and practice	Nepal	Before-and-after cohort study	Nurses	Written tests and simulated skills evaluation before, immediately after, and at 1 and 3 mo after training; educational intervention was a self-directed learning program	Knowledge and skills significantly improved after training; there was significant falloff
Sibley et al[67]	*Journal of Midwifery & Women's Health*, 2014	Improving maternal and newborn health care delivery in rural Amhara and Oromiya regions of Ethiopia through the Maternal and Newborn Health in Ethiopia Partnership	Ethiopia	Before-and-after cohort study	TBAs, HEWs, community health development agents	Written tests before, immediately after, and 2 y after training; simulated skills evaluation immediately after and 2 y after training	Measures of retention were mixed, with some birth attendant groups showing no falloff
Singhal et al[25]	*Resuscitation*, 2012	Helping Babies Breathe: global neonatal resuscitation program development and formative educational evaluation	Kenya, Pakistan	HBB, before-and-after cohort study	Physicians, nurses, midwives	Written tests and simulated skills evaluation before and immediately after training; OSCE conducted immediately after training	Knowledge and skills significantly improved after training; BMV performance remained poor
Theron[68]	*Midwifery*, 1999	Improved cognitive knowledge of midwives practicing in the eastern Cape Province of the Republic of South Africa through the study of a self-education manual	South Africa	Controlled trial; before-and-after cohort study	Midwives	Written knowledge test before and 12 mo after training	Knowledge significantly improved among midwives who underwent training
Trevisanuto et al[69]	*Journal of Pediatrics*, 2010	Neonatal resuscitation in developing countries	Iraq	Posttraining knowledge assessment	Pediatric and obstetric residents	Written knowledge test after training	Skill performance was moderate after training
Trevisanuto et al[70]	*Pediatric Anesthesia*, 2007	Neonatal resuscitation courses for pediatric residents: comparison between Khartoum (Sudan) and Padova (Italy)	Sudan, Italy	Before-and-after cohort study	Pediatric residents	Written knowledge test before and after training	Knowledge significantly improved after training
Vidal et al[43]	*Bulletin of the World Health Organization*, 2001	Comparison of two training strategies for essential newborn care in Brazil	Brazil	Controlled trial; before-and-after cohort study	Physicians, nurses	Written knowledge tests before, immediately after, and 3–6 mo after training; evaluated clinical management by direct observation in the delivery room and interviewing newborns' mothers	Knowledge and skills significantly improved, and to similar extents, in birth attendants who underwent traditional training and those who underwent self-directed learning
Woods et al[71]	*Int J Gynaecol Obstet*, 2015	An innovative approach to in-service training of maternal health staff in Cambodian hospitals	Cambodia	Controlled trial; posttraining skills assessment	Physicians, midwives	Simulated skills test conducted 7–11 mo after training	Skills improved significantly more among birth attendants who underwent training and those who did not directly undergo training but worked with birth attendants who did
Woods and Theron[72]	*South African Medical Journal*, 1995	The impact of the Perinatal Education Program on cognitive knowledge in midwives	South Africa	Before-and-after cohort study	Midwives	Written knowledge test before and after training	Knowledge significantly improved after training

Author	Journal/Year	Title	Country(ies)	Study Type	Health Cadres	Type of Evaluation	Key Findings
Xu et al[73]	Resuscitation, 2014	The impact of an intervention package promoting effective neonatal resuscitation training in rural China	China	Controlled trial; posttraining skills assessment	Physicians, midwives	Written knowledge test after training; neonatal mortality rate was monitored	Knowledge was significantly higher in counties where birth attendants underwent training
Zanardo et al[74]	BMC Health Services Research, 2010	Laryngeal mask airway for neonatal resuscitation in a developing country: evaluation of an educational intervention. Neonatal LMA: an educational intervention in DRC	Congo	Before-and-after cohort study	Physicians, midwives	Written knowledge test before and after training; simulation skills test after training	Knowledge significantly improved after training, greater improvements were seen in lower-cadre birth attendants

DRC, Democratic Republic of Congo; HEW, health extension workers; MBBS, Bachelor of Medicine, Bachelor of Surgery; TBAs, traditional birth attendants; WHO, World Health Organization.

showed that only 65% of hospital nurses achieved passing grades after 4 educational sessions.[44]

Impact of Theoretical Knowledge on Delivery Room Behaviors and Newborn Outcomes

Five studies (11.1%) attempted to measure transference of theoretical knowledge and skills into clinical scenarios by correlating test performance with actual clinical behavior in the delivery room.[36,37,43,44,59] Of these, 4 studies (80.0%) found that high or low test scores accurately predicted clinical behavior,[37,43,44,59] and only 1 study (20.0%) reported improved test scores but reduced use of stimulation and longer time to BMV initiation in the delivery room at 7 months after training.[36]

Nine studies (20%) attempted to correlate performance on either standardized tests or actual behavior in the delivery room with changes in neonatal mortality statistics, and the results were mixed.[18,30,31,37,42,60,62,64,73] Four (44.4%) of these studies documented significant declines in neonatal mortality correlating with improvement in test scores and delivery room behavior, respectively.[30,31,42,60] Five studies (55.6%) reported no improvement in mortality despite improvement in test scores and/or delivery room behavior.[18,37,62,64,73] However, 3 of these studies (33.3%) showed a decrease either in newborns classified as stillborn or in asphyxia-related cause-specific mortality, suggesting the training programs had a positive impact.[18,37,73]

Controlled Trials of Training Strategies

We found 9 controlled trials evaluating knowledge and skills acquisition in classroom and/or clinical settings.[41,47,60,62–65,71,73] Of these, 7 studies (77.8%) compared knowledge and skills

of birth attendants undergoing training versus a control group who remained untrained, and all 7 found training resulted in significant improvement in knowledge and/or skills. One trial compared the skill levels achieved with 2 different training strategies and found no significant difference in performance between physicians and nurses who underwent a traditional 5-day training course and those given materials for self-directed study over a 5-week period.[43] Furthermore, in the self-directed study group, training costs were significantly lower. Self-directed study was analyzed in 1 other article, in which Shrestha et al[66] reported significant acquisition of knowledge and skills by Nepali nurses who underwent a self-directed educational intervention. Both knowledge and skills declined over subsequent months after the training but remained above pretraining levels when the study ended 3 months after the intervention. The levels of acquisition and falloff in this study were comparable to those seen in studies using more traditional training interventions.

Acquisition of BMV Skills

BMV, widely considered one of the most important interventions for newborns not responding to stimulation, proved to be more difficult to learn than other skills. In all, 24 studies (53.3%) specifically measured and reported acquisition of BMV skills. Of these, 6 studies (25.0%) found that birth attendants performed this skill more poorly than other skills when being tested and/or observed in the delivery room.[25,26,38–40,59] One study found pass rates on BMV skills as low as 20.8% immediately after training.[25] Although the skill was difficult to learn and sometimes performed incorrectly after training, 8 (72.7%) of 11 studies measuring actual observed use of BMV in the delivery room demonstrated a significantly

increased frequency of use. Two studies found that BMV use in the delivery room decreased after training, likely due to improved stimulation obviating the need for assisted ventilation.[30,31]

Association Between Birth Attendant Characteristics and Acquisition of Knowledge and Skills

Acquisition of knowledge and skills was associated with certain birth attendant characteristics, including level of training (health cadre) and the facility type in which they work. Ten (22.2%) of the 45 studies reported a breakdown of scores according to cadre,[26,36,39,40,44,50,53,55,56,74] and 7 (70.0%) of these studies showed that birth attendants from lower cadres (eg, midwives) improved significantly more from pretraining to posttraining than those from higher cadres (eg, physicians).[26,40,42,50,53,56,74] In all 7 of these studies, significant differences in pretraining test performance between different cadres were diminished or completely eliminated upon retesting after training. Similarly, a study from HBB in Tanzania found that nurses outperformed health care providers of both higher and lower training levels on a standardized OSCE.[39] Two studies analyzed a breakdown of test scores based on the type of birth facility in which birth attendants work and both found a significant association between working in a facility with higher birth volume and higher scores on examinations.[39,53] Another provider-level factor whose association with the adoption and retention of skills has been explored is provider self-efficacy (ie, one's belief in their own competence). Four studies (8.8%) measured self-efficacy by using questionnaires, and although all 4 studies reported increased self-efficacy of birth attendants with training, they were mixed on the value and relevance of self-efficacy.[36,48,61,63] Interestingly,

2 of the studies examining self-efficacy (50%) found that higher levels of confidence were inversely related to skills performance.[36,48]

Three studies found that training not only increased adoption of evidence-based measures but also reduced the use in a clinical setting of traditional and potentially harmful measures such as slapping the buttocks or back as a stimulation technique.[57,60,64] Furthermore, 1 of these studies, a controlled trial of training traditional birth attendants, found a 97% higher referral rate in those trained compared with those who did not receive training.[60] Another study documented increased BMV use in the clinical setting along with decreased use of medications and chest compressions,[18] interventions that are considered less useful than ventilation at improving outcomes in the low-resource setting.

Secondary Effects of NR Training

Woods et al[71] evaluated the secondary effects of training in a controlled trial. The investigators measured the skills of birth attendants who had undergone training as well as those who had not; in addition, they measured skills among birth attendants who had not directly undergone training but worked with those who did. Skill level was significantly higher in both experimental groups compared with the control group, and, although the mean test score among birth attendants who directly underwent training was higher than among those who did not undergo training but worked with those who did, the difference did not achieve statistical significance.

Retention of Knowledge and Skills

In all, 19 studies (42.2%) evaluated the retention of knowledge and skills over time by measuring birth attendant knowledge and skills after a time period after training. Ten of these studies (52.6%) looked directly

at knowledge and skills falloff by testing birth attendants both immediately after training and again after a period of time ranging from 1 month to 2 years. Five (50.0%) of these studies showed significant performance falloff over the time period analyzed.[37,38,48,56,66] Three studies (30.0%) showed no falloff[41,43,52]; the 2 remaining studies (20.0%), both from Ethiopia, found varying levels of retention in different groups of birth attendants, with higher levels of training associated with less falloff.[55,67]

These latter 5 studies showing either no falloff or mixed results included the 4 longest running studies in our literature review, ranging from 9 months to 2 years.[41,52,55,67] Furthermore, 4 (80%) of the 5 studies showing no falloff or mixed results featured refresher training or regular meetings to reinforce material learned.[43,52,55,67] Two of the studies with refresher courses showed an actual increase in knowledge and skills at 1 year and 18 months after training, respectively, compared with immediately after training.[52,55] Although Gobezayehu et al[55] recorded this improvement only in high-cadre birth attendants, Dynes et al[52] demonstrated improvement among community health workers assisting with home births in Bangladesh who received refresher training twice per month.

Of note, the 2 educational interventions from Ethiopia provided refresher training, but they also sought to educate women in the community and increase their demand for skilled maternal and newborn care, which may have been an important incentive for birth attendants to maintain their knowledge and skills.[55,67] The 1 study that found no falloff of skills over 9 to 12 months after training despite having no refresher training was conducted in 1 of Ghana's main

referral institutions.[41] The high birth volume at this center may have prevented falloff by providing birth attendants with frequent clinical practice.

Retention of BMV Skills

Six studies specifically measured retention of BMV skills over time and reported mixed results.[18,36,39,48,59,62] All but 1 of these studies showed that significantly increased BMV use (83.3%) persisted after training compared with before training; however, application of this life-saving maneuver was far from universal, and the technique was often incorrect. In a study from Tanzania's HBB program, only 21.5% of trained participants correctly demonstrated all 3 maneuvers to improve BMV 6 weeks after training.[39] Another study from Tanzania's HBB program showed increased use of BMV 7 months after training; however, researchers found that the average time to first ventilation attempt for newborns requiring this intervention had increased.[36] A third study from Tanzania (although not HBB related) measured BMV use through direct observation before and 2 years after training and found a decline in BMV use.[59]

Gray Literature

A review of the gray literature identified 19 reports that fit our inclusion criteria of discussing acquisition and/or retention of newborn resuscitation skills. The gray literature indicates that implementers and in-country teams are aware of a decline in trained providers' skills and knowledge when there is no or minimal follow-up after the initial HBB training. Importantly, teams are trying different methods to improve providers' retention of skills and knowledge. In a joint report of country-level HBB programs in Bangladesh and Malawi,[76] both countries reported that unstructured worksite practice is an ineffective

method for improving skills retention because few providers reported practicing at their worksite. There was no evidence of improved performance of resuscitation by trained providers in Malawi or Bangladesh 1 or 2 years into the HBB program, respectively. In contrast, in a 2009 HBB study within 8 referral-level facilities in Tanzania, a structured cascade model of training used regional trainers and district instructors to provide in-service and refresher training after initial HBB training.[77] In addition, every provider had to document practicing resuscitation by using a mannequin before the start of every shift, and 1 midwife at each hospital was given the responsibility of reinforcing the HBB training. With this relatively large investment in close oversight, longitudinal refresher training, and required practice, this study reported a 47% decline in early neonatal mortality in referral-level facilities after initiation of HBB.

Many countries reported ongoing or planned supportive supervision or mentoring programs as a method for improving skills retention.[78–83] In Uganda, for example, plans for on-site mentoring of providers would allow mentors and mentees to meet at least once per month to reinforce HBB training. In the large-scale implementation of HBB in Tanzania, feedback and coaching are targeted to reach providers who have low follow-up OSCE scores.[84] The program in Tanzania also introduced guided on-the-job HBB practice scenarios, DVD refresher training videos, and text messages to reinforce key messages among trained providers. In Malawi, a peer-to-peer training technique was used in which only 30% of skilled birth attendants were trained in HBB and then instructed to informally train their colleagues at their worksites.[76] This program was reportedly unsuccessful, however, because the skilled birth attendants who did not receive formal HBB training showed

little interest in being informally trained by their colleagues.

Several countries are also integrating HBB into preservice and in-service curricula.[76,78,85,86] It was found in Bangladesh and Malawi that integrating HBB into preservice training should be accompanied by a skills assessment. Nursing and medical students reported perceiving HBB skills to be less important than other preservice skills learned because the students are not assessed on HBB (while they are assessed on their other preservice training).

DISCUSSION

In recent years, neonatal mortality in LMICs has improved more slowly than other child health indicators, despite intensive efforts to enhance newborn care among birth attendants in these countries.[1,11–13] Falloff in knowledge and skills after training may be one of the barriers to reducing neonatal mortality from these training efforts. The present review examined the literature on the acquisition and retention of newborn resuscitation knowledge and skills by birth attendants in LMICs.

We found that newborn resuscitation training among providers in LMICs can significantly increase provider knowledge and skills. Along with stimulation, high-quality BMV is among the most important interventions; however, several studies found that birth attendants had more difficulty learning to provide BMV than other aspects of newborn resuscitation. Low rates of proficiency with BMV immediately after training suggest that educational programs should strengthen their emphasis on learning this technique, including methods of improving ventilation that is initially ineffective. Although most studies measuring the

relationship between classroom learning and clinical behavior showed good correlation, Ersdal et al[36] found that, after an HBB course, improved simulated performance did not lead to improved behavior in a clinical scenario. Transference of theoretical knowledge and skills into the delivery room is an important barrier to the success of NR training programs, and more research is needed to better understand this phenomenon. The review also highlights the potential impact of training's secondary effects, in which birth attendants can acquire knowledge and skills simply by working with those who are trained, rather than undergoing the training themselves. Furthermore, the literature suggests that self-directed learning may be a viable and cost-effective strategy for improving newborn care in LMICs.

Our review found numerous studies demonstrating that knowledge and skills fall off over time after training. However, this decline can be prevented. Of 5 studies reporting no appreciable falloff or mixed results, 4 of them featured refresher courses, suggesting that such a strategy may be effective at improving retention of knowledge and skills. The literature suggests that formal refresher training is uncommonly included in newborn resuscitation training programs; however, they are likely necessary to improve the impact of these programs on neonatal mortality and should become the standard. Mduma et al[31] showed the benefits of frequent brief on-site simulation training, but the optimal length of training courses and frequency of refresher courses are not known. In addition to ongoing quality improvement efforts, Sibley et al demonstrated the importance of community education.[67] In this study of Ethiopian birth attendants, who showed no falloff of knowledge and skills over a 2-year period after

training, education of community women featured prominently in the intervention. In a separate analysis of the same program, Barry et al[87] found that community women who attended more educational meetings were more likely to use skilled care providers to deliver their infants as well as more likely to receive a higher mean percentage of elements included in a maternal and newborn health package. This finding suggests that programs educating both providers and their communities may have more impact on neonatal mortality in LMICs than programs solely focused on provider education.

Review of the gray literature shows ongoing experimentation with a variety of refresher training strategies, including both structured and unstructured skills practice with a mannequin, as well as text messaging with reminders. Our preliminary analysis of these efforts suggests that more structured and formal practice regimens may be more effective in improving retention of knowledge and skills. The effectiveness of current efforts to train birth attendants in LMICs could also likely be increased by various training programs sharing lessons learned as countries experiment with different methods to promote providers' retention of skills.

We found that both acquisition and retention of knowledge and skills were associated with certain provider characteristics, including health cadre and the facility type in which providers work. Although acquisition of knowledge and skills was acceptable for providers from all cadres, several studies suggested that proficiency was more easily achieved by those birth attendants working in birth centers with higher patient volume. Furthermore, the literature shows better retention of knowledge and skills among birth attendants at higher volume institutions, suggesting that more frequent use of

the newborn resuscitation techniques prevents falloff. Training design should take these differences into account, including more intensive instruction and more regular practice and refresher training for those providers from smaller birth centers. Other factors that may affect adoption and retention of knowledge and skills include a birth attendant's previous experience with NR, the precise number of deliveries attended per month, and personal leadership commitment.

There are several limitations to the present study. Articles were limited to English-language only, and a publication bias may have favored articles with more positive results. Although this literature review did not directly measure the impact of training programs on neonatal mortality, multiple studies in the literature have reported improvement.[19,22,23,30] Simulated skills and written examinations are not completely transferrable to the clinical environment; however, a majority of the studies included in the review focused on classroom assessments of knowledge and skills whereas only one-third of the articles evaluated clinical practice, which reflects limitations in the medical literature on this topic. Although we tried to comprehensively search the gray literature, it is possible that some nongovernmental organization or country-level reports were missed. It is also likely that other approaches to improve retention are being attempted but not yet described in the literature.

CONCLUSIONS

Knowledge and skills falloff is a significant barrier to the success of newborn resuscitation training programs and possibly to reducing newborn mortality in LMICs. This literature review highlights some of the challenges that birth attendants face with learning

effective resuscitation skills, including stimulation and BMV, and the importance of refresher training and structured practice sessions in improving retention of knowledge and skills. A focus on acquisition of skills and preventing falloff through more frequent regular practice will likely increase the impact of the training programs on newborn outcomes in LMICs.[31] Going forward, a better understanding of how knowledge and skills are learned, transferred, and retained is essential.

ABBREVIATIONS

AAP: American Academy of Pediatrics
BMV: bag-mask ventilation
HBB: Helping Babies Breathe
LMICs: low- and middle-income countries
NR: neonatal resuscitation
OSCE: objective structured clinical examination

REFERENCES

1. UNICEF. Levels & trends in child mortality: report 2015. UN Inter-agency Group for Child Mortality Estimation. Available at: www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2015/en/

2. World Health Organization. Global health observatory data. Neonatal mortality. Available at: www.who.int/gho/child_health/mortality/neonatal_text/en/. Accessed February 15, 2016

3. Lawn J, Shibuya K, Stein C. No cry at birth: global estimates of intrapartum stillbirths and intrapartum-related neonatal deaths. *Bull World Health Organ.* 2005;83(6):409–417

4. Wang H, Liddell CA, Coates MM, et al. Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet.* 2014;384(9947):957–979

5. Lawn JE, Cousens S, Zupan J; Lancet Neonatal Survival Steering Team. 4 million neonatal deaths: when? Where? Why? *Lancet.* 2005;365(9462):891–900

6. Campbell O, Gipson R, el-Mohandes A, et al. The Egypt National Perinatal/Neonatal Mortality Study 2000. *J Perinatol.* 2004;24(5):284–289

7. Bhutta ZA, Darmstadt GL, Haws RA, Yakoob MY, Lawn JE. Delivering interventions to reduce the global burden of stillbirths: improving service supply and community demand. *BMC Pregnancy Childbirth.* 2009; 9(suppl 1):S7

8. Black RE, Cousens S, Johnson HL, et al; Child Health Epidemiology Reference Group of WHO and UNICEF. Global, regional, and national causes of child mortality in 2008: a systematic analysis. *Lancet.* 2010;375(9730):1969–1987

9. Lee AC, Cousens S, Wall SN, et al. Neonatal resuscitation and immediate newborn assessment and stimulation for the prevention of neonatal deaths: a systematic review, meta-analysis and Delphi estimation of mortality effect. *BMC Public Health.* 2011; 11(suppl 3):S12

10. World Health Organization. Make every mother and child count. The World Health Report. Geneva, Switzerland: WHO Press. Available at: www.who.int/whr/2005/en/. Accessed February 15, 2016

11. Darmstadt GL. Global perinatal health: accelerating progress through innovations, interactions, and interconnections. *Semin Perinatol.* 2010;34(6):367–370

12. World Health Organization. Accountability for maternal, newborn and child survival: The 2013 update. Geneva, Switzerland: World Health Organization; 2013. Available at: www.who.int/woman_child_accountability/ierg/reports/Countdown_Accountability_2013Report.pdf. Accessed February 15, 2016

13. United Nations Inter-agency Group for Child Mortality Estimation. Levels and trends in child mortality: report 2012. Estimates developed by the Inter-agency Group for Child Mortality Estimation. Available at: www.unicef.org/videoaudio/PDFs/UNICEF_2012_child_mortality_for_web_0904.pdf. Accessed February 15, 2016

14. Lawn JE, Kinney M, Lee AC, et al. Reducing intrapartum-related deaths and disability: can the health system deliver? *Int J Gynaecol Obstet.* 2009;107(suppl 1):S123–S142

15. Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS; Bellagio Child Survival Study Group. How many child deaths can we prevent this year? *Lancet.* 2003;362(9377):65–71

16. Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L; Lancet Neonatal Survival Steering Team. Evidence-based, cost-effective interventions: how many newborn babies can we save? *Lancet*. 2005;365(9463):977–988

17. Lawn JE, Yakoob MY, Haws RA, Soomro T, Darmstadt GL, Bhutta ZA. 3.2 million stillbirths: epidemiology and overview of the evidence review. *BMC Pregnancy Childbirth*. 2009;9(suppl 1):S2

18. Deorari AK, Paul VK, Singh M, Vidyasagar D; Medical Colleges Network. Impact of education and training on neonatal resuscitation practices in 14 teaching hospitals in India. *Ann Trop Paediatr*. 2001;21(1):29–33

19. Zhu XY, Fang HQ, Zeng SP, Li YM, Lin HL, Shi SZ. The impact of the neonatal resuscitation program guidelines (NRPG) on the neonatal mortality in a hospital in Zhuhai, China. *Singapore Med J*. 1997;38(11):485–487

20. Wegman ME. Annual summary of vital statistics—1990. *Pediatrics*. 1991;88(6):1081–1092

21. Guyer B, Hoyert DL, Martin JA, Ventura SJ, MacDorman MF, Strobino DM. Annual summary of vital statistics—1998. *Pediatrics*. 1999;104(6):1229–1246

22. Lawn JE, Manandhar A, Haws RA, Darmstadt GL. Reducing one million child deaths from birth asphyxia—a survey of health systems gaps and priorities. *Health Res Policy Syst*. 2007;5(4):4

23. O'Hare BA, Nakakeeto M, Southall DP. A pilot study to determine if nurses trained in basic neonatal resuscitation would impact the outcome of neonates delivered in Kampala, Uganda. *J Trop Pediatr*. 2006;52(5):376–379

24. American Academy of Pediatrics. Helping Babies Breathe. Available at: www.helpingbabiesbreathe.org. Accessed February 15, 2016

25. Singhal N, Lockyer J, Fidler H, et al. Helping Babies Breathe: global neonatal resuscitation program development and formative educational evaluation. *Resuscitation*. 2012;83(1):90–96

26. Hoban R, Bucher S, Neuman I, Chen M, Tesfaye N, Spector JM. 'Helping babies breathe' training in sub-Saharan Africa: educational impact and learner impressions. *J Trop Pediatr*. 2013;59(3):180–186

27. Ashish KC, Målqvist M, Wrammert J, et al. Implementing a simplified neonatal resuscitation protocol—helping babies breathe at birth (HBB)—at a tertiary level hospital in Nepal for an increased perinatal survival. *BMC Pediatr*. 2012;12:159

28. Kak LP, Johnson J, McPherson R, et al. Helping Babies Breathe: lessons learned guiding the way forward. Helping Babies Breathe. Available at: www.helpingbabiesbreathe.org/docs/HBB-Report-2010-2015.pdf. Accessed February 15, 2016

29. Ersdal HL, Singhal N. Resuscitation in resource-limited settings. *Semin Fetal Neonatal Med*. 2013;18(6):373–378

30. Msemo G, Massawe A, Mmbando D, et al. Newborn mortality and fresh stillbirth rates in Tanzania after helping babies breathe training. *Pediatrics*. 2013;131(2). Available at: www.pediatrics.org/cgi/content/full/131/2/e353

31. Mduma E, Ersdal H, Svensen E, Kidanto H, Auestad B, Perlman J. Frequent brief on-site simulation training and reduction in 24-h neonatal mortality—an educational intervention study. *Resuscitation*. 2015;93:1–7

32. Patel J, Posencheg M, Ades A. Proficiency and retention of neonatal resuscitation skills by pediatric residents. *Pediatrics*. 2012;130(3):515–521

33. Soar J, Mancini ME, Bhanji F, et al; Education, Implementation, and Teams Chapter Collaborators. Part 12: education, implementation, and teams: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation*. 2010;81(suppl 1):e288–e330

34. Bhanji F, Mancini ME, Sinz E, et al. Part 16: education, implementation, and teams: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010;122(18 suppl 3):S920–S933

35. Wall SN, Lee AC, Niermeyer S, et al. Neonatal resuscitation in low-resource settings: what, who, and how to overcome challenges to scale up? *Int J Gynaecol Obstet*. 2009;107(suppl 1):S47–S64

36. Ersdal HL, Vossius C, Bayo E, et al. A one-day "Helping Babies Breathe" course improves simulated performance but not clinical management of neonates. *Resuscitation*. 2013;84(10):1422–1427

37. Goudar SS, Somannavar MS, Clark R, et al. Stillbirth and newborn mortality in India after Helping Babies Breathe training. *Pediatrics*. 2013;131(2). Available at: www.pediatrics.org/cgi/content/full/131/2/e344

38. Musafili A, Essén B, Baribwira C, Rukundo A, Persson LÅ. Evaluating Helping Babies Breathe: training for healthcare workers at hospitals in Rwanda. *Acta Paediatr*. 2013;102(1):e34–e38

39. Reisman J, Martineau N, Kairuki A, et al. Validation of a novel tool for assessing newborn resuscitation skills among birth attendants trained by the Helping Babies Breathe program. *Int J Gynaecol Obstet*. 2015;131(2):196–200

40. Seto TL, Tabangin ME, Josyula S, Taylor KK, Vasquez JC, Kamath-Rayne BD. Educational outcomes of Helping Babies Breathe training at a community hospital in Honduras. *Perspect Med Educ*. 2015;4(5):225–232

41. Bookman L, Engmann C, Srofenyoh E, et al. Educational impact of a hospital-based neonatal resuscitation program in Ghana. *Resuscitation*. 2010;81(9):1180–1182

42. Jeffery HE, Kocova M, Tozija F, et al. The impact of evidence-based education on a perinatal capacity-building initiative in Macedonia. *Med Educ*. 2004;38(4):435–447

43. Vidal SA, Ronfani L, da Mota Silveira S, et al. Comparison of two training strategies for essential newborn care in Brazil. *Bull World Health Organ*. 2001;79(11):1024–1031

44. Allen CW, Jeffery H. Implementation and evaluation of a neonatal

educational program in rural Nepal. *J Trop Pediatr*. 2006;52(3):218–222

45. Berglund A, Lefevre-Cholay H, Bacci A, Blyumina A, Lindmark G. Successful implementation of evidence-based routines in Ukrainian maternities. *Acta Obstet Gynecol Scand*. 2010;89(2):230–237

46. Bhatia BD, Bhat BV, Dey AK, Mohan PV. Training of final year MBBS students in neonatal resuscitation. *Indian Pediatr*. 1993;30(1):113–115

47. Bhuiyan AB, Mukherjee S, Acharya S, Haider SJ, Begum F. Evaluation of a skilled birth attendant pilot training program in Bangladesh. *Int J Gynaecol Obstet*. 2005;90(1):56–60

48. Carlo WA, Wright LL, Chomba E, et al. Educational impact of the neonatal resuscitation program in low-risk delivery centers in a developing country. *J Pediatr*. 2009;154(4):504–508.e5

49. Couper ID, Thurley JD, Hugo JF. The neonatal resuscitation training project in rural South Africa. *Rural Remote Health*. 2005;5(4):459

50. Disu EA, Ferguson IC, Njokanma OF, et al. National neonatal resuscitation training program in Nigeria (2008-2012): a preliminary report. *Niger J Clin Pract*. 2015;18(1):102–109

51. Dynes M, Buffington ST, Carpenter M, et al. Strengthening maternal and newborn health in rural Ethiopia: early results from frontline health worker community maternal and newborn health training. *Midwifery*. 2013;29(3):251–259

52. Dynes M, Rahman A, Beck D, et al. Home-based life saving skills in Matlab, Bangladesh: a process evaluation of a community-based maternal child health programme. *Midwifery*. 2011;27(1):15–22

53. Enweronu-Laryea C, Engmann C, Osafo A, Bose C. Evaluating the effectiveness of a strategy for teaching neonatal resuscitation in West Africa. *Resuscitation*. 2009;80(11):1308–1311

54. Ergenekon E, Koç E, Atalay Y, Soysal S. Neonatal resuscitation course experience in Turkey. *Resuscitation*. 2000;45(3):225–227

55. Gobezayehu AG, Mohammed H, Dynes MM, et al. Knowledge and skills retention among frontline health workers: community maternal and newborn health training in rural Ethiopia. *J Midwifery Womens Health*. 2014;59(suppl 1):S21–S31

56. Hosokawa S. Impact of neonatal resuscitation training workshop in Mongolia. *International Medical Journal*. 2011;18(2):133–136

57. Kumar R. Effect of training on the resuscitation practices of traditional birth attendants. *Trans R Soc Trop Med Hyg*. 1994;88(2):159–160

58. Lai NM, Ngim CF, Fullerton PD. Teaching medical students neonatal resuscitation: knowledge gained and retained from a brief simulation-based training workshop. *Educ Health (Abingdon)*. 2012;25(2):105–110

59. Makene CL, Plotkin M, Currie S, et al. Improvements in newborn care and newborn resuscitation following a quality improvement program at scale: results from a before and after study in Tanzania. *BMC Pregnancy Childbirth*. 2014;14:381

60. Malhotra S, Zodpey SP. Can traditional birth attendants be trained to reduce neonatal mortality rate? Lessons from Lufwanyama Neonatal Survival Project. *Natl Med J India*. 2011;24(4):220–222

61. McClure EM, Carlo WA, Wright LL, et al. Evaluation of the educational impact of the WHO Essential Newborn Care course in Zambia. *Acta Paediatr*. 2007;96(8):1135–1138

62. Olson KR, Caldwell A, Sihombing M, Guarino AJ, Nelson BD. Community-based newborn resuscitation among frontline providers in a low-resource country. *Int J Gynaecol Obstet*. 2012;119(3):244–247

63. Olson KR, Caldwell A, Sihombing M, Guarino AJ, Nelson BD, Petersen R. Assessing self-efficacy of frontline providers to perform newborn resuscitation in a low-resource setting. *Resuscitation*. 2015;89:58–63

64. Opiyo N, Were F, Govedi F, Fegan G, Wasunna A, English M. Effect of newborn resuscitation training on health worker practices in Pumwani Hospital, Kenya. *PLoS One*. 2008;3(2):e1599

65. Senarath U, Fernando DN, Rodrigo I. Effect of training for care providers on practice of essential newborn care in hospitals in Sri Lanka. *J Obstet Gynecol Neonatal Nurs*. 2007;36(6):531–541

66. Shrestha S, Petrini M, Turale S. Newborn care in Nepal: the effects of an educational intervention on nurses' knowledge and practice. *Int Nurs Rev*. 2013;60(2):205–211

67. Sibley LM, Tesfaye S, Fekadu Desta B, et al. Improving maternal and newborn health care delivery in rural Amhara and Oromiya regions of Ethiopia through the Maternal and Newborn Health in Ethiopia Partnership. *J Midwifery Womens Health*. 2014;59(suppl 1):S6–S20

68. Theron GB. Improved cognitive knowledge of midwives practising in the eastern Cape Province of the Republic of South Africa through the study of a self-education manual. *Midwifery*. 1999;15(2):66–71

69. Trevisanuto D, Doglioni N, Zanardo V, Fadhil T, Jabir MM. Neonatal resuscitation in developing countries. *J Pediatr*. 2010;156(2):343–344, author reply 344

70. Trevisanuto D, Ibrahim SA, Doglioni N, Salvadori S, Ferrarese P, Zanardo V. Neonatal resuscitation courses for pediatric residents: comparison between Khartoum (Sudan) and Padova (Italy). *Paediatr Anaesth*. 2007;17(1):28–31

71. Woods J, Gagliardi L, Nara S, et al. An innovative approach to in-service training of maternal health staff in Cambodian hospitals. *Int J Gynaecol Obstet*. 2015;129(2):178–183

72. Woods DL, Theron GB. The impact of the Perinatal Education Programme on cognitive knowledge in midwives. *S Afr Med J*. 1995;85(3):150–153

73. Xu T, Wang H, Gong L, et al. The impact of an intervention package promoting effective neonatal resuscitation training in rural China. *Resuscitation*. 2014;85(2):253–259

74. Zanardo V, Simbi A, Micaglio M, Cavallin F, Tshilolo L, Trevisanuto D. Laryngeal mask airway for neonatal resuscitation in a developing country: evaluation of an educational intervention. Neonatal LMA: an educational intervention in DRC. *BMC Health Serv Res*. 2010;10:254

75. Jabir MM, Doglioni N, Fadhil T, Zanardo V, Trevisanuto D. Knowledge and practical performance gained by Iraqi residents after participation to a neonatal resuscitation program course. *Acta Paediatr*. 2009;98(8):1265–1268

76. McPherson R. A joint process documentation of the scale-up of the Helping Babies Breathe initiative in Bangladesh and Malawi. Maternal and child health integrated program. Available at: www.mchip.net/node/3133. Accessed on January 23, 2016

77. Msemo G. Implementation of the Helping Babies Breathe (HBB) program in Tanzania: comprehensive final report. Available at: www.helpingbabiesbreathe.org/docs/AAP Final Report docx.pdf. Accessed January 23, 2016

78. Helping Babies Breathe. Helping Babies Breathe global development alliance status report. Available at: www.helpingbabiesbreathe.org/docs/HBB GDA Semi Annual Report_July 21 2012_pdf.pdf. Accessed January 23, 2016

79. Dangaiso E. Zimbabwe: HBB Integration Into Emergency Obstetric and Neonatal Care (EmONC) and Quality Improvement. Presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

80. Kachule E. Malawi: HBB Implementation—Preparatory Mechanisms Toward Initiation of HBB and Processes Toward Scale-up, In-service and Pre-service Training, Monitoring and Evaluation, and Resource Mobilization. Presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

81. Care EN. Scaling Up Helping Babies Breathe in Zambia. Poster presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

82. Helping Babies Breathe in Kenya. Poster presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

83. Update on Newborn Health in Liberia. Poster presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

84. Azayo M. Tanzania: HBB Quality of Care/Services and Quality Improvement Mechanisms. Presented at: *Essential Care for Every Baby Africa Regional Workshop*; May 26–29, 2014; Addis Ababa, Ethiopia

85. Implementation of Helping Babies Breathe (HBB): Republic of South Sudan. Poster presented at: Essential Care for Every Baby Africa Regional Workshop; May 26–29, 2014; Addis Ababa, Ethiopia

86. Zimbabwe: Focusing on the Golden Minute. Poster presented at: Essential Care for Every Baby Africa Regional Workshop; May 26–29, 2014; Addis Ababa, Ethiopia

87. Barry D, Frew AH, Mohammed H, et al. The effect of community maternal and newborn health family meetings on type of birth attendant and completeness of maternal and newborn care received during birth and the early postnatal period in rural Ethiopia. *J Midwifery Womens Health*. 2014;59(suppl 1):S44–S54

Newborn Resuscitation Training in Resource-Limited Settings: A Systematic Literature Review

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