Achieving Country-Wide Scale for Helping Babies Breathe and Helping Babies Survive

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abstract

Helping Babies Breathe (HBB) was piloted in 2009 as a program targeted to reduce neonatal mortality (NM). The program has morphed into a suite of programs termed Helping Babies Survive that includes Essential Care for Every Baby. Since 2010, the HBB and Helping Babies Survive training programs have been taught to >850 000 providers in 80 countries. Initial HBB training is associated with a significant improvement in knowledge and skills. However, at refresher training, there is a knowledge-skill gap evident, with a falloff in skills. Accumulating evidence supports the role for frequent refresher resuscitation training in facilitating skills retention. Beyond skill acquisition, HBB has been associated with a significant reduction in early NM (<24 hours) and fresh stillbirth rates. To evaluate the large-scale impact of the growth of skilled birth attendants, we analyzed NM rates in sub-Saharan Africa (n = 11) and Nepal (as areas of growing HBB implementation). All have revealed a consistent reduction in NM at 28 days between 2009 and 2018; a mean reduction of 5.34%. The number of skilled birth attendants, an indirect measure of HBB sustained rollout, reveals significant correlation with NM, fresh stillbirth, and perinatal mortality rates, highlighting HBB's success and the need for continued efforts to train frontline providers. A novel live newborn resuscitation trainer as well as a novel app (HBB Prompt) have been developed, increasing knowledge and skills while providing simulation-based repeated practice. Ongoing challenges in sustaining resources (financial and other) for newborn programming emphasize the need for innovative implementation strategies and training tools.

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DOI: https://doi.org/10.1542/peds.2020-016915K

Accepted for publication Aug 4, 2020

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

Most recent global estimates are that 2.5 million newborns die annually, which contributes ~47% of the <5 child mortality.[1,2] Common causes of death are birth asphyxia (BA), defined as a 5-minute Apgar score <7 and lack of spontaneous respirations after birth (30%–35%), prematurity and/or low birth weight (LBW) (25%–30%), presumed infection (~30%), and congenital anomalies (8%–15%).[3] In addition, an estimated 1.3 million infants are reported to be "fresh stillborn," suggestive of an intrapartum demise, shortly before delivery.[4,5] The first day and especially first hour are critical to newborn survival, with the highest risk of intrapartum-related neonatal deaths (60%–70%) occurring within 24 hours of birth.[1,2] In Tanzania in 2009, the neonatal mortality rate (NMR) was ~26 of 1000 live births, translating into 52 000 deaths annually, and ~14 000 attributed to BA. Importantly, although there were several programs aimed at newborn resuscitation and care (see below), it was also clear from a "Situation Analysis of Newborn Health in Tanzania" report published in March 2009 that the incidence of BA-related mortality had remained unchanged over the previous 15 years.[6] Factors contributing to this problem included a lack of skilled providers present at birth (~50%), coupled with a paucity of essential basic resuscitation equipment. These deficiencies were universal within the health care system.[6] Using Tanzania as an example, in this review, we will focus on the factors necessary to achieve a consistent reduction in neonatal morality (NM) over time, with the following aims: (1) describe the system obstacles existing before initiating Helping Babies Breathe (HBB) in Tanzania; (2) provide a brief review of perinatal physiology in relation to BA and the relevance to HBB training and implementation; (3) describe how the introduction of HBB has resulted in a consistent reduction of early neonatal mortality (ENM) (<24 hours) and fresh stillbirth (FSB) rates; (4) review the most effective methodology for translating the HBB curriculum (knowledge) into acquisition of resuscitation skills and, specifically, mastery of bag mask ventilation (BMV); and (5) review the impact of HBB on NMR and FSB rates over the past decade in sub-Saharan Africa and Nepal, as examples of the programs
impact.

INITIAL OBSTACLES TO ACHIEVING A REDUCTION IN PERINATAL MORTALITY IN TANZANIA

System Issues

These included vertical and horizontal obstacles. The principal vertical obstacle was a disconnect between the numerous layers of bureaucracy from the permanent secretary or minister of health extending to a chief medical officer of a hospital and the needs of the providers in the delivery room (DR) (Fig 1). A critical transformation occurred in Tanzania in 2009, when the Ministry of Health and Social Welfare pledged to elevate BA as a health care priority and committed to train all birth attendants in the health care workforce in HBB and provide health care providers at all levels with required resuscitation equipment: all critical components for transforming a health care system and enhancing perinatal newborn care. Horizontal obstacles included insufficiently trained providers, specifically midwives, to meet clinical needs in the DR (Fig 2). The midwife focused primarily on the mother and not on the newborn immediately after delivery, even when depressed. This reflected a lack of knowledge related to the basic steps necessary to help an infant breathe. Finally, there was often a lack of a functional and clean bag mask resuscitator. It was clear that to reduce ENM empowering the midwife was a critical first step.

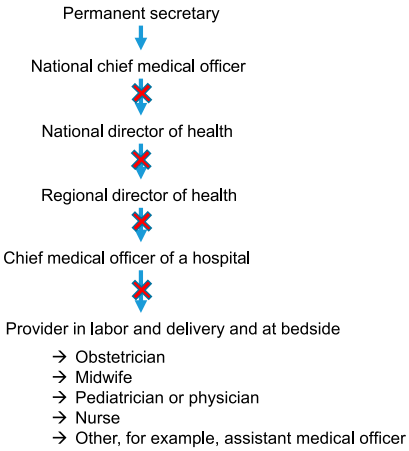

FIGURE 1
Vertical obstacles to successful implementation of HBB in Tanzania (bottlenecks in the system). Note that blocks at paths in the system will limit the ability to effect change at the functional provider level.

PHYSIOLOGIC CHANGES AT BIRTH: RELEVANCE TO HBB AND REDUCTION IN ENM (<24 HOURS) AND FSB RATES

The majority of infants adapt seamlessly from the in utero to the extra utero environment. Thus, observations from Tanzania indicate that ~84% of infants will initiate spontaneous respirations within 30 seconds after birth, and an additional 10% will start breathing promptly in response to basic stabilization steps, including drying and stimulation.[7] Of the remaining infants, most will start breathing in response to brief BMV, if initiated in a timely and effective manner. These clinical observations are consistent with experimental data in the nonbreathing asphyxiated animal describing 2 types of apnea, namely, primary or secondary apnea, which are related to the duration of an asphyxial process.[8] Primary apnea relates to a short duration of

During Labor	Immediately After Delivery
Insufficient providers to meet clinical needs	Focus on the mother and not the infant
Midwives with limited understanding of the newborn's needs	Delay in initiating basic steps of resuscitation
	Frequent lack of basic equipment (resuscitator)
	Delay in transfer of a distressed infant to a newborn area

FIGURE 2
Horizontal obstacles to successful resuscitation of a depressed infant.

asphyxia, as reflected by a normal systemic pH, with spontaneous respirations initiated in most cases with immediate basic interventions, namely, stimulation. Secondary apnea relates to a more prolonged process, with a marked decrease in heart rate, usually <60 beats per minute as well as a systemic pH <7.00. In this situation, more intensive resuscitative efforts, including intubation and ventilation and/or chest compressions and medications, may be required. The duration of the placental blood flow changes is highly relevant to HBB, in which the emphasis is on the basic steps of drying, stimulation, and, if indicated, BMV within the Golden Minute. The assumption is that most nonbreathing newborns are in primary apnea (with a short duration of reduced placental blood flow) and will respond to the immediate basic steps, as outlined above, with the onset of breathing. This is the principal hypothesis accounting for the consistent reduction in ENM and FSB rates noted in most reported HBB implementation studies.

EARLY IMPLEMENTATION OF HBB IN TANZANIA

In 2009, HBB, an evidence-based educational program, was developed to teach neonatal resuscitation (NR) techniques in low-resource settings.[9,10] More recently, Helping Babies Survive (HBS), a suite of evidence-based, hands-on educational programs, which includes HBB, Essential Care for Small Babies, and Improving Care of Mothers and Babies, has been designed to improve newborn care and reduce NM.[11] In this review, we will largely focus on HBB.

The first implementation study of HBB was performed in Tanzania by using a pre-implementation (2 months; n = 8124 births) and post-implementation (18 months; n = 78 500 births) strategy from September 2009 through March 2012. The findings in this landmark study included a significant 47% reduction in ENM (<24 hours) from 13.4 to 7.1 per 1000 live born (LB) deliveries ($P < .0001$) and a significant 24% reduction in FSB rates from 19.0 to 14.4 per 1000 births pre- versus postimplementation ($P = .001$).[12] The percentage of deliveries attended by providers trained in HBB increased from 10 ± 5 to 80 ± 13% ($P = .0001$).

Providers followed the HBB algorithm in that stimulation increased from 47% to 88% ($P \leq .0001$) and suctioning from 15% to 22% ($P \leq .0001$) pre- compared to postimplementation. By contrast, the use of BMV decreased from 8.2% to 5.2% ($P < .0001$) pre- compared to postimplementation, suggesting that infants responded to stimulation alone.[12]

On the basis of the successful pilot study, the Children's Investment Fund Foundation from the United Kingdom funded a rollout implementation of the HBB program, which was initiated September 1, 2012, and completed in 2015. During this time, 15 000 providers were trained in HBB. Findings from this rollout have been the subject of several reports.[13–15] Since this initial pilot study, there have been at least 5 studies that have revealed a reduction in ENM (<24 hours), with risk reduction ranging from 0.32 to 0.65.[12,16–19] (Table 1) Longer term reduction in NMR after HBB training does not reveal a similar effect. Thus, 1 study failed to show

TABLE 1 Mortality Rates per 1000 Deliveries Pre- and Post-HBB at <24 Hours, 7 Days, and 28 Days

Author	Mortality Pre-HBB	Mortality Post-HBB	Risk Ratio	95% Confidence Interval	P
24-h mortality					
Msemo et al[12]	13.4	7.1	0.53	0.43–0.65	<.0001
Mduma et al[16,a]	11.1	7.2	0.65	0.41–0.98	.04
KC et al[17,b]	5.2	1.9	0.37	0.23–0.57	.001
Arabi et al[18,c]	13.5	4.3	0.32	—	.001
Gomez et al[19,a]	7.6	3.4	0.49	0.36–0.65	<.0001
7-d mortality					
Wrammert et al[20]	9.8	7.7	0.52	0.19–1.42	.08
28-d mortality					
Wrammert et al[20]	12.8	11.7	0.91	0.80–1.47	.17
Goudar et al[21]	18.0	19.0	0.95	0.70–1.27	.73

—, not applicable.
[a] LDHF training.
[b] Used QI.
[c] Peer-to-peer training (see later). In a study not included in the table, researchers used a rapid scale up training model of facility birth attendants in 3 diverse sites in India and Kenya with inconsistent results. Specifically, HBB training was not associated with consistent improvements in mortality among all neonates ≥1500 g; however, differential improvements in <2500 g survival was noted at 1 site.[24]

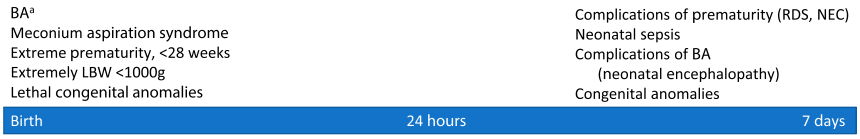

FIGURE 3
Primary causes of death in relation to postnatal age. NEC, necrotizing enterocolitis; RDS, respiratory distress syndrome. [a] Defined as a 5-minute Apgar score of <7 and the need of BMV at birth.

any effect of HBB NM rates at 7 days,[20] and 2 studies revealed no effect at 28 days.[20,21] These longer negative findings are akin to that of Carlo et al,[22] who demonstrated no effect on NM at 7 days with a more comprehensive essential newborn care program. The absence of findings at 28 days also should not be unanticipated. Although the significant reduction in ENM can be attributed to HBB, other causes of mortality, including prematurity and its complications, LBW, neonatal sepsis or complications from BA, and congenital anomalies, predominate in the first 28 days of life.[23] (Fig 3). The programs contained in HBS (Essential Care for Every Baby and Essential Care for Small Babies) may have an important impact in this regard.

IMPACT OF HBB ON FSB

There has been a consistent decrease in FSB rates associated with HBB, with 5 of 6 studies revealing a significant reduction (the risk ratio ranged from 0.31 to 0.76; Table 2).[12,16–19,21] These findings parallel experimental observations, suggesting that most nonbreathing infants are in primary apnea and will initiate spontaneous respirations in response to drying and stimulation, only if implemented in a timely manner (Fig 4).[8,12] If left alone, the newly born will remain without obvious signs of life and will likely be misidentified as an FSB, as has been suggested in previous reports.[25,26] Although counterintuitive, this is the most plausible explanation for the significant reduction in both FSB and ENM rates (Fig 4).

THE USE OF STIMULATION, SUCTIONING, AND BMV AFTER HBB TRAINING

Three studies revealed a reduction in the use of stimulation and suctioning and increase in the use of BMV after HBB training,[17,18,21] whereas Msemo et al[12] showed the opposite effect. The HBB algorithm calls for stimulation, brief clearing of the airway, and, if no response, initiation of BMV within the Golden Minute. Irrespective of steps taken, early intervention appears to be the critical factor in initiating spontaneous respirations and reducing ENM. The impact of HBB and HBS on NM and FSB has been the focus of 4 meta-analyses. The findings have been consistent with those discussed in this review.[27–30]

TABLE 2 Intrapartum-Related Stillbirth Rates Per 1000 Births Pre- and Post-HBB

Author	Pre-HBB	Post-HBB	Risk Ratio	95% Confidence Interval	*P*
Gouda et al[21]	17.2	9.2	0.53	0.37–0.78	.001
Msemo et al[12]	19.0	14.4	0.76	0.64–0.90	.001
Mduma et al[16]	16.0	14.5	0.91	0.65–1.24	.91
KC et al[17]	9.0	3.2	0.36	0.64–0.90	.001
Arabi et al[18]	10.5	3.3	0.31	0.13–0.68	.004
Gomez et al[19,a]	10.3	5.2	0.30	0.21–0.43	<.0001

[a] Baseline compared to 7 to 12 mo postintervention.

HBB IMPLEMENTATION IN THE OLIVER REGINALD TAMBO DISTRICT OF SOUTH AFRICA AND NEPAL

Oliver Reginald Tambo District of South Africa

The NM rate (<7 days) in South Africa (SA) was reported to be 10.2 per 1000 LB for the years 2011 and 2012.[31,32] Potential contributing factors to this high early neonatal mortality rate (ENMR) included inadequate neonatal care, including a lack of neonatal beds and suboptimal NR.[32] The Eastern Cape province was identified as a region with the highest ENMR at 14.9 per 1000 LB, with the Oliver Reginald (OR) Tambo district within the province having the highest ENMR in the country at 20.8 per 1000 LB. In efforts to reduce the NM rate in the OR Tambo district, it was elected to focus on training in NR, which had been associated with a 30% reduction in term intrapartum-related deaths.[33] HBB was identified as the program to be used for training providers in NR and was implemented in 2012, by using the "train the trainer" concept to disseminate the training of health care workers in facilities. Five specific hospitals were targeted for HBB training. The cluster selected represented district, regional, and tertiary hospitals, with a referral pattern from the lower hospitals to one tertiary hospital, as indicated. This facilitated the opportunity to follow-up on the outcome of all in this subset of infants in the district. A significant reduction in FSB rates was noted, from 16.6 per 1000

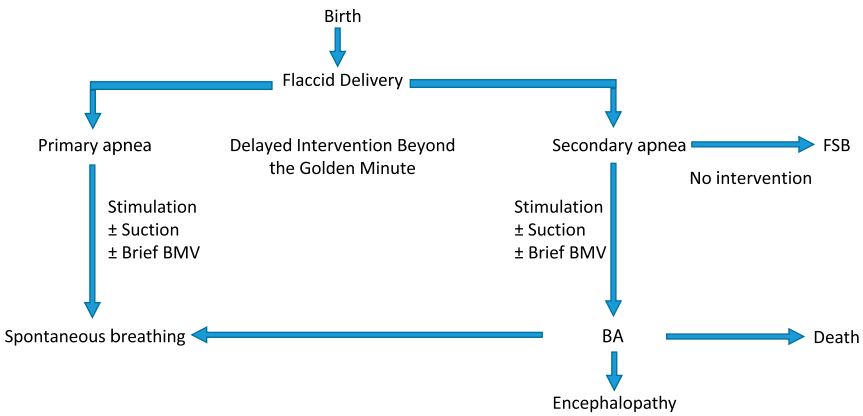

FIGURE 4
Schema depicting potential outcomes in a nonbreathing infant at birth. Infants in primary apnea will generally respond to drying and stimulation only. With delayed or no intervention, progression to secondary apnea to "apparent FSB" may follow. Infants in secondary apnea generally start breathing with drying, stimulation, and BMV. Adapted from 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):e358.

births to 12.8 per 1000 (24%) births, consistent with findings from other implementation studies mentioned previously (Table 2).[12,17–19,21] Although this reduction was associated with implementation of HBB training, other interventions were introduced concurrently, such as the establishment of district clinical specialist teams.

Additional funding was sourced in 2015 from Ronald McDonald House Charities through the American Academy of Pediatrics for the period from 2016 to 2020 to continue HBB training focusing on in-house training and mentoring and to support emergency medical services through recruiting paramedics and equipping ambulances for the OR Tambo district. A further reduction in ENMR from 24.5 to 20.4 per 1000 LB (21%), when comparing 2015 to 2016, was observed. However, no further reduction through 2019 has been noted (Fig 5). The FSB rate has continued to decline over the years and, in 2019, was 7.0 per 1000 births. In summary, HBB implementation has resulted in a 50% reduction in NM (7 d) since 2012 through 2019 and 60% reduction in FSB rates. However, the influence of HBB has plateaued in recent years, suggesting that further reduction in NMR requires multiple interventions, as contained in the HBS program.

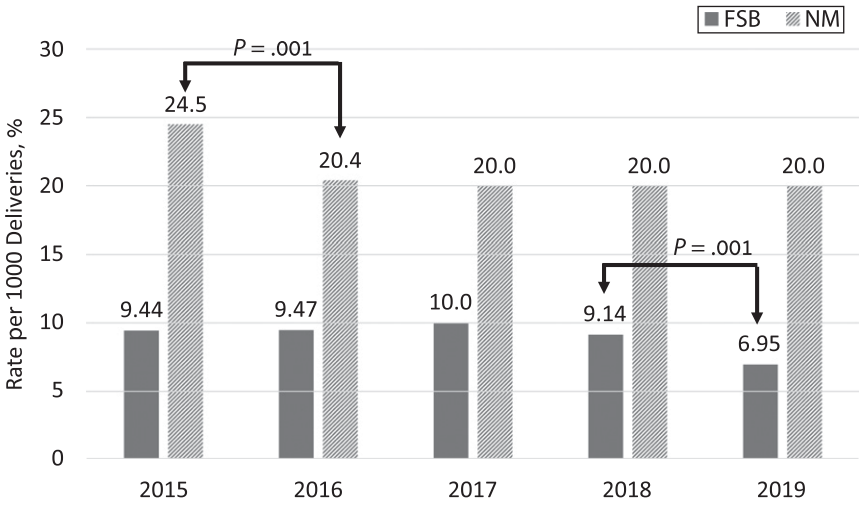

FIGURE 5
NM and FSB rates (per 1000 deliveries) for the OR Tambo region in SA 2015–2019. NM revealed a significant difference when comparing the years 2015 and 2016 but no difference when comparing 2016–2019. Conversely, FSB rates revealed no difference when comparing 2015 to 2016 but a significant decrease for the years 2018–2019.

Quality Improvement in Nepal

A second country example is Nepal, where the use of quality improvement (QI) has been shown to be an effective strategy in reducing NM. The first HBB course in Nepal in early 2012, sponsored by Latter-day Saint Charities, introduced the curriculum to medical and organizational leaders as well as the Ministry of Health. A clinical trial initiated in 2012 in the country's largest maternity hospital demonstrated HBB efficacy: the FSB rate decreased from 9.2 to 3.2 per 1000 births (46%), and ENM <24 hours was reduced from 5.2 to 1.9 per 1000 LB (51%).[17] A key finding was video-documented improvement in the timing of assisted ventilation. Before intervention, no apneic infants received BMV within 1 minute of birth, compared with 84% of infants after training.[17] The QI methodology was used in this pilot program to establish a pattern for continued HBB dissemination in Nepal. Key elements of this approach included initial HBB training of all staff and students, followed by daily BMV skill checks, weekly review and debriefing meetings, self-evaluation checklists, daily hospital leadership briefings, progress board communication in all units, and periodic refresher training.

Secondary analysis revealed the implementation strategies associated with the highest skill retention were daily BMV skill checks and self-evaluation checklists after every delivery.[17]

The continued rollout of HBB training across Nepal has built on this foundation, with a similar QI strategy employed to sustain newly acquired skills. Initially, a remote communication program was employed to provide supportive supervision.[17] More recently, full-time mentors have been used, with the responsibility of supporting hospitals in a geographic area. Modeled after the Saving 100 000 Lives program in India, this approach has been associated with further reductions in mortality in high-risk areas.[34,35] The Nepal Perinatal Quality Improvement Package initiative was focused on using facility-based facilitators to sustain QI activities over time and was associated with a 21% reduction in FSB and ENM (P = .002) and an increase in use of BMV from 2.5% to 5.4% (P = .0001; for infants with an Apgar score <7), when comparing intervention to pre-intervention.[36]

Two major challenges have decreased the long-term effectiveness of HBB training despite the QI initiatives. First, facilities enrolled in the major trials gradually lose their resuscitation effectiveness after trial-related personnel support is withdrawn. Second, widespread routine staff rotations between units disrupts acquired experience (R. Clark, MD, personal communication, 2019).

HBB TRAINING AND MAINTAINING SKILLS IS CRITICAL TO ACHIEVE CONTINUED REDUCTION IN NM

HBB has many features that facilitate learning and acquisition of the critical skill of BMV, the latter through the use of the simulator NeoNatalie. However, administrating effective BMV requires practice to avoid mechanical issues, such as obstructing the upper airway by malposition of the neck or mask leak, both of which will limit the ability to establish effective ventilation and cardio-respiratory recovery. Many studies demonstrate that initial HBB training is associated with a significant improvement in knowledge and skills (representative studies are shown in Table 3). However, at refresher training as early as 3 months after the initial course, there is a knowledge-skill gap evident, with retention of knowledge but a falloff in skills.[37,38] Mduma et al,[16] in an important study, assessed the impact of frequent, brief (3–5 minutes weekly) on-site HBB simulation training in the labor ward, coupled with 40-minute monthly retraining sessions. The findings included a significant increase in the number of stimulated and suctioned infants, coupled with a significant decrease in the number of infants receiving BMV after training. Importantly, ENM (<24 hours) decreased from 11.1 per 1000 to 7.2 per 1000 (P = .040).[17] Using a QI strategy, KC et al[17] showed that daily BMV skill checks were associated with the highest skill retention among providers and a significant reduction in ENM and FSB rates. In total, 3 studies used a weekly model of simulated training (referred to as low-dose high-frequency [LDHF] training) and all demonstrated a significant reduction in mortality, and 2 demonstrated a reduction in FSB rates as well (see Table 3 for detailed descriptions of these studies).[16,18,19] A study worthy of further mention is that by Arabi et al,[18] who trained village midwives in HBB with regular peer-to-peer skills practiced in rural medical centers in Sudan and showed a significant reduction in FSB rates and ENM. Pertinent findings include a 10-fold increase in drying and fivefold decrease in suctioning. Importantly, mouth to mouth ventilation was eliminated post-training. FSB rates decreased from 10.5 to 3.3 per 1000 births (P = .0003), and ENM decreased from 13.5 to 4.3 per 1000 live births (P = .0001). This is proof of concept that basic interventions, as outlined in the HBB program, can be effective in a rural setting, particularly when coupled with ongoing training, namely, peer-to-peer training. Innovative tools targeting human resource barriers to LDHF training, in addition to data collection, are being explored to address gaps in implementation. Representative examples will be discussed in the following section.

THE WAY FORWARD IN TRAINING

Supporting Implementation: Development of NeoNatalie Live

To address gaps in implementation at Haydom Lutheran Hospital, in central Tanzania, data from live newborn resuscitations have been consecutively reported and used to guide and motivate providers for ongoing frequent trainings. A significant reduction in perinatal mortality has been recorded over a 5-year period.[40] After adjusting for risk factors among the delivering women over time, the extra number of newborns saved in this hospital (with 3000–4000 deliveries per year) was 250 from 2011 to 2017.[41] However, resuscitating a nonbreathing newborn was perceived as stressful, and frequent ventilation training and "being prepared" were reported as critical factors to improve clinical practice.[42] Therefore, the observational data from Haydom (including 50 000 deliveries and 2500 newborn resuscitations) have been used to develop a NeoNatalie Live Newborn Resuscitation Trainer. This is a more advanced simulator than the original NeoNatalie used in

TABLE 3 HBB Training by Using Different Strategies and Impact on ENM and FSB Rates

	Summary of Selected Studies
Bang et al[37] (India and Kenya)	Birth attendants in HBB (n = 2227; 35% physicians and 65% nurses). At initial training, nurses' knowledge increased from 67% to 98% ($P < .0001$), and bag mask skills increased from 5.3% to 95% ($P < .0001$). At refresher training 6 mo later, BA revealed no decay in knowledge ($P = .43$). However, for OSCE, there was significant decay for nurses, comparing initial post- to pre-refresher, that is, 99% vs 84% ($P < .0001$), which increased to 99% post-refresher training. The knowledge-skill gap evident at initial training was persistent in 18% of providers at the refresher training despite ongoing mentoring and supervision. Conclusion: Characteristics associated with deterioration of resuscitation skills were birth attendants from tertiary care facilities, no previous resuscitation training, and the timing of training (initial versus catch-up training).
Musafili et al[38] (Rwanda)	Trainees (n = 118) underwent HBB training. The correct answer on a written test increased significantly pre- versus post-training. The post-course skill evaluation was 89% posttraining and decreased to 83% 3 mo later. The percentage of passing grades decreased from 64% to 43% ($P = .01$). Conclusion: A single refresher training course had no impact on skills.
Tabangin et al[39] (Ecuador)	Clinic (n = 12) and hospital providers (n = 34) were trained in HBB (1 d) and evaluated with OSCEs. Clinic providers practiced monthly versus hospital providers randomly assigned to monthly practices for 6 wk vs consecutive practices at 3, 5, and 6 wk, regardless of resuscitation skills after initial training. Conclusion: Those with monthly testing had a 2.9 greater odds of passing versus those who practiced less frequently.
KC et al[17] (Nepal)	A QI cycle was implemented to improve adherence to the HBB protocol. Key elements of this approach included daily BMV skill checks, weekly review and debriefing meetings, self-evaluation checklists, daily hospital leadership briefings, progress board communication in all units, and periodic refresher training. At the end of the trial period, the strategies associated with the highest skill retention were daily BMV skill checks and use of self-evaluation checklists after every delivery. Conclusion: QI cycle decreased the FSB rate from 9.2 to 3.2 per 1000 births and decreased ENM from 5.2 to 1.9 per 1000 live births.
Drake et al[14] (Tanzania)	Providers (n = 8391) underwent HBB training and received verbal instruction versus a second group who received on-the-job training. Immediately posttraining average skill scores were similar between groups, that is, 80.5 vs 81.33% ($P = .07$), respectively. Both groups experienced significant decreases in resuscitation skills over time. The modified training was associated with higher skills scores versus the initial training approach, that is, 77.6 vs 70.7% ($P = .0001$), respectively. Conclusion: On-the-job training improves resuscitation skills.
Gomez et al[19] (Ghana)	This was a cluster randomized trial assessing the impact of LDHF training (weekly practice sessions coupled with phone-based mentoring) on intrapartum still births (FSB) and ENM (<24 h). RR was assessed at months 1–6 and 7–12 after implementation. The RR of ENM was 0.41 for months 1–6 and 0.30 for months 7–12. For FSB, the RR was 0.64 and 0.48 ($P < .0001$) at comparable time points. Conclusion: LDHF training was associated with a significant reduction in ENM and FSB rates.
Mduma et al[16] (Tanzania)	In this study, researchers evaluated the impact of brief frequent (3–5 min weekly) on-site HBB simulation training. Comparing pre- to post-implementation periods, stimulated neonates increased from 14.5% to 16.3% ($P = .01$) suctioning increased from 13% to 15.8% ($P \leq .0005$), bag mask ventilation decreased from 7.3% to 5.9% ($P = .005$), and 24-h mortality decreased from 11.1% to 7.2% ($P = .04$). Conclusion: Brief weekly simulation was associated with a reduction in ENM.
Aribi et al[18] (Sudan)	The study was designed to determine the impact of weekly peer-to-peer skills training on village midwives' resuscitation practices and outcomes. Comparing a pre- (6 mo) to a post-implementation of HBB training, drying of the newborn increased, ENM decreased from 13.5 to 4.3 per 1000 live births ($P = .001$), and FSB rates decreased from 10.5 to 3.3 per 1000 births ($P = .003$). Conclusion: Weekly peer-to-peer training was associated with reduction in ENM and FSB in rural Africa.

OSCE, objective structured clinical evaluation; RR, relative risk.

HBB. NeoNatalie Live must connect to a tablet that operates the simulator (which have different features and scenarios) and provides feedback on key elements found to be difficult during real newborn resuscitations. This type of objective feedback minimizes the need for a skilled facilitator (who is often unavailable or already overburdened) to be present during all trainings. Each training session can take <5 minutes, allowing greater flexibility to busy health care providers. The NeoNatalie Live

system automatically creates training logs, enabling hospital management to follow the number of providers trained, training sessions, progress made, and areas of improvement to focus on. Providers can follow their own learning curve.

Complementing the NeoNatalie Live, Laerdal Global Health's Safer Births initiative and program has developed additional equipment to assist in monitoring and resuscitation at birth, including Moyo (fetal heart rate monitor),[43–47] NeoBeat (newborn heart rate monitor),[48–50] and the upright resuscitator (with or without a novel positive end-expiratory pressure valve).[51–53] Both Moyo and NeoBeat record and store signal data (ie, continuous fetal heart rate Doppler signals and newborn heart rate electrocardiographic signals) that can be automatically uploaded to a server for automatic processing and descriptive analyses for rapid feedback. These signal data, in combination with process and management and patient outcome data, can support local facility continuous quality initiatives and guide local training needs, which are essential for sustainability and scale up.

TABLE 4 NMR per 1000 Live Births (2009), NMR per 1000 Live Births (2018), Percentage Decline in NM per 5 Years (2009–2013), Percentage Decline in NM per 5 Years (2014–2018), and Difference in Percentage Reduction Between 2 Epochs

Country	NMR per 1000 Deliveries in 2009	NMR per 1000 Deliveries in 2018	Difference in NMR in 2009–2018	% Yearly Decline in NM per 5 y in 2009–2013	% Yearly Decline in NM per 5 y in 2014–2018	Difference in % Between 2 Epochs
Tanzania	25.7	21.3	4.3	2.14	2.03	−0.11
Ethiopia	38.1	28.1	10	3.42	3.16	−0.26
Malawi	29.7	22.4	7.3	2.65	3.04	+0.35
Rwanda	24.5	15.9	8.6	5.51	4.49	−1.02
Kenya	23.4	19.6	3.8	2.06	1.92	−0.14
Zambia	26.2	23.5	2.7	0.92	1.46	+0.54
Ghana	30.9	23.9	7	2.67	2.84	+0.17
Uganda	25.6	19.9	5.7	2.40	3.01	+0.61
Sudan	32.9	28.6	4.1	1.04	1.84	+0.80
Nigeria	38.8	36	2.2	1.04	0.7	−0.34
SA	13.8	10.7	3.1	3.12	2.58	−0.42
Nepal	28.7	19.9	9.3	3.92	3.96	+0.04

All countries showed a decrease in NMR from 2009 to 2018. The lowest NMR in 2018 was in SA, followed by Rwanda, Nepal, Kenya, and Uganda, which were all <20 per 1000 live births. The largest decline was noted in Ethiopia 10 per 1000 live births, with the smallest decline noted in Nigeria and Zambia, both with <3 per 1000 live births. Comparing the yearly decline in percentage between 2009 and 2013 to 2014–2018, when HBB and other programs began to disseminate, namely, kangaroo mother care, increase use of antenatal steroids, closer attention to temperature regulation, and a greater percentage reduction was noted in 6 countries (Malawi, Zambia, Ghana, Uganda, Sudan, and Nepal), with a slower yearly percentage reduction in 6 countries (Tanzania, Ethiopia, Rwanda, Kenya, Nigeria, and SA). Data were derived from ref 65.

Supporting Implementation: Newborn App HBB Prompt

Mobile health solutions (using tablets or smartphones to support health care providers) have been increasingly used over the last decade. Within the sphere of neonatal care, in high-income countries, these applications have been trialed in a variety of settings, including neonatal resuscitation program training[54] and electronic fetal monitoring.[55] In low- and middle-income countries, in the largest systematic review to date, researchers included 27 studies and found that mobile health solutions may be effective.[56–59] The Safe Delivery app developed in 2012 can be used for education and clinical practice for obstetrical and neonatal emergencies. Numerous mobile applications used in low- and middle-income countries for newborn care have revealed short-term increases in knowledge and skills.[60–62] HBB Prompt was recently developed to address refresher training and knowledge and skills retention by using a low-cost, simulation-based method of LDHF practice.[63] The app includes 4 parts: training mode, simulation mode, knowledge check, and a scoreboard and dashboard. Training mode includes a series of

TABLE 5 NMR, Proportion of <5 Child Deaths That Are Newborns (%), Still Rates (Deaths per 1000 Births), SBAs (%), and Preterm Birth Rate (<37 wk) (2018)

Country	NMR (Deaths per 1000 Live Births)	Stillbirth Rate (Deaths per 1000 Births)	Perinatal Mortality	SBAs, %	Proportion of <5 Child Deaths That Are Newborn, %	Preterm Birth Rate[a] (<37 wk)
SA	10.7	17.4	28.1	97	32	12
Rwanda	15.9	17.3	33.2	91	46	12
Kenya	19.6	22.5	42.1	62	48	9
Uganda	19.9	21	40.9	74	44	7
Tanzania	21.3	22.4	43.7	64	41	17
Malawi	22.4	21.8	44.2	90	46	11
Zambia	23.5	20.9	44.4	63	42	12
Ghana	23.9	22.7	46.6	71	51	12
Ethiopia	28.1	29.7	58.8	28	52	12
Sudan	28.6	24.4	53	78	48	13
Nigeria	36	42.9	78.9	43	31	11
Nepal	19.9	18.4	38.3	58	62	5

Data were derived from ref 66. Note there is a significant correlation between NMR and SBA (R^2 0.45 [P = .01]). FSB and SBA (R^2 0.44 [P = .01]), and PMR (R^2 0.49 [P = .01]). Note the countries with the highest percentage of SBA (SA and Rwanda) had the lowest NMR, stillbirth rate, and PMR. Conversely, the 2 countries with the lowest percentage of SBA had the highest rates. Also, note that Tanzania has the highest preterm birth rate.

[a] Births <37 wk per 1000 live births (death per 10 000 live births).

TABLE 6 Proposed Processes for the National and Sustained Rollout of HBB and HBS

Ministry of Health must make newborn care including that of premature infants a national health care priority
A commitment to train all birth attendants in the current health workforce in HBB, HBS, and integration of HBB and HBS with other relevant programs
Empower the midwife in countries where they are the primary provider at deliveries
Identify and support local leaders and champions of high quality DR care
Establish a system for training of providers (cascade, LDHF practice [tailored to needs and self-reflective])
Provide appropriately adapted learning materials, equipment, and supplies simultaneously with training
Strengthen policies and regulations, supporting high quality care (training, commodities, facilities, and personnel)
Build a reliable supply chain, procurement, maintenance, and reprocessing system to provide health care providers at all levels with required resuscitation equipment (resuscitator, suction, etc)
Accountability to collect and report defined core data on an ongoing basis to and from all levels of the health system
Use data to guide improvement and budgeting at a national and local level
Commitment to sustainability
Encourage community participation and mobilization (awareness and advocacy and training of families in basic care)
Work with stakeholders who are ready for implementation (national and facility level)

Adapted, in part, from Ersdal HL, Singhal N, Msemo G, et al; participants in the Utstein consensus process: How to implement successful Helping Babies Survive and Helping Mothers Survive programs. Successful implementation of Helping Babies Survive and Helping Mothers Survive programs-an Utstein formula for newborn and maternal survival. *PLoS One*. 2017;12(6):6; and Perlman JM, Msemo G, Ersdal H, Ringia P. Designing and implementing the Helping Babies Breathe program in Tanzania. *J Pediatr Intensive Care*. 2017;6(1):5.

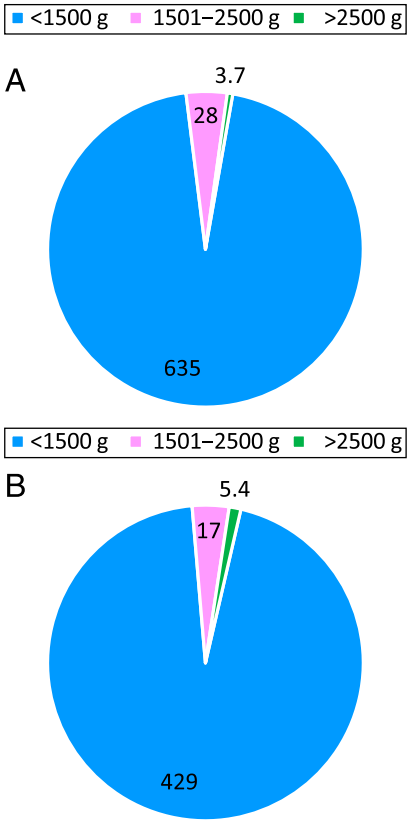

FIGURE 6
Mortality per 1000 live births. NM as a function of BW in (A) a regional hospital in Tanzania and (B) district hospital in the OR Tambo region of SA. Note the increasing mortality as a function of decreasing BW in both hospital settings.

videos that demonstrate each step of the HBB algorithm. A NeoNatalie simulator is used to go through the case-based scenarios (core of the app) and allows for individual or paired practice. When working in pairs, the second person rates performance with an in-app checklist and provides feedback. The knowledge check section provides participants with HBB multiple choice questions and feedback. Finally, the scoreboard and dashboard function allows participants to see their scores for knowledge and skills over time and compare them with other users. All content, including videos, are downloaded to smartphones or tablets and if and/or when an Internet connection is available, user data are uploaded to a central server. Another advantage is easy scalability because it would likely only require language translation and minor changes to the interface for different contexts. However, one significant limitation of using this app is the high initial cost to build.[64] HBB Prompt is being trialed in 2 hospitals in Southwestern Uganda, 1 acting as the intervention site, using the app, and the other as the control site, using standard HBB teaching. Data collection will end in 2020, and educational outcomes will be measured.[63]

ACCOMPLISHING COUNTRY-WIDE IMPLEMENTATION OF HBB: DOES IT IMPACT NM

Sub-Saharan Africa has made significant progress, with all countries reviewed (n = 11) showing a consistent reduction in NM between 2009 and 2018, with a mean reduction of 5.34% (a range of 2.2%–10%; Table 4).[65] When comparing the NMR decline between 2009 and 2013 (pre-HBB) to 2014–2018 (post-HBB), Tanzania showed a slightly slower yearly decline, whereas Nepal had a slightly greater decline in the second epoch, in comparison to the first epoch. Overall, 6 countries showed a greater yearly percentage decline in the second in comparison to the first epoch, whereas 6 countries showed a slower yearly percentage decline (Table 4). The number of skilled birth attendants (SBAs), an indirect measure of successful HBB rollout in 2018, is shown in Table 5.[66] There is a significant correlation between NMR and SBA (R^2: 0.45; P = .01), FSB and SBA (R^2: 0.44; P = .01), and perinatal mortality rate (PMR) (R^2: 0.49; P = .01). There are limitations to the above data, including factors such as the implementation status of HBB in each of the abovementioned countries or the potential for variable health reporting systems.

Achieving widespread dissemination of HBB is complex and influenced by many factors. In Table 6, some key processes essential to facilitating

Table 7 Interventions to Reduce Neonatal Mortality (NM)

Strategy	Important Components
HBB[68–70]	Focused on reducing BA related mortality and FSB rates. Actions: Interventions in Golden Minute, clean working resuscitator.
HBS[30]	Focused on all major causes of newborn death including BA, infections, and complications related to preterm/low-birth weight infants.
Empower the Midwife[43,44,79]	Providing tools to manage mothers during labor (MOYO) and newborns at birth (resuscitator).
Maternal Antibiotics for Unexplained prematurity and PPROM[76]	Action: treat Gram-positive and negative organisms.
Avoiding Moderate Hypothermia[71–73]	28% dose dependent ↑ in NM for every 1°C below 36.5°C.
Antenatal Steroids[77]	Enhance lung function, ↓ IVH, enhances temperature maintenance.
Early Postnatal Antibiotics	Prevent and/or treat Gram-positive and negative organisms.
Early Kangaroo Mother Care[74,75]	Maintain temperature homeostasis, ↓ Infections.
Care Bundle[73]	Incorporated antenatal steroids, maternal and neonatal antibiotics and avoiding moderate hypothermia.
CPAP[78]	Establish FRC, facilitates gas exchange.

CPAP, continuous positive airway pressure; FRC functional residual capacity; IVH, intraventricular hemorrhage.

sustained and widespread rollout of HBB and HBS, consistent with a recent workshop on improving neonatal survival, are outlined.[67] Although each process is important, empowering the midwife, the primary provider at most facility deliveries, is critical to success.[64,68–70] In addition, there is overwhelming evidence that some form of LDHF training (either in person or using a technical feedback mechanism) is essential for maintaining skills. Finally, the commitment of the Ministry of Health to improving the health of newborns is fundamental to reaching the goal of widespread dissemination.

A second critical issue is reducing overall NM through 28 days. This may be accomplished by a series of interventions outlined in HBS, with a focus on the premature infant (Table 7). These include avoiding moderate hypothermia,[71–73] assuring early kangaroo mother care is initiated in the DR,[74,75] using a premature care bundle (antenatal steroids, targeted use of maternal and neonatal antibiotics),[73,76,77] and the targeted use of bubble continuous positive airway pressure.[78] In addition, we would suggest the importance of using birth weight (BW) (more reliable) as opposed to gestational age (highly variable) as predictor of NM, as shown in 2 pie charts from 1 hospital each, in SA and Tanzania (Fig 6). The NMR for infants of BW <1500 g is strikingly high compared to that of larger BW infants.

CONCLUSIONS

Tremendous progress has been made over the past decade to disseminate HBB and, more recently, HBS, which has been associated with a reduction in NMRs in all sub-Saharan countries reviewed and Nepal. An important association between the number of trained SBA (indirect proxy of dissemination) and NM and FSB was noted (Table 5). Although the data in this review are encouraging, the impact of the ongoing coronavirus disease 2019 pandemic and the ability to sustain resources (financial and other), both local and global, for these programs remains unclear, and a future concerning issue.

ABBREVIATIONS

BA: birth asphyxia
BMV: bag mask ventilation
BW: birth weight
DR: delivery room
ENM: early neonatal mortality
ENMR: early neonatal mortality rate
FSB: fresh stillbirth
HBB: Helping Babies Breathe
HBS: Helping Babies Survive
LB: live born
LBW: low birth weight
LDHF: low-dose high-frequency
NM: neonatal mortality
NMR: neonatal mortality rate
NR: neonatal resuscitation
OR: Oliver Reginald
PMR: perinatal mortality rate
QI: quality improvement
SA: South Africa
SBA: skilled birth attendant

POTENTIAL CONFLICT OF INTEREST: Drs Perlman, Clarke, and Merali are current and/or past members of the Helping Babies Survive Planning Group; and Drs Velaphi, Massewe, and Ersdal have indicated they have no potential conflicts of interest to disclose.

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Pediatrics 2020;146;S194
DOI: 10.1542/peds.2020-016915K

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