Abstract:

Significant progress has been made in reducing global child mortality rates over the past 2 decades, with the improvements in survival primarily occurring among children between 1 month and 5 years of age. As a result, neonatal mortality now accounts for almost half of all deaths in children less than 5 years of age. Helping Babies Breathe is a neonatal resuscitation program developed by the American Academy of Pediatrics for use in low-resource settings and aims to teach basic resuscitation skills to providers who are present at deliveries. Using a train-the-trainer curricular model and low-cost simulator and equipment, Helping Babies Breathe has been implemented in more than 80 countries to train 500 000 providers and has resulted in a marked decline in early neonatal deaths and fresh stillbirths. Ongoing research is being done to optimize strategies to maintain resuscitation skills and knowledge over time, as well as to develop additional methods to improve neonatal resuscitation in low-resource settings, with hopes of achieving the United Nations Sustainable Development Goals for neonatal mortality rates by 2030 worldwide.

Keywords:

neonatal mortality; global health; neonatal resuscitation; Helping Babies Breathe; simulation

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Helping Babies Breathe: Improving Neonatal Resuscitation and Global Neonatal Mortality

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Over the past 2 decades, significant progress has been made in improving both childhood and neonatal mortality worldwide. Children are at the greatest risk of dying during the neonatal period (the first 28 days of life), with an average rate of 18 neonatal deaths per 1000 live births globally in 2017.[1] Reduction in mortality for children aged 1-59 months has outpaced reduction in neonatal mortality, with a decline of 63% from 1990 to 2017 compared with only 51% for neonatal mortality.[1] As a result, neonatal deaths now account for nearly half of all deaths in children less than 5 years of age. However, these deaths are distributed unevenly. Vast disparities exist in neonatal mortality, with 80% of the burden of neonatal deaths concentrated in sub-Saharan Africa and southern Asia.[1] Despite substantial gains, 28 million newborns are still predicted to die between 2018 and 2030 if the current trajectory of neonatal mortality remains the same.[1]

Many of these deaths are due to preventable or treatable causes. Complications due to preterm birth, intrapartum-related events

(birth asphyxia or not breathing at birth), infectious diseases, and congenital abnormalities are the leading causes of neonatal death.[2] Approximately 36% of the 2.5 million neonatal deaths in 2017 occurred on the first day of life, with nearly three quarters within the first week of life.[1] Many of the deaths within the first day of life occur at or shortly after birth. Up to 15% of term newborns are estimated to require some degree of assistance at birth to start breathing. The majority will respond to drying and stimulation (10%), whereas a smaller number will require positive-pressure ventilation (3%) or intubation (2%), and very few will need chest compressions and/or epinephrine (0.1%).[3]

Further improvement of child and neonatal mortality rates continues to be a focus of the United Nations Sustainable Development Goals, which set a target of ending preventable deaths of newborns and children less than 5 years of age by 2030, with a goal neonatal mortality rate of 12 deaths or less per 1000 live births for all countries.[4] A critical strategy to achieve this goal is increasing access to skilled care at delivery, particularly in low- and middle-income countries. This article will review the history of global neonatal resuscitation programs and the development of Helping Babies Breathe (HBB), a newborn resuscitation training program designed for use in low-resource settings. We will also address the impact and sustainability of HBB, as well as future efforts toward the improvement of neonatal resuscitation.

DEVELOPMENT OF NEONATAL RESUSCITATION PROGRAMS ON A GLOBAL SCALE

Released by the American Heart Association and the American Academy of Pediatrics in 1987, the Neonatal Resuscitation Program (NRP) sought to standardize the approach to neonatal resuscitation and emphasized the importance of having a dedicated provider trained in neonatal resuscitation present at each delivery.[5] Informed by research from the International Liaison Committee on Resuscitation, NRP protocols are updated regularly, and providers must demonstrate competence in skills and knowledge every 2 years to maintain certification. Since 1987, NRP has been used in more than 130 countries[6] and has prompted many health ministries to create their own formal neonatal resuscitation programs.[7] NRP includes guidelines on drying, stimulating, and suctioning infants, as well as when to initiate positive-pressure ventilation, when to intubate, and when to begin chest compressions. It also discusses umbilical line placement and administration of medications such as epinephrine. Although these procedures are appropriate for a high-income country such as the United States, the recommendations may not be feasible for countries with a high proportion of out-of-hospital births or births in resource-limited settings. As countries began to adopt NRP for use in larger hospitals, more rural areas adapted the formal NRP protocols to better meet their own needs and work within their specific resource constraints.[8]

As these alternate versions of NRP were being implemented and studied in various low-resource settings, the need emerged for a specific resuscitation program to be designed for use in resource-limited settings. NRP was created for use within a hospital setting and is most often used by providers with formal medical training. However, up to 60 million births occur each year outside of a health care facility, and up to 50% of those births occur with no formally trained birth attendant present.[9] In general, only 1% of infants will require advanced resuscitation at birth such as compressions or medications; 99% of infants will respond to either routine interventions or basic resuscitation techniques such as positive-pressure ventilation.[10] It became clear that neonatal resuscitation training programs could successfully save lives even without teaching advanced resuscitation measures in areas where the supplies or technology were not available. The American Academy of Pediatrics created a Global Implementation Task Force to develop a standardized resuscitation curriculum specifically for use in low-resource settings.[11] The curriculum, named *Helping Babies Breathe*, was formally released in 2010. Since then, HBB has been taught in more than 80 countries, with 500 000 providers trained.[12]

HBB is structured such that the skills taught can be mastered by a wide range of learners, from neonatologists to birth attendants without any formal medical training. HBB uses a pictorial flowchart to lead the learners through various scenarios and uses both didactic and hands-on skills sessions to teach the basic steps of neonatal resuscitation. Curriculum materials include a facilitator flip chart and learner workbook that correspond to the flowchart and allow the learner to proceed stepwise through the clinical scenarios. The flowchart, or Action Plan, is divided into 3 zones: green zone (vigorous neonate who can receive routine care), yellow zone (neonate who is not immediately crying and on whom additional interventions must be performed), and red zone (neonate who is not breathing and needs ongoing bag-mask ventilation and advanced care). After each set of interventions (drying, stimulating, and suctioning an infant in the yellow zone, for example), the learner is taught to reevaluate the neonate and decide whether the neonate needs more interventions or can simply be

monitored. In addition to the concrete skills taught to the learner, the urgency of intervention is also conveyed with the concept of the "Golden Minute." The Golden Minute refers to a desired outcome when resuscitating a neonate according to HBB protocols—every neonate should either be spontaneously breathing or receiving positive-pressure ventilation by 1 minute of life. During a training session, a trainer or facilitator helps the learners work through various scenarios to practice these skills and decision-making steps.

Engineers at the Laerdal Foundation (Stavanger, Norway) worked with members of the Global Implementation Task Force to design and create a low-cost neonatal simulator with enough fidelity to allow participants to learn to perform the desired skills.[13] The neonatal simulator, "NeoNatalie," can be inflated with either air or water and when filled with water weighs approximately 2 kg. The simulator is operated by use of attached squeeze bulbs and has visible chest rise with breaths as well as a palpable umbilical pulse. The simulator kit also comes with equipment that can be sterilized and reused for live resuscitations, including a suction device, self-inflating ventilation bag, and 2 sizes of facemasks (FMs). When bag-mask ventilation is performed with appropriate technique, chest rise is actually achieved on the neonatal simulator, allowing learners to practice troubleshooting ventilation.

HELPING BABIES BREATHE TRAINING PROGRAMS WORLDWIDE: SUCCESSES AND CHALLENGES

As HBB was introduced, several small- and large-scale studies were performed to assess its effectiveness. One of the initial studies was conducted at a series of 8 hospitals in Tanzania. The study investigated the early neonatal mortality rate before and after HBB training was conducted at each site. Across all sites, neonatal deaths at 24 hours of life decreased by 47% (P .0001) and fresh stillbirths decreased by 24% (P = .001).[14] In this study, *fresh stillbirths* were defined as an Apgar score of 0 at 1 and 5 minutes, with birth weight 1000 g and suspected death during labor/delivery. As HBB focuses on interventions at birth, the finding of decreased fresh stillbirth deaths across sites suggests that some neonates may have been nonvigorous, liveborn infants who were miscategorized as stillbirths. Decreases in neonatal mortality[15,16] and stillbirth rate[17] were also found at other sites where providers underwent HBB training. By expanding access to skilled birth attendants trained to perform simple interventions such as drying, stimulating, and providing positive-pressure ventilation, HBB enables these neonates to survive.

The initial pilots of HBB involved a 1- or 2-day "train-the-trainer" workshop in which providers learned HBB methodology and became "master trainers." After the workshop, the master trainers returned to their home regions or hospitals and trained other individuals at a local level.[18] Regardless of their prior level of medical training, providers generally demonstrated an improvement in both skills and knowledge from pre- to immediately posttraining.[19,20] However, reduction of skills and loss of knowledge gained in HBB training courses over time have been well documented in multiple studies and represent a significant limitation of the program.[19,21,22] Refresher courses, just-in-time training, and on-the-job training at various time intervals after the initial training session have all been shown to ameliorate the deterioration in skills that occurs as the amount of time since the initial training increases and may serve to counteract this challenge.[21,23,24]

Neonatal resuscitation skills have been shown to decrease over time in US-trained providers as well. Pediatric emergency medicine faculty, for example, may rarely encounter a clinical situation in which a neonate requires immediate resuscitation at birth. A study of 18 emergency medicine providers in Wisconsin found that 65% of faculty had not participated in a neonatal resuscitation since residency;[25] this supports findings in another study which reported that community ED physicians were uncomfortable with neonatal resuscitations.[26] In both studies, it was suggested that simulation-based exercises may help bolster skills and comfort in this area. However, as with retraining providers in low- and middle-income countries, the ideal frequency of these simulations has not yet been investigated.

NEXT STEPS IN ADVANCING NEONATAL RESUSCITATION PRACTICES

While studies are ongoing regarding how best to strengthen and reinforce neonatal resuscitation training, some researchers are working to improve the resuscitation equipment itself. A team comprised of researchers from Mbarara University in Uganda, Massachusetts General Hospital, and Massachusetts Institute of Technology is evaluating a device that can be attached to conventional bag-mask ventilation equipment to provide real-time feedback on technique.[27] In pilot trials with the HBB "NeoNatalie" simulator, the device was able to accurately deliver feedback on ventilation rate and airway blockage, and could identify if a leak around the FM was present. A clinical trial is

currently underway in Uganda to evaluate both the device's ability to help clinicians improve their ventilation skills in real-time and its potential impact on the success of neonatal resuscitations.

Another research team recently studied the efficacy of uncuffed laryngeal mask airways (LMAs) instead of FM for delivery of positive-pressure ventilation during neonatal resuscitation in Uganda.[28] Several studies assessing the ability of birth attendants to perform skills learned in HBB training have demonstrated that FM ventilation is the most difficult skill to acquire and execute correctly.[19,21,29] Insertion of an LMA may be less prone to error than FM ventilation and thus may be more easily performed by staff with less clinical experience or training. In this study, neonates requiring positive-pressure ventilation at birth were randomized to either FM (n = 25) or LMA (n = 24). Mean time to spontaneous breathing was shorter in the LMA arm compared to the FM arm (P = .005), as was total ventilation time (P = .02). Additionally, 11 of the 25 neonates receiving FM ventilation required conversion to LMA due to lack of improvement, whereas all LMA resuscitations were successful. There were no differences between the 2 arms in secondary outcomes such as admission to the neonatal care unit, hypoxic encephalopathy, or death. These findings were consistent with a 2018 Cochrane review, which found that neonates ventilated using an LMA had shorter resuscitation times but ultimately no differences in deaths or hypoxic encephalopathy.[30]

SUMMARY

Global neonatal mortality rates have significantly declined over the last 2 decades. Although these improvements are multifactorial, the contribution of advancements in worldwide neonatal resuscitation practices cannot be understated. For example, between 2012 and 2017, almost 80% of live births occurred in the presence of skilled health personnel, an increase from 62% of live births from 2000 to 2005.[4] By providing resuscitation training and equipment tailored to resource-limited settings, HBB has been able to have a profound impact. Despite these successes, much work remains to be done. More than 60 countries remain on track to fall short of the neonatal mortality goal set forth for 2030 in the Sustainable Development Goals. Improvements that can help these countries reach this benchmark have the potential to save the lives of 5 million newborns over the period from 2018 to 2030.[1] Ongoing efforts to improve knowledge and skill retention for providers already trained in HBB, increasing access to skilled birth attendants through expansion of HBB, as well as continued innovation in neonatal resuscitation technology and methodology will enable further progress toward achieving this as a reality.

CONFLICTS OF INTEREST

None.

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