

Digital Health Innovations, Tools, and Resources to Support Helping Babies Survive Programs

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The Helping Babies Survive (HBS) initiative features a suite of evidence-based curricula and simulation-based training programs designed to provide health workers in low- and middle-income countries (LMICs) with the knowledge, skills, and competencies to prevent, recognize, and manage leading causes of newborn morbidity and mortality. Global scale-up of HBS initiatives has been rapid. As HBS initiatives rolled out across LMIC settings, numerous bottlenecks, gaps, and barriers to the effective, consistent dissemination and implementation of the programs, across both the pre- and in-service continuums, emerged. Within the first decade of expansive scale-up of HBS programs, mobile phone ownership and access to cellular networks have also concomitantly surged in LMICs. In this article, we describe a number of HBS digital health innovations and resources that have been developed from 2010 to 2020 to support education and training, data collection for monitoring and evaluation, clinical decision support, and quality improvement. Helping Babies Survive partners and stakeholders can potentially integrate the described digital tools with HBS dissemination and implementation efforts in a myriad of ways to support low-dose high-frequency skills practice, in-person refresher courses, continuing medical and nursing education, on-the-job training, or peer-to-peer learning, and strengthen data collection for key newborn care and quality improvement indicators and outcomes. Thoughtful integration of purpose-built digital health tools, innovations, and resources may assist HBS practitioners to more effectively disseminate and implement newborn care programs in LMICs, and facilitate progress toward the achievement of Sustainable Development Goal health goals, targets, and objectives.

abstract

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BACKGROUND AND SIGNIFICANCE

History and Context of Helping Babies Survive Programs

The Helping Babies Survive (HBS) initiative features a suite of evidence-based curricula and simulation-based training programs designed to provide health workers in low- and middle-income countries (LMICs) with the knowledge, skills, and competencies to prevent, recognize, and manage leading causes of newborn morbidity and mortality. HBS was built on the success of its flagship program, Helping Babies Breathe (HBB), a global initiative launched in 2010 to educate and train LMIC health care providers (HCPs) in knowledge, skills, and competencies for basic neonatal resuscitation.¹⁻⁴ In addition to HBB, HBS includes Essential Care for Every Baby (ECEB),⁵ essential newborn care from birth through 24 hours postnatal,^{6,7} and Essential Care for Small Babies (ECSB),⁸ essential care for the small well infant.⁹

Dissemination and Implementation Challenges

The scale-up of HBS programs has been explosive; during the initial 5 years after the global launch, HBB was disseminated in >80 countries, many at a national scale.¹⁰ As HBS initiatives rolled out across LMIC settings, numerous bottlenecks, gaps, and barriers to the effective, consistent dissemination and implementation of the programs emerged. These educational, data collection, and quality improvement (QI) challenges were detected across both the pre- and in-service continuums and emerged at multiple points throughout the HBS training cascade, including before, during, and after training.¹¹⁻¹³ For example, although HBS training is successful at initially improving knowledge, skills, and competencies among HCPs,¹⁴ HBB 1-day training courses, on their own, are often insufficient in leading

to sustained translation of knowledge and skills into clinical practice.¹⁵ Also, even when knowledge and skills are robustly acquired initially, if not supported by subsequent in-person refresher courses,¹⁶ peer learning, or low-dose high-frequency training,¹⁷ competencies rapidly decay over time.^{18,19}

Another key challenge that emerged, as HBS programs rapidly scaled, was reliance on paper-based methods for data collection and reporting. As compared to digitized data collection systems, paper-based efforts are often plagued by a higher rate of data entry errors and are difficult to search.²⁰ Thus, although paper-based systems can be easy to use for initial data collection, this can create bottlenecks in the subsequent collation and extraction of crucial information, which, in turn, can then impede integrated and timely documentation efforts, underlie time lags in reporting, and hamper effective monitoring, evaluation, and QI efforts.^{21,22} Thoughtfully designed digital health interventions may help to ameliorate educational and training gaps, barriers, and bottlenecks identified within the HBS dissemination and implementation cascade or that are created by reliance on paper-based data collection systems.²³⁻²⁷

THE PROMISE OF DIGITAL HEALTH TO SUPPORT HBS

Within the first decade of expansive scale-up of HBS programs, mobile phone ownership and access to cellular networks has concomitantly surged in LMICs.²⁸⁻³¹ In 2018, there were 5.135 billion mobile phone users, and two-thirds of the world's population of 7.6 billion people owned a mobile phone; half of these devices were "smart" (ie, enabled with Internet access, data storage, and other computing capabilities). Globally, Internet penetration also continues to rise, with an estimated

53% of global citizens (4.021 billion) with access in 2018.³² Acceptance of, and access to, a wide variety of digital health interventions has also skyrocketed, among a wide range of stakeholders, including HCPs.³³⁻³⁸ Implementation of mobile health and digital tools in LMICs has been demonstrated to have numerous benefits, including improving access to care for patients,^{39,40} increasing knowledge retention and competencies among community health workers,^{41,42} and improving training outcomes, confidence and satisfaction, and reporting of key indicators among health providers.^{35,43-46}

Over the past decade, a number of digital resources and innovations have been developed to augment HBS initiatives. Below, we describe some of these. This article does not serve as an exhaustive systematic review of all digital tools or educational repositories that have been reported during 2010–2020. Rather, the interventions selected have been designed and developed in collaboration with partners of the former Survive and Thrive Global Development Alliance (2012–2017),⁴⁷ and as such, have received significant input from a broad coalition of local, national, and international stakeholders for specific alignment with evidence-based HBS curriculum and training content. The featured digital resources and innovations are organized according to their primary function(s). Broadly, we describe HBS digital innovations that support (1) education and training, (2) data collection for monitoring and evaluation, (3) clinical decision support, and (4) QI. Some of the innovations described in this article have multiple, overlapping functions (Table 1). Additional digital health tools of potential interest to HBS practitioners are shown in Table 2.

TABLE 1 Digital Tools To Support HBS Programs

Digital Tool	Developer	Brief Description	HBS Content	Functions	Web Site
GHMP Video Repository	GHMP	Live-action videos of evidence-based practices with patients and HCPs in clinical settings in LMICs	HBB, ECEB, ESCB	Education and training	https://globalhealthmedia.org/
AIIMS ECEB app	AIIMS	Digital reference for ECEB curriculum with scenarios for role playing and evaluation of knowledge through case exercises	ECEB	Education and training; clinical decision support	https://play.google.com/store/apps/details?id=com.eceb
AIIMS ECSB app	AIIMS	Digital reference for ECSB curriculum with scenarios for role playing and evaluation of knowledge through case exercises	ECSB	Education and training; clinical decision support	https://play.google.com/store/apps/details?id=com.ecsb
LIFE (VR and mobile)	KEMRI Oxford University	Mobile VR simulation for neonatal resuscitation	HBB	Education and training	https://play.google.com/store/apps/details?id=uk.ac.ox.NDM.LIFE
eHBB VR and eHBB mobile apps	University of Washington and Oxford LIFE team	Mobile VR simulation for neonatal resuscitation	HBB	Education and training	https://play.google.com/store/search?q=eHBB
Liveborn	Laerdal Global Health, UNC SOM	Audit-feedback app for observer documentation of timing of resuscitation actions; gives automated feedback that is based on the HBB algorithm	HBB	Data collection for monitoring and evaluation; QI	https://play.google.com/store/apps/details?id=com.laerdalglobalhealth.neobeatbirthregistration.newborn_ventilation_tool
mHBS-DHIS2 ^{72,91,92,94} Trainer module	Indiana University School of Medicine, IUPUI School of Informatics and Computing, Alupe University College, and Moi Teaching and Referral Hospital	Digitized curricula, such as the provider's guide; access to educational and VR training videos (ie, eHBB); linkage to partner Web sites	HBB, ECEB, ECSB	Education and training	https://github.com/iupui-soic/mHBS_tracker
mHBS-DHIS2 ^{71,73-75,93,94} Tracker module	Indiana University School of Medicine, IUPUI School of Informatics and Computing, Alupe University College, and Moi Teaching and Referral Hospital	Digitized knowledge checks, BMV and OSCE skills checklists, and QI tools such as delivery observation checklist, and perinatal death audit; linkage to partner apps (eg, AIIMS, Safe Delivery, eHBB)	HBB, ECEB, ECSB	Data collection for monitoring and evaluation; QI	https://github.com/iupui-soic/dhis2-android-trackercapture
mHBS-DHIS2 ⁹⁵⁻⁹⁷ ECEB Digital Action Plan app	Indiana University School of Medicine, IUPUI School of Informatics and Computing, Alupe University College, and Moi Teaching and Referral Hospital	Support tool to track multiple infants with automated advice for management	ECEB	Clinical decision support	—

BMV, bag mask ventilation; IUPUI, Indiana University–Purdue University Indianapolis; KEMRI, Kenya Medical Research Institute; —, not applicable.

EDUCATION AND TRAINING

Global Health Media Project Educational Video Repository

Global Health Media Project (GHMP) is a US-based nonprofit founded in 2010 that has created a large digital repository of live-action videos to help health workers and caregivers in low-resource settings obtain information and skills that can improve health care

and health outcomes.⁴⁸ The media are designed to be basic, practical, and reliable. The content is distilled from current international guidelines, and scripts and videos are rigorously reviewed by global content experts with extensive experience in low-resource settings. The videos are shot with in-service frontline health workers, exhibiting best practices with patients in actual LMIC clinical settings.

The videos, which are accessible across various modalities, demonstrate kind and respectful behavior and are carefully crafted to draw a trainee's eyes and ears to all the subtleties that lead to good knowledge acquisition. Voice-over makes it easy to narrate the films in multiple languages. Using real HCPs who role model best practices for delivery of evidence-based health

TABLE 2 Additional Digital Health Innovations of Potential Interest to HBS Practitioners

Delivery room timer

In conjunction with a large global implementation trial of HBB in Kenya and India,^{3,4,116} Somannavar et al¹¹⁷ developed and tested a voice-activated mobile phone-based timer to be used during deliveries for capture of time elapsed between birth and beginning of bag mask ventilation efforts in non-crying infants.

HBB Prompt

Investigators from North America and Uganda are currently designing, developing, and performing feasibility testing in Uganda for an app, HBB Prompt, to improve retention of HBB skills and competencies.¹⁰⁴

NeoTree

This is an mHealth tool that integrates educational, data collection, and neonatal care decision support functions to improve the quality of care provided to newborns in LMICs. The content is aligned with HBS curricula. Usability testing was conducted in Malawi.¹¹⁸

Safe Delivery app

The Safe Delivery app is a digital health tool used to support acquisition of knowledge and skills for basic emergency obstetric and neonatal care; the guidelines for neonatal resuscitation align with recommendations found in HBB, second edition. Recommendations for labor, delivery, and postpartum care harmonize with those found in the Helping Mothers Survive curricula.⁴³⁻⁴⁵

Telehealth

Increasingly, Telehealth is being used for telementoring to foster north-south and south-south educational and training relationships and to support virtual learning within neonatal resuscitation training programs,¹¹⁹ including HBB.¹²⁰

care aligns with adult-learning principles for the development of competencies through self-directed learning.^{49,50}

GHMP has created 150 videos that are focused on maternal, newborn, and child health. For HBS, there are 4 videos with live footage to complement HBB and 30 videos closely aligned with ECEB, covering newborn care skills, problems, and breastfeeding.⁵¹ To support ECSB content, 27 videos are available.⁵² GHMP videos have been watched in

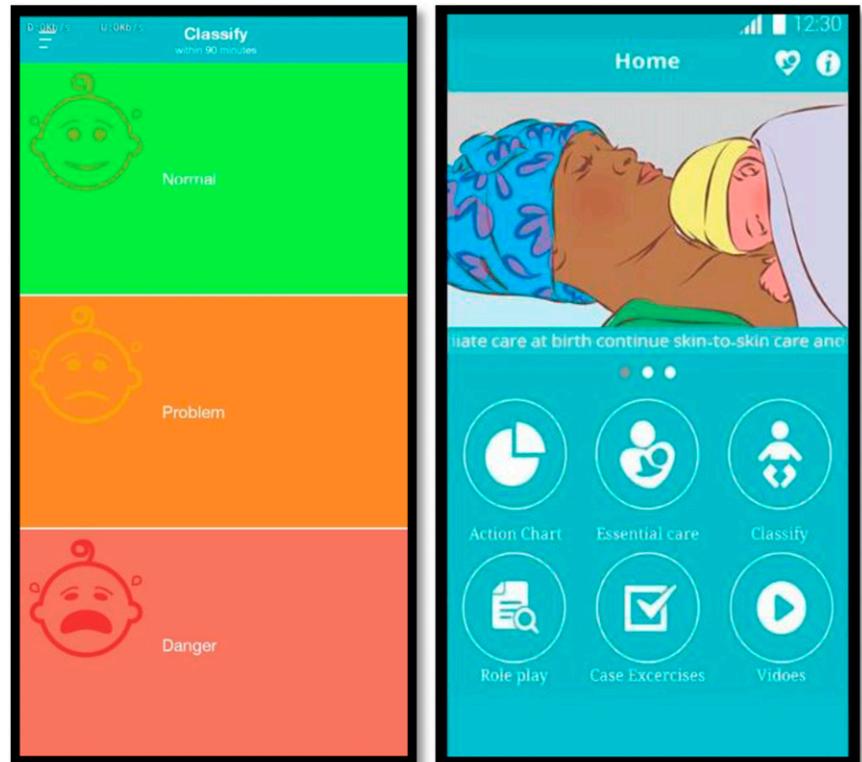


FIGURE 1 AIIMS HBS-ECEB Android app (reproduced with the permission from A.D.). Screenshots from the AIIMS HBS-ECEB Android app demonstrating the classify-the-infant function.

nearly every country in the world and streamed online >430 million times. Available in >40 languages, they have been downloaded by >7500 organizations. Recently, GHMP released the Birth & Beyond app, available on iOS; it allows 1-click access to their 28 videos that have been designed specifically for mothers and caregivers and are available in 21 languages.

The All India Institute of Medical Sciences Essential Newborn Care and ECSB Apps

Developed by collaborators at the All India Institute of Medical Sciences (AIIMS), the Helping Babies Survive-Essential Newborn Care (HBS-ENC) and Helping Babies Survive-Essential Care for Small Babies (HBS-ECSB) apps are available on Google Play and iOS; the Android versions of HBS-ENC and HBS-ECSB have been downloaded >5000 and 1000 times, respectively. Both apps

are aligned with existing versions of the American Academy of Pediatrics' (AAP) ECEB and ECSB programs. They support acquisition of knowledge among HCPs in regard to immediate care of the newborn after birth and during the first day (HBS-ENC) and for well small infants (HBS-ECSB).

The HBS-ENC can be paired with the ECEB curriculum as a ready digital reference for the action plan, which highlights key steps in essential care and classification of the newborn. (Fig 1). The app also has case exercises for paired practice by health care workers that combine several actions with an objective to harness skills for each component of the action plan.

The HBS-ECSB app is structured similar to the HBS-ENC app, but the content is based on the ECSB program (Fig 2).⁸ In addition to offering opportunities for self-directed

learning to serve as memory aides and tips for facility-based QI, both apps also link to educational videos that are offered by a variety of newborn care partners, including GHMP. HCPs may use the apps as preparation for and during an initial training workshop, as well as after the completion of the course for self-directed knowledge refresher training and as point-of-care tools at the bedside. The apps guide activities that help providers maintain and improve knowledge and skills through review and practice. In addition, both apps also incorporate QI functions.

VIRTUAL REALITY EDUCATION AND TRAINING TOOLS

In high-income countries, computer-based training simulations such as HeartCode Pediatric Advanced Life Support and the Neonatal Resuscitation Program eSIM programs complement in-person

courses.^{53,54} Although these software programs require a high-speed Internet connection and a personal computer with sufficient graphics capabilities, mobile virtual simulations, such as Life-Saving Instruction for Emergencies (LIFE) (mobile) and the electronic Helping Babies Breathe (eHBB) program (see descriptions below), can be delivered off-line on mobile phones as screen-based experiences transformed into immersive experiences with the use of a low-cost virtual reality (VR) headset.⁵⁴ Game-based learning creates interconnections between the off-line identity, the game scenarios, and the actual interactions with and within the virtual simulation, allowing the learner to demonstrate skills and modify behaviors that relate to clinical practice.⁵⁵⁻⁵⁷

“Serious games” are electronic games or apps that are deliberately designed for learning as well as

entertainment. Through integration of simulations, virtual environments, and mixed reality and media, they provide educational and training opportunities through storytelling, narratives, and game-play encounters.⁵⁸ There is evidence that serious-game simulations result in a 20% higher post-training self-efficacy, 11% higher declarative knowledge, 14% higher procedural knowledge, and 9% higher retention.⁵⁹ Serious games and virtual simulations are increasingly being used to augment traditional methods of neonatal resuscitation training and have particular potential to augment simulation-based medical and nursing education.^{53,54,60,61} Mobile VR simulations can be used to demonstrate real-world phenomena, illustrate abstract concepts, and motivate learners.⁶² In a national survey of 161 pediatric health care workers in Nigeria, nearly all respondents (98% physicians [$n =$

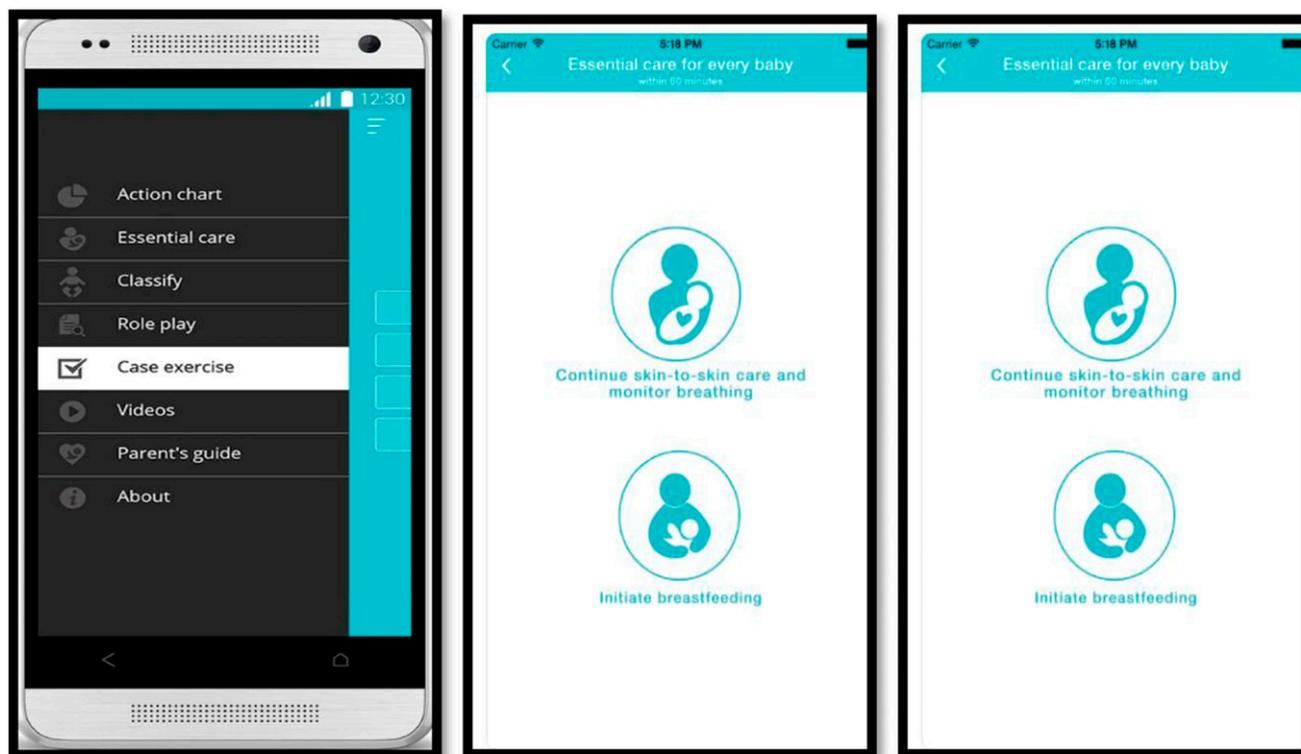


FIGURE 2
AIIMS HBS-ECEB iOS app (reproduced with the permission from A.D.). Screenshots from the AIIMS HBS-ECEB iOS app: home screen, tabs to navigate through content, “Essential care for every baby,” and prevention of disease.

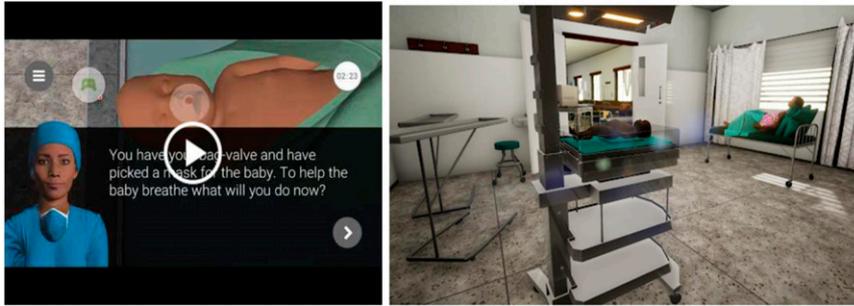


FIGURE 3 LIFE screenshots (reproduced with permission from Dr Chris Paton, Oxford University). Screenshots from the LIFE VR serious gaming platform reveal interactive learning and labor and delivery room screens.

92] and 96% of nurses [$n = 52$] would recommend the use of online simulation for their center.⁶³

LIFE

LIFE is a platform that was developed in a partnership between researchers in Kenya and the United Kingdom.^{64,65} It hosts mobile and VR training scenarios that help health workers to learn the steps they need to manage medical emergencies. The LIFE platform employs the concept of serious games to deliver training in a virtual environment that follows highly structured care pathways (or algorithms; Fig 3).

The LIFE platform is intended to serve as a tool for neonatal resuscitation refresher training to prevent the documented decay in knowledge and skills that occur after initial skills acquisition.⁶⁶ When subsequent face-to-face training courses are not accessible, LIFE offers realistic simulation training via VR

headsets or mobile phones. The scenarios hosted in the LIFE app, available on Google Play⁶⁷ and iOS, are based on the Emergency Triage, Assessment and Treatment plus admission care program (ETAT+).⁶⁸ More than 5000 African health workers have received ETAT+ training. The initial steps of ETAT+ basic neonatal resuscitation training are closely aligned with those of HBB; also similar to HBB, ETAT+ training among health workers is associated with reduced child mortality at facilities where it is implemented.⁶⁹

LIFE (mobile) is a highly interactive three-dimensional mobile game, currently being rolled out nationwide in Kenya, in collaboration with the Kenya Pediatric Association. Using LIFE (mobile), health workers can access neonatal resuscitation training modules off-line via their smartphones whenever desired. To incentivize health workers to keep using the app,

LIFE has partnered with the Kenya Pediatric Association to offer Continuing Professional Development points to providers using the platform. Additional training modules are being developed, and user design and evaluation research is currently being conducted.⁷⁰

eHBB

eHBB VR and mobile applications feature 3 simulations that are based on the HBB curriculum (second edition) in which a newborn may require only routine care, some resuscitation, or resuscitation with positive-pressure ventilation (Fig 4). eHBB VR is designed primarily to work on low-cost mobile VR viewers such as Google Cardboard. The focus of the activity is to have the user “show” what they would do for the infant by interacting with the three-dimensional objects in the simulation and making selections by pressing a button-lever mechanism on the outside of the headset or by touching the screen. eHBB is designed to complement in-person classes, promote individualized learning, and provide standardized feedback that is based on the HBB Action Plan.

To develop eHBB, the eHBB research team, led by the University of Washington, worked with the Oxford LIFE team to codesign scenarios with stakeholders representing a range of technical and clinical experience in Nigeria and Kenya. The working group used an agile, iterative codesign and testing approach to create VR scenario storyboards, identify game actions and animations, specify user prompts, and create individualized feedback. Internal testing during development was performed by the project team at several international sites: University of Washington, Seattle, Washington; Indiana University, Indianapolis, Indiana; National Hospital Abuja, Abuja, Nigeria; and the Kenya Medical Research Institute, Nairobi, Kenya.

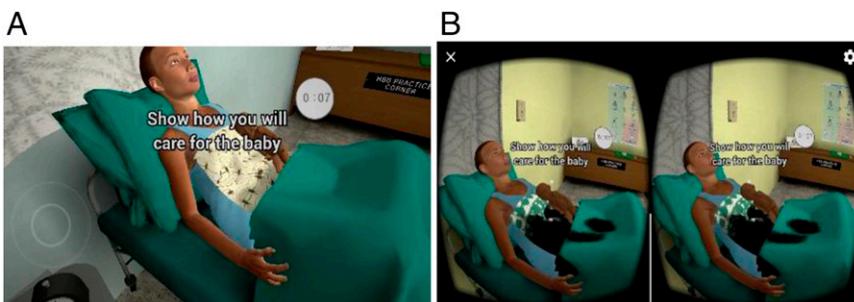


FIGURE 4 eHBB screenshots (reproduced with permission from R.U.). A, eHBB mobile screen-based simulation. B, eHBB mobile VR simulation.

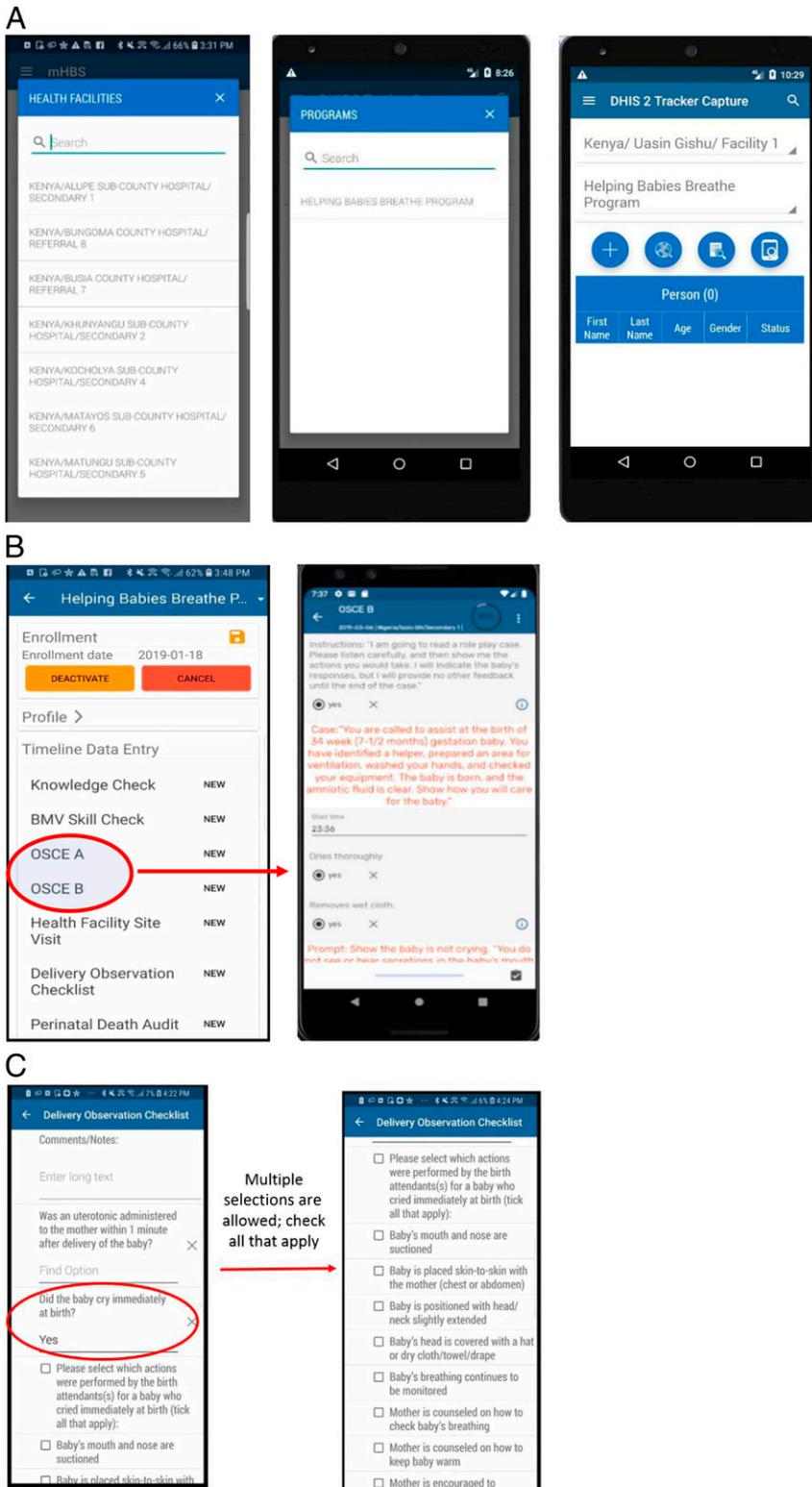


FIGURE 5 Screenshots of the mHBS-DHIS2 tracker (version 1.0.1, build 653). A, Enrollment of new participants can be customized by geographic location, facility, and type of HBS program. B, Digitized data collection forms enable mobile devices to be used for monitoring, evaluating, and reporting of HBS educational and training outcomes; OSCE B is shown. C, Providers can self-report information that may be useful for QI initiatives; the delivery observation checklist is shown. Screenshots were reproduced with permission from S.L.B. BMV, bag mask ventilation.

User feedback was also obtained during demonstrations at several national and international meetings. Collaborating institutions for pilot testing were the University of Lagos (Nigeria) and Alupe University College (Busia, Kenya). Mobile eHBB VR training for retention of neonatal resuscitation knowledge and skills is being field tested in a randomized controlled trial among nurses and midwives in Nigeria and Kenya.

EDUCATION, TRAINING, AND DATA COLLECTION FOR MONITORING AND EVALUATION: MOBILE HELPING BABIES SURVIVE POWERED BY DISTRICT HEALTH INFORMATION SYSTEM 2

The mobile Helping Babies Survive powered by District Health Information System 2 app (mHBS-DHIS2) is an integrated suite of open-source digital health tools to equip HCPs with one-stop access to, and linkage of, key resources and functions that are of particular importance to them in their educational, training, and clinical service trajectories.⁷¹⁻⁷⁵ mHBS-DHIS2 supports off-line mobile phone- and tablet-based data collection, education and training, reporting, and QI functions, as well as Web-based data visualization and dashboards via individually owned or shared (facility-based) Android devices. Built within the District Health Information System 2 platform,⁷⁶ which is currently used in >60 countries, including by many ministries of health that have also integrated HBB at the national level,⁷⁷⁻⁸¹ mHBS-DHIS2 is extremely flexible and customizable; it is purpose designed for rapid scale-up and sustainability within the global regions where neonatal mortality is the highest,^{82,83} where HBS programs have scaled, and where partners are focused on achieving Sustainable Development Goals.^{19,79,84-89}

The methods used to develop the mHBS-DHIS2 app included a human-

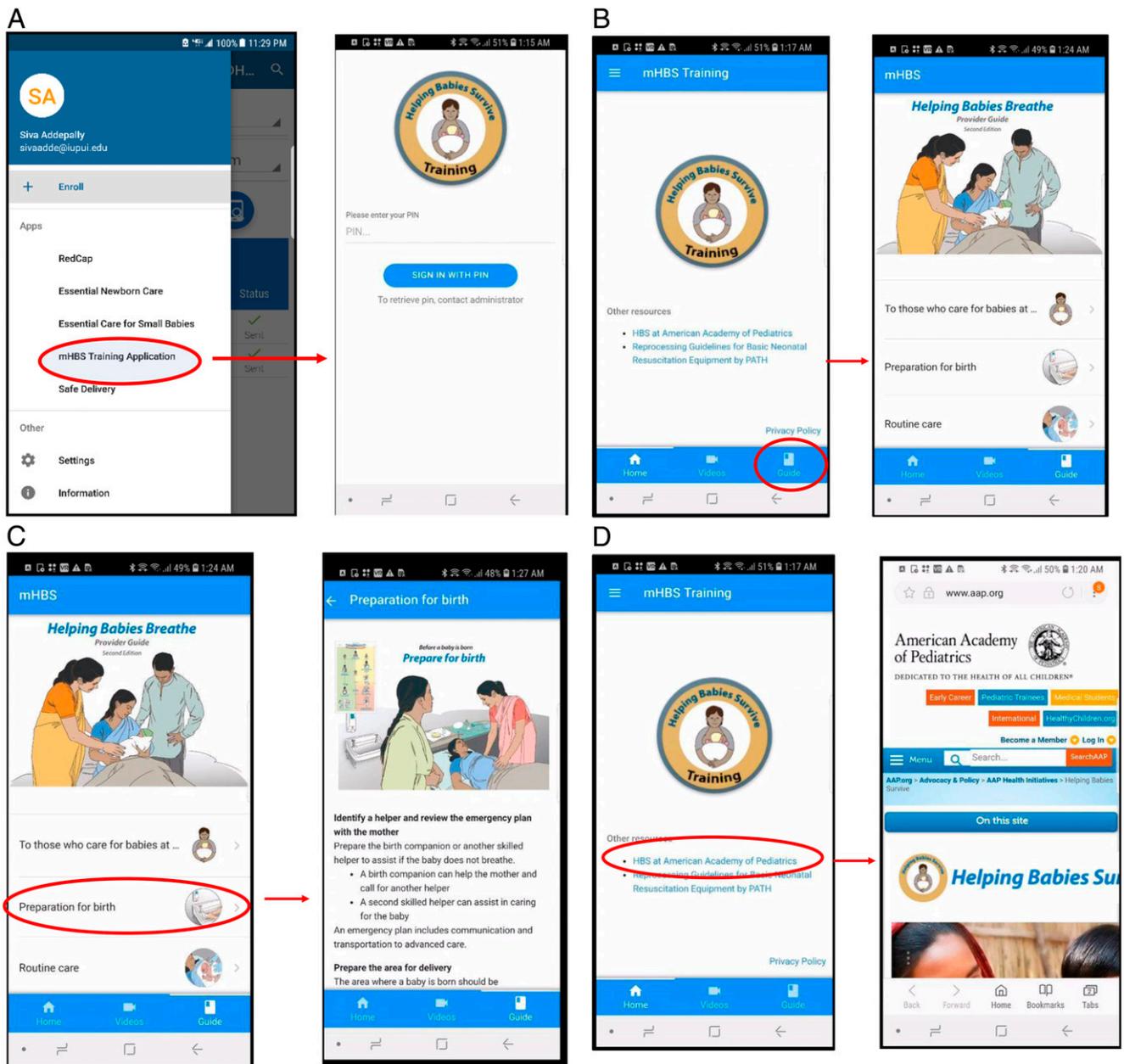


FIGURE 6

Screenshots from the mHBS-DHIS2 trainer app. A, The mHBS-DHIS2 trainer app, in addition to other Android-based educational, training, and data collection apps, is accessed from links integrated in the mHBS-DHIS2 tracker app. B, From the mHBS-DHIS2 trainer home screen (left) users can navigate to partner Web sites, educational videos, and digitized HBS materials, including action plans and provider's guides (right). C, Users can navigate as desired through the digitized HBB second edition provider's guide. D, Web-based resources can be accessed from the mHBS-DHIS2 trainer app. Screenshots were reproduced with permission from S.L.B.

centered design approach in conjunction with agile, iterative development processes, heuristic evaluation,⁹⁰ and extensive usability testing, in conjunction with international partners.⁹¹ All mHBS-DHIS2 innovations are open source, and code is available on GitHub.^{92,93} The mHBS-DHIS2 privacy policy is

compliant with the General Data Protection Regulation (2016/679).

The mHBS-DHIS2 app is composed of a suite of integrated digital modules (trainer and tracker). It is accessed via a single, customizable log-on screen using an assigned or self-selected username, pin code, or other

credential. After logging on, users toggle seamlessly between self-directed learning (mHBS-DHIS2 trainer module) and data collection and reporting or QI functions (mHBS-DHIS2 tracker module). Customized, permission-based access allows various types and levels of users (eg, country champions, district

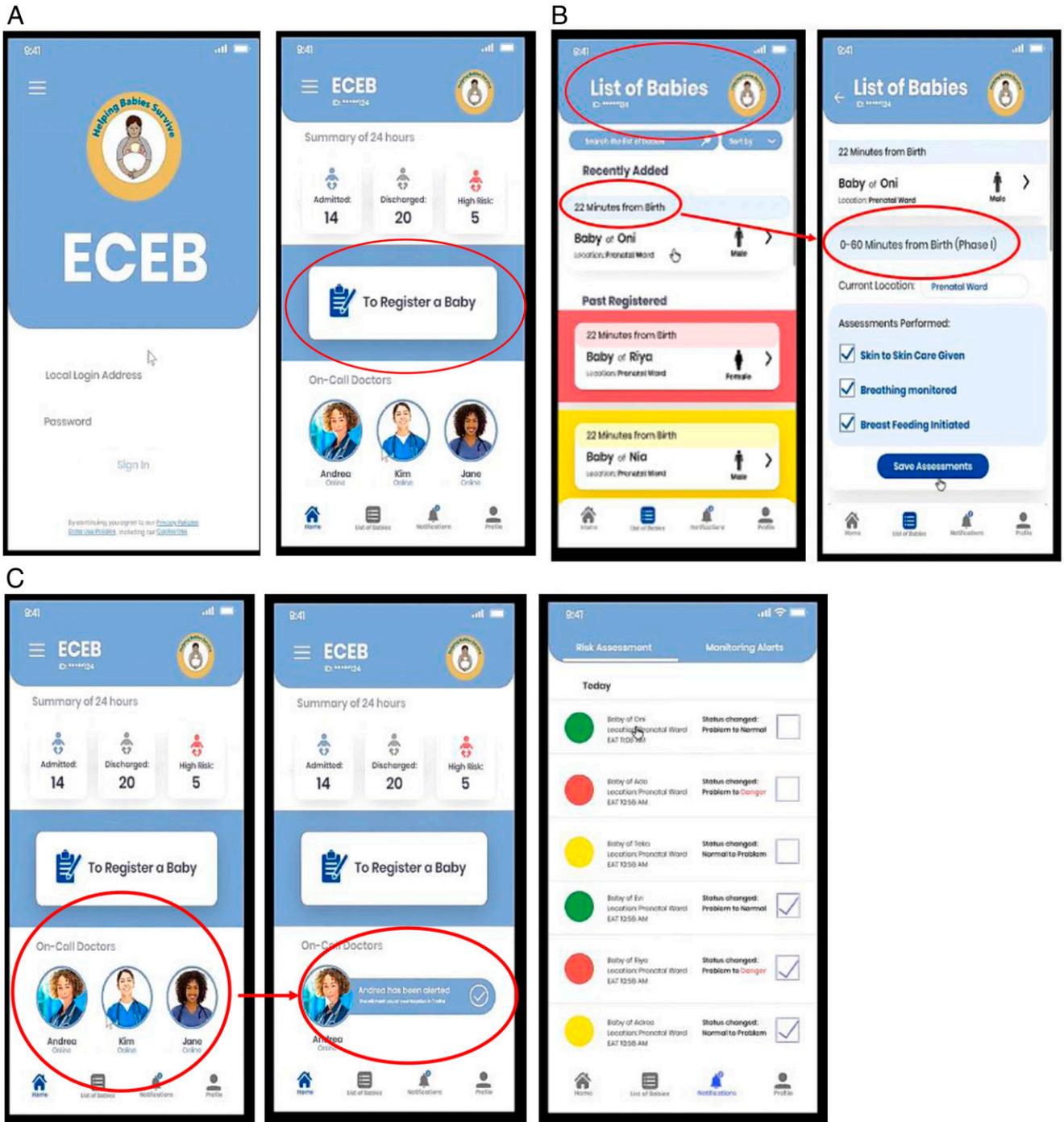


FIGURE 7

A, Screenshots from the ECEB Digital Action Plan; clinical decision support to guide essential newborn care. A, Customized log-on (left) and then register and track multiple infants (right). B, Births are time stamped, and automated care reminders are generated. C, Requests for consultation are embedded in the app (left); HCPs can track changes in infants' health status over time (right). Screenshots were reproduced with permission from S.L.B.

managers, HBS master trainers or providers) to enroll and track participating health facilities and HBS trainees or providers according to geographic location (country, province, district), level of health

facility, and the HBS program in which a health worker is participating (Fig 5A).⁹³

The mHBS-DHIS2 trainer module⁹¹ provides linkage to digital and Web-

based educational, training, and implementation partner resources (eg, AAP HBS site), educational videos, and easily navigable digitized HBB second edition materials, including the action plan and

00:40



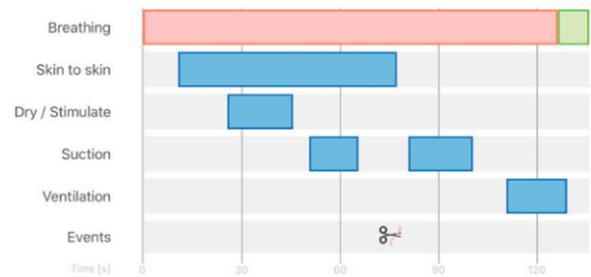
Event registration screen

Summary

Debrief

2020-04-21 16:19

02:16



Observation
The baby received ventilation at 1 minute and 50 seconds after birth.

HBB recommendation
Ventilate the baby who is not breathing well within 1 minute after birth.



Discussion

What delayed the start of ventilation?

Debrief performed

Feedback screen

FIGURE 8

Screenshots from the Liveborn app. The Liveborn event registration screen allows an observer to document the timing of resuscitation actions and breathing status of the newborn. The feedback screen depicts a time line of the resuscitation, highlights a gap in quality, provides an HBB recommendation about how to improve care, and suggests a question for discussion. Screenshots were reproduced with permission from Laerdal Global Health (<https://laerdalglobalhealth.com/>).

provider's guide. Android-based partner apps (eg, AIIMS apps, eHBB, Safe Delivery⁴³) and online toolkits (eg, PATH) are seamlessly integrated with and accessible via the trainer module (Fig 6 A–D). In addition to using the mHBS-DHIS2 app for educational and training functions, end users can easily and effectively capture a wide variety of key monitoring and evaluation metrics, indicators, and outcomes. Currently, a total of 12 HBB educational evaluation, data collection, and reporting tools are available. Scoring is automated, and “pass” or “fail” messages as well as guided debriefing sequences are fully customizable. After submission to the mHBS-DHIS2 server, evaluation forms are no longer editable, providing a digital record of

the progression of learning, skills, and competencies among trainees.⁹⁴

In addition to digitized versions of the HBB second edition multiple choice questionnaire, bag-and-mask skills assessment (bag mask ventilation), and Objective Structured Clinical Examinations (OSCEs) (Fig 5B), the mHBS-DHIS2 tracker module includes QI tools, such as the health facility site visit, delivery observation checklist (Fig 5C), and HBB delivery and practice log. The former is a standardized tool used to rapidly assess a facility's readiness to provide basic neonatal resuscitation services. The delivery observation checklist is used to assess HBB competencies among HCPs during actual, observed deliveries. HBB providers use the HBB

delivery and practice log to self-report (1) the number of deliveries and resuscitations they perform each shift and (2) stillbirths, as well as (3) if they had an opportunity to engage in peer learning or skills practice. QI champions can use the mHBS-DHIS2 app to follow-up on reported resuscitations and perinatal deaths through use of the resuscitation debriefing form and perinatal death audit.

HBS program implementers and participants can use mHBS-DHIS2 in various ways to support acquisition, retention, and evaluation of key knowledge, skills, and competencies at different time points throughout the dissemination and implementation cascade. For example, facilitators or champions can use mHBS-

DHIS2 to administer educational evaluations and skills assessments to trainees before and after a course or during QI exercises. HBS providers can use the app to evaluate one another during peer learning at a course or subsequently as part of low-dose high-frequency training sessions after an in-person workshop.

Currently used as a research tool in conjunction with partners from Alupe University College, Lagos University, University of Washington, and Kenya Medical Research Institute/Oxford University (United Kingdom), mHBS-DHIS2 is undergoing field testing among HBB providers at 20 health facilities in Kenya and Nigeria. After completion of the study, mHBS-DHIS2 will be available for free download from Google Play.

CLINICAL DECISION SUPPORT

The ECEB Digital Action Plan (Fig 7 A–C) is a mobile phone–based clinical decision support tool built to support nurses, midwives, and physicians in LMICs to more effectively deliver key newborn care interventions from birth through 24 hours postnatal and to equip HCPs to prevent, recognize, and manage common newborn complications as outlined in the AAP's ECEB educational and training curriculum.

The ECEB app, which can be used as a standalone app or as a module with mHBS-DHIS2, has numerous functions, including allowing health workers to simultaneously track multiple infants across nursing shifts and to quickly ascertain, in real time, the overall patient acuity in a facility's newborn population (eg, number of “normal” versus “problem” versus “high-risk”). Births are time stamped, and automated, time-specific reminders for ECEB interventions are generated for each infant according to the infant's time of birth. There are checklists that providers can use to track the delivery of ECEB interventions for each infant. On the basis of information entered by the

user (eg, birth weight, vital signs), the ECEB app automatically classifies each infant into green (normal), yellow (problem), or red (high-risk) zones and generates advice for management. The app then automatically tracks the infants' health status over time, including their movement between ECEB zones. Requests for consultation or help from on-call providers can be sent directly from the app.

The ECEB Digital Action Plan was designed by an international team of faculty, students, and clinicians, including content experts and mobile app developers from Indiana University School of Medicine, Indiana University–Purdue University School of Informatics and Computing, Alupe University College, and Moi Teaching and Referral Hospital (Eldoret, Kenya). The multidisciplinary team collaborated over 10 months to design, develop, evaluate, and build a user interface prototype.⁹⁵ Heuristic evaluation and person-centered design assessments were conducted in Kenya among 40 nurses and midwives from 3 facilities.⁹⁶ The app, which works off-line, was awarded first prize in the American Medical Informatics Association 2019 Student Design Challenge.⁹⁷ It is anticipated to be available on Google Play in 2021.

QUALITY IMPROVEMENT

Evaluation of resuscitation care in LMICs is challenged by poor documentation of delivery room practices. As such, these evaluations are frequently limited to an assessment of delivery room preparedness (availability of an HBB-trained birth attendant and essential resuscitation equipment) rather than actions taken during a resuscitation. Digital tools to document resuscitation actions in real time provide a unique opportunity to enhance understanding of delivery room practices in LMICs and ultimately support QI.

Liveborn is an audit-feedback mobile health application for newborn resuscitation designed by Laerdal Global Health in partnership with the University of North Carolina School of Medicine (UNC SOM). Initially developed as a data collection tool, the application has been adapted for clinical use with the additions of a simplified documentation screen and automated feedback after a resuscitation. To date, Liveborn has been used in the Democratic Republic of the Congo (DRC), Nepal, Norway, and Tanzania to document >26 564 newborn resuscitations.⁹⁸

Using Liveborn, an observer can document the timing of resuscitation actions using push buttons with HBB icons for dry or stimulate, skin-to-skin, clamp cord, suction, and ventilate (Fig 8). The observer can also document when the infant begins breathing and crying. Using Bluetooth technology, Liveborn includes the option to stream heart rate from NeoBeat, Laerdal's battery-operated newborn heart rate meter. After the resuscitation, providers can review a feedback screen that visually displays a time line of resuscitation events and the newborn's breathing status and heart rate (if NeoBeat is used). This screen includes an observation about a gap in quality derived from an automatic comparison of recorded actions to the HBB algorithm. The observation is accompanied by an HBB recommendation for how to improve care and a discussion question for reflection. Data from multiple resuscitations can also be aggregated through a Microsoft Power BI dashboard system to support facility-based QI activities. Liveborn is free of charge and publicly available on both Android and iOS platforms with English and French versions.

Although publicly available, there is still uncertainty regarding how best to use Liveborn in the clinical setting. A team of investigators from UNC SOM, the Kinshasa School of Public Health, and

Laerdal are evaluating usability, feasibility, and acceptability of Liveborn in a pilot study in one health center in Kinshasa, DRC (University of North Carolina Institutional Review Board 19–3479; DRC Institutional Review Board 166/CNES/BN/PMMF/2020). Future directions for Liveborn include audiovisual real-time feedback during a resuscitation when paired with NeoBeat, as well as automation of data capture to eliminate the need for an observer.

CONCLUSIONS

The global community has 10 years to achieve Sustainable Development Goals, including health target 3.2, to reduce the overall global neonatal mortality rate to 12 per 1000 live births.⁹⁹ HBS partners and related collaboratives, such as the World Health Organization's Every Newborn Action Plan and Quality, Equity, Dignity Network, are striving to achieve this ambitious goal. To be successful, there is a critical need to substantially improve the quality of health worker education and training and delivery of newborn care for effective, high-impact interventions such as neonatal resuscitation, essential newborn care, and care for premature and small infants.^{19,84,85,100} Better tracking of high-quality neonatal data and key indicators is also urgently needed.^{79,101}

Over the past decade, a number of mobile phone app and digital health innovations have been developed to support education and training, data collection for monitoring and evaluation, clinical decision support, and QI for HBS programs. Additional data are needed regarding the efficacy, cost, and impact of each of these apps as standalone tools and as bundled innovations, where applicable.^{102,103} A number of trials are currently underway.^{98,104} If shown to be effective, and if adopted and scaled, particularly as integrated interventions,¹⁰⁵ digital tools and

platforms may have the potential to address some of the gaps and barriers that have been identified in the dissemination and implementation cascade for HBS. Overcoming these challenges might, in turn, augment global progress toward better policies, outcomes, and clinical care for newborns in LMICs.^{106–108}

Stakeholders can potentially integrate digital innovations with HBS dissemination and implementation efforts in a myriad of ways. For example, all of the digital tools described in this article could be potentially used in creative ways to support acquisition, consolidation, and retention of knowledge, skills, and performance competencies for neonatal resuscitation,^{2,4,109} both during pre-service and through integration into low-dose high-frequency skills practice, in-person refresher courses, continuing medical and/or nursing education, on-the-job training, or peer-to-peer learning among in-service providers.^{2,4,109,110} The quality of newborn care is also often impacted by high rates of staff turnover and chronic shortages of skilled nursing and physician cadres, as well as lack of high-quality data regarding key indicators and outcomes.¹¹¹ Thus, any training and data collection efficiencies that can be leveraged, via digital health interventions, to ameliorate these challenges and strengthen health systems¹¹² are potentially of high value.^{113–115}

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ABBREVIATIONS

AAP:	American Academy of Pediatrics
AIIMS:	All India Institute for Medical Science
DRC:	Democratic Republic of the Congo
ECEB:	Essential Care for Every Baby
ECSB:	Essential Care for Small Babies
eHBB:	electronic Helping Babies Breathe
ETAT+:	Emergency Triage, Assessment and Treatment plus admission care program
GHMP:	Global Health Media Project
HBB:	Helping Babies Breathe
HBS:	Helping Babies Survive
HBS-ECSB:	Helping Babies Survive–Essential Care for Small Babies
HBS-ENC:	Helping Babies Survive–Essential Newborn Care
HCP:	health care providers
LIFE:	Life-Saving Instruction for Emergencies
LMIC:	low- and middle-income country
mHBS-DHIS2:	mobile Helping Babies Survive powered by District Health Information System 2
OSCE:	Objective Structured Clinical Examination
QI:	quality improvement
UNC SOM:	University of North Carolina School of Medicine
VR:	virtual reality

Dr Bucher conceptualized and designed the review, drafted the initial manuscript, coauthored the sections on mobile Helping Babies Survive powered by the District Health Information System 2 (mHBS-DHIS2), was the primary author for the section regarding the Essential Care for Every Baby Digital Action Plan, and created the mHBS-DHIS2 and mobile Helping Babies Survive—Essential Care for Every Baby figures; Dr Cardellichio was the primary author for the section regarding Global Health Media Project; Ms Muinga was the primary author for the section regarding the Life-Saving Instruction for Emergencies platform and created the Life-Saving Instruction for Emergencies figure; Dr Patterson was the primary author for the section regarding Liveborn, created the Liveborn figure, and developed Table 1; Drs Thukral and Deorari were the primary authors for the section regarding the All India Institute for Medical Science apps and created the All India Institute for Medical Science app figures; Dr Umoren was the primary author for the section regarding electronic Helping Babies Breathe and created the electronic Helping Babies Breathe figure; Dr Purkayastha coauthored the sections on mHBS-DHIS2 and cocreated the mHBS-DHIS2 figures; and all authors reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

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