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An innovative approach to strengthen provider capacity for the prevention and treatment of postpartum hemorrhage at frontline facilities

Implementation report of a pilot study in two regions of Madagascar

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USAID'S HEALTH EVALUATION AND APPLIED RESEARCH DEVELOPMENT (HEARD) PROJECT

Authors

This report was written by Gift Kiti, Tiffany Lundeen, Professor Justin Ranjalahy Rasolofomanana, Anja Noeliarivelo, Sara Flanagan, Karen Kirk, Ietje Reerink, Charlotte Warren, Dilys Walker. We would like to acknowledge the following people for their contribution to the realization and implementation of this project: Danielle Charlet from URC who contributed to the project design and implementation support; Jana Smith, Maddie Kau, Tina Razafinimanana, John Kunz, and Marie Sandra Lennon from ideas42 who contributed to the formative research, development, and user-testing of the provider support tools implemented in this pilot; Dr. Anthony Wanyoro from Kenyatta University involved in the development of Virtual Mentor through a pilot study in Kenya; Dr.Tanjona Ratsiatosika (COMAGO), Liliane Ingabire (ACCESS), Voahirana Ravololomihanta (MoH), and Dr. Andrimbazotiana Rakotomanana (MoH) who were actively involved in the development of the algorithm and customizing it to the Madagascar context, offering feedback to the training curriculum and participating in the mentor training.

Abbreviations and acronyms

ACCESS	Accessible Continuum of Care and Essential Services Sustained
ATS	Atsinanana region (Madagascar)
APPHC	Advancements in Postpartum Hemorrhage Care
COMAGO	Collège Malgache des Gynécologues-Obstétriciens (Malagasy College of Gynecologist-Obstetricians and Gynecologists)
COVID-19	Coronavirus disease 2019
CSB	Centre de Santé de Base (Basic Health Center)
EMaD	Equipe Managériale au niveau du District
EMaR	Equipe Managériale au niveau de la Région
HEARD	Health Evaluation and Applied Research Development
PRONTO	Name of a non-governmental organization
PPH	Postpartum Hemorrhage
MV	Mentor Virtuel/Virtual Mentor
SUS	System Usability Scale
TIDieR	Template for Intervention Description and Replication
TXA	Tranexamic acid
UCSF	University of California at San Francisco
URC	University Research Co., LLC
USAID	United Nations Agency for International Development
V7V	Vatovavy Fitovinany region (Madagascar)
VM	Virtual Mentor

Introduction

The World Health Organization and others reported that almost 300,000 women died as a result of pregnancy or childbirth in 2017, with the vast majority of these deaths occurring in the low- and middle-income countries (LMICs).[1] Nearly one-quarter of global maternal deaths are associated with postpartum hemorrhage (PPH). PPH is the leading cause of maternal death in most low-income countries[2] and strategies to improve prevention and treatment must be prioritized. In response to this challenge, USAID's longstanding efforts to accelerate reductions in maternal deaths include a one-time catalytic investment in Malawi and Madagascar collectively referred to as Advancements in Postpartum Hemorrhage Care (APPHC). The objective of the APPHC investment is to inform the design and implementation of effective interventions to advance PPH prevention and treatment. USAID invested in both Breakthrough-RESEARCH (implemented by the Population Council) and the Health Evaluation and Applied Research Development (HEARD) Project (implemented by University Research Co, LLC) as co-leads in this effort.

The Virtual Mentor (VM) is a digital decision-support tool in the form of a hands-free, "talking" chatbot. VM for PPH treatment is a simple software application that can be downloaded to a mobile device that uses Android operating system. In this project, VM was downloaded to 23 7-inch Lenovo tablet devices. The VM application is not publicly available at this time.

This pilot study was designed to explore the utility, acceptability, and feasibility of a novel approach to strengthen provider capacity for the prevention, identification and management of PPH, in two regions of Madagascar. The components of the approach include:

1. **Mentorship model using Virtual Mentor and Simulation** to optimally prevent and manage PPH, including mentor visits to basic health centers (CSBs) to facilitate PPH simulation practice combined with a mobile decision support tool called Virtual Mentor; and

2. **Enhancing the clinical environment to optimize provider behaviors** by introducing new provider support tools, including a glow-in-the-dark PPH algorithm poster, task badges for delegating important support roles during childbirth to members of the family, a custom timer to encourage timely administration of the preventative dose of oxytocin immediately after birth, and an activity during the introduction of the tools to help providers visualize each woman's risk for PPH and its consequences.

This report describes the implementation process of the 2020 APPHC pilot study. A separate report details measurement and analysis of outcomes results.

[1] Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva: World Health Organization; 2019.

[2] Countdown to 2015: Maternal, Newborn, and Child Survival [Internet]. WHO and UNICEF, 2012.

Available at: http://www.countdown2015mnch.org/documents/2012Report/2012- Complete.pdf.

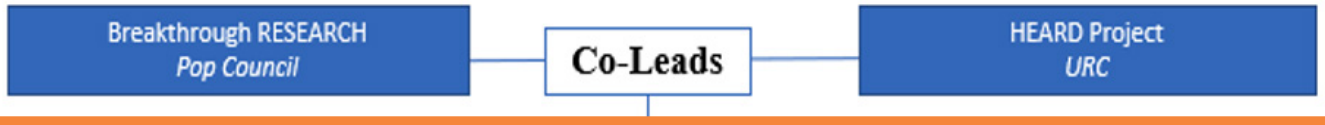
Background

In Madagascar, the maternal mortality ratio is approximately 335 maternal deaths per 100,000 live births,[3] of which approximately 30% are due to PPH.[4] Other leading causes of maternal mortality in Madagascar are sepsis (23.6%), uterine rupture (15.3%), abortion complications (11.8%) and eclampsia/pre-eclampsia (8.3%).[5] Health care providers are in short supply; Madagascar has an insufficient number of qualified health care providers, an inadequate distribution of providers in rural areas, frequent movement of providers, an aging health workforce, and 40% of the population live in areas far from health centers. [6]Quality evidence on the behavioral and structural factors that influence PPH prevention and management is limited.

The overall objectives of the APPHC collaboration were to identify the main barriers to optimal PPH treatment and to generate and test novel solutions that could change providers' PPH-related behaviors. The specific objective of this pilot study was to develop and test an approach in two regions of Madagascar that offers mentorship to providers at the CSB level and addresses selected barriers in providers' working environment.

To accomplish these goals, the co-lead organizations leveraged the expertise of several technical partners and key collaborators. Table 1 summarizes this APPHC partnership in Madagascar.

TABLE 1. APPHC LEADERSHIP, TECHNICAL PARTNERS, AND KEY COLLABORATORS IN MADAGASCAR



Technical Partners	
University of California San Francisco (UCSF)	Developed the VM, created a simulation-based training curriculum specific to PPH with VM. Supported the local team to train mentors to implement capacity-strengthening tools and provided data collection instruments.
Ideas42 (part of Breakthrough- RESEARCH consortium	Identified barriers inhibiting prevention, detection, and management of PPH by providers in Madagascar. Designed 4 provider support tools to address barriers: task badges, a PPH risk visualization activity, a timer, and a glow-in-the-dark PPH management poster; developed training videos for orientation and use of these tools; trained mentors virtually on the use of these tools; and provided monitoring instruments.
TANDEM	Worked with Breakthrough-RESEARCH to design data collection instruments, trained data collectors, coordinated training and BHC visit logistics, coordinated data collection, including quality assurance, cleaned and analyzed data.
PRONTO International	Provided simulation supplies and content for the curriculum

[3]Trends in maternal mortality 2000 to 2017, p 74.

[4] Besaina R et al. Maternal mortality related to postpartum hemorrhage: a case-control study at the Befelatanana maternity of Madagascar. Int J Reprod Contracept Obstet Gynecol 2018, 8(1):121-126.

[5] Madagascar Ministry of Public Health. Confidential investigation of maternal deaths. 2012 Report.

[6] Barmania, Sima. Madagascar's health challenges.The Lancet, 2015 Volume 386, Issue 9995, 729 - 730.

Key Collaborators	
USAID/Washington	Key stakeholder and funder
USAID/Madagascar	Key in-country stakeholder
Accessible Continuum of Care and Essential Services Sustained (ACCESS) bilateral project implemented by Management Sciences for Health	Launched in April 2019, the ACCESS program is increasing the availability of quality health services, improving health infrastructure, strengthening the capacity of the health system, and promoting healthy behaviors among Malagasy communities.[7] Contributed to tool development and implementation
Ministry of Public Health	Provided a list of mentors, provided input for a context-appropriate PPH algorithm for VM, participated in co-design of the provider support tools and reviewed and approved their training videos, participated in training of mentors, provided recommendations for future adaptations/modifications.
COMAGO	Provided input for a context-appropriate PPH algorithm for VM

The global COVID-19 pandemic introduced unexpected challenges to the APPHC effort in Madagascar due to restricted international travel forcing us to opt for virtual training. Infection control policies required that each intervention in this pilot study be consistent with global, national, and regional rules for social distancing, mask-wearing, and hygiene.

This report uses the Template for Intervention Description and Replication (TIDieR)[8] framework developed to help to improve completeness in the reporting of interventions in research studies. The TIDieR checklist is included as Appendix 1. Following the TIDieR framework, the name, rationale, description, mode of delivery and study sites (items 6-7) for each intervention are described in the "Methods" section of this report, while the intervention procedures, dose, adaptations, and fidelity (items 4-5 and 8–12) are presented in the "Results" section. We employed the TIDieR framework for this report in order to clearly describe the project plan, pragmatic variation from that plan, and the implementation of the study's interventions.

[7] Management Sciences for Health Projects. The Accessible Continuum Of Care And Essential Services Sustained (Access) Activity Available at: https://www.msh.org/our-work/projects/the-accessible-continuum-of-care-and-essential-services-sustained-access-activity

[8] Hoffmann Tammy C, Glasziou Paul P, Boutron Isabelle, Milne Ruairidh, Perera Rafael, Moher David et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide BMJ 2014; 348 :g1687

Methods

Study sites and study design

In March 2019, members of the APPHC partnership conducted a scoping visit to better understand the PPH landscape in Madagascar.[9] The scoping team engaged in numerous discussions and meetings with MSH/ACCESS, USAID/Madagascar, UN agencies, other implementing partners, and various divisions of the Ministry of Health. The team also conducted site visits at various levels of the health care system. This scoping visit presented the team with a clear understanding of the types of challenges that most commonly prevent women from accessing preventative and life-saving services both generally and specific to PPH. Delays in deciding to seek care due to cultural reasons, access challenges (e.g., lack of funds for transportation or medication, long distances from home to facility), and understaffed and undersupplied health facilities impact the care available to the population. Given the realities of the situation at the lowest level of the health system, APPHC wanted to test strategies to improve the provision of care at CSB level. This report highlights the implementation of interventions for which baseline and end-line data was collected and will be reported separately.

We conducted this pilot study in the Atsinanana (ATS) and Vatovavy Fitovinany (V7V) regions of Madagascar. These regions were chosen in consultation with ACCESS and the MOH, largely because they had the highest number of maternal deaths at CSBs in 2020.[10] A convenience sample of 10 CSBs in each of these regions were selected to participate and receive all or part of the intervention components. We used simple descriptive statistics to explain the intervention implementation and selected process outcomes.

CSBs are basic health centers and the lowest-level birth care facilities in the Madagascar health system, offering basic emergency obstetric and neonatal care. There are two types of CSBs. The CSB1 can be described as a frontline, community-based facility staffed by a nurse or midwife/paramedical staff/ nurse-midwife or a single medical doctor, while the CSB2 is located in a bigger village or district town and usually staffed by 1-2 nurses/ nurse-midwives and a doctor. Resources not available at CSB facilities include operating theater, blood supply, and many medications; individuals needing advanced care are transferred from CSBs to higher-level facilities. The most recent standard Madagascar Demographic and Health Survey (2008-2009) reports that 64% of births in Madagascar occurred at home,[11] and input from ACCESS and other key stakeholders reveals it is common for CSB providers to receive women who have delivered at home and present with PPH.[12]

All 20 CSBs selected for this study received the PPH simulation practice with VM intervention. The set of provider support tools aimed at enhancing the clinical environment were only implemented in the 10 study facilities in V7V region due to budgetary and logistical constraints (Table 2). While 19 of the selected study facilities are categorized as “CSB2” and 1 is categorized as “CSB1,” most of the CSBs we selected employed a doctor and 2 recently graduated paramedical staff.

[9] Charlet, D., Warren, C., Walker, D., Kirk, K., and Diop A. “Advancements in Post-Partum Hemorrhage Care (APPHC) start-up: Breakthrough RESEARCH (B-R) and Health Evaluation And Applied Research Development (HEARD) Projects. Antananarivo, Madagascar, March 2019: Introductory PPH Scoping Visit'' 2019.

[10] Madagascar Ministry of Health. 2020. Digital Health Information System, version 2.

[11] USAID. Enquête Démographique et de Santé 2008-2009. Available at https://dhsprogram.com/pubs/pdf/FR236/FR236.pdf. Accessed 11 March 2021.

TABLE 2. NAME, TYPE, AND LOCATION OF FACILITIES INCLUDED IN THIS STUDY AND WHICH INTERVENTIONS EACH FACILITY RECEIVED

Interventions	Region	District	Municipality	CSB Type	Name of the CSB
Provider support tools + Virtual-Mentor- Enhanced Simulation	VATOVAVY FITOVINANY (V7V)	VOHIPENO	Agnoloka	2	Agnoloka
			Andemaka	2	Andemaka
			Ivato Savana	2	Ivato
			Mahasoabe	2	Mahasoabe
			Nato	2	Nato
			Vohindava	2	Vohindava
			Vohitrindry	2	Vohitrindry
		MANAKARA ATSIMO	Ambila	2	Ambila
			Marofarihy	2	Marofarihy
			Sakoana	2	Sakoana
Virtual-Mentor-Enhanced Simulation Only	ATSINANANA (ATS)	BRICKAVILLE	Ambinaninony	2	Ambinaninony
			Brickaville	2	Maromamy
			Brickaville	2	Brickaville
		TOAMASINA 2	Foulpointe Mahavelona	2	Foulpointe Mahavelona
			Antetezambaro	2	Antetezambaro
			Toamasina Suburbaine	1	Ambalamanasy Mitsimbina IV
			Toamasina Suburbaine	2	Lazaret
		VATOMANDRY	Ambodivoananto	2	Ambodivoananto
			Maintinandry	2	Maintinandry
			Tsarasambo	2	Tsarasambo

Intervention Package Rationale

Most deaths caused by PPH are preventable. A 2018 report on maternal death published by the government of Kenya found that in 91 percent of cases, "a different management of care could have made a difference to the outcome."[13] Providers who have access to medications and methods to prevent and treat PPH may lack knowledge, experience, or confidence to apply them during an emergency. Providers at frontline facilities may be alone and unable to ask the advice of a more seasoned colleague while being solely responsible for hands-on patient care.

We created VM to provide frontline health providers with a hands-free computer decision support tool to implement the most up-to-date, evidence- and place-based treatment protocols during emergencies. For this pilot study, we hypothesized that providers who repeatedly practiced PPH management in a realistic, in situ simulation while being coached by a voice-only algorithmic chatbot would gain knowledge and confidence through the repetition of correct PPH treatment actions.

The provider support tools to enhance the clinical environment addressed behavioral barriers to provider-adherence with best practices regarding PPH that had been identified during formative research in the study area.[14] They were developed and refined together with providers and local stakeholders through a collaborative design process so that they would be responsive to the context. Providing care in CSBs is a challenging context where providers must constantly strive to overcome the structural challenges that impede their work, which can be cognitively taxing and affect their ability to respond to and manage complications. Providers often focus on the risks for other complications and perceive low risk for PPH, which leads to undervaluing prevention and monitoring measures. Providers performing deliveries alone also lack cues or feedback on their compliance with best practices for PPH prevention (for example, administration of a uterotonic within one minute of birth) or on the consequences of their current performance, which inhibits improvement of clinical practice. When women experiencing PPH do arrive it can be difficult for providers to recall their training in the moment without visual and intuitive references, especially without electricity or anyone to call for help. The provider support tools were meant to address these challenges by creating a more supportive environment for PPH prevention and treatment.

Intervention package

The intervention package tested in this pilot study was designed to strengthen provider capacity at the CSB to prevent, identify, and manage PPH. The package had two main components:

1. A mentorship model using VM and in-situ simulation practice; and
2. Enhancing the clinical environment with provider support tools to optimize PPH management behaviors.

Mentorship model using VM and simulation training

The individuals selected as mentors were midwives and physicians, members of the management teams at the regional (EMaR) and/or district (EMaD) level or were health managers with some experience in facilitating simulations (Table 3). Mentors met all the following criteria:

[13] Kenya Ministry of Health. 2017. Saving Mothers' Lives: Confidential Enquiry into Maternal Deaths in Kenya.

Available at https://familyhealth.go.ke/wp-content/uploads/2018/02/CEMD-Policy-Brief-Sept-3-FINAL.pdf. Accessed 17 Feb 2021.

[14] Flanagan, S.V., Razafinamanana, T., Warren, C., and J. Smith.. Barriers inhibiting effective detection and management of postpartum hemorrhage during facility-based births in Madagascar: findings from a qualitative study using a behavioral science lens. BMC Pregnancy Childbirth 21, 320 (2021). https://doi.org/10.1186/s12884-021-03801-w

- Available to work as a health staff with the APPHC project between July and December 2020
- Very good command of French (oral, written) to receive distance training in French with tablet/ phone application
- Motivation to learn new training techniques and openness to work in a team with external (French-speaking) trainers
- Had experience/training in one or more of the following: maternal and neonatal health, how to handle obstetric emergencies, resuscitation of newborns, and previous simulation exposure

During each CSB visit, mentors were asked to:

- Prepare a room in the CSB to serve as the simulation environment,
- Support the simulation participants in their various roles,
- Direct the progress of the simulated emergency,
- Discuss the simulation experience with participants, and
- Return the location of the simulation activity to its original state before leaving the facility.

Each CSB selected for this study received 4 mentor visits between October and December 2020.

Virtual Mentor

The VM's software is programmed according to algorithmic treatment recommendations. These recommendations are consistent with global and national treatment guidelines. For this pilot study the Virtual Mentor software was altered to

1. Be consistent with Madagascar's PPH treatment guidelines at the CSB level, and
2. "Speak" and "listen" using Google's French-language text-to-speech technology.

Obstetric experts from COMAGO, MOH, and ACCESS provided invaluable inputs to the design of Virtual Mentor's algorithm for this study.

PPH simulation

Simulation training offers an opportunity to practice responding to an emergency in a realistic setting without any danger to any participants. To practice PPH response at the CSB level in this pilot study, a patient actress was engaged to play the role of the bleeding patient. To make the simulation as realistic as possible, the patient actress wears a pair of pants with unique modifications made to help simulate birth and PPH. Fake blood is prepared before the simulation and loaded into IV-type bags and tubing that can run through the "vaginal" opening in the pants. Other materials that help make the simulation realistic are fake medications, a pad to administer injections worn by the actress and a soft newborn doll with a recorded baby cry. These materials have been developed by PRONTO International and are gathered together as a "ProntoPack.

While the patient actress lies on a clinic bed and manages the flow of fake blood, she is encouraged to speak and act like a real mother who experiences PPH. A maternity provider is instructed to interact with the patient actress as if she is a real patient and the provider should take all the actions necessary to manage the PPH. The provider uses the flowing fake blood as an indicator for the ongoing severity of the emergency and need for treatment; they also use a combination of fake medications and real assessment equipment to simulate optimal PPH treatment. Four distinct scenarios for PPH treatment practice were defined and, in collaboration with PRONTO, a written guide for each simulation was produced in French (called "SimPacks A-D") as described in Table 3 below.

PRONTO International. Available at https://prontointernational.org/

TABLE 3. PPH SIMULATION PLAN FOR EACH OF 4 CSB VISITS

Visit#	SimPack	Simulation description
1	A	Normal birth followed by a moderate PPH caused by uterine atony
2	B	Normal birth followed by a severe PPH caused by uterine atony, signs of shock
3	C	PPH diagnosed 30 minutes after birth caused by retained placental fragments, signs of shock
4	D	Precipitous birth followed by PPH caused by cervical laceration, signs of shock

In this pilot, PPH simulations were conducted in small groups of 3-5 people, including the patient actress, the mentor, and between 1 and 3 CSB providers available at the time of the facility visit. Each PPH simulation was meant to last 15-20 minutes, and after the simulation the mentor led a debrief discussion among all participants to review what happened and what was learned during the experience. Each CSB was meant to receive four different visits by a mentor, on four different days. One simulation scenario, from simulation A to simulation D, was scheduled to be done at each visit (Table 3).

Combining PPH simulation and VM

For this study, we combined PPH simulation with VM interaction. VM aims to standardize practice, decrease cognitive burden, provide up-to-date recommendations, increase timelines of interventions, and give an isolated provider the sense that they are not alone. We hypothesized that providers would retain PPH management knowledge by practicing in simulation while being "coached" in real time by the VM chatbot.

The VM application was turned on and available on the tablet device, which was generally laid on a table nearby. As each provider worked through the PPH simulation, she/he could start a "conversation" with VM by saying "Help!" When the provider spoke this trigger word, the VM algorithmic interaction began. VM asked questions about the patient condition and the provider answered, using only spoken words. VM offered assessment and treatment recommendations, such as "check vital signs" and "start an IV infusion," and the provider could choose to follow VM's recommendations to manage the PPH. The VM application stopped itself, offering a goodbye message, in 2 circumstances:

1. The PPH was successfully treated, and the woman stopped bleeding, and
2. The patient required transfer to a higher-level facility for advanced care.

Providers could stop interacting with VM at any time by saying "Stop."

Enhancing the clinical environment with provider tools to optimize behaviors

We developed and tested a set of context-specific tools meant to create a more supportive environment for providers to optimally prevent and manage PPH at the CSBs. The provider support tools package includes an introductory exercise to visualize PPH risk and consequences, a custom-built uterotonic timer to facilitate consistent and timely administration of oxytocin during active management of the third stage of labor, task badges allowing providers to easily assign specific support

roles to family members, and a glow-in-the-dark simplified and illustrated algorithm poster for PPH management. Mentors introduced these tools at the first visit to facilities in V7V region and left them to be used by providers.

Due to Breakthrough-RESEARCH restrictions against convening in-person meetings during the COVID-19 pandemic, we created videos to remotely train providers on each tool they would receive. These videos were played from a tablet the mentor carried to each facility visit. Scripts for the Malagasy-language video narration were approved by the Ministry of Health to ensure that the messaging was consistent with local guidelines for PPH. Given the context of the pandemic and the need to use a video-training format, the risk visualization exercise, originally intended to be a facilitated group activity and discussion, was adapted into an introductory video that incorporates an interactive dice rolling activity for the provider to simulate PPH risk. The intention of this risk and consequence visualization activity was to motivate providers to adhere to PPH prevention guidelines and use the tools to improve PPH detection and management.

The timers are meant to be used during routine deliveries at the CSBs to support consistent and timely oxytocin administration, which is a component of active management of the third stage of labor. Wall mounts were provided so that the timers could be installed within reach of the delivery beds in each facility. The timer is activated by the provider by pushing a button with an elbow once the baby is born. This action causes the birth time to be displayed and starts a 60-second countdown. The provider pushes the timer button again after administering the prophylactic uterotonic (oxytocin). The device can also be removed from the wall mount and used to set flexible timers for other clinical tasks; this feature was added at the request of providers during user testing before the study period. The timer training video demonstrates how to use the timer in each of these situations, incorporates moments for providers to practice by following along with the video, includes instructions for installation of the wall mount, care of the timer, and battery installation and removal. The video ends with the suggestion that provider and mentor identify an appropriate location for the wall mount and install it immediately. Each facility received one timer, a wall mount, multiple sets of rechargeable batteries, a battery charger, an instructions sheet, and a “cheat sheet” of common clinical uses for the flexible timer function.

Facilities received two sets of the 7 task badges: (1) emotional support, (2) food and water, (3) runner, (4) bleeding monitor, (5) baby care, (6) torch bearer, and (7) cleaner. A wall hanger with hooks for each type of badge was provided so they could be hung by their lanyards. The task badges are a flexible tool for providers to incorporate into their normal delivery processes in whichever way is most helpful. For example, if there are few family members available, providers can assign multiple tasks per person or prioritize the tasks most important to them. If a woman arrives at the facility late in labor or with delivery complications, providers can assign high-priority tasks verbally and distribute badges later. It is left up to providers how to implement the badges in their own facility, although the badges training video suggests these various ways providers could adapt the tool to their practice. The video also incorporates moments for providers to pause and role-play introducing the badges to family members, and suggests appropriate locations for installing the wall hanger, again recommending that it be installed immediately.

Posters are laminated and meant to be hung on walls where they will both be visible to providers during a delivery and have exposure from a light source (e.g. window) to recharge their glow during the day. The poster video explains how the photoluminescent paper works with guidance on suitable locations to hang it and suggests that it be installed immediately.

Results

Planning

First, we planned for one mentor and one patient actress to pair up and visit two CSBs in person four different times over the course of two months. Between October and November 2020, 13 mentors and 11 patient actresses were invited to participate in order to ensure sufficient personnel to accomplish all planned CSB visits. We planned for 1-3 providers to be present at CSBs during each visit, and we estimated a total of 33 unique providers would participate.

In the ATS region, three mentors were midwives and six were physicians. In the V7V region, three mentors were midwives and three mentors were physicians. All 11 patient actresses were either nurses or midwives. Mentors and patient actresses were incentivized with travel and per diem reimbursements. Next, VM was tested by ACCESS staff on the tablet devices and software updates were made to improve performance of the application before implementation.

Training of mentors

Before the effective implementation of the intervention package in the two regions, the mentors and patient actresses received an initial training respectively at the Splendide Hotel in Tamatave for the ATS region and at the H1 Hotel in Manakara for the V7V region. This first training was held in parallel in the two regions, on October 19 and 20, 2020. Detailed reports of the trainings are available upon request.

Training 1 objectives

The objectives of the first training of mentors and patient actresses were to:

1. Inform participants about the USAID APPHC project, the two interventions to be tested (provider support tools and Virtual Mentor), the roles and responsibilities of mentors;
2. Initiate mentors to the joint use of the Virtual Mentor and the PRONTO material kit for simulation training, with application of the first scenario (SimPack A); and
3. Train mentors in data collection, including the provider behavior checklist after each PPH simulation and the mentor logbook completed after each CSB visit.

Because of travel restrictions imposed by the COVID-19 pandemic, the first training was facilitated remotely by officials from UCSF and URC alongside support from on-the-ground APPHC consultants and TANDEM (made up of a regional supervisor, a computer scientist and a research assistant) who supported the facilitation, logistics and administrative aspects. The in-country participants met in person in each region and were connected via Zoom to the UCSF and URC team.

The second training for mentors and patient actresses was held after the first visit had already occurred at most CSB sites. In Manakara (V7V), it took place on November 6, 2020 at the Hotel La Vanille. For the ATS region, it was organized on November 21, 2020 at the Concordia Hotel in Tamatave.

Training 2 objectives

The objectives of the 2nd training of mentors and patient actresses were to:

1. Debrief and review experiences of the first visit,
2. Orient mentors and patient actresses to SimPacks B, C and D,
3. Review the research objectives of the project, review the data collection tools, share any updates or clarifications,
4. Apply the comments / feedback received during the first training.

In addition to the mentors and patient actresses, representatives of the Ministry of Public Health (central level, DRSP, SDSP) and ACCESS attended both training sessions in both localities.

Through an online learning management system, PRONTO International provided access to several French-language training videos detailing how to facilitate simulations. The research team provided mentors with SimPacks and mentor guides that included step-by-step instructions for each of the 4 planned mentor visits for the 4 PPH scenarios.

Mentors in V7V were also provided with a checklist to introduce the tools to enhance the clinical environment during the first visit, including playing the training videos for providers and installing each tool in its appropriate location. The training videos were downloaded onto mentors' tablets to allow for access even while offline.

During this phase, the research team also developed a monitoring and evaluation plan. Table 4 displays the data collection instruments used during this pilot study. Detailed results of the data collected (instrument 1-7) will be available in a separate report.

TABLE 4. DATA COLLECTION INSTRUMENTS USED DURING APPHC PILOT STUDY

	Instrument name	Time point(s)	Description	Completed the instrument
1	**PPH knowledge assessment**	Before 1st PPH simulation and after 4th PPH simulation (pre- and post-)	A 10-item questionnaire and an open-ended interview about a PPH case	Providers
2	**Self-efficacy questionnaire**	Before 1st PPH simulation and after 4th PPH simulation (pre- and post-)	7-item questionnaire with a 10-point Likert scale for responses	Providers
3	**System Usability Scale**	After 4th PPH simulation	10-item questionnaire validated and used widely in technology product design	Providers and mentors
4	**Acceptability and feasibility question naire**	After 4th PPH simulation	30-item questionnaire with 5-point Likert scale for responses	Providers and mentors
5	**Simulation behavior checklist**	After every visit	A list of 21 PPH management actions that providers could have accomplished during any simulation	Mentors
6	**Mentor log book**	After every visit	A record of participants and activities accomplished during the visit	Mentors
7	**Sustainability interview**	After 4th CSB visit	Short open-ended interview focused on sustainability of APPHC approach	Providers
8	**Implementation interview**	After all visits complete	In-depth, open-ended interview about mentors' experiences	Mentors
9	**Facility observation of the use of provider support tools**	During visits 2-4	An 18-item questionnaire about the location and condition of the provider support tools	TANDEM data collectors
10	**Semi-structured interview with providers on their experiences and perceptions on the use of support tools**	During visit 2 and 4	In-depth, open-ended interview about providers' experiences with the support tools	Providers

Visit participants

Each CSB visit was carried out by a team consisting of a mentor, a patient actress (Tandem) and a research assistant (Tandem). When the visit schedule allowed, the regional supervisor (Tandem) accompanied the team. A local videographer provided video coverage of a few simulation sessions in the CSBs. Other stakeholders (APPHC, ACCESS, etc.) also participated in some visits as observers. The roles of the participants during CSB visits are summarized in Table 5.

TABLE 5. ROLES OF PARTICIPANTS IN EACH CSB VISIT

Participant type	Role
CSB providers	• Practice managing PPH via simulation training with Virtual Mentor • Use tools to enhance clinical environment • Participate in data collection activities
Mentors	• Prepare the environment (space, PRONTO materials, etc.) for the simulation • Present support tools for providers (support toolkit, videos on support tools) • Theoretical reminder of the management of PPH (PowerPoint presentation) • Present VM and PRONTO materials to service providers • Brief providers prior to each simulation • Support participants (providers, patient actress) in their different roles • Facilitate PPH simulations using VM, the supplies and Simpack guides • Conduct debriefing after the simulation • Collect monitoring data (provider behavior checklist and mentor's logbook on the use of VM) • Participate in monitoring data collection activities (Table 4)
Patient actresses	• Play the role of patient actress during the simulations using the VM at the CSBs
Research assistants	• Obtain informed consent from providers to participate in the study • Collect monitoring data on the two interventions, from providers and mentors, according to the pre-established collection schedule

These visits were conducted by six mentors and six patient actresses in V7V and nine mentors and five patient actresses in the ATS region. Mentor participation in CSB visits is summarized in Table 6. Two CSBs (1 in ATS and 1 in V7V region) received visits 3 and 4 on consecutive days because they were very remote, but we confirmed that all four PPH simulation scenarios were conducted in each CSB. Most CSB visits were made by one mentor, but 30% of visits in ATS region were made by two mentors together; these 2 mentors preferred to collaborate and insisted on this arrangement.

TABLE 6. SUMMARY OF MENTOR PARTICIPATION AT CSB VISITS

	ATS	V7V	Both regions combined
Average # of visits accomplished by each mentor (range)	5 (1-12)	7 (2-10)	6 (1-12)
% of mentors who accomplished	80	50	6 (1-12)
<8 visits	10	33	
8 visits	10	17	
>8 visits			
% of mentors that accomplished 4 visits to 2 CSBs	10	33	
% of CSB visits that included 1 mentor	70	100	
% of CSB visits that included 2 mentors	30	0	

Implementation

At the time of each CSB visit, the mentor and TANDEM representative together invited providers to participate. Providers were free to decline without any negative consequences. Participating providers met the following criteria:

- physicians, nurses, or midwives responsible for birth care;
- between 18 and 64 years of age;
- fluent in French and;
- able to hear.

Each provider who consented to participate was asked to attend four mentor visits to her/his CSB during the study period (capacity strengthening) and to use the tools to enhance the clinical environment at her/his CSB. The majority of participants were women, younger than 40 years old, midwives, with less than five years' experience since qualification. A selection of provider characteristics appears in Table 7.

TABLE 7. PROVIDER CHARACTERISTICS REPORTED AT 4TH MENTOR VISIT

Characteristic	ATS (n=11)	V7V (n=10)	Both regions combined (n=21)
Gender			
Female	(73%) 8	(80%) 8	(76%) 16
Male	(27%) 3	(20%) 2	(24%) 5
Age			
Less than 40 years	(82%) 9	(80%) 8	(81%) 17
40 years or more	(18%) 2	(20%) 2	(19%) 4
Professional qualification			
General practitioner	(9%) 1	(20%) 2	(14%) 3
Generalist midwife	(55%) 6	(60%) 6	(57%) 12
General nurse	(36%) 4	(20%) 2	(29%) 6
Years of qualification			
Less than 5 years	(64%) 7	(40%) 4	(52%) 11
5 to 9 years	(18%) 2	(30%) 3	(24%) 5
10 years or more	(18%) 2	(30%) 3	(24%) 5

During the first visits in V7V mentors introduced the provider support tools to enhance the clinical environment and played their training videos via tablet. After watching the videos, providers practiced use of the tools and identified a suitable location in the facility for their immediate installation. Once the tools and initial training were delivered, providers were asked to incorporate their use into routine care without follow-up engagement.

In both V7V and ATS, before each CSB visit, the mentor and patient actress prepared to conduct 1 of 4 PPH simulation scenarios (Table 3). At the beginning of each CSB visit, the mentor engaged provider participants in a 30-minute discussion of correct PPH management. Mentors used a discussion guide aligned with the "Training in Maternal and Neonatal Health: Facilitator's Guide" provided by the Ministry of Public Health in Madagascar (September 2019). Next, the mentor-oriented provider participants to PPH simulation, including the role of the patient actress, materials available to simulate clinical consumables, the "rules" of simulation, and the patient case. Finally, the mentor-oriented provider participants to VM and instructed them to say "Help!" when they noted the patient was bleeding excessively during the simulation. Providers practiced "talking" to VM before the simulation began. The tablet to which Virtual Mentor was downloaded was placed near the PPH simulation area.

As the simulation proceeded, the patient actress pretended to experience PPH with simulated blood flowing in large quantities on the absorbent pads under her. The patient actress and mentor communicated silently with hand signals as the scenario progressed. The provider called for

help after diagnosing PPH. If a second provider was in attendance, that colleague could enter the simulation and provide hands-on assistance. When the call for "Help!" was heard, the Virtual Mentor turned on and began coaching the provider. Each of the four PPH scenarios was brought to a predetermined end point, either with resolution of the bleeding or refractory hemorrhage requiring referral to a higher level of care. Table 3 summarizes the four PPH simulation scenarios. The simulations were meant to feel as real as possible. After the simulation, the mentor facilitated a discussion about the participants' mental, emotional and physical response to the simulation to ensure that the individual was not stressed or traumatized by the experience. In a few cases, more than one of the scheduled four simulation scenarios was conducted during a single mentor visit because the CSB was very remote, and the mentor could not make four separate journeys.

A TANDEM research assistant accompanied the mentor on each CSB visit and completed most of the planned data collection activities (highlighted in Table 4) during the visit. These 10 research assistants were all either nurses or midwives. The mentor completed two data collection instruments after each visit: a mentor log and a provider behavior checklist. This checklist documented all the simulated actions the provider took to treat PPH and was meant to record whether providers completed the actions recommended to them by Virtual Mentor.

Implementation Support

Several activities served to support the implementation of this study. They include:

1. Careful scheduling of mentor visits to CSBs;
2. Providing per diem reimbursements for mentors on the basis of rates validated by USAID;
3. Organizing and funding transportation of mentors to study sites; and
4. Collaborating with regional TANDEM supervisors that monitored mentor activities.

Monitoring

Throughout the period of this pilot study, 14 unique providers in the ATS region and 16 unique providers in the V7V region participated in any of the CSB visits. Of the 30 unique providers consented across both regions, 18 providers (60%) attended all four visits to their CSB. Table 8 gives an overview of these CSB visits. On average, visits occurred every 15 days during the study period. 70% of visits included one provider participant, 30% of visits included two provider participants, and only one CSB visit included three provider participants. PPE was provided by TANDEM staff during all visits but during 13% of visits not all participants chose to use it; this data was documented in the TANDEM supervisor's log.

TABLE 8. SUMMARY OF CSB VISITS

Description	ATS	V7V	Both regions combined
Average number of days between visits (range)	15 (1-37)	14 (2-28)	15 (1-37)
Average number of provider participants present during the visit (range)	1 (1-2)	1 (1-3)	
% of visits at which 1 provider was present	70%	70%	
% of visits at which 2-3 providers were present	30%	30%	
Average length of each PPH simulation activity in minutes (range)	80 (20-180)	65 (17-120)	74 (17-180)
Yes, PPE was used during the visit	84%	90%	87%

With the exception of CSB2 Brickaville (Atsinanana region), for which the first visit had to be repeated due to technical difficulties with Virtual Mentor, each of the 20 intervention CSBs benefited from four mentor visits, for a total of 81 visits. These visits were carried out during the period from October 23 to December 18, 2020 in the V7V region and from October 27 to December 23, 2020 in ATS region.

Mentor support

Throughout the study period, mentors were offered three sources of support: a WhatsApp group, three telephone coaching sessions with technical advisors at UCSF and the APPHC in-country consultant, and frequent check-in calls by TANDEM supervisors. Nine of 15 mentors participated in the coaching sessions and all 15 mentors were contacted by TANDEM supervisors for frequent check-ins by phone. Very few mentors participated in the WhatsApp group.

The WhatsApp group provided mentors the opportunity to ask one another questions and get support from their peers. In the telephone coaching sessions, mentors shared questions and challenges and asked for advice. For example, during a coaching session mentors expressed that they needed more information about facilitating simulations and that they wanted to watch the videos exclusively available on the online PRONTO learning management system. In response, the project provided mentors with more data use credits so they could watch these videos.

Feedback

As described above, most visits to each CSB selected were observed and documented by a TANDEM supervisor. These observers wrote comments after the visits, which fell into three main categories: 1) providers were excited about the potential of the VM and asked to use it during real PPH, even though at times they felt frustrated VM did not understand their speech; 2) some providers appeared very inexperienced and were not ready to successfully manage PPH, but they were open to feedback; and 3) some mentors struggled through the first visit. Selected observations written by TANDEM supervisors that demonstrate these themes are included below.

1) Providers were excited about the potential of the Virtual Mentor and asked to use it during real PPH, even though there are usability issues with Virtual Mentor that require improvement.

> **"[The provider was] very surprised and interested in the Virtual Mentor. All the tablets work well, except the utterances of the provider which disrupts the Virtual Mentor. After the simulation, the provider would like to obtain the Virtual Mentor as an aid or support device in the event that a PPH presents itself."**

> **"After the simulation, the service provider is very surprised, he accepts and fully agrees with the feasibility of the Virtual Mentor, he asks for an endowment of this device for the CSB because it facilitates and serves as a guide in the event that a PPH arises in the center."**

> **"The providers are surprised; the Virtual Mentor makes the work easier. Improve the sound of the Virtual Mentor. Providers are eager to have the Virtual Mentor."**

> **"Interesting and innovative Virtual Mentor according to the providers. Rewarding experience despite a little stress and fear of PPH. Virtual Mentor can be a real help in the event of PPH."**

> **"Motivated provider for the Virtual Mentor, speaks good French. Easy to handle training material, a great help to providers in the management of PPH. Simulation carried out. Virtual Mentor [has a] sound problem. You have to repeat several times before the Virtual Mentor responds. Suggestions: speak loudly and articulate well."**

> **"Providers interested in the Virtual Mentor application: useful application. Existence of a pause time between the mentor's call and the Virtual Mentor's response. Need to repeat the message several times before having a response from the Virtual Mentor, which can cause problems in a real case, because it is an emergency."**

> **"The Virtual Mentor asked the provider to reassure the patient, he admitted to never having done this before."**

2) Some providers appeared inexperienced and were not ready to successfully manage PPH, but they were open to feedback. The providers mentioned in these comments may have been very recently qualified, but we do not have disaggregated data about them.

> **"[The provider] is not so suitable to take charge of PPH, and she will require a lot of simulation exercises."**

> **"Service provider motivated to participate in the simulation points to be improved."**

3) Some mentors struggled through the first visit. Combining the first simulations and support tool introduction into the same CSB visit may also have overwhelmed mentors and providers in V7V.

> **"Unsatisfactory preparation of the tools (4 support tools not well explained to the service providers)."**

> **"Simulation 1 not well prepared: Mentor didn't have her textbook with her, she seemed a bit confused, not really knowing what to do."**

> **"The debriefing the mentor should do was not done properly."**

> **"According to the provider, the instructions given by the mentor [for placement of the support tools] were not clear."**

Four other sources of feedback were vital during and after the study:

1. Video recordings of the mentor visits,
2. Coaching sessions conducted by colleagues at UCSF,
3. Anecdotes shared by mentors and TANDEM staff during calls and in the WhatsApp group, and;
4. Mentor workshops convened at the end of the study period.

Adaptations made to the intervention in response to these inputs are summarized in Table 9.

TABLE 9. ADAPTATIONS MADE DURING THE STUDY PERIOD IN RESPONSE TO FEEDBACK

Challenge	Adaption
Virtual Mentor could not reliably understand providers' speech	• We removed the pieces of sachets covering the microphones of the tablets to achieve better audio function. • We disabled automatic tablet updating to prevent the system from automatically switching to a language not recognized by the Virtual Mentor when the tablet is connected to the Internet. • The wearable Bluetooth-enabled speaker-microphone devices we provided did not reliably connect to the tablets, so they were abandoned. The provider had to interact with Virtual Mentor directly through the tablet, which did not have optimal microphone quality. In some simulations the TANDEM representative had to carry the tablet around, keeping it close to the provider's face during the simulation so the tablet could hear the provider's speech. • We updated Virtual Mentor's software with additional phrases that were more easily detected when spoken by providers.
The COVID-19 pandemic restricted international travel, which required adjustment to training activities	• The first mentor training meeting included mentors in both regions, connected by Zoom meeting with the UCSF team. This proved too difficult, so the second training meeting was convened separately in each region again with UCSF connected via Zoom. • From time to time the virtual training was interrupted by poor internet connection. Given local facilitators had the materials downloaded on their laptops they were able to continue with the presentations to save time. • We provided mentors with airtime so they could watch training videos asynchronously, as many times as they desired
Some mentors required coaching	• Remote coaching sessions with technical experts • Check-in and guidance calls from Tandem staff
Tools to enhance clinical environment	• The TANDEM team helped to make sure the provider support tools were all in place during the 2nd visit, as not all tools had been installed during the first mentor visit.

Although V7V providers were interviewed on their use and understanding of the environment enhancing support tools during CSB visits 2 and 4, responses were not available until after the study period and so could not be used to assess the need for additional support or training (particularly on features of the timer) during implementation. Instances of minor misunderstanding revealed later suggest that rewatching the training videos or having a designated introduction and installation visit not combined with simulations and other activities may have enhanced provider understanding of their use.

Approximately one month after the study ended, a selection of mentor and provider participants convened in a one-day workshop; one of these was convened in each region. Detailed report on these workshops is available upon request. The objectives of these meetings were:

1. To understand how the APPHC approach could be scaled sustainably in Madagascar, and;
2. To define an ideal mentoring model for Madagascar.

These workshops provided invaluable feedback. Participants provided a list of personal and professional characteristics the ideal mentor must possess. They asserted that in order for this training approach to be sustainable, the following must be accomplished:

- Technology
    - Mobile devices available at CSBs, and with better audio capability
    - Reliable power source to charge mobile device
- Providers
    - Staff retention at CSBs
    - Motivation/incentives, such as certificates
- Mentors
    - Remote and in-person coaching
    - Allowances
    - Data credits to access streaming videos

Other key findings and recommendations from these workshops include:

1. Provider participants recommended that all providers should have access to this training and that mentors should provide follow-up and supervision (in-person or remote) to reinforce the training content.
2. Providers requested to have access to Virtual Mentor at the CSB even when clinical mentors are not present.
3. Mentor participants desired further training in order to master simulation and mentorship skills and certification, in order to advance their opportunities for professional promotion.
4. The average recommended frequency of mentor visits to CSBs was between 2-4 times in a year for a duration of half a day to two days.
5. Providers and mentors were asked if matrons (community-based, unlicensed midwives) should be invited to participate in simulation training; their opinions were divided on this subject.
6. Providers in V7V wanted to continue using the physical provider support tools (timer, badges, and poster) provided to their facilities and recommended that all providers have access to them.
7. Despite enthusiasm for the physical support tools, participants raised concerns about the risk messaging in the adapted visualization exercise, which suggests it was not received as intended.
8. Facilities in ATS region did not receive provider support tools; however, providers from ATS region who watched the provider support tools training videos during the post-study workshop commented on the tools' usefulness and wanted to learn more about them.

Intervention Package Fidelity

Mentors documented that PPH simulations occurred at 100% of CSB visits. Most simulations took place in the labor room and in other cases the delivery room, consultation room or midwife's office. The average PPH simulation lasted about 1 hour and 15 minutes, from orientation to post-simulation discussion, but these were slightly longer at CSBs in Atsinanana (Table 7). Mentors also documented that VM was used in 100% of PPH simulations, but that they experienced technical problems with VM about 30% of the time. Two technical difficulties documented by mentors were that the tablet microphone and/or speaker did not function well, and that VM could not reliably understand the provider's responses in French. Other VM usability challenges related to the software design were that VM's speech in French was too fast to be captured completely by the provider and that VM did not pause long enough to allow the provider to complete actions that require a significant amount of time, such as cervical laceration repair.

Facility observations by TANDEM data collectors and endline provider interviews confirmed that all 10 study facilities in V7V region received the environment-enhancing tools during the first mentor visit: a timer with a charger and spare batteries, two sets of badges with a hanger, and the glow-in-the-dark poster. Data for 30 observations of implementation of the environment-enhancing tools during facility visits are available (Table 10). We do not have data to report whether or not all providers watched every training video, or how long was spent reviewing the environment-enhancing tools and practicing their use.

During the second mentor visit, the TANDEM data collectors noted that at four CSBs not all the environment-enhancing tools were installed. Barriers to successful implementation were varied. At two CSBs, a hammer was not available during the first mentor visit to install wall mounts for the timer device and task badge hangers, and so these intended tasks were not completed. In other CSBs, some tools (e.g. timer device) were stored in an office while the Chief was away. At one CSB, the Chief was away for the entire study period and the midwife was on maternity leave during the mentor's first CSB visit; the mentor explained the tools to her during the third visit. By the fourth mentor visit, TANDEM staff documented the tools were in place and used in all 10 facilities in V7V region.

TABLE 10. OBSERVATIONS OF PROVIDER SUPPORT TOOLS TO ENHANCE THE CLINICAL ENVIRONMENT FOR EACH OF 30 FACILITY VISITS

Return visits to V7V CSBs at which:	Percentage (n=30)
The timer was functioning (i.e. batteries charged)	90%
The timer had been used during a delivery in the previous 24 hours*	78%
The badges were in good condition	100%
The badges were currently or recently in use by family members	37%
The poster was clearly visible from the delivery bed	97%

*May also reflect use during simulation sessions, depending on when observations occurred during visits, as many CSBs were unlikely to have had a delivery within the previous 24 hours.

The mentor completed a "logbook" entry after each CSB visit. This entry documented everything that occurred during the visit. According to these logbook entries, the intended simulation was done, with Virtual Mentor, at 100% of the visits. We intended that each CSB would receive 4 visits from the same mentor. 100% fidelity to this goal was not possible, but just over half of CSBs did achieve this. Continuity of mentors over time is reported in Table 11.

TABLE 11. CONTINUITY OF MENTORS ACROSS CSB VISITS

	ATS (10 CSBs)	V7V (10 CSBs)	Both regions (20 CSBs)
CSBs that received all 4 visits from the same mentor	4	7	11
CSBs that received visits from 2 different mentors	1	3	4
CSBs that received visits from 3 different mentors	4	0	4
CSBs that received visits from 4 different mentors	1	0	1

It appears that the intervention, as it was planned, may have been delivered with greater fidelity in V7V region, using the following measures:

- More CSBs received 4 visits from a continuous mentor in V7V region
- 50% of CSBs in ATS region received visits from 3-4 different mentors compared to 0% in V7V region

Mentor activities during most CSB visits were observed and documented by a data collection team supervisor, who completed an intervention fidelity checklist. Among these observed visits, the average total length of the visit was:

- V7V region
  - 6 hours from mentor's arrival to departure at CSB (range 3-8 hours)
  - 3 hours recorded as "length of visit" (range 2-5 hours)
- ATS region
  - 4 hours from mentor's arrival to departure at CSB (range 1.5-11 hours)
  - 4 hours recorded as "length of visit" (range 1.5-8 hours)

The pre-simulation review of PPH management and intended simulation was completed at 100% of these observed visits. Virtual Mentor was used 100% of the time.

Discussion

We assert that this pilot study accomplished the overall objective of the APPHC collaboration, which is to identify barriers to optimal PPH treatment in Madagascar and to generate and test novel solutions that can change frontline providers' PPH-related behaviors. From project planning to implementation to evaluation, key collaborators and technical partners were fully engaged. The implementation data we present here suggest that the project was successfully executed and can be replicated or scaled in similar contexts. Outcomes data specific to the PPH simulation plus VM intervention, including PPH knowledge and self-efficacy and tool usability, acceptability, and feasibility measures, are reported separately in the accompanying document, titled "Outcomes of a novel mentorship approach tested in 2 regions of Madagascar."

This study successfully demonstrated several components of the approach.

- Use of realistic emergency in-situ simulations at frontline facilities in Madagascar is feasible and adding a device like the Virtual Mentor to reinforce correct management actions is both feasible and acceptable.
- This mentorship model is feasible. CSB providers were enthusiastic participants in mentor visits to their facilities. Full-time work as expert simulation trainers may even be a professional path for skilled mentors in Madagascar.
- Remote participation in training events by stakeholders and technical advisors is possible if best practices are applied. Additional in-person training in simulation facilitation is recommended for mentors.
- Video introduction of support tools to enhance the clinical environment for preventing, detecting and managing PPH is feasible and functional, although additional follow up support may be needed to ensure proper installation and full understanding of operation in the case of the timer.
- Providers can use the support tools during PPH simulation practice. In V7V, there were documented instances when the timer was used or poster was referenced during PPH simulations.

The success of this project relied on inputs from key collaborators, especially towards the:

- Design of the PPH algorithm for VM
- Initial design and refinement of the tools to enhance the clinical environment
- Significant adjustments to the training curriculum and activity plan
- Transportation and storage of materials and supplies
- Extracurricular monitoring visits to CSBs

Table 12 summarizes lessons we learned during this pilot that we recommend be applied to future implementation of this approach. Tasks such as scheduling visits and coordinating with regional and district MoH were essential and would need to be assigned to appropriate individuals to ensure consistency in implementation.

TABLE 12. RECOMMENDATIONS FOR FUTURE IMPLEMENTATION

Topic	Recommendations and rationale
Provider motivation	• Provide snacks during a brief break; keeps participants engaged and helps them feel valued.
Mentor motivation	• Provide a unique certification to mentors for the participation
Simulation	• At least one hour should be allocated to each simulation-plus-debrief session, per every 1-2 participants, to increase their comprehension of key concepts.
Virtual Mentor	• Software must be revised to better understand users' voices. • The next implementation could use smartphones with better microphones. • Plan for time and collaborators to test Virtual Mentor "in the field" before deployment. • In Madagascar, users prefer that Virtual Mentor's language is changed to Malagasy

Tablet	• Automatic operating system updates should be disabled to avoid language setting changes • Devices should be checked for any pieces of plastic covering microphone that might limit audio capabilities • Presence of IT specialist in training room is helpful to help trainees become comfortable with unfamiliar devices • If a wearable bluetooth-enabled microphone is desired, compatibility with tablet or phone device must be proven
Mentor training events	• Ensure 1-2 competent coordinators who can aid in the training and workshop facilitation, handle logistics, and manage mentor queries for smooth training. • Have at least one facilitator who speaks Malagasy very well for barrier-free communication with the participants. • Tech support to manage internet and remote connectivity issues as they arise. • Set up the room and materials in advance. • Run a dress rehearsal of the entire training to troubleshoot any challenges that might occur. • Add 2-3 days of in-person mentor training to focus on simulation facilitation and debriefing skills. • WhatsApp groups and Zoom Whiteboard could be useful platforms for time reminders. • Participants should be allocated time to read or watch preparatory materials in advance of the training. • Devices should all be checked and repaired before training. • The hotel selected for the training should have good broadband connection and a working back-up generator. • High-quality audio system for remote training is key.
Mentor support	• Coaching sessions, scheduled after the training and hosted by intervention experts, help mentors succeed. • Mentors appreciate routine phone calls by program managers or regional supervisors.
Tools to enhance the clinical environment	• Allow time for providers to practice using the new tools to make sure they fully understand the training. This may require a designated visit that is not combined with simulation training. • Support providers to install the tools in appropriate locations in their facility immediately after training on their use and reinforce to providers the importance of their availability and accessibility during all deliveries. • The COVID-19 adaptation of the risk visualization exercise into a video and individual activity was not understood well and should be re-tested as a facilitated group activity when conditions permit.

Conclusion

In this pilot study, clinical mentors successfully delivered an intervention to improve frontline facility providers' readiness to manage PPH, despite a short study period and significant travel times to CSBs. Providers were eager to receive mentorship and were enthusiastic about the realistic in-situ simulations, VM, and the 3 of the 4 provider support tools (timer, family task badges, glow-in-the-dark PPH management algorithm).

Mentor and provider participants consistently communicated that while VM is suitable for training and even real patient care, the application requires further improvement to be fully functional.

This mentorship approach tested in this study warrants further exploration in more facilities and with additional high-priority maternal-newborn scenarios, such as maternal hypertension or neonatal resuscitation. Mentors will benefit from advanced training in simulation facilitation.

Providers reported during interviews that they appreciated the provider support tools and intend to continue using them during routine birth care in their CSBs. The three physical tools (timer, badges and poster) were easy to implement but not all facilities installed the tools as intended. Using the oxytocin timer was straightforward and the providers did not have trouble using it. The family task badges were seen as improving provider organization and productivity by distributing non-clinical tasks to family members present during delivery. Finally, the glow-in-the-dark poster served as a reminder for providers on the steps of managing PPH. There is potential for these support tools to be introduced in additional facilities to aid and reinforce knowledge related to PPH care.

In this report, we have described in detail the implementation of a pilot study to test a novel approach using mentorship and provider support tools to improve prevention and treatment of PPH at 20 frontline facilities in Madagascar. We aimed to report our process and results in enough detail that this approach could be replicated or advanced using the implementation lessons we learned. These findings can inform the design and content of the next phase of capacity-strengthening efforts that will support frontline maternity providers in Madagascar.

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