Obstetric Simulation Training and Teamwork

Immediate Impact on Knowledge, Teamwork, and Adherence to Hemorrhage Protocols

Joy A. Greer, MD, FACOG, FPMRS, CHSE, CAPT, MC, USN;

Monica A. Lutgendorf, MD, FACOG, CDR, MC, USN;

Christopher S. Ennen, MD, CDR, MC, USN;

Lauren Van Petten, PhD, CHSE;

Adrian Modzik, BS, CCRC;

Dominick Salas, BA;

Jessica Fish, MS;

Reginald Middlebrooks, DNP, CRNA;

Carmen N. Spalding, PhD, RN, CHSE;

Donald R. Delorey, PhD

Introduction: The Obstetric Simulation Training and Teamwork (OB-STaT) curriculum was an in situ interprofessional program to provide standardized postpartum hemorrhage (PPH) simulation training throughout a health system to decrease PPH morbidity. In this study portion, investigators hypothesized that OB-STaT would increase: (a) team member knowledge in diagnosis and management of PPH, (b) teamwork, (c) adherence to established PPH protocols, and (d) patient satisfaction.

Methods: The OB-STaT was implemented at 8 US Navy hospitals between February 2018 and November 2019. Participant PPH treatment and maternal/neonatal resuscitation pretraining/posttraining knowledge was assessed via an 11-item test, whereas teamwork and standardized patient assessment were rated using validated Likert-type scales: the 15-item Clinical Teamwork Scale and 3-item Patient Perception Score, with item ranges of 0 to 10 and 0 to 5, respectively. Local PPH protocol adherence was assessed using role-specific checklists, with a potential maximum of 14 points (anesthesia/nursing) or 22 points (obstetrics).

Results: Fifty-four interprofessional teams participated. Obstetricians (trainees and attendings) demonstrated significantly improved knowledge test scores (8.33 ± 1.6 vs. 8.66 ± 1.5, $P < 0.01$). Between the 2 scenarios, overall mean Clinical Teamwork Scale scores improved significantly for all interprofessional teams (5.82 ± 2.0 vs. 7.25 ± 1.9, $P < 0.01$). Anesthesia, nursing, and obstetric subteams demonstrated significant increases in protocol adherence as measured by critical action scores (12.28 ± 1.7 vs. 13.56 ± 1.0, 12.43 ± 1.6 vs. 13.14 ± 1.3, and 18.14 ± 2.7 vs. 19.56 ± 2.1 respectively, all $P < 0.02$). Although overall standardized patient satisfaction did not significantly improve, scores for feeling well informed did (3.36 ± 1.0 vs. 3.76 ± 0.8, $P < 0.01$).

Conclusions: The OB-STaT curriculum modestly improved participants' teamwork, communication, and protocol adherence during simulated PPH scenarios; OB-STaT may decrease PPH morbidity.

(*Sim Healthcare* 18:32–41, 2023)

Key Words: Medical simulation, obstetric simulation training, postpartum hemorrhage, teamwork.

Postpartum hemorrhage (PPH), a subset of obstetric hemorrhage, is a life-threatening, unpredictable emergency that complicates 4–6% of all deliveries.[1] Healthcare simulation is an integral part of obstetric hemorrhage safety programs and bundles that have been associated with improved outcomes.[2–4] Despite the widespread use of obstetric simulation, publications related to simulation benefits in the management of obstetric hemorrhage are limited, possibly due to differences in curriculum, simulation resources, and implementation that hamper system-wide policy changes.[5–13] Studies examining teamwork training for PPH did not show a benefit in reducing composite obstetric outcomes, though hemorrhage management improved with increased interventions for severe PPH.[10]

Pregnancy-related care accounts for 49% of the inpatient care provided to female beneficiaries within the Military Health System (MHS), with approximately 40,000 annual deliveries.[14] Since July 2018, system-wide changes have been implemented to improve care and standardize PPH treatment

From the Healthcare Simulation and Bioskills Training Center (J.A.G., L.V.P., A.M., D.R.D.), and Department of Gynecologic Surgery and Obstetrics, Naval Medical Center, Portsmouth, VA (J.A.G., C.S.E.); Department of Gynecologic Surgery and Obstetrics (J.A.G., M.A.L.), Uniformed Services University of Health Sciences, Bethesda, MD; Department of Gynecologic Surgery and Obstetrics (M.A.L., D.S., J.F.), Naval Medical Center, San Diego, CA; Department of Anesthesia, Naval Medical Center, Portsmouth, VA (R.M.); and Bioskills (C.N.S.), Simulation Training Center, Naval Medical Center, San Diego, CA.

Correspondence to: Joy A. Greer, MD, FACOG, FPMRS, CHSE, CAPT, MC, USN, Naval Medical Center Portsmouth, 620 John Paul Jones Cir, Portsmouth, VA 23708 (e-mail: joy.a.greer.mil@mail.mil).

The authors declare no conflict of interest.

This study was supported by funding from Department of Defense, Joint Program Committee 1, Medical Simulation and Information Sciences Research Program, and Congressionally Directed Medical Research Programs under award number DM17-0-467.

The study protocol was approved by the Navy Medical Center Portsmouth Institutional Review Board in compliance with all applicable federal regulations governing the protection of human subjects.

Research data were derived from an approved Naval Medical Center, Portsmouth, Virginia IRB (protocol number NMCP.2018.0001).

The views expressed in this abstract reflect the results of research conducted by the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the US Government.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.simulationinhealthcare.com).

DOI: 10.1097/SIH.0000000000000641

across institutions in the MHS, including required participation in semiannual simulation drills on the identification and treatment of PPH.[15] Recently, the Joint Commission mandated annual participation in obstetric hemorrhage drills as part of its Provision of Care, Treatment and Services chapter.[16] With these new Joint Commission mandates, each labor and delivery unit will have to conduct regular simulations and will need to provide information and documentation to meet these requirements. Those multidisciplinary drills will need to be conducted annually to assess for systems issues and must include a team debrief.

Despite the early adoption of PPH simulation training in the MHS,[17] PPH simulation drills have not been entirely standardized in terms of scenario content, equipment, and required simulation expertise at each facility, as the geographic locations and delivery volumes of each hospital within the MHS vary tremendously. Prior mobile obstetric simulation training in the military did not include anesthesia providers, assess surgical treatment of hemorrhage, or assess standardized patient satisfaction.[17] Other published in situ interprofessional simulation-based programs have only included a single patient in a care environment.[18,19] In the setting of an intrapartum hemorrhage, the interprofessional team has a minimum of 2 patients—mother and fetus—and depending on the timing of the hemorrhage, interventions to help the mother may negatively impact the fetus and transitions between environments, such as moving from the delivery room to the operating room, are more common. The communication challenges are also increased as these teams are often ad hoc comprised of members from multiple disciplines. In addition, leadership roles may change across specialties during the emergency response. Hence, teamwork is an even more critical component as the complexity of caring for the maternal-fetal couplet in an emergency. Because of these gaps in knowledge related to standardizing simulation training for PPH management, we undertook this large-scale perinatal training program to learn how to build a robust and effective training program for a large healthcare system.

The Obstetric Simulation Training and Teamwork (OB-STaT) is an in situ simulation training program designed to standardize in situ simulation training, reduce postpartum hemorrhage morbidity, and improve postpartum hemorrhage management. Because of the large scale of the OB-STaT program, we chose to focus on teamwork and performance metrics during simulation at the time of the initial roll out at multiple sites, while collecting patient outcomes data for later analysis. The objective of this portion of the study was to determine the impact of the OB-STaT program on team member knowledge of diagnosis and management of PPH using pretest and posttest scores, assessment of adherence to established PPH protocols, teamwork, and standardized patient perception scores across a nationwide healthcare system using a combination of traveling simulation experts (proctors) and local clinical subject matter experts to train and debrief participants. We hypothesized that OB-STaT would improve the following: team member knowledge, protocol adherence, teamwork, and patient satisfaction when caring for patients with PPH.

METHODS

The study was a prospective, multisite, cohort study conducted from February 2018 to November 2019 at 8 US Navy military treatment facilities (MTFs) within the continental United States that provided delivery services. The study was approved by the institutional review board at the Naval Medical Center Portsmouth, with all participants providing informed consent, and the study was conducted according to the US Federal Policy for the Protection of Human Subjects. The OB-STaT simulation program replaced mandatory semiannual simulation drills required by the MHS before its roll out; thus, participation in the simulation scenarios and training was required. However, participation in the study was voluntary. Subjects could refuse to participate by opting out of study instruments at the time of OB-STaT training. Clinicians who participated in OB-STaT simulation training but declined to participate in the study underwent the same training as those who enrolled into the study.

Components of the OB-STaT Program

The OB-STaT program was designed to teach the complex and diverse skills necessary to effectively manage other emergencies (Text, Supplemental Digital Content 1, learning objectives, http://links.lww.com/SIH/A794). The cognitive pretest, posttest, and 2 simulation scenarios were designed by maternal-fetal medicine specialists (M.L., C.E.) and obstetric simulation specialists (J.G., C.S.) with experience in creating and validating PPH scenarios for national organizations.

The OB-STaT training program consisted of 4 phases and required 4 hours to complete (Fig. 1). Phase 1 included consent of participants, baseline knowledge test, and a prebrief that covered the purpose of the simulation, psychological safety, and instructions regarding the use of mannequins and actors and that participants would be working in patient care areas and should get, open, and use supplies as they would in real life.[20] Psychological safety was established in written presimulation materials and reinforced during the introduction script that read: "the simulation exercise is safe space to learn, and all participants are intelligent, well trained and here to improve patient care." The knowledge pretest consisted of an 11-item test focused on critical aspects that contributed to a shared mental model surrounding the identification and management of postpartum hemorrhage (Text, Supplemental Digital Content 2, knowledge test, http://links.lww.com/SIH/A795).

Phase 2 consisted of the first simulation scenario (30 minutes) that required the team to recognize a postpartum hemorrhage, initiate management, and coordinate patient care in a safe and effective manner (Text, Supplemental Digital Content 3, OB-STaT instructor manual and simulation scenarios, http://links.lww.com/SIH/A796). After the simulation, proctors facilitated a team debrief for 30 minutes using the Clinical Teamwork Scale (CTS)[21] and the critical item checklist forms (Text, Supplemental Digital Content 4, nursing, http://links.lww.com/SIH/A797; Text, Supplemental Digital Content 5, OBGYN, http://links.lww.com/SIH/A798; Text, Supplemental Digital Content 6, pediatric, http://links.lww.com/SIH/A799; Text, Supplemental Digital Content 7, anesthesia, http://links.lww.com/SIH/A800). During the debrief sessions, the proctors relayed feedback provided by the standardized patient, including scores from the Patient Perception Scale (PPS)[22] and any specific behaviors that either made her feel safe, respected, and informed or detracted from the medical care provided. Phase

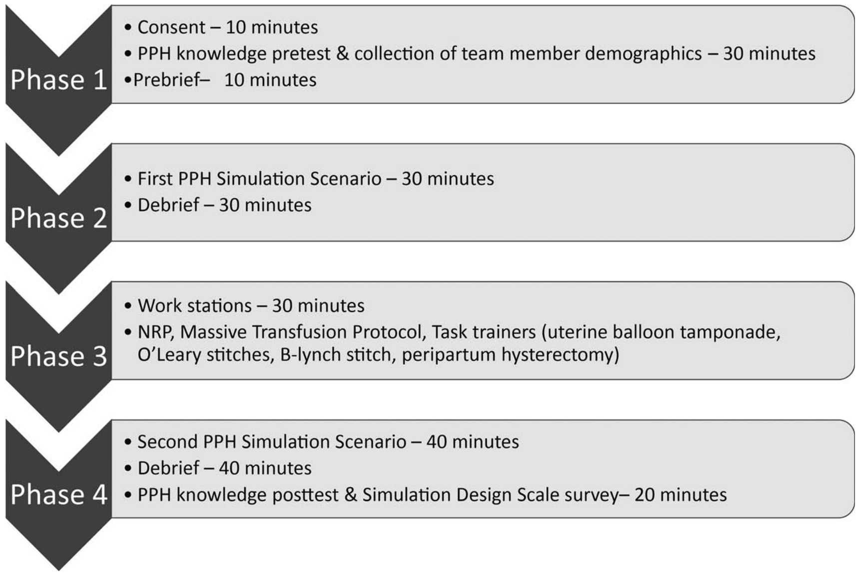

FIGURE 1. Timeline for the OB-STaT program.

3 consisted of rotations through skills stations to become more familiar with site-specific massive transfusion protocols and rapid transfusion systems, neonatal resuscitation protocol, placement of a uterine balloon tamponade device, uterine compression sutures and uterine artery sutures, and a review of the steps of a peripartum hysterectomy. Each skill station was a hybrid of hands-on task trainers and didactic instructions on the specific skills and institutional protocols, with all participants rotating through all stations. Participants then completed a second PPH simulation scenario (Supplemental Digital Content 3, http://links.lww.com/SIH/A796) followed by a debriefing, and knowledge posttest and posttraining surveys (Fig. 1).

Because the intent and purpose of this training was to practice and improve skills, no adverse actions were taken related to clinical competencies. All materials were reviewed by the interdisciplinary research team of subject matter experts to ensure the inclusion of each discipline's specific goals, objectives, and measures for their respective specialties.

Training Team

The obstetric proctors, all board-certified obstetricians (J.G., M.L., C.E.), standardized ratings before study implementation by reviewing and rating videos of 7 obstetric emergency simulation scenarios. These proctors then oriented the local site subject matter experts from perinatal nursing, pediatrics and neonatal nursing, and anesthesiology to participate as part of the OB-STaT team and enhance the training and debriefing of the teams. The CTS interrater class coefficient (ICC) between obstetric proctors initially ranged from 0.30 to 0.90 on the video review of the 7 obstetric emergency scenarios. More agreement was seen with high-performing teams and lower agreement was seen with poor-performing teams. The average ICC was 0.75 for all 7 scenarios and 5 of 7 scenarios had ICC of 0.83 or greater. The obstetric proctors then oriented the other proctors to the CTS at each study site. The ICC for all proctors for 10 randomly selected teams ranged from 0.49 to 0.92 with an average ICC of 0.67.

The training teams were comprised of 3 obstetric proctors and a pool of 27 local subject matter experts: 3 obstetrician-gynecologists, 10 perinatal nurses, 8 anesthesia providers (anesthesiologists and certified registered nurse anesthetists), and 6 neonatologists, neonatal nurse practitioners, or neonatal intensive care nurses. The 3 standardized patients participating in the training teams received standardized patient training from the Eastern Virginia Medical School Sentara Center for Simulation and Immersive Learning, Norfolk, VA. Each site's mobile training team was composed of 1 standardized patient, 2 obstetric proctors, and 2 subject matter experts from each clinical discipline. Because of the large scale of the training planned, we found it to be more efficient to use additional subject matter experts at the individual sites to assist with evaluations and debriefing of the teams. This allowed us to train these local subject matter experts in an efficient manner and ensure the project was feasibly implemented at multiple sites. Local subject matter experts were selected based on their clinical expertise and prior involvement in simulation training and were practicing clinicians at the training sites. Although a formal course was not required, all subject matter experts received training and mentorship regarding the OB-STaT program and debriefing techniques from the obstetric proctors before the simulation training.

Training at each MTF was provided by 1 to 2 mobile training teams over 2 to 5 days at each site, depending on the number of participants and teams being trained to ensure standardized training and assessment. The training window was scheduled in advance to maximize the number of clinicians able to participate at each site. Leaders of individual departments: obstetrics and gynecology, anesthesiology, pediatrics/neonatology, nursing, operating room technologists, and blood bank were aware of the training and scheduling requirements, and approved participation as well as time away from clinical duties for participation. Schedules were typically finalized 1 to 3 months before the date of the planned simulation.

Participants

The study participants included obstetric and gynecologic attending physicians and residents, anesthesia attending physicians and residents, certified and student nurse anesthetists, pediatric attending physicians and residents, family practice attending physicians and residents, certified nurse midwives, obstetric and neonatal nurses, Navy hospital corpsmen (who function as medical assistants), blood bank personnel, and operating room personnel. Simulation teams were formed to include a realistic interprofessional team similar to actual practicing clinical teams, while accounting for clinical demands and hospital staffing. Participants were recruited from each department, with participants assigned as part of a care team based on usual work assignments and call teams. The goal was to ensure that all obstetricians working at each site could participate in the training. An example of a team would include an attending obstetrician, an obstetric resident, an anesthesia resident and an anesthesia attending and 3–4 obstetric nurses, as well as 2–3 hospital corpsmen and an operating room technician. Ancillary support staff such as those in the blood bank participated as part of their usual work of the day. Clinical participants completed the 4-hour training session once. Ancillary support staff such as those in the blood bank likely participated in more than 1 training session as 4 teams typically received training during 1 work shift.

Although the ideal end state was to train as many participants as possible at each site, we also recognized the potential for surges in clinical needs that could impact training or lead to decreased participation. To mitigate this risk, the labor and delivery induction and cesarean schedule was decreased by approximately 50% for the day before and the day of the planned simulation training. In addition, simulation participants were not counted in the staffing census for labor and delivery or the inpatient wards.

Data Collected

Demographic data collected from subjects included their role on labor and delivery, previous experience with various obstetric emergencies and previous experience with various interventions to control PPH. The investigators and subject matter experts developed the 11-item knowledge test based on current clinical guidelines for management of obstetric hemorrhage and neonatal resuscitation (Supplementary Digital Content 2, http://links.lww.com/SIH/A795) because there were no existing validated knowledge tests for PPH. The knowledge test was designed to assess participant knowledge of hemorrhage identification and management as well as resuscitation of a postpartum hemorrhage. The same questions were used for the pretest and posttest scores. All participants were administered both tests (Fig. 1). The answers were not reviewed after the knowledge test; however, the concepts pertaining to the test questions were reviewed in the skills stations and during the simulation debriefs. Subjects also self-reported the amount of time spent with the various skill stations.

Performance of interprofessional teams was assessed, including teamwork and checklist adherence during simulation drills at these institutions. Proctors and subject matter experts assessed overall team performance using the validated CTS, consisting of 15-items in 5 different teamwork domains: communication, decision making, role responsibility, situational awareness/resource management, and patient friendliness.[21] The rating scale ranged from 0 to 10 and was used for 14 items. The remaining item, target fixation, was scored dichotomously (yes/no).

Proctors and subject matter experts from obstetrics, perinatal nursing, pediatrics/neonatal nursing, and anesthesia also completed the specialty-specific performance element critical action checklist during each simulation scenario (Supplemental Digital Content 4, http://links.lww.com/SIH/A797; Supplemental Digital Content 5, http://links.lww.com/SIH/A798; Supplemental Digital Content 6, http://links.lww.com/SIH/A799; and Supplemental Digital Content 7, http://links.lww.com/SIH/A800). These specialty-specific checklists were created by the OB-STaT team based on required elements from the US Navy Bureau of Medicine and Surgery PPH Bundle because such checklists were not previously developed. For the obstetrics, anesthesia, and nursing performance element critical action checklist, items were labeled and scored as "Not done" (0), "Done poorly" (1), or "Done well" (2). Inappropriate actions performed were also rated and assigned a score (−1) if noted. For the pediatric performance element critical action checklist, items were labeled and scored as "Not done" (0) or "Done" (1). Critical action performance checklist scores were totaled to provide an overall critical action checklist score for each training team to determine protocol adherence. Scoring was completed in person by proctors using paper forms during all simulations.

Each simulation session was recorded using GoPro cameras (GoPro, San Mateo, CA) that were mounted in the simulation rooms, for post hoc data collection and verification purposes in the study. The videos were used as back-up as we were aware that there would likely be task overload for the proctors who were monitoring scenario progress, completing checklists, and rating teamwork. Post hoc review of the videos were completed as needed if less than 80% of the items were rated during the simulations. If the video was not available for review, data from other specialty critical action-item checklists (obstetrics, anesthesia, and nursing) were used to impute values where there was item overlap on the checklists. Some team members performed different roles at different institutions.

The standardized patient assessed each team's interactions at the end of each simulation scenario using the validated 3-item PPS[22] (maximum score of 15). All participants completed the National League of Nursing Simulation Design Scale (SDS)[23] at the end of the session to ascertain feedback on the participants' perceived quality and value of the simulation sessions in keeping with simulation center standard operating procedures. A debriefing was held with the research team, subject matter experts and local site point of contacts after each training day was completed and at the conclusion of the site to identify lessons learned and opportunities for local improvements in processes and protocols.

Statistical Analysis

The primary outcome was the teamwork score on the CTS. Secondary outcomes included: team protocol adherence as measured by scores on the specialty-specific performance element critical action checklist, standardized patient ratings on the PPS, participant ratings on the SDS, and knowledge test scores. Protocol adherence was chosen as a secondary outcome because the training was designed to educate and assess team performance based on clinical recommendations from the US Navy Bureau of Medicine and Surgery postpartum hemorrhage bundle.

An a priori power calculation determined that we needed to have paired data from at least 32 teams in each specialty

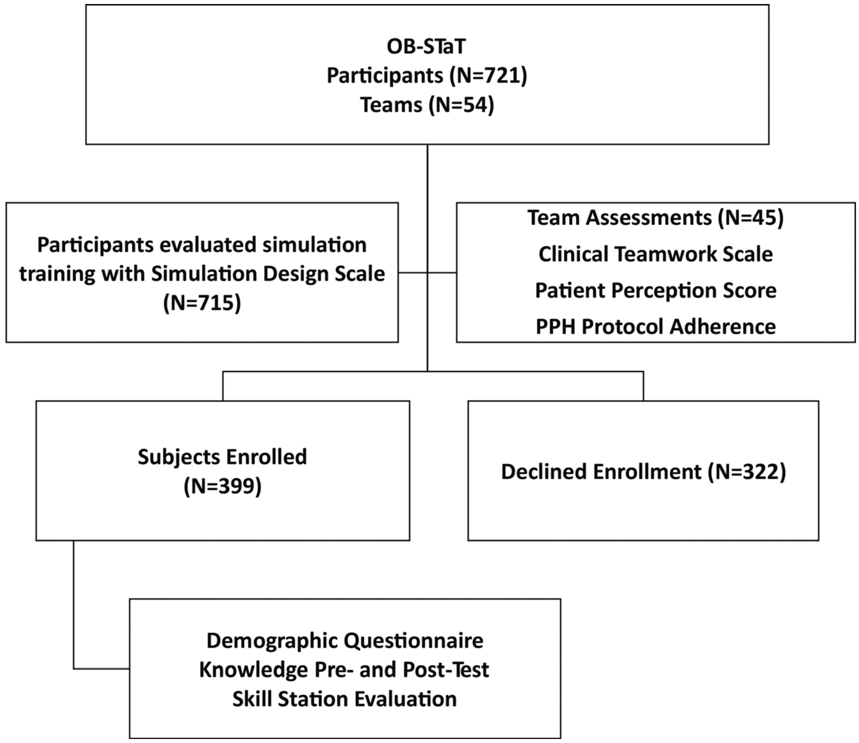

FIGURE 2. Flow diagram of the OB-STaT participants.

group to have 80% power to determine a statistically significant change of 1 point on the critical action-item list and knowledge tests. Power calculations used secondary outcomes as the minimum clinically important difference has not been reported for the CTS. A 1-point change has been reported to be a clinically meaningful improvement as a result of 1 simulation session by other authors.[24,25] The data distribution and presence of outliers were assessed. Paired *t* tests were used to analyze subject knowledge pretest and posttest scores and critical action-item checklist scores for each specialty. Paired scores from the critical action-item checklists were included for analysis as long as there were less than 20% missing data. Logistic regression analyses were not performed as less than 50 teams had complete data. Corrections for multiple pairwise comparisons were performed for the CTS and PPS and their subdomains using 1-way repeated-measures analysis of variance with a Greenhouse-Geisser correction. Post hoc tests used the Bonferroni correction.

Descriptive analysis was used to evaluate subject demographics. A qualitative review of the standardized patient comments was performed. The lessons learned were categorized and improvements implemented to minimize challenges with future training evolutions.

Fleiss κ was used to determine the ICC using CTS categories (poor, average, good, perfect). Statistical analysis was performed using Excel (Microsoft, Redmond, WA), MedCalc (MedCalc Software Limited, Belgium), IBM SPSS Statistics 24 (IBM, Armonk, NY), and an online statistics calculator (https://www.socscistatistics.com/).

RESULTS

During the study period, 90% (54/60) of the scheduled interprofessional teams, composed of 721 healthcare professionals, completed training at 8 MTFs. In total, 399 subjects enrolled in the study by signing a consent and returning a demographics questionnaire (Fig. 2). Approximately 73% of those working on labor and delivery units received OB-STaT training. Staff composition included: board-certified OB-GYN physicians, residents, midwives, family practice physicians, residents, anesthesiologists, residents and nurse anesthetists, student nurse anesthetists, neonatologists and neonatal nurse practitioners, pediatricians, residents, nurses, and corpsmen. Demographics of the subjects are reported in Table 1. Subjects included nurses (n = 129), pediatrics attendings and residents (n = 43), and obstetrics attendings and residents (n = 102), anesthesia (n = 47), and family medicine attendings and residents (n = 31). Most subjects were active duty. Of the subjects,

TABLE 1. OB-STaT Subject Demographics

	OB-STaT Subjects (N = 399)
Discipline	
Ancillary services	4 (1%)
Anesthesia	47 (12%)
Family medicine	31 (8%)
Nursing	129 (32%)
Obstetrics	102 (26%)
Pediatrics	43 (11%)
Respiratory services	8 (2%)
Missing	35 (9%)
Employment status	
Active duty	307 (77%)
Contract	12 (3%)
Civilian service	90 (20%)
Trainee	77 (19%)
Treat postpartum hemorrhage at least twice yearly	210 (70%)
Frequency of participation in simulations twice yearly	235 (59%)

19% (77/399) identified as students or residents; obstetric residents comprised 39% (30/77) of this group. More than 70% reported that they treated PPH at least twice a year and 59% participated in simulations at least twice a year. More than 50% of pediatrics and 40% of anesthesia participants reported never participating in a PPH simulation (Fig. 3). Knowledge scores were similar from pretraining to posttraining for anesthesia, family medicine, nursing, and pediatrics (Table 2). Only subjects from the obstetrics specialty had significant increases in the knowledge test at the conclusion of training (8.33 ± 1.6 vs. 8.66 ± 1.5, $P = 0.008$; Table 2).

Of the 54 teams that received the training, 45 teams completed both simulation scenarios and had paired data for analysis of teamwork and patient satisfaction (Table 3). Teamwork as assessed by the average CTS score increased significantly between the 2 scenarios (5.82 ± 2.0 vs. 7.25 ± 1.9, $P = 0.008$) for all the training teams. Each individual domain of the CTS also significantly improved, including the rating of the patient friendliness of the team's care except target fixation (Table 3). Post hoc analysis with correction for multiple comparisons revealed that CTS scores significantly increased from preintervention to postintervention ($P < 0.001$) for all CTS items except for "other/patient friendly" ($P = 0.087$).

For protocol adherence using the specialty-specific critical action-item checklists, 32 anesthesia subteams, 37 nursing subteams, 36 obstetric subteams, and 14 pediatrics subteams were included (Table 3). The maximum scores for each specialty's checklist are as follows: anesthesia (14), nursing (14), pediatrics (14), and obstetrics (22). Protocol adherence significantly improved for anesthesia, nursing, and obstetric subteams (12.28 ± 1.7 vs. 13.56 ± 1.0, 12.43 ± 1.6 vs. 13.14 ± 1.3, and 18.14 ± 2.7 vs. 19.56 ± 2.1, respectively, all $P < 0.02$). The pediatrics subteams demonstrated a nonsignificant increase in protocol adherence (11.93 ± .8 vs. 12.36 ± .97, $P = 0.31$). Data were only imputed for the nursing and obstetric teams. When the teams where data were imputed were removed from the analysis, protocol adherence remained significantly improved for obstetric team (n = 30; 18.26 ± 2.9 vs. 19.47 ± 2.1, $P < 0.01$) but not for the nursing teams (n = 29; 12.48 ± 1.6 vs. 13.10 ± 1.4, $P = 0.06$).

TABLE 2. Immediate Impact of the OB-STaT on Individual Team Member Knowledge

	n	Before	After	P
Anesthesia	44	8.00 ± 1.6	8.34 ± 1.7	0.25
Family medicine	31	8.74 ± 1.4	8.71 ± 1.4	0.82
Nursing	111	7.14 ± 1.8	7.24 ± 1.7	0.41
Obstetrics	93	**8.33 ± 1.6**	**8.66 ± 1.5**	**<0.01**
Pediatrics	31	7.19 ± 1.5	6.84 ± 1.8	0.05

For obstetrics, the 2 most frequently missed checklist items were "Provider excludes other causes of PPH" and "Inserts Foley." For nursing, the 2 most frequently missed checklist items were "Team uses local obstetric hemorrhage checklist" and "Nurse starts second IV." For anesthesia, the 2 most frequently missed checklist items were "Administers correct dose of uterotonic medications" and "Appropriately administers blood products." For pediatrics, the 2 most frequently missed checklist items were "Performs initial steps" and "Request for pulse oximetry."

Although the overall standardized patient satisfaction did not significantly improve from the first to the second scenario (10.45 ± 2.3 vs. 11.07 ± 2.1, $P = 0.08$), there was significant improvement noted in the standardized patient feeling well-informed by the medical team (3.36 ± 1.0 vs. 3.76 ± 0.8, $P = 0.01$). After controlling for multiple comparisons, the training intervention did not lead to any statistically significant

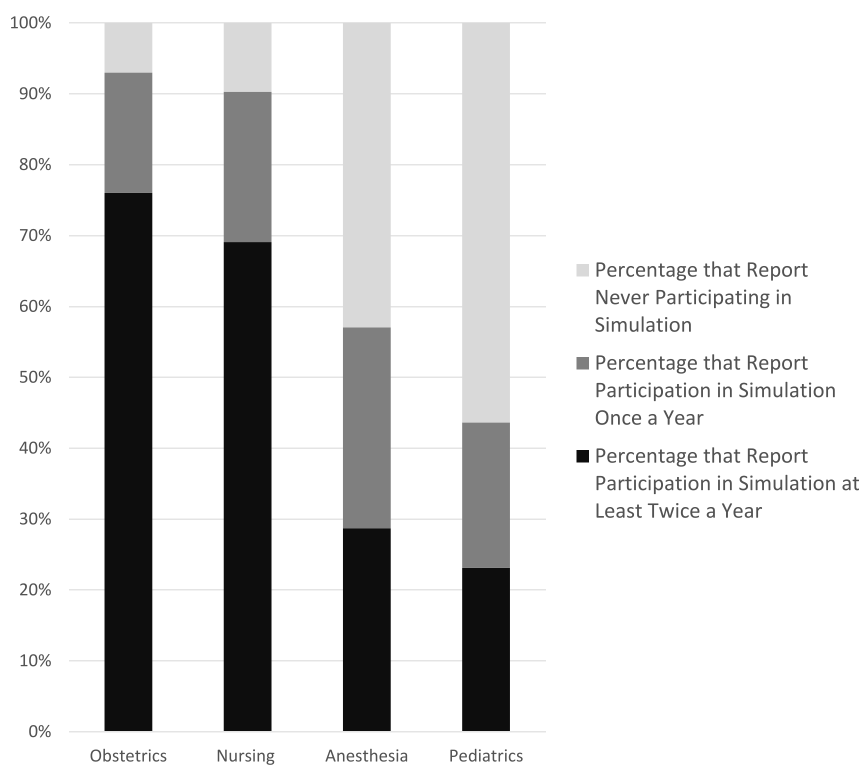

FIGURE 3. Participant PPH simulation experience.

TABLE 3. Immediate Impact of the OB-STaT on Team Performance by Instrument and Domain (n = 45)

	Scenario 1	Scenario 2	*P*
Teamwork (CTS)			
Total score	85.3 ± 20.1	106.7 ± 14.1	<0.001*
Overall	5.82 ± 2.0	7.25 ± 1.9	<0.001*
Communication	5.72 ± 1.8	7.43 ± 1.33	<0.001*
Situational awareness	5.99 ± 1.6	7.63 ± 1.1	<0.001*
Target fixation, n (%)	7 (8%)	1 (1%)	0.064†
Decision making	6.48 ± 1.5	7.76 ± 1.1	<0.001*
Role responsibility (leader/helper)	6.18 ± 1.6	7.75 ± 1.2	<0.001*
Other/patient friendly	7.22 ± 2.2	7.88 ± 1.5	0.087*
Protocol adherence (critical action-item list score)‡			
Anesthesia (n = 32)	12.28 ± 1.7	13.56 ± 1.0	<0.01§
Nursing (n = 37)	12.43 ± 1.6	13.14 ± 1.3	0.02§
Obstetrics (n = 36)	18.14 ± 2.7	19.56 ± 2.1	<0.01§
Pediatrics (n = 14)	11.93 ± 0.8	12.36 ± 1.0	0.31§
Standardized patient satisfaction (PPS; max score, 15)			
Total score (mean)	10.45 ± 2.3	11.07 ± 2.1	0.084*
Treated with respect (max score, 5)	3.50 ± 0.9	3.60 ± 0.9	0.562*
Felt safe at all times (max score, 5)	3.60 ± 0.8	3.71 ± 0.8	0.376*
Felt well informed because of good communication (max score, 5)	3.36 ± 1.0	3.76 ± 0.8	0.076*

*One-way repeated-measures analysis of variance.
†Fisher exact.
‡Results by specialty (original evaluations, video reviews, and imputed evaluations where available); maximum scores for each specialty are as follows: anesthesia, 14; nursing, 14; obstetrics, 22; and pediatrics, 14.
§Paired *t* tests.

increases in patient perception scores over the implementation of the OB-STaT training ($P = 0.084$; Table 3). Written feedback from standardized patients included the following regarding how they felt cared for during the scenario:

> *"They asked permission to check my cervix. They covered me on the way to the operating room (OR). The team was efficient. They explained the situation and moved quickly to the OR. They let me know they would be talking as a team to arrange my care but were not ignoring me. The team explained what was going to happen next on the way to the OR. The providers got down on my level and made eye-contact to ensure I was well-informed. They engaged me in the conversation that increased my feeling of safety."*

Behaviors that caused the standardized patient to provide feedback about feeling unsafe or less cared for included the following: failure to ask her permission before checking her cervix, feeling exposed or left uncovered during transport to the OR, and narrowly avoiding colliding with structures on the way to the operating room. In addition, the standardized patient reported feeling unsafe when there was poor communication or team leadership resulting in delays to form a treatment plan. The lack of coverage of her pelvic region during transport to the OR made the patient feel degraded. Standardized patients reported feeling disrespected when her pain concerns were ignored or the providers made degrading comments when the patient pushed their hands away during a painful abdominal examination. If the team did not explain the diagnosis or discuss the risks or the process of the recommended procedures or address her pain issues, the standardized patients reported feeling less well informed.

When given the opportunity to review specific PPH skills, participants spent the most time reviewing Neonatal Resuscitation Program skills (average 13 minutes by self-report) and selected to review anesthesia/massive transfusion protocol skills most frequently (data not shown). Of the 721 participants, 715 rated the session using the Simulation Design Scale after training evaluation. Of the respondents, 92% stated that they agreed or strongly agreed with each positively worded item on the Simulation Design Scale.

One participant sent a follow-up email the week after her institution received the OB-STaT curriculum:

> *"I wanted to drop you an email and let you know I appreciate having been through the simulation training before the massive transfusion. The patient we had was symptomatic with a heart rate up to the 170's. In order to get the blood on board quickly, we activated the massive transfusion protocol. We had [an additional anesthesiologist] come down, they started an arterial line so we could more accurately monitor the patient's blood pressure. I feel like having gone through the SIM training, we were more cohesive, our closed loop communication was effective and jobs were delegated. I knew while [the other nurses] and I were in the room, our coworkers at the desk were also working hard to make sure we had what we needed (ordering labs, running labs, bringing in equipment and supplies as needed)."*

A nursing supervisor sent this email after observing the team's performance during the previously mentioned patient event: "I just wanted to briefly highlight some outstanding performance and teamwork I observed last night on [unit] during a massive transfusion and simultaneous crash cesarean delivery in the operating room. The individuals did an outstanding job both in knowledge of situation, leadership, communication and had the best attitude I have seen."

Challenges experienced with the multisite implementation are summarized in Table 4. Although all institutions were part of the MHS, a lack of standardization was noted in terms of equipment, local massive transfusion protocols, and PPH bundle checklists. At several institutions, back-up operating rooms were used because of construction or emergent patient care. Two of the 8 institutions had to cancel some team training because of emergent patient care requiring the use of the back-up operating rooms. Room-specific latent safety threats and staff member orientation gaps were identified and addressed during scenario debriefs and during the phase 3 component of the program.

DISCUSSION

The OB-STaT program significantly improved knowledge for the obstetrics participants, teamwork, and PPH protocol adherence by obstetric, anesthesia, and nursing teams. Although statistically significant, the overall improvements in protocol adherence scores were relatively small, ranging from 0.71 points improvement for nursing participants to 1.42 points for obstetric participants. It is possible that such small changes in scores relate to the fact that most teams were relatively well trained at the outset. Overall standardized patient perception

TABLE 4. Challenges With Multisite Implementation of the OB-STaT

Challenge	Specific Examples	Mitigation Strategy
Standardization	1) Processes: massive transfusion protocols, checklists 2) Consumables: cesarean delivery	1) Subject matter experts learned local processes; suggested best practices 2) Local consumables were used
Expertise	Scenario reset	Extra corpsmen
Communication	1. Course expectations for participants/ancillary staff availability 2. Local point of contact deployments	1) Written and oral communication 2) Identified alternate points of contacts
Flexibility	1) Construction 2) Patient census 3) Participant nonavailability 4) Emergent patient care 5) Alternate training spaces 6) Alternate training hours	1) Alternate dates and training spaces 2) Minimized elective cases/delayed training 3) Subject matter experts participated when needed 4) Delayed/canceled training 5) Back-up operating rooms used 6) Used active duty sim team members to work evenings

scores did not significantly increase after correcting for multiple comparisons. These results set the stage to determine the overall clinical impact of OB-STaT on PPH outcomes in this ongoing study.

Cognitive knowledge of PPH diagnosis and management only significantly improved for members of the obstetrics teams; this group also had the highest percentage of trainees (20%). Although overall knowledge did not improve after the OB-STaT program, we saw significant improvements in communication, situational awareness, decision making, role responsibility, and overall teamwork as measured by the CTS through this training. In a systematic review by Fung and colleagues,[26] team training did not reliably increase clinical knowledge or skills but did increase communication and team coordination. This finding was reproduced in our study.

The use of protocols to manage obstetric emergencies, particularly postpartum hemorrhage, has been shown to improve morbidity and mortality.[3,27,28] International organizations, such as the World Health Organization, have developed consensus statements on PPH to guide management and further research. The National Partnership for Patient Safety has provided a Consensus Bundle[29] on the management of PPH to guide institutions in developing local practice guidelines and checklists. In the present study, investigators noted that knowledge of the local blood transfusions protocols at each institution was relatively high and that team generally used the protocols appropriately during scenarios. Participants used checklists inconsistently during the first simulation scenarios for most teams; this was addressed during the debrief. An improvement was noted during the second scenarios.

Standardized patient scores demonstrated a statistically significant difference in only 1 of the 3 elements before correcting for multiple comparisons. It is worth noting, however, that the other 2 elements (being treated with respect and feeling safe at all times) were rated higher than feeling well informed because of good communication in the formative simulation. These findings warrant ongoing use of standardized patients both in training and in research to better understand how well professional teams communicate with patients during crises.[30]

The strengths of this study include the successful execution of an IPE standardized simulation program with high-fidelity in situ simulations across multiple teams at multiple institutions of varying sizes within a large health system. Because of the buy-in from hospital leadership and support with protected simulation time and a temporary decrease of clinical volume, 90% of the planned teams received training. Such support is a testament to the commitment to the central tenants of high-reliability organizations and learning cultures that provide improved and high-quality patient care in the long term. Our project used regional and system-wide experts (proctors) to develop the training and mentor local subject matter experts to successfully implement training across the MHS. The use of traveling experts bringing high-fidelity equipment to smaller sites may be a cost-effective solution to implement effective simulation training across a healthcare system, rather than purchasing expensive equipment that must be run and maintained at each site.

This training was well received by the participants as confirmed by the high SDS scores and unsolicited emails from participants and supervisors. The interprofessional training team of proctors and subject matter experts ensured that each team member received role-specific training and feedback. Validated instruments were used to assess team performance and patient satisfaction. Furthermore, proctors and subject matter experts from multiple specialties were able to successfully complete the CTS scoring instrument at several different institutions. Finally, although not part of the data collection plan, study investigators received emails from individuals at several institutions describing improvements in clinical care that occurred after receiving the training that they directly attributed to receiving the OB-STaT training.

One limitation of this study is that only slightly more than 50% of the simulation participants enrolled in the study; there were lower rates of participation from pediatrics and anesthesia. These selection biases may have skewed the knowledge results. In addition, most pediatric teams only participated in 1 simulation scenario. In addition, there was no overlap between the pediatric team's critical action checklist and the other specialty critical action-item checklists preventing the imputation of missing values.

A second limitation was a lower ICC among raters during the study than in the rater standardization period. It is possible that lower ICC among raters may have affected the overall scores for the teams as none of the raters were eliminated. It was not feasible to have multiple specialty raters per scenario. The CTS was chosen when designing the study as the published validation paper reported that little training was required to use this instrument.[19] In contrast to the validation study, raters in our study were clinicians from different specialties and institutions as opposed to a single specialty (obstetrics) and were evaluating individual teams (eg, nursing, obstetric providers, anesthesia) in addition to the overall larger team.

Finally, because of geographic and logistic limitations, only the study investigators (proctors) were able to do group training on the rating scale; local site subject matter experts were oriented to the scale at the time of the simulations. In the future, this could be addressed with increased standardized rater reviewing and multispecialty validation of the CTS, perhaps including formal training on simulation assessment.

Other potential sources of bias were the facts that the proctors and subject matter experts scored the participants in person and were not blinded to the order of the scenarios, and the order of the scenarios was not randomized. In-person rating and debriefing may also have led to cognitive overload for the OB-STaT team; however, the real-time discussion and review of simulations provide important and timely feedback to participants. Adding the video reviews and imputed data also potentially added bias as team performance was sometimes clearer when the proctor who was assessing the simulation in real time also had the responsibility for facilitating the simulation. We were unable to use a blinded review of all the videos as the primary assessment as 51% (366/721) were lost during a storage system update at one of the study sites.

We used the same knowledge test for both the pretest assessment and the posttest assessment; thus, we are unable to exclude a testing effect in our results. The knowledge test was also based on basic hemorrhage management and knowledge; thus, it was not tailored to specific knowledge skills and abilities of each participant. Furthermore, the validity of knowledge tests in simulation are limited, in that such measures do not assess application of knowledge in clinical scenarios. Thus, the improvements in knowledge scores in this study do not necessarily translate to improved clinical performance in actual scenarios. Additional changes in participant scores may have been due to the instrument rather than actual changes in knowledge. Future studies could be designed to investigate and develop better knowledge-based measures.

In conclusion, a large-scale interprofessional simulation study across a large health system demonstrated an immediate impact of improved team performance and protocol adherence with an in situ standardized simulation training program. In the short term, we encourage the use of interprofessional team training within health systems. We also recommend training programs that systematically train all individuals involved in perinatal care and allow dedicated time for participation to ensure that staff routinely participate in simulations rather than convenience samples of staff working and available when unit simulations occur. Local challenges should be anticipated in undertaking multisite implementation of a standardized simulation curriculum, but with proper planning, flexibility, and commitment to ensuring the training occurs, these challenges can be mitigated and training objectives can be accomplished. Although the clinical outcomes and skills maintenance components of this study are under ongoing further analysis, the initial improvements in team performance are encouraging positive results of our study.

ACKNOWLEDGMENTS

The authors thank the following simulationists: Michael Spooner, MD, MBA, CAPT MC USN; Ms Rebecca Kiser, CHSE; HM2 Jasmine Ansink; HM2 Tana Gran; HM2 (FMF) Michael Hennessey; HM3 (SW) Benjamin Osborne; HN Richard Menard; Mr Clinton Rombaoa; and Mr David Simmons from the Healthcare Simulation and Bioskills Training Center, Naval Medical Center, Portsmouth, VA; Donald Cure, David T. Coenen, HM2 Michael McClendon, HM3 Quintavius Chappel, HM3 Yanique Fagan, HN Carol Rathoff, and HN Victoria Suzzelli from the Bioskills and Simulation Training Center, Naval Medical Center, San Diego, CA; Shad Deering COL, MD, FACOG, from the Department of Obstetrics and Gynecology, Uniformed Services University of Health Sciences, Bethesda, MD; and Geoffrey Miller, MS, from the Telemedicine & Advanced Technology Research Command Medical Modeling and Simulation Innovation Center, Fort Detrick, MD.

The authors thank the following anesthesia proctors: Dr Julie Rose; CAPT Mark Lenart, MC, USN; LCDR Michael Rucker, NC, USN; and LCDR Lauren Suszan, NC, USN, from the Department of Anesthesia, Naval Medical Center, Portsmouth, VA; and CDR Tiffany Uranga, NC, USN, and LT James Rauschnot, MC, USN, from the Department of Anesthesia, Naval Medical Center, San Diego, CA.

The authors thank the following nursing proctors: CDR Colleen Blosser, NC, USN; Ms Denise Devonshire; Ms Fayon Fell; Ms Darlene Godwin; Ms Rachel Savage; and Ms Dana Wiggins from the Naval Medical Center, Portsmouth, VA; LCDR Virginia Sullivan, NC, USN; LT Kimberly Snoop, NC, USN; and LT Melissa Schmidt, NC, USN, from the Naval Medical Center, San Diego, CA; Ms Carrie Licht and Ms Jessica Peluso from the Naval Medical Center, Camp Lejeune, NC; and LT Kayla Hennen, NC, USN; and LT Andra Wilke, NC, USN, from the Naval Hospital, Jacksonville, FL.

The authors thank the following pediatric proctors: LtCol Christopher Monnikendam, MC, USA, and LCDR Heather Solaria, MC, USN, from the Naval Medical Center, Portsmouth, VA; and LCDR Laura Boerste, NC, USN; LCDR Yvonne Marenco, NC, USN; and LCDR Jamie Overbey, MC, USN, from the Naval Medical Center, San Diego, CA.

REFERENCES

1. AbouZahr C. Global burden of maternal death and disability. *Br Med Bull* 2003;67:1–11.
2. Einerson BD, Miller ES, Grobman WA. Does a postpartum hemorrhage safety program result in sustained changes in management and outcomes? *Am J Obstet Gynecol* 2015;212:140–144.e1.
3. Shields LE, Wiesner S, Fulton J, et al. Comprehensive maternal hemorrhage protocols reduce the use of blood products and improve patient safety. *Am J Obstet Gynecol* 2015;212:272–280.
4. Lopreiato JO, Downing D, Gammon W, et al, Terminology & Concepts Working Group. *Healthcare Simulation*. Dictionary. Rockville, MD: Agency for Healthcare Research and Quality; 2016. AHRQ Publication 16 (17)-0043. Available at: https://www.ahrq.gov/sites/default/files/publications/files/sim-dictionary.pdf. Accessed January 26, 2022.
5. Crofts JF, Lenguerrand E, Bentham GL, et al. Prevention of brachial plexus injury—12 years of shoulder dystocia training: an interrupted time-series study. *BJOG* 2015;123(1):111–118.
6. Fuhrmann L, Pedersen TH, Atke A, Møller AM, Østergaard D. Multidisciplinary team training reduces the decision-to-delivery interval for emergency caesarean section. *Acta Anaesthesiol Scand* 2015 Nov;59(10): 1287–1295.
7. Egenberg S, Øian P, Bru LE, et al. Can inter-professional simulation training influence the frequency of blood transfusions after birth? *Acta Obstet Gynecol Scand* 2015;94(3):316–323.
8. Wagner B, Meirowitz N, Shah J, et al. Comprehensive perinatal safety initiative to reduce adverse obstetric events. *J Healthc Qual* 2012;34(1): 6–15.
9. Marshall NE, Vanderhoeven J, Eden KB, Segel SY, Guise J. Impact of simulation and team training on postpartum hemorrhage management in non-academic centers. *J Matern Fetal Neonatal Med* 2015;28(5): 495–499. doi:10.3109/14767058.2014.923393.
10. Fransen AF, van de Ven J, Schuit E, van Tetering J, Mol BW, Oei SG. Simulation-based team training for multi-professional obstetric care teams to improve patient outcome: a multicentre, cluster randomised controlled trial. *BJOG* 2016;124:641–650. doi:10.1111/1471-0528.14369.

11. Phipps MG, Lindquist DG, McConaughey E, et al. Outcomes from a labor and delivery team training program with simulation component. *Am J Obstet Gynecol* 2012;206:3–9.

12. Freeth D, Ayida G, Berridge EJ, et al. Multidisciplinary Obstetric Simulated Emergency Scenarios (MOSES): promoting patient safety in obstetrics with teamwork-focused interprofessional simulations. *J Contin Educ Health Prof* 2009;29(2):98–104.

13. Kim T, Vogel RI, Mackenthun SM, Das K. Rigorous simulation training protocol does not improve maternal and neonatal outcomes from shoulder dystocia [10]. *Obstet Gynecol* 2016;127(Suppl 1):3S. doi:10.1097/01.AOG.0000483626.00192.81.

14. National Perinatal Information Center/Quality Analytic Services (NPIC/QAS). Perinatal performance information project: executive summary: analysis of obstetrical and neonatal data by military service, calendar year 2015.

15. Defense Health Agency Procedural Instruction Number 6025.35. Guidance for Implementation of the Postpartum Hemorrhage Bundle (PPHB). January 22, 2021. Available at: https://health.mil/Reference-Center/Policies/2021/01/22/Guidance-for-Implementation-of-the-Postpartum-Hemorrhage-Bundle. Accessed January 26, 2022.

16. Quick Safety 51: advisory on preventing maternal death from obstetric hemorrhage. *The Joint Commission* 2019. Available at: https://www.jointcommission.org/resources/news-and-multimedia/newsletters/newsletters/quick-safety/quick-safety-issue-51-proactive-prevention-of-maternal-death-from-maternal-hemorrhage/. Accessed January 26, 2022.

17. Deering S, Rosen MA, Salas E, King HB. Building team and technical competency for obstetric emergencies: the mobile obstetric emergencies simulator (MOES) system. *Simul Healthc* 2009;4(3):166–173. doi:10.1097/SIH.0b013e31819aaf2a. PMID: 19680084.

18. Abulebda K, Lutfi R, Whitfill T, et al. A collaborative in situ simulation-based pediatric readiness improvement program for community emergency departments. *Acad Emerg Med* 2018;25:177–185.

19. Walsh BM, Auerbach MA, Gawel MN, Brown LL, Byrne BJ, Calhoun A. Community-based in situ simulation: bringing simulation to the masses. *Adv Simul (Lond)* 2019;4:30.

20. Rudolph JW, Raemer DB, Simon R. Establishing a safe container for learning in simulation. *Simul Healthc* 2014;9:339–349.

21. Guise JM, Deering SH, Kanki BG, et al. Validation of a tool to measure and promote clinical teamwork simulation in healthcare. *Simul Healthc* 2008 Winter;3(4):217–223. doi:10.1097/SIH.0b013e31816fdd0a.

22. Siassakos D, Clark J, Sibanda T, et al. A simple tool to measure patient perceptions of operative birth. *BJOG* 2009;116:1755–1761.

23. National League of Nursing Simulation Design Scale (Student Version). Available at: https://safe.menlosecurity.com/doc/docview/viewer/docND04A7624466F1b486b00708e8516960eb0e3b7ee195b0ff426395650cee9ab08586cfbcb2ed0. Accessed December 9, 2021.

24. Greer JA, Segal S, Salva CR, Arya LA. Development and validation of simulation training for vaginal hysterectomy. *J Minim Invasive Gynecol* 2014;21(1):74–82.

25. Pernar LIM, Smink DS, Hicks G, Peyre SE. Residents can successfully teach basic surgical skills in the simulation center. *J Surg Educ* 2012;69:617–622.

26. Fung L, Boet S, Bould MD, et al. Impact of crisis resource management simulation-based training for interprofessional and interdisciplinary teams: a systematic review. *J Interprof Care* 2015;29(5):433–444.

27. Skupski DW, Lowenwirt IP, Weinbaum FI, Brodsky D, Danek M, Eglinton GS. Improving hospital systems for the care of women with major obstetric hemorrhage. *Obstet Gynecol* 2006 May;107(5):977–983. doi:10.1097/01.AOG.0000215561.68257.c5. PMID: 16648399.

28. Rizvi F, Mackey R, Barrett T, McKenna P, Geary M. Successful reduction of massive postpartum haemorrhage by use of guidelines and staff education. *BJOG* 2004;111(5):495–498. doi:10.1111/j.1471-0528.2004.00103.x. Erratum in: BJOG. 2007 May;114(5):660. PMID: 15104617.

29. Main EK, Goffman D, Scavone BM, et al, National Partnership for Maternal Safety; Council on Patient Safety in Women's Health Care. National Partnership for Maternal Safety: consensus bundle on obstetric hemorrhage. *Obstet Gynecol* 2015;126(1):155–162. doi:10.1097/AOG.0000000000000869. Erratum in: *Obstet Gynecol*. 2015 Nov;126(5):1111. Erratum in: *Obstet Gyneco*l. 2019 Jun;133(6):1288. PMID: 26241269.

30. O'Daniel M, Rosenstein AH. Professional communication and team collaboration. In: Hughes RG, ed. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville, MD: Agency for Healthcare Research and Quality (US); 2008: Chapter 33. Available at: https://www.ncbi.nlm.nih.gov/books/NBK2637/.