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Feasibility, implementation, and outcomes of in situ simulation-based curriculum to manage common emergencies in the pediatric post-anesthesia care unit

Shivani Patel, M.B.B.S [a,*], Grace Carter, MSN, RN, CPN [b], Dawn Minton, MSN, RN, CPN [b], Joann B. Hunsberger, MD, MS [a], Rahul Koka, MD, MPH [a], Richard Collins, NRP [c], Lisa Shoemaker, MS, RN, CPN [b], Serkan Toy, PhD [a], Sapna R. Kudchadkar, MD, PhD, FCCM [a,d,e]

[a] Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University, 1800 Orleans Street, Baltimore, MD 21287, USA
[b] Johns Hopkins Hospital, 1800 Orleans Street, Baltimore, MD, United States of America
[c] Johns Hopkins Simulation Center, Baltimore, MD, United States of America
[d] Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America
[e] Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America

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ABSTRACT

Purpose: Studies have shown that most critical events that occur in the post-anesthesia care unit (PACU), including cardiac arrests, are preventable and respiratory in origin. Admission to the PACU necessitates transfer of care from anesthesiology staff to PACU nurses. The aim of the study is to assess a) feasibility in implementing an in-situ curriculum for PACU nurses to manage common pediatric emergencies, b) the effectiveness of the curriculum in improving self-confidence of the PACU nurses in performing essential skills c) nurses" perception of such an offering.

Design and methods: This was a single center curricular evaluation study. Anonymous surveys were used to assess curriculum effectiveness by comparing self-reported confidence in the execution of key technical skills and application of knowledge in a real clinical environment at three time points: baseline, immediately post-simulation, and 3 months later.

Results: Of 50 PACU nurses, 80%, 98% and 58% responded to the targeted needs assessment, post-simulation and follow up (at 3 months) survey respectively. Self-reported confidence levels for most of the essential skills were significantly increased immediately after simulation and at 3 months. Most of the participants responded that the simulation training helped them improve care of hypoxic (83%) and hypotensive (62%) patients in the PACU.

Conclusion: Implementation of in situ curriculum for PACU nurses was feasible. The self-reported confidence in performing essential skills increased significantly and the nurses could apply these skills in real clinical environment.

Practice implications: Interprofessional simulation should be implemented in all high risk units to optimize safety of children.

Introduction

Children in the post-anesthesia care unit (PACU) represent a uniquely vulnerable patient population. As they recover from anesthesia and surgery, they are often unable to communicate their needs owing to the residual effects of general anesthesia, sedation, or narcotics; their age; and/or comorbid conditions. The PACU admission necessitates a transfer of care from anesthesiology staff to PACU nurses, who become primarily responsible for patient management until either discharge to home or transfer to the inpatient unit. As such, PACU nurses are the first responders for all emergencies in the post-anesthesia recovery period.

According to the Perioperative Cardiac Arrest Registry, 19% of pediatric anesthesia-related cardiac arrests (defined as administration of chest compression or death in children ≤18 years of age) occur during emergence or recovery from anesthesia (Bhananker et al., 2007). Wake Up Safe, a patient safety organization that maintains a national registry of serious events for the specialty of pediatric anesthesiology, reported

* Corresponding author at: Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University, 1800 Orleans Street, Charlotte R. Bloomberg Children's Center, Room 6349G, Baltimore, MD 21287, United States of America.
E-mail address: skadaki1@jhmi.edu (S. Patel).

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that 4.7% of pediatric perioperative cardiac arrests occur in the PACU, with 69% of these events likely or almost certainly preventable and respiratory in origin (Christensen et al., 2017). In the APRICOT study, which examined severe critical events in pediatric anesthesia across 261 hospitals in Europe, the incidence of severe perioperative critical events during anesthesia, emergence, or post-anesthesia care was 5.2% (Habre et al., 2017). More specifically, rates of critical respiratory and cardiac events that required intervention were 3.1 and 1.9%, respectively (Habre et al., 2017). These studies highlight the importance of training and reinforcement of basic resuscitation skills for early recognition and intervention to manage clinically deteriorating patients in the pediatric PACU.

As per the American Society of Perianesthesia Nurses and Perianesthesia Nursing Standards, Staffing and Personnel Management, all nurses who care for patients in the Phase 1 level of care maintain competencies in Advanced Cardiac Life Support (ACLS) and Pediatric Advanced Life Support (PALS). Phase 1 level of care is typically required for (1) patients recovering from general anesthesia, (2) patients who have undergone neuraxial regional techniques, and/or (3) patients with comorbidities or surgical techniques/complications that require monitoring (Open Anesthesia). For such patients, monitoring and staffing ratios are equivalent to those of an intensive care unit (ICU). American Heart Association guidelines indicate that Basic Life Support, PALS, and ACLS courses be repeated every 2 years. Studies have shown that cardiopulmonary resuscitation (CPR) skills decline over time and that repeated training and reinforcement are necessary (Hamilton, 2005). Simulation-based training to reinforce resuscitation skills such as correct rate, depth, and hand positioning for chest compressions; correct rate and depth for ventilation or use of defibrillator; and timely delivery of a shock in case of a shockable rhythm, has been well-described in the literature (Allan et al., 2010; Drake et al., 2019; Hamilton, 2005; Toback et al., 2006).

Anesthesia providers are often called on to lead or assist in the management of pediatric PACU emergencies, but the PACU nurse assumes the role of first responder to identify, initiate, and stabilize the patient until help arrives. The aim of the study was to assess (a) feasibility in implementing an in-situ curriculum for PACU nurses using Kern's six-step approach (Kern et al., 2009); (b) the effectiveness of the curriculum in improving self-confidence of the PACU nurses in performing essential airway and resuscitation skills and, (c) nurses' perception of such an offering.

Methods

Our School of Medicine, Institutional Review Board approved this curricular evaluation as exempt with a waiver of consent. The study was conducted in the pediatric PACU, of a large academic center in the Mid-Atlantic region from April to October 2018.

Our PACU is a 32-bed unit that provides care for patients recovering from surgery or other procedures that require anesthesia. The PACU is staffed by skilled nurses who work closely with the other members of the perioperative team and admits the full spectrum of outpatients, inpatients, same-day admits and children requiring 23-h observation during recovery from anesthesia. Occasionally, stable, non-ventilated patients who are waiting for an ICU bed to become available are also admitted to the PACU for observation.

Curriculum design, implementation, and evaluation

Educational framework

The curriculum was designed and implemented based on the principles of Adult Learning Theory as described by Malcolm Knowles (Knowles, 1972). To enable participants to engage in experiential learning hands-on, high-fidelity in situ simulation practices based on real-life scenarios was provided. Participants were encouraged to reflect on their actions during facilitated debriefings and to explore their behaviors or underlying frames, modify them, and develop new concepts to apply in real-life situations. This reflective debriefing is the cornerstone for Kolb's experiential learning (Kolb & Fry, 1975).

Curriculum design

The curriculum was developed based on Kern's six-step approach (Kern et al., 2009), which includes (1) problem identification, (2) targeted needs assessment, (3) goals and objectives, (4) educational session, (5) implementation, and (6) evaluation, as outlined below.

Problem identification and targeted needs assessment (Steps 1 & 2)

A cross-sectional, anonymous survey was designed and distributed via Qualtrics^{XM} (Provo, Utah) to all pediatric PACU nurses at our site. The survey queried baseline demographic data which include years of experience; time of their most recent PALS certification; whether they had experience administering blood products in the PACU; and their confidence level in carrying out time-sensitive critical actions while managing targeted common pediatric emergencies. We also included an open-ended question regarding which skills they would like to be included in a simulation program. They were asked to rate their level of confidence for each skill from very low to very high on a 5-point Likert scale. Three authors reviewed the survey prior to implementation.

Of the 50 PACU nurses, 40 (80%) responded to the baseline needs assessment survey. A majority of the nurses had 1–10 years of experience in the PACU and had received PALS training within 2 years. At baseline, self-reported confidence (rated as high or very high) by the respondents varied across different airway skills, including jaw thrust (82%), placement of appropriate size oral airway (32%) or nasal airway (37%), and applying positive pressure ventilation using a baby safe (30%). Similarly, baseline confidence (rated as high or very high) by the PACU nurses varied for performing effective chest compressions (82%), placing Zoll pads to monitor qCPR or shock delivery (69%) and delivery of shock in case of shockable rhythm (52%).

Twenty-one respondents (52%) replied to the question regarding which skills they would want to be included during a simulation session. The most common theme was one or more airway management skills (17/21, 80%) such as head and neck repositioning, jaw thrust, application of continuous positive pressure with AirLife™ baby safe flow-inflating resuscitating device circuit, placement of oral or nasal airway to relieve airway obstruction or obtaining appropriate age and/or weight-based laryngeal mask airway, or intubation supplies (endotracheal tube, laryngoscope blade and handles) to manage airway emergencies. Nineteen percent of nurses made a specific request for training in laryngospasm management. Other themes identified were preparing emergency medications (24%), managing cardiac arrest (24%), managing malignant hyperthermia or post-obstructive pulmonary edema (<1%), code documentation (<1%), needle decompression for pneumothorax (<1%), blood transfusion (<1%), and closed loop communication (<1%).

Goals and objectives (Step 3)

Based on the results of the survey, a 3-h simulation session was developed for the PACU nurses. The goals of the simulation scenarios included:

a) *Task training*: The key technical skills that were emphasized during training were bag-mask ventilation, placement of oral or nasal airways, use of an AirLife™ baby safe flow-inflating resuscitating device, and use of a Zoll defibrillator (Zoll Medical Corporation, Chelmsford, MA) during cardiac arrest. These tasks provided learners with the opportunity to practice skills and improve their self-confidence in executing them.
b) *Cognitive skill development:* Examples included using an emergency drug card to prepare weight-based medication, early recognition, and management of a clinically deteriorating patient, applying principles of PALS during cardiac arrest, and crisis resource management.

c) *System-based practice*: Using the electronic medical record for real-time documentation of events; simulating all steps for medication administration, including acquisition of medication, preparing correct dose as prescribed, and administering the medication; inventorying contents of the code cart; and identifying any latent threats within the system that would prevent execution of the tasks as planned.
d) *Practicing principles of crisis resource management:* Examples include calling for help early, anticipating and planning, role assignment, practicing closed loop communication, leadership and followership, resource utilization, use of cognitive aids, and continuously reassessing and re-evaluating the situation.

Educational session (Step 4)

Before the training session, all nurses were given the following materials to review.

- A recorded lecture on Pediatric Airway Skills Education developed by Children's Hospital of Philadelphia (a learning module within the institutions computer-based learning system) (Children's Hospital of Philadelphia Continuing Education (cloud-cme.com)
- Articles on local anesthetic toxicity by the Anesthesia Patient Safety Foundation (Neal et al., 2012; Stiles & Prielipp, 2009; Weinberg, 2012).

The three high-fidelity simulation scenarios were planned based on the identified goals and objectives and common pediatric emergencies seen in the PACU.

a) *Hypoxia.* This scenario is designed to address a clinically deteriorating patient who develops hypoxia from airway obstruction and progresses to laryngospasm and bradycardia but does not experience cardiac arrest. This child had been extubated deep (extubated before emergence from anesthesia) after routine surgery.

b) *Hemodynamic instability requiring blood transfusion.* According to data from the Wake Up Safe Registry, cardiac arrest with a cardiac origin, secondary to hypovolemia, hemorrhage, arrhythmia, or cardiac failure, is associated with a greater level of patient harm than cardiac arrest of a respiratory origin. For this scenario we simulated management of a hypotensive patient in the PACU who requires blood transfusion despite aggressive volume resuscitation with crystalloid, owing to a blood hemoglobin of 6.0 g/dL. Transfusion of blood products in the PACU is rare and has a high risk for errors. The scenario was designed to allow PACU nurses to practice all steps required for safe blood administration, including collection and delivery of blood components in the clinical area, administration to the patient, accurate documentation, including two provider checks (at our institution), monitoring the patient, and completion of the transfusion.

c) *Code due to local anesthetic toxicity.* To optimize operating room efficiency, anesthesiologists perform regional blocks in the preoperative area, at the end of the case just prior to emergence, and rarely as rescue blocks in the PACU. Once the blocks are in place, patients are monitored by the bedside nurse. It is essential that the PACU nurse be able to identify signs of local anesthetic toxicity before cardiovascular collapse ensues. This scenario was designed to educate the nurses about signs and symptoms of local anesthetic toxicity and its management (identifying where intralipid is stored in the PACU and how to administer). The scenario included practice running a code in the PACU.

Implementation (Step 5)

Participants. All nurses working in the pediatric PACU were required by their leadership to participate in the simulation session as part of their mandatory annual training. Simulation training took place between 7:00 am and 5:00 pm. To accommodate nurses who work only night shifts, some training sessions were scheduled early in the morning and late in the afternoon. The available simulation dates were posted in advance with multiple sign-up options. No monetary compensation was provided to any nurses or anesthesia faculty. Nurses were divided into groups of no more than 4–5 to maximize learning.

Faculty. The faculty for simulation included two nurse educators from the PACU and pediatric anesthesia faculty who had experience in simulation-based education and debriefing.

Facility and Supplies. One of the PACU bays was transformed for in situ simulation. A portable Sim Baby manikin (Laerdal Medical, Stavanger, Norway), compressor, and laptop to operate the manikin was used for simulation. The vital signs were displayed on the monitor in the PACU bay similar to a real-life scenario. An EPIC Playground was integrated into the simulation session to simulate real-time monitoring and charting by the bedside nurse.

Simulation Process. Average duration for each scenario varied from 45 min to an hour. As in a typical clinical scenario, the PACU nurse received patient information/handoff from the confederate anesthesiologist using the routine handoff tool. They could call for help from other nurses (those participating in the simulation session) or request an attending physician (simulation faculty) for assistance if needed. Use of the code button during simulation was avoided to prevent disruption of the clinical workflow, but participants were asked to verbalize their intended action. Scenarios were not timed or pre-programmed but were ran based on participant response to optimize learning.

Debriefing. At the end of each simulation session, a pediatric anesthesia faculty member with debriefing expertise facilitated the debrief along with the PACU nurse educator. Participants were given an opportunity to share their simulation experience, reflect on their actions, rationalize their decision-making process, ask questions, and develop new or build on existing concepts for future application in either simulated or real-life situations. Participants were also allowed additional time to practice skills learned during the scenario.

Evaluation (Step 6)

To assess the quality of the educational curriculum and identify areas for improvement, we collected written feedback in two post-course surveys. The first was a paper-based survey administered immediately after the simulation session. This survey was used to gauge participants' perceived confidence in executing basic skills after the simulation training and to obtain their opinions on course effectiveness. The second follow-up survey was administered electronically via Qualtrics^{XM} 3 months after the training. The purpose of this survey was to measure effectiveness of the training by asking the extent to which the simulation activity helped participants deal with hypoxic patients, hypotensive patients, and cardiac arrest in the PACU. Because it included some of the same items from the pre- and post-test surveys, including questions about confidence levels associated with common skills used in the PACU, it allowed for comparisons at three time points.

Data analysis

The participant characteristics and their satisfaction with the training were reported using frequencies and percentages. To assess whether differences existed between baseline, posttest, and follow-up confidence levels for each of the seven essential skills, a repeated measures ANOVA could not be conducted because the surveys were anonymous and a series of one-way ANOVAs with Bonferroni post hoc tests was used. All statistical analyses were conducted with Statistical Package for the Social Sciences (IBM SPSS Statistics for Mac, Version 25.0. Armonk, NY: IBM Corp.). Significance level was set at $p < 0.05$.

Results

Demographic data for nurses participating in the simulation

Forty-nine of 50 (98%) nurses participated in the simulation activity. Of those, 5 (10%) had less than 1 year of PACU experience and 17 (35%) had 6–10 years of PACU experience. Only 3 nurses (6%) had received PALS training more than 2 years ago. The demographic details of the participants are displayed in Table 1.

Confidence levels for performing predefined essential skills in the PACU

A series of one-way ANOVA results showed significant differences between baseline, posttest, and follow-up confidence levels for all the seven essential skills except delivering shock in case of a shockable rhythm. In post hoc pairwise comparisons using Bonferroni correction (Table 2), self-reported confidence levels on the posttest and at 3 months were statistically significantly higher than those at baseline for placing an appropriate size oral airway and nasal airway, applying positive pressure by bag-mask, and placing electrode pads for qCPR monitoring or shock delivery.

Posttest satisfaction survey (immediately after simulation session)

Forty-nine of 50 (98%) nurses participated and completed the post-simulation survey. Sixty-nine percent of the participants reported reviewing the course material prior to the simulation activity. Most of the participants agreed/strongly agreed that the simulation activity was helpful for improving their confidence, knowledge, and skills in the included topics (Fig. 1). Twenty-five of the 49 participants (51%) who responded to the survey provided written free-text suggestions to improve the simulation activity. Most written comments and feedback were positive. Participants thought that the learning environment during simulation sessions maintained psychological safety. They requested similar training to occur annually as an opportunity to practice technical skills. Suggested areas for improvement included (1) adding more scenarios into the training, such as a code scenario; (2) having the opportunity to critically think through causes of cardiac arrest; (3) extending the training to clinical technicians and nursing students rotating in the PACU; (4) reviewing the capabilities and limitations of the simulation manikins before the start of the simulation; and (5) clarifying the role of anesthesia coordinator during management of PACU emergencies.

Follow-up survey: 3 months

Surveys were used to measure the effectiveness of the educational curriculum. Twenty-nine (58%) of the nurses completed the follow-up survey at 3 months. No demographic data were collected at that time point. The survey queried respondents on whether the simulation activity had helped improve their ability to deal with any of the following situations in real life:

Managing hypoxic patients in the PACU. Among respondents, 24 (83%) agreed or strongly agreed that participating in the simulation activity helped them improve care of hypoxic patients in the PACU; however, 2 (7%) had never encountered a similar situation and 3 (10%) strongly disagreed.

Hypotensive patients in the PACU. Among the 29 respondents, 18 (62%) agreed or strongly agreed that participation in the simulation activity helped them improve management of hypotensive patients in the PACU, 4 (14%) stated that they had not encountered a similar situation, and 2 (7%) strongly disagreed.

Cardiac arrest or any condition that required chest compressions in the PACU. Only 9 (31%) of the respondents agreed or strongly agreed that participating in the simulation activity had helped them manage cardiac arrest in the PACU; 17 (61%) had not encountered a similar situation, and 2 (7%) strongly disagreed.

Most of the written comments on this survey echoed similar themes of wanting the simulations to be repeated regularly, especially with new hires. Specific requests included training in cooperating tasks not limited to giving a jaw thrust, delivering bag-mask ventilation, and applying continuous positive pressure. One respondent would have preferred a pre-brief or walkthrough of teaching points before immersive high-fidelity simulation.

Table 1
Demographics of nurses who participated in the pretest (baseline) and posttest.

Participant characteristics	Baseline ($n = 40$)	Posttest ($n = 49$)
Years practicing as PACU nurse, n (%)		
< 1 y	7 (18)	5 (10)
1–5 y	13 (33)	19 (39)
6–10 y	13 (33)	17 (35)
> 10 y	7 (18)	8 (16)
Last PALS certification, n (%)		
< 1 y ago	18 (45)	28 (57)
1–2 y ago	19 (48)	18 (37)
> 2 y ago	3 (8)	3 (6)
Performed blood transfusion in PACU, n (%)		
Yes	23 (58)	22 (45)
No	17 (42)	27 (55)

Note: PACU, post-anesthesia care unit; PALS, Pediatric Advanced Life Support.

Table 2
Means, standard deviations, and post hoc pairwise comparisons of PACU nurses' confidence for each of the seven essential skills at pretest, posttest, and follow-up.

Skill[a]	n	Mean	SD	Bonferroni Comparisons (p value)	
				Pretest	Posttest
Performing jaw thrust					
Pretest	39	4.03	0.78		
Posttest	49	4.27	0.60	0.262	
Follow-up	29	4.48	0.51	0.014	0.463
Placing an appropriate size oral airway					
Pretest	40	3.15	0.92		
Posttest	49	4.12	0.67	<0.001	
Follow-up	29	3.86	0.88	0.001	0.521
Placing an appropriate size nasal airway					
Pretest	40	3.30	0.82		
Posttest	46	3.91	0.78	0.002	
Follow-up	29	3.79	0.86	0.045	1.00
Applying positive pressure using bag-mask					
Pretest	40	3.20	0.97		
Posttest	49	4.20	0.79	<0.001	
Follow-up	29	3.90	0.90	0.005	0.416
Performing effective chest compressions					
Pretest	40	4.08	0.73		
Posttest	49	4.41	0.64	0.080	
Follow-up	29	4.45	0.74	0.090	1.00
Placing electrode pads to monitor qCPR or for shock delivery					
Pretest	39	3.87	0.83		
Posttest	49	4.35	0.75	0.019	
Follow-up	29	4.38	0.82	0.032	1.00
Delivering shock in case of a shockable rhythm					
Pretest	40	3.68	0.94		
Posttest	49	4.12	0.86	0.072	
Follow-up	29	4.03	0.98	0.334	1.00

Note: Participants reported their confidence on a 5-point Likert scale in which 1 = very low confidence and 5 = very high confidence.
qCPR, quality cardiopulmonary resuscitation.
[a] The posttest was conducted immediately after the simulation session, and the follow-up test was conducted 3 months later.

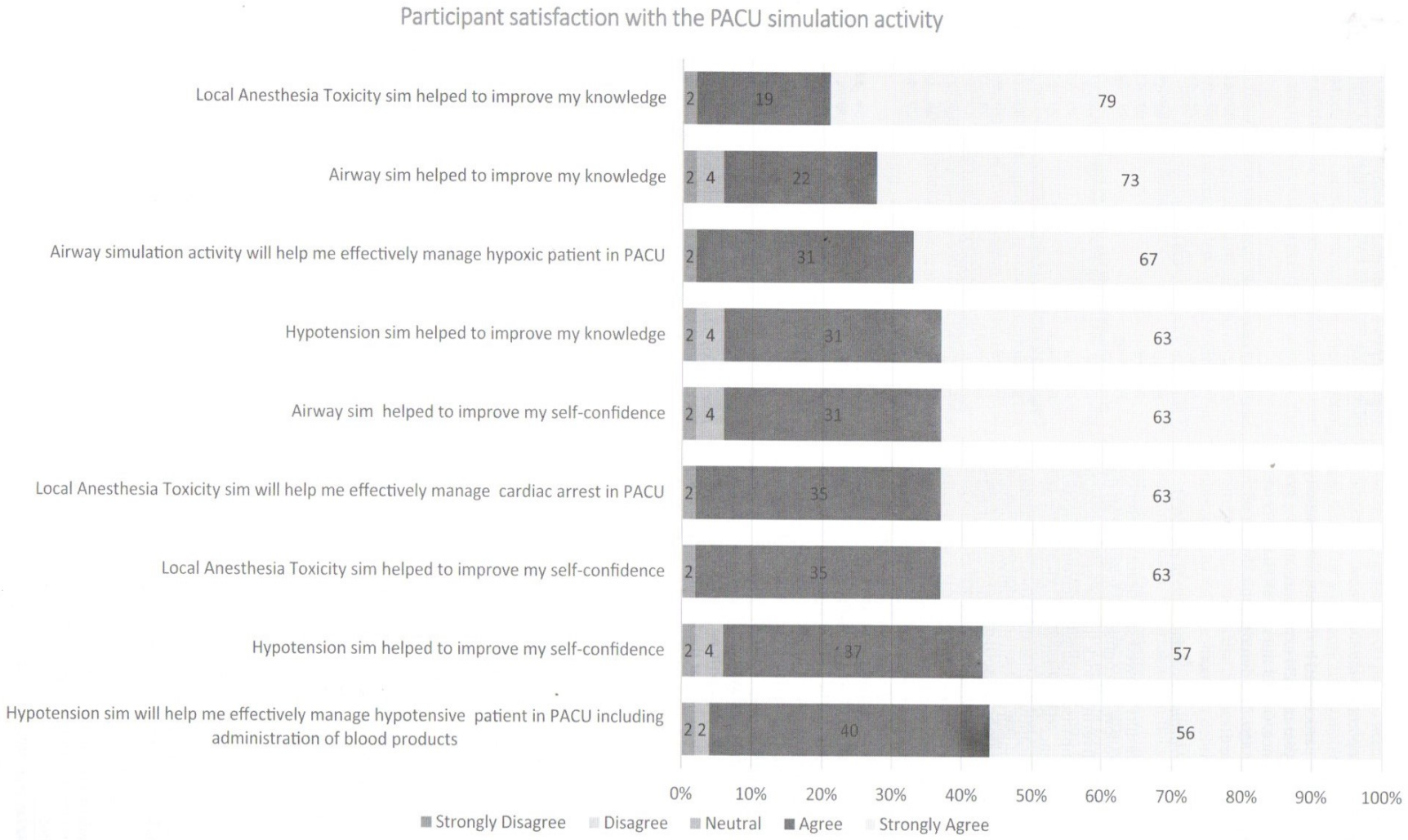

Fig. 1. Participant satisfaction with the post-anesthesia care unit (PACU) simulation activity.

Discussion

We describe development of an in situ simulation-based curriculum for PACU nurses that used Kern's six-step approach to teach technical skills and crisis resource management principles for managing common emergencies in the pediatric PACU. This curriculum was well received by the nurses, who requested that similar training occur annually.

Simulation-based training has been well-incorporated in both nursing and medical education internationally. It is used to augment clinical skills in a safe learning environment, where mastery can be achieved via deliberate practice and mistakes can be made without any consequence to patients. To achieve our goals, we provided learners with the scope (clinical scenario), environment, and modality (simulator itself) that enabled them to interact, behave, and learn in a realistic manner (Choi et al., 2017). The fidelity of a simulation is defined as the degree of realism and depends on the learner's perception of it (Choi et al., 2017). By using in situ simulation, that is, the actual work environment (physical fidelity), real-life scenarios and equipment (conceptual fidelity), and life-size programmable manikins that display realistic physiologic responses, we were able to provide a sense of realism that allowed learners to engage behaviorally, cognitively, and emotionally (experiential/emotional fidelity) (Choi et al., 2017).

We had an excellent participation rate for our surveys and for the simulation. The pre-simulation survey provided opportunity for the learners to reflect on their perceived confidence or lack thereof in performing critical time-sensitive skills for a clinically deteriorating patient in the PACU and to identify areas or topics for simulation activity. This approach helped learners to become behaviorally and cognitively engaged in the curricular design. Their review of the pre-simulation reading materials and active participation in the simulation session highlights the behavioral engagement.

Simulation-based education helps to build knowledge, skills, and attitudes among learners, who can then apply these skills in the next simulation session or real-life situation. The success of this educational initiative is reflected in our findings that 83% of the respondents reported improvement in their capacity to manage hypoxic patients in the PACU and that 62% reported improvement in their management of hypotensive patients. Fewer respondents (31%) reported that simulation had improved their ability to manage cardiac arrest because these events are rare in the PACU, and 61% of respondents had not encountered the situation within 3 months post-simulation. Future direction includes creation of a simulation-based education session focused on managing a code in the PACU and modifying our instructional technique, such as by using a rapid cycle deliberate practice instructional strategy to teach and reinforce various skills that are required to manage cardiac arrest in the PACU (e.g. effective chest compressions, defibrillation, time-to-task, and adherence to guidelines).

The key concerns for in situ simulations are (1) separating the equipment used for training from the real-world environment to prevent cross-contamination, (2) last-minute cancellations based on clinical workflow, and (3) addressing technological challenges when simulations are conducted outside the simulation center (Sørensen et al., 2017). We overcame these challenges by appropriately labeling the supplies for simulation and systematically removing them from the clinical workspace. We also had an on-site simulation specialist who helped to troubleshoot any technical problems or equipment malfunctions that occurred during the training session. Additionally, because we did not engage nurses from the clinical work pool, the clinical workflow did not affect our educational activity.

Managing clinically deteriorating patients in the PACU requires complex decision-making and interaction with personnel from various specialties with different levels of training and expertise. One of the objectives of our simulation session was to practice principles of crisis resource management—that is, decision making and cognition, and teamwork and resource management (Gaba et al., 2001). However, we did not formally assess team performance. To obtain quality data using observer rating scales, we would need to train the observers to eliminate bias (Rosen et al., 2010), which was beyond the scope of this study. This curriculum was implemented for the first time within our PACU; and we wanted to assess feasibility, learner engagement, and experience with such an endeavor. As described by Kern et al. (Kern et al., 2009), curriculum development is a continuous process that requires evaluation and feedback to improvise. We would consider assessing team performance during our next iteration.

Most medical training occurs in silos, whereas managing emergencies in real life requires interprofessional teams. Our learner group included only PACU nurses; anesthesia residents, fellows, faculty, certified registered nurse anesthetists, and surgeons were excluded. Because the simulation activity occurred during routine business hours, it was difficult for anesthesia providers or surgeons to be relieved from clinical roles. The targeted needs assessment and objectives of this curriculum were geared toward reported self-confidence in executing certain critical time-sensitive tasks by the PACU nurses. Anesthesia faculty primarily respond to crises in real life, and some participated as educators or faculty confederates during the simulation sessions. These faculty responded during the scenarios similar to the way they would in real life and actively participated in the debriefing sessions.

Clinical implications

Conducting an in situ simulation in which staff can practice technical and non-technical skills to manage common pediatric emergencies is feasible. We recognize that this was not interprofessional education, as the only participants were PACU nurses; however interprofessional education led collaboratively by educators from different disciplines should be implemented in all high-risk units such as ICUs, emergency rooms, or operating rooms to optimize patient care and safety, and ideally should occur annually.

Limitations

Our study had some limitations. It was a single center study and the survey results are based upon voluntary response. The effectiveness of the curriculum was assessed by self-perceived confidence in executing key tasks on a Likert scale; no objective scoring such as pre/posttest knowledge gained, time to task, or formal observational or self-assessment team performance was used. This educational activity occurred in a silo involving PACU nurses only. In the future, similar training should involve anesthesia providers, nursing technicians, and operating room nurses who routinely respond during an emergency. Finally, our pre-training reading material might have given clues to the participants regarding the scenario, thereby creating a lost opportunity for the participants to think through the causes of cardiac arrest.

Conclusion

We describe feasibility of developing and implementing an in situ simulation based curriculum for PACU nurses using Kern's six-step approach. (Kern et al., 2009). After the training session, self-reported confidence level of PACU nurses increased significantly in performing several essential skills. Nurses reported that the training was effective for increasing their confidence to manage hypoxic and hypotensive patients in the PACU. Most of the participants agreed/strongly agreed that the simulation activity was helpful for improving their confidence, knowledge, and skills in the included topics. The specific feedback that was provided will drive future changes in the curriculum. Interprofessional education that uses simulation grounded in adult learning theory can be an important tool in the armamentarium to optimize safety for children after surgery and anesthesia.

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CRediT authorship contribution statement

Shivani Patel: Conceptualization, Methodology, Writing – original draft, Investigation, Supervision, Project administration. **Grace Carter:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision, Investigation, Project administration. **Dawn Minton:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision, Project administration. **Joann B. Hunsberger:** Investigation, Writing – review & editing, Project administration. **Rahul Koka:** Investigation, Writing – review & editing, Project administration. **Richard Collins:** Conceptualization, Resources, Writing – review & editing. **Lisa Shoemaker:** Conceptualization, Methodology, Resources, Writing – review & editing. **Serkan Toy:** Conceptualization, Methodology, Formal analysis, Writing – original draft. **Sapna R. Kudchadkar:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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