

Improving Procedural Skill Confidence in Pediatric Residents: A Longitudinal Simulation-Based Workshop Curriculum

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Abstract

Introduction: Exit surveys among our pediatric residency graduates found 50% were not confident performing required procedures. While procedural competency poses many curricular challenges, simulation is an effective educational modality many programs have adopted, though often only through onetime workshops limited to single procedures, clinical settings, or levels of training. We sought to develop a comprehensive, recurring, yearlong, simulation-based curriculum covering many important pediatric procedures. **Methods:** We created a longitudinal curriculum of recurring monthly workshops using both low- and high-fidelity simulators, highlighting 17 pediatric procedures. Comprehensive facilitator guides contained equipment lists, instructions, competency checklists, and quizzes for each workshop. Correlation between attendance and confidence was assessed for skills in which residents attended two or more workshops on the same skill. ACGME exit surveys compared graduates' confidence regarding procedural skills before and after curriculum implementation. **Results:** On exit surveys, graduates who agreed or strongly agreed to feeling comfortable with the procedures in our curriculum improved from 50% to 66% after 2 years, and those who disagreed or strongly disagreed decreased from 40% to 22%. A positive correlation existed between repeated workshop attendance and confidence in many procedures (R^2 range, .60-.99). **Discussion:** Longitudinal simulation is an effective educational modality that increases learner confidence in performing procedures. Our curriculum addresses adult learners' need for repetition and can be adopted by other programs to improve graduates' confidence. The curriculum's sustainability is underscored by use of cost-reducing low-fidelity simulators and comprehensive guides that allow any instructor to conduct the workshop.

Keywords:

Clinical/Procedural Skills Training, Pediatrics, Simulation

Educational Objectives

By the end of this activity, learners will be able to:

1. Perform procedural skills using simulators with direct feedback from a facilitator.
2. Demonstrate proper use of basic equipment needed for each procedure.
3. Improve confidence in performing common pediatric procedural skills.

Introduction

All pediatric residency training programs governed by the Accreditation Council for Graduate Medical Education (ACGME)

are to provide clinical training in procedural skills for pediatric resident physicians.¹ Program directors face challenges in ensuring residents receive adequate opportunities for procedure practice, feedback, and assessment.^{2,3} Consistent with national attitudes on pediatric procedural skill readiness,⁴ an ACGME exit survey among trainees in our pediatric residency program indicated that 50% were not confident in performing ACGME-required procedures.

Historically, studies have shown that residents gain procedural skills at a patient's bedside.⁵ However, there are often limitations in the number of procedures residents are exposed to, and patient safety sometimes limits resident opportunities to practice.⁶⁻⁸ This may be compounded by the frequency with which patients undergo procedures prior to their transfer to our tertiary care center. Because effective adult learning includes engagement in repetitive practice,⁹ this lack of practice poses a challenge to mastering procedural skills learned at the bedside.⁶ Simulation-based education can increase opportunities for trainees to practice their skills. Furthermore, standardized

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checklists and feedback in the setting of simulation-based education have been shown to improve residents' confidence in procedural skills.¹⁰ In fact, residents trained on simulators perform better and are more likely to adhere to protocol compared to those receiving standard training.^{8,11}

The literature has shown success in improving learner confidence after onetime simulation workshops,¹² and many of the published studies available are limited to single clinical settings^{10,13-16} or a small number of procedures^{10,13,14,16-21} or include only senior residents^{10,13} or interns.²² Several *MedEdPORTAL* resources available pertain to pediatric procedural skills. Sagalowsky et al. provided a longitudinal curriculum for four simulated pediatric resuscitation scenarios in which a small number of basic procedures were embedded (including bag mask ventilation, intubation, and intravenous access).²¹ Good et al. published a simulation-based training for ultrasound-guided central venous catheter placement for pediatric trainees demonstrating improved confidence and knowledge, although they did not implement or assess this long-term.²³ Auerbach et al. provided a comprehensive training package for formative feedback on simulated infant lumbar puncture, but like Good et al.'s curriculum, focused on only one procedural skill.²⁰ Sawyer et al. created skills checklists for seven common pediatric procedures for use during a skills training day, but these were only available for incoming interns at an annual workshop.²²

Our curriculum aims to address some of the limitations of prior work by offering a curriculum with repetitive, longitudinal practice for many procedures found across multiple clinical settings and all training levels in order to improve access to and confidence in performing required procedures. This was done by implementing recurring monthly procedure workshops using both low- and high-fidelity simulators accompanied by didactic sessions highlighting the ACGME-required procedures. Building off prior work by Sawyer et al.,²² facilitator workshop guides for 17 procedural skills were developed for implementation in a comprehensive yearlong curriculum in our pediatric residency program. Our facilitator guides offer a unique contribution to the literature by including goals and objectives, equipment lists, risks/benefits, indications/contraindications, workshop setup, skills checklists, and knowledge pretests, allowing other residencies to implement the curriculum within their respective programs.

Methods

In response to our ACGME exit survey results, we aimed to develop a longitudinal curriculum in which pediatric residents

could practice core pediatric procedures on simulators. The workshops were added to our standing daily noontime conferences and were generally 1.5 hours in duration. The workshopped skills included venipuncture, intravenous line placement, arterial puncture, chest compressions, bag valve mask ventilation, defibrillation, intubation, lumbar puncture, intraosseous access, bladder catheterization, neonatal intubation, umbilical arterial and venous catheterization, incision/drainage, suturing, and joint reduction and splinting. The skills covered and those repeated in a given year (Figure) were determined by the program to be important high-value ones (i.e., deemed highest yield for residents and graduated pediatricians, including both ACGME-required and other important resuscitative skills). All the skills repeated once in an academic year, except for incision/drainage, suturing, joint reduction, and splinting, to prioritize repetition for the skills thought most likely to be encountered within our specialty. In the case of our residency, the unrepeated skills tended to be consistently encountered in senior emergency department rotations and had relatively higher confidence on the baseline exit survey. Prior to implementing the procedure curriculum, we obtained feedback regarding the format and content of the workshop and fidelity of the simulators following one pilot workshop. Feedback included having multiple stations available, limiting the number of learners per station, and increasing the time dedicated to learner engagement with the

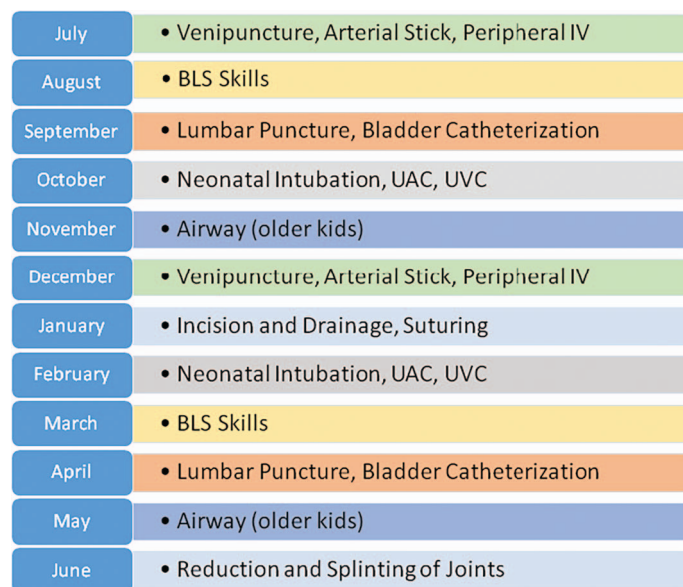


Figure. Timeline of procedure curriculum for an academic year color-coded by workshop. BLS skills workshops included cardiopulmonary resuscitation, defibrillator training, and bag mask ventilation. Airway workshops included endotracheal intubation and laryngeal mask airways. Abbreviations: BLS, basic life support; IV, intravenous line; UAC, umbilical artery catheterization; UVC, umbilical vein catheterization.

simulator. The curriculum was fully implemented during the 2018-2019 academic year.

Facilitators for each workshop were intended to be pediatric hospitalists without prerequisite knowledge outside of their normal scope of practice. Each workshop included two to three facilitators, often one or more pediatric hospitalists with or without expert faculty. For example, intensivists and anesthesiologists were invited to airway workshops, intensive care nurses to intraosseous line workshops, pediatric nurses to intravenous line workshops, and neonatologists to neonatal intubation and umbilical catheterization workshops. The use of expert faculty was optional but added the benefit of experience in discussing risks, benefits, indications, and equipment troubleshooting.

The equipment necessary to run each workshop varied based on the skills included in that workshop, and the amount of supplies required was based on our 30-resident program (Appendix A). There was a mix of high-fidelity simulators and low-cost simulators. For example, instead of an abscess task trainer for incision/drainage, we made our own low-cost abscesses, like other simulation workshops in the literature.²⁴ The workshops were carried out in either conference rooms or empty hospital patient rooms (depending on availability) and had computer access for the facilitators.

At the start of each workshop, residents completed a short pretest on paper to assess knowledge of each skill (Appendices B-H), then split into groups to attend each station. Facilitators used checklists for each skill to review indications, risks, and benefits for each procedure as well as how to troubleshoot the equipment. Prior checklists published by Sawyer et al. were utilized alongside checklists for additional skills adapted for our curriculum (Appendices B-H).²² This gave the facilitators a guide by which to check off each resident's skill proficiency in real time and offer feedback. Facilitators also used answer sheets to review the correct responses to the pretests with the participants (Appendices B-H). Facilitator guides included a list of optional supplemental information facilitators could find via web search to help them prepare for each session; computers were available in the rooms if they wanted to display any supplemental information at their discretion, but specific resources were not provided. The ideal setup and timing for each workshop were provided in each facilitator guide.

To assess our curriculum's main purpose of improving graduates' procedural confidence, the ACGME exit survey was used to evaluate the effectiveness of the overall curriculum, comparing

mean confidence for procedural skills in residency classes prior to and after implementation of the curriculum. Changes were evaluated using paired *t* tests to test for statistical significance.

To evaluate the quality of each workshop in improving trainee confidence, as well as the effect of longitudinal repetition, trainees completed anonymous surveys on paper that ranked their self-reported confidence in each skill in a given workshop on a 10-point Likert scale (1 = *least confident*, 10 = *most confident*) at the beginning of the workshop (Appendix I). Trainees also indicated the number of times they had participated in that particular workshop. To limit cognitive bias, we did not reassess confidence immediately after the workshop but rather in future surveys of the same workshop. For example, a resident who attended three workshops on the same skill provided survey responses prior to their first workshop, prior to their second workshop, and prior to their third workshop. The latter two responses would represent delayed confidence responses after exposure to the first and second workshops, respectively. Mean confidence scores were plotted against number of workshops attended for each skill, and best-fit linear trendlines were obtained. The correlation coefficient (R^2) was determined for each skill that had residents attending two or more of its workshops. Level of training (PGY year) was also obtained to assess for relationships between confidence and year. To protect anonymity, residents were not compared to their own selves. Instead, aggregate data were obtained, and confidence was assessed for correlation with number of workshops attended. Data were collected during the 2018-2019 and 2019-2020 academic years.

The Research Determination Committee for the Kaiser Permanente Northern California region determined the project did not meet the regulatory definition of research involving human subjects per 45 CFR 46.102(d).

Results

The procedure curriculum was implemented successfully and continues as a regular monthly workshop series within the residency noon conferences. For our program of 30 residents, attendance varied from 10 to 25 residents for each session, consisting of two to three stations with facilitators at each station. Each workshop's ideal flow and setup are included in its respective facilitator guide. Residents split up into groups to attend each station, taking turns between observing and performing each skill, with the facilitator supervising. Faculty facilitators consisted of pediatric hospitalists (including the authors) but, depending on the workshop, also included

expert faculty. To prepare for the workshops ahead of time, facilitators received with the facilitator guides with the goals of the workshops, checklists for procedural competence, and suggested types of optional resources they could find via web search should they need additional information in preparation for the session.

While each of the workshops was not individually assessed by the residents after the initial pilot feedback, the pediatric hospitalists at each workshop included the authors, who could assure the sessions ran smoothly. Debriefs and informal feedback indicated that facilitators found the workshop timing and flow to be appropriate and had enough time to provide valuable feedback on performance, observe that residents used the equipment properly, and review the session quiz answers. Facilitators oversaw the residents verbalizing indications, contraindications, risks, and benefits of each procedure as they practiced at each station and guided them with real-time coaching as necessary. The performance checklists were not collected but rather were used for direct feedback to the residents.

When evaluating the attitudes of graduating residents ($n = 10$ for each graduating class) on the ACGME exit survey, the percentage who agreed or strongly agreed they felt comfortable with the procedures included in our curriculum improved from 50% to 66% after 2 years of the curriculum ($p = .10$). The proportion of graduating residents disagreeing or strongly disagreeing they felt comfortable across procedures included in our curriculum decreased from 40% to 22% after 2 years of the curriculum ($p = .002$). Residents who graduated 3 years from the start of the curriculum were not assessed due to temporary cancellation of in-person didactics secondary to the COVID-19 pandemic, which limited our ability to perform these workshops for over 10 months.

The residents were also evaluated on their confidence in performing each procedure, and correlation between repeated attendance and confidence was assessed for skills for which residents attended two or more workshops on the same procedural skill. For several skills, there was a positive correlation between the number of workshops of a particular skill attended and confidence in that skill, with R^2 ranging between .60 and .99 (intubation $R^2 = .99$, intraosseous access $R^2 = .99$, venipuncture $R^2 = .96$, bladder catheterization $R^2 = .84$, peripheral IV placement $R^2 = .82$, lumbar puncture $R^2 = .79$, and umbilical catheterization $R^2 = .60$). However, there was no change in confidence for bag mask ventilation and chest compressions, which remained stably high, or neonatal intubation

and defibrillation, which remained stably low. Data collection on arterial puncture was interrupted due to lack of access to the arterial task trainer during the sampling period, and not enough workshops were attended to make assessments on incision/drainage, suturing, splinting, and reduction. The results were not controlled for potential confounding variables, such as number of procedures a resident may have completed on real patients between each workshop, or by PGY year, which we expand on in the Discussion section.

Discussion

This project adds to the existing body of literature indicating that longitudinal simulation is an effective educational modality that can increase learner confidence in performing procedures in a safe environment. After implementation of this curriculum, our residents demonstrated improved procedural skill confidence at the time of graduation, as evidenced by the ACGME exit surveys. To our knowledge, this is the first procedure-based publication that includes comprehensive facilitator guides with equipment lists, performance checklists, and competency quizzes for an entire year's worth of curriculum for a pediatric residency. Our curriculum addresses adult learners' need for repetitive practice by building redundancy into the yearlong monthly curriculum and allowing pediatric trainees from three to six opportunities to attend the simulation workshop on a particular skill throughout the course of their residency.

To avoid cognitive biases such as recency/availability bias, whereby resident confidence may be inflated immediately after a workshop, we chose to administer confidence surveys the subsequent time residents attended the same workshop, rather than immediately afterward, and to assess for long-term improvements in confidence. One trade-off of this decision is that it did not control for any real-life procedure exposures that could have affected confidence scores between workshops. Given the limited amount of procedure opportunities our pediatric residents faced, we felt that the increases in self-reported confidence with increased workshop attendance over time suggested a positive dose-related effect and justified continuing this simulation-based procedural curriculum in our residency program.

Potential limitations of the curriculum could include the frequent need for facilitators, though this has been alleviated by the use of facilitator guides that include all the materials required for each workshop, as well as the need for sometimes costly simulator equipment. We were able to secure access to simulators through partnership with our institution's simulation lab and other departments, including the pediatric and neonatal intensive care

units. However, despite this partnership, we were still limited by temporary lack of access to an arterial task trainer. Nonetheless, not all the workshops required high-fidelity simulators. Some required only bananas for suturing practice or bandages filled with toothpaste for incision/drainage practice, whereas others, such as for splinting practice, used residents as participants.

Assessment of the curriculum also had limitations, including participants' recall bias regarding how many workshops had been attended or potential errors in confusing which workshops had previously been attended (i.e., airway management vs. neonatal intubation), as well as the confounding factor of time, whereby residents may have had exposure to procedures on real patients in the time between workshops. Due to attendance variability, a workshop conducted at the end of an academic year could capture one senior resident's first time at the workshop and another's third time, yet both should have had comparable real-patient exposures. While the correlation we observed (between number of workshops attended and stated confidence) need not imply causation, we are nonetheless encouraged by the improvements in the ACGME exit survey since implementing the curriculum and will therefore continue the curriculum in our residency.

Only self-reported confidence was assessed as an outcome of the curriculum, rather than competence, which could be a future aim to study. We attempted to use the pretests as a way to track improved competence/knowledge for each skill with repeated workshop exposure but were limited by resident engagement and inability to collect enough pretests to make a valuable assessment. We were not able to gather data on every skill for which residents had attended at least two workshops because not enough residents had that repeated exposure during our sampling period and the COVID-19 pandemic resulted in a pause of all in-person gatherings during the third year of curriculum implementation. Similarly, we were not able to meaningfully stratify the results by PGY year given our sampling period and relatively small residency size. However, this only underscores the need for a longitudinal repetitive curriculum to address the challenges of capturing all our residents at a given time (due to residents missing the workshops while on night shifts, away rotations, off-site rotations, vacation, etc.).

Overall, this comprehensive curriculum can be adopted immediately by other programs to improve both procedure exposure and graduate confidence thanks to the instructor guides that allow any instructor to lead the workshop. Programs can further tailor the curriculum by conducting a needs assessment to understand the needs of their residents,

evaluating their exit survey results, and deciding which skills to include and which to repeat. The curriculum's sustainability is underscored by its use of cost-reducing low-fidelity simulators. The workshops can also be utilized to formally evaluate struggling learners' competence in particular procedural skills through the use of procedure checklists or checking off residents on skills they may not have had exposure to in clinical practice. Our residency program continues to use these recurring monthly procedure workshops in its didactic schedule given the impact they have had on trainee confidence both during and after residency.

Furthermore, the small-group setup of the workshops made them accessible during the COVID-19 pandemic when social distancing was a priority. After an initial hiatus from in-person gatherings mandated by our graduate medical education office, we were able to safely restart the curriculum with appropriate personal protective equipment and cleaning procedures.

Appendices

- A. Equipment Checklist for Procedure Workshops.docx
- B. Facilitator Guide - Venipuncture, IV, Arterial Puncture.docx
- C. Facilitator Guide - BLS Skills.docx
- D. Facilitator Guide - LP, IO, Bladder Cath.docx
- E. Facilitator Guide - UVC, UAC, Neonatal Intubation.docx
- F. Facilitator Guide - Airway Management.docx
- G. Facilitator Guide - I&D, Suturing.docx
- H. Facilitator Guide - Splinting and Reduction.docx
- I. Resident Confidence Surveys.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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Prior Presentations

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Ethical Approval

The Kaiser Permanente Northern California Research Determination Committee approved this project.

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