Prehospital Emergency Care

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ipec20

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To cite this article: Sang Hoon Lee, Lauren C. Riney, Brant Merkt, Shawn D. McDonough, Jordan Baker, Stephanie Boyd, Yin Zhang & Gary L. Geis (26 Sep 2023): Improving Pediatric Procedural Skills for EMS Clinicians: A Longitudinal Simulation-Based Curriculum with Novel, Remote, First-Person-View Video-Based Outcome Measurement, Prehospital Emergency Care, DOI: 10.1080/10903127.2023.2263555

To link to this article: https://doi.org/10.1080/10903127.2023.2263555

Improving Pediatric Procedural Skills for EMS Clinicians: A Longitudinal Simulation-Based Curriculum with Novel, Remote, First-Person-View Video-Based Outcome Measurement

Sang Hoon Lee,[a]* Lauren C. Riney,[a] Brant Merkt,[b] Shawn D. McDonough,[b] Jordan Baker,[c] Stephanie Boyd,[c] Yin Zhang,[d] and Gary L. Geis[a]

[a]*Department of Pediatrics, University of Cincinnati, College of Medicine, Cincinnati, USA;* [b]*Center for Simulation and Research, Cincinnati Children's Hospital Medical Center, Cincinnati, USA;* [c]*Division of Pediatric Emergency Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, USA;* [d]*Division of Biostatistics and Epidemiology, Cincinnati Children's Hospital Medical Center, Cincinnati, USA*

Correspondence e-mail address: sanghoon.lee@cchmc.org

ORCiDs:

Sang Hoon Lee: 0000-0002-8785-8311

Stephanie Boyd: 0000-0003-2433-4147

Yin Zhang: 0000-0002-6127-7535

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Abstract

Objective

Emergency medical services (EMS) clinicians are expected to provide expert care to all patients, but face obstacles in maintaining skillsets required in the care of critically ill or injured children. The objectives of this study were to describe and assess the effectiveness of a pediatric-focused, simulation-based, procedural training program for EMS clinicians, delivered on-site by a pediatric simulation education team. We also describe a novel, remote, asynchronous performance outcome measurement system using first-person-view video review.

Methods

This was a prospective study of simulation-based training and procedural outcomes. The study population involved EMS clinicians at three fire-based EMS agencies stratified as urban, suburban, and rural sites. The primary outcome was performance of intraosseous catheterization (IO), bag-valve-mask ventilation (BVM), and supraglottic device placement (SGD), measured across three time points. Secondary outcomes were identification of differences across EMS agencies and participant survey responses.

Results

We obtained video data from 122 clinicians, totalling 561 videos, with survey response rates of 89.0-91.3%. Pre-intervention scores were high: least-square means (95% confident-

intervals) 9.5 (8.9, 10.2) for IO; 9.6 (9.3, 9.9) for BVM; and 11.6 (10.9, 12.2) for SGD. There was significant improvement post-intervention: 11.5 (10.7, 12.3) for IO; 11.0 (10.7, 11.4) for BVM; and 13.6 (12.8, 14.4) for SGD. Improvement was maintained at follow-up after a median of 9.5 months: 10.5 (9.8, 11.2) for IO; 10.2 (9.9, 10.6) for BVM; and 12.4 (11.7, 13.1) for SGD. There were no statistical differences between sites. Of survey respondents, half had not cared for a critically ill or injured child in at least a year, the vast majority had not had hands-on pediatric training in over 6 months, and the majority felt that training should occur at least every 6 months.

Conclusions

Our pediatric-focused, simulation-based procedural training program was associated with improvement and maintenance of high-baseline procedural performance for EMS clinicians over the study period. Findings were consistent across sites. Remote assessment was feasible. Participant surveys emphasized a desire for more pediatric-focused training and highlighted the low frequency of clinical exposure to procedures potentially needed in the care of critically ill or injured pediatric patients.

Keywords: emergency medical services; pediatric emergencies; simulation-based education; remote assessment; wearable technology; prehospital research

Introduction

The achievement and maintenance of procedural proficiency in the care of critically ill or injured children is an important but unique challenge in the emergency medical services (EMS) community. Despite several studies at the national, regional, and local levels reporting the continued need for prioritization, standardization, and research in education for EMS clinicians, the ground-level obstacles of inadequate time, resources, and expertise are still poorly addressed and hinder forward progress (1-9). The coronavirus disease (COVID-19) pandemic has exacerbated these barriers, revealing the fragility of EMS educational programs, prompting numerous cancellations, and bringing to light a need for more non-traditional options (10). Furthermore, clinical practice alone cannot maintain vital skillsets due to the rarity of critical procedural interventions in the field for pediatric patients, with one study estimating a time span of 2 to 3 years between such EMS encounters for critically ill or injured children (11), and another demonstrating only 67 prehospital pediatric intraosseous (IO) catheterization attempts in one large regional health system during an 8-year study period (12). As with other medical specialties' response to training for low-frequency, high-acuity events, there has been an increasing call for simulation-based training (SBT) for EMS clinicians. However, there is inconsistent evidence for the most effective and efficient educational methods to improve and maintain knowledge, skills, attitudes, and behaviors around pediatric-focused care for EMS clinicians (13).

The objectives of this study were twofold: (1) to describe and assess the effectiveness of a pediatric-focused SBT program designed for EMS clinicians; and (2) to provide proof of concept for the implementation of a first-person-view video capture method for procedural training and assessment. For our first objective, we hypothesized that EMS clinicians' skills would improve after training and be maintainable over the study time period. For the second, we aimed to illustrate the use of first-person-view video recording, which would allow for

remote, asynchronous performance outcome measurement. This study serves as the first step in the creation and assessment of a longitudinal, asynchronous, pediatric-focused training curriculum. The long-term goals of our work are to improve access to high-quality pediatric-focused education for the EMS community, develop new modalities for on-site and remote procedural training and assessment, and ultimately improve the care provided to critically ill or injured children in the prehospital care environment.

METHODS

Study Setting, Population, and Recruitment

Three EMS agencies were recruited from three separate areas of Southwest Ohio with the goal of studying an EMS agency in an urban, suburban, and rural area. EMS agencies were identified through querying an internal database of local EMS agencies that transport patients to our pediatric, academic emergency department, removing those known to already have established SBT programs, and sorting by total number of transports. Training officers (or chiefs) were contacted via e-mail explaining the curriculum, research study, and anticipated time commitment. Demographic characteristics of the enrolled EMS agencies are shown in Table 1. Each EMS agency was fire-based.

The study population included all full-time or part-time EMS clinicians at the recruited agencies with IO catheterization, bag-valve mask (BVM) ventilation, and/or supraglottic device (SGD) placement within their scope of practice. Those with scope of practice in only one or two of the three procedures submitted data only for those procedures. EMS clinicians who did not have any of the procedures within their scope of practice, and those who declined to participate in the video-based research portion of the SBT program, could still participate in the educational and survey portions of the program. Study staff obtained informed consent for the research portion of the SBT program at the beginning of

each session. Participants could withdraw at any time and could enroll at a later time point if they had declined earlier. Those who were not present at the initial session of the SBT program (e.g., new hires) were still eligible and similarly consented at the time of entry into the SBT program. These participants' procedural video data were collected but not included in analysis; however, their survey responses were included. No participants worked at more than one eligible agency. The Cincinnati Children's Hospital Medical Center Institutional Review Board reviewed the study and determined it to be exempt from review.

Study Design and Protocol

This was a prospective study of SBT and simulated procedural outcomes for EMS clinicians. We developed our SBT program using standard tenets of curriculum design (14). This program consisted of two educational modalities: task-trainer-based procedural training and scenario-based team training. To overcome the obstacles of time and access, our simulation team brought a mobile simulation unit on-site to each of three shift-days at each EMS agency's training location. To cover each shift during both the initial training period and the follow-up period, this required three visits for each site during each period – we therefore went on-site for a total of 18 sessions. Depending on the size of the agency, the simulation team was on-site for 4-8 hours for each of the initial training sessions, and 3-6 hours for each of the follow-up training sessions.

At the initial training session, our simulation team oriented all participants to the SBT program, research study, high-fidelity simulation manikin for scenario training, and task trainer stations. During orientation, participants were allowed to touch and examine all pieces of simulation equipment, but the simulation team did not answer questions regarding how to perform any aspect of the procedures. After orientation, a clinical research coordinator (CRC) obtained informed consent and assigned each consenting participant a random identification

(ID) number. Participants then individually went to one of three identical task training stations for initial, pre-intervention assessment. These stations were isolated so that participants could not see or hear other participants. The simulation team member at the station read a standardized script that included a short clinical scenario prompt, followed by a series of prompts (Appendix A). Some prompts were action-based (e.g., "Medical control has been notified and they recommend placing a supraglottic device") while others were knowledge-based (e.g., "We do not have an oxygen tank here, but if you were to hook it up, what flow of oxygen would you turn it to?"). If a participant performed a targeted action without prompting, the respective prompt could be skipped. The simulation team would answer questions regarding the scenario (e.g., "Is there a pulse?"), but would not answer questions related to the procedures themselves. The team assessed participants only for the procedures within their scope of practice. This process generated the "pre-intervention" assessment data.

After the pre-intervention assessment, participants were asked to return to the main training area and to not discuss the assessment with other participants. Once everyone had completed the pre-intervention assessment, they were split into three groups. Each group then rotated through BVM, SGD, and IO stations. In the stations, clinicians received short didactic instruction, followed by individual hands-on practice for the procedure using the outcome measure scoring criteria as a training guide. To standardize the education provided, the same simulation team member taught the same designated procedure at their station at all sites. Once training was complete, participants again individually went to one of three, isolated, identical task training stations, where they were assessed using the same script and equipment. This process generated the "post-intervention" assessment data.

To maximize the efficiency of on-site training we implemented a novel method of data collection using head-mounted, first-person-view cameras (GoPro, Inc., San Mateo,

CA). These lightweight cameras can be secured onto an object or person and provide high-resolution, motion-stabilized, audio and video recordings. Described sporadically in surgical and anesthesia training literature (15-18), we assumed that the high-resolution capabilities of such devices would allow for adequate data capture and be well-tolerated by participants. We piloted the camera with a non-eligible group of emergency department paramedics to assess for tolerance and adequacy of data capture prior to implementation. However, given the extra risks to participant confidentiality, we took reasonable steps to ensure that no identifiable features (e.g., badges, tattoos, jewelry) were visible on video. As some data measures required verbal responses, voices could not be masked. Video files were downloaded onto password-protected study computers immediately following training sessions and then deleted from the memory cards.

The scenario-based team training exercise consisted of a drowning scenario using high-fidelity simulation requiring cardiopulmonary resuscitation and care of a pediatric patient in full arrest. Each team ran the scenario for 15-20 minutes and then participated in a facilitator-led debriefing for 15-20 minutes. As the case involved the procedures of interest, the scenario-based exercise took place at the end of each training session with participants who had already completed post-intervention data collection, so that no clinician received additional "practice" compared to the other participants prior to data collection. Procedural outcome data were not collected from the scenario-based training exercise.

The original follow-up assessment period was planned for 3 months after the initial training date. Due to COVID-19, the majority of follow-up assessments were cancelled and rescheduled past the original protocol window. During the follow-up training session, the simulation team again obtained informed consent from eligible participants. Participants were provided with their previously assigned ID numbers; each new participant was assigned a unique random ID number. Without additional training, participants individually went to one

of three identical, isolated task trainer stations and completed the same procedural assessments using the same script. This process generated the "follow-up assessment" data. New participants were allowed to examine the simulation equipment immediately prior to their assessment but received no additional education – new participant data were not included in the analysis. After each participant's assessment was complete, the simulation team member at that station offered one-on-one training based on their observations. This concluded the follow-up training session.

If any portion of training was interrupted by an EMS call, clinicians were given the opportunity to restart or resume from the point of interruption. The on-site CRC maintained a record of interruptions. In cases where a participant restarted from the beginning, or where there was overlap in outcome measures, the first attempt scores were used to decrease any effect of having an "additional" attempt.

Lastly, clinicians who participated in the training and provided e-mail addresses received electronic surveys at the end of the session asking questions regarding personal clinical experiences and educational needs assessments. No incentives were offered for training or survey participation.

Outcomes of Interest: The primary outcome was performance of individual clinicians on IO catheterization, BVM ventilation, and SGD placement measured longitudinally across three time points: pre-intervention, post-intervention, and follow-up. Secondary outcomes were identification of differences across EMS agencies by environment (urban, suburban, and rural) and participant survey responses.

Measures of Outcome: To assess procedural performance in IO catheterization, BVM ventilation, and SGD placement, we applied a scoring tool to each procedure (Appendices B-

D). The IO catheterization (Appendix B) and BVM ventilation (Appendix C) tools were previously developed and externally validated by the Cincinnati Children's Center for Simulation and Research and included dichotomous "performed" or "not performed" measures. We based the SGD placement tool (Appendix D) on the one used for the National Registry of Emergency Medical Technicians psychomotor examination and included dichotomous "performed" or "not performed" measures and critical "failure" criteria – this was modified to apply to pediatric patients. For secondary outcomes, one survey was sent to participants after the initial training session (Appendix E), and another survey was sent to participants after the follow-up training session (Appendix F). Surveys included multiple-choice questions regarding personal clinical experiences, prior educational activities, future needs assessments, and open-ended free-text questions. All surveys were built and implemented via REDCap (19, 20).

Application of outcome measures and reviewer training: We video-captured all procedure attempts using a head-mounted, first-person-view camera. The camera also provided simultaneous mirrored views on a GoPro app-connected device, which the team used to adjust the camera angle before and during recording. We disabled automatic, cloud-based, upload capabilities where applicable. All videos were saved to a password-protected computer accessible only to study staff, then moved to our medical center's cloud-based network storage drive, which is also password-protected and requires additional access permissions. A CRC maintained the video library, sorted by site, training date, and training session. The CRC also watched the beginning of each video file to ensure that there were no blank videos (i.e., accidental captures) and to determine each participant's ID number (which had been written on a note card and placed within the video frame). Finally, the CRC renamed each video to include reviewer number (1, 2, or 3) and a randomly generated video

number. Reviewers did not watch any videos until all videos were collected, including the follow-up videos. The CRC who was on site and maintained the videos was a different CRC from the one who later conducted primary video data review. This allowed for reviewer blinding across all time points. To ensure reviewers were equally likely to get videos from each site, procedure, and time point, we block randomized videos in groups of 18, and evenly divided all videos to the three primary reviewers.

A sample of procedural videos created during piloting was used for video reviewer training by the three primary reviewers and the one secondary reviewer until reviewers were consistent. Consistency was defined as no discrepancy for dichotomous outcomes.

Feasibility did not allow for secondary review of every video. However, following protocols for video-based scoring described in the literature, the secondary reviewer co-reviewed every primary reviewer's tenth video to prevent scoring drift and improve reliability (21, 22). If both sets of scores were consistent, the primary reviewer continued the next set of 10 videos. If there were any discrepant measures, the two reviewers reconciled the discrepancy, and agreed upon a final choice. Then, the primary and secondary reviewers co-reviewed the next video and repeated this process until they achieved consistency.

Data Analysis

To calculate the needed sample size, we *a priori* assumed pre-intervention mean scores of 50%, and post-intervention and follow-up mean scores of 80%. We also assumed within-clincian correlation to be 0.1, and within-site correlation to be 0.2. Therefore, with α=0.05 and β=0.20 (80% power), the sample size required to detect all three differences was estimated to be 53 participants. Accounting for an approximate 40% loss-to-follow-up due to staff turnover, EMS runs occurring during training, and voluntary withdrawal from the study, we targeted an enrollment of at least 89 total participants.

We depicted raw scores using box plots at each site and session. Normality tests were conducted and log-transformations were performed on each score. We tested between-site differences using one-way ANOVA. Pre-intervention, post-intervention, and follow-up scores were compared using linear mixed models with session as a fixed effect and site as a random effect to account for between-site variation. We report exponential-transformed least-square means, the 95% confidence intervals, and Tukey adjusted p-values. We also conducted secondary analyses using generalized linear mixed models to assess for training effects on each single item for all three scoring tools. P-values less than 0.05 were considered statistically significant. We conducted all statistical analyses using SAS 9.4 and SPSS v25.

RESULTS

Over the study period, we enrolled 129 EMS clinicians, one who submitted no data and another who was a non-EMT/paramedic physician wanting to experience the training program – both were removed prior to analysis. Full enrollment data of the remaining 127 participants are depicted in Figure 1, including the numbers and breakdown of time points at which videos and surveys were collected. There were three videos without identifiable ID numbers whose data were included in overall analyses but were not included in per-site analyses. Table 2 summarizes participant demographics, reporting certification and self-reported years of experience at time of video submission, with count representing the number of unique enrollments at each time point and percentages based on respondents within respective category. The suburban site had fewer years of certification experience when compared to other sites, while the urban site had greater years of experience overall.

We were able to complete one follow-up training session within the initial, planned, protocol period for 13 participants, with an interval time gap of 4.0-4.2 months. For the

remainder of the participants, the interval time gap range was 8.7-10.5 months (median 9.6 months). Median time gap for all participants was 9.5 months.

We collected 561 videos: 266 IO and 295 airway (combined BVM and SGD) videos. We initially distributed videos equally between the three primary reviewers (JB, GG, LR), but re-allocated videos based on availability due to reviewers' differing clinical and administrative responsibilities. Ultimately, JB reviewed 314 (56.0%) videos; GG, 136 (24.2%) videos; and LR, 111 (19.8%) videos. All videos could be scored. We maintained reliability checks per the planned protocol, with co-review of 47 (8.4%) videos – 23 IO videos and 24 airway videos. Of the 970 co-reviewed data measures, there were 69 (7.1%) inconsistent measures. Overall, we collected 11,641 video-based data measures.

Our primary outcomes (Table 3) were the skills demonstrated in three procedures across three time points. Overall, for all three procedures, there was statistical improvement from pre- to post-intervention, as well as maintenance of these improvements at follow-up. Figure 2 shows box plots for each procedure, depicting the means, medians, interquartile ranges, and ranges for raw scores, demonstrating improvement in scores by time point, site, and overall. Tables 4-6 report aggregate per-outcome-measure analyses for each procedure, with "Yes" indicating the desired, correct action, along with comparisons across each time point. Per-outcome-measure analysis demonstrated several measures where the participants already started with high levels of skill with little margin for improvement, but also revealed several measures with a greater opportunity for improvement.

As a secondary outcome, there were no significant differences between urban, suburban, and rural sites for any procedure at any time point (Figure 2). We also surveyed clinicians after the initial training and after follow-up sessions (detailed results can be found in Appendices G and H, respectively). Of the 109 clinicians who participated in the initial training sessions, 97 (89.0%) completed the post-intervention survey; of the 92 participants

who participated in the follow-up training sessions, 84 (91.3%) completed the follow-up survey. Notably, of the clinicians who responded at the time of initial training, half had not cared for a critically ill or injured child in at least a year, the vast majority had not had hands-on pediatric training in over 6 months, and the majority felt that training should occur at least every 6 months. Of the clinicians who responded at follow-up, only 6 (7.1%) had performed BVM ventilation, 1 (1.2%) had placed an SGD, and 4 (4.8%) had inserted an IO catheter on a pediatric patient in the interim time period. These exposures did not change their perceptions of needed training frequency. There were no significant differences across sites in their needs assessment.

During training sessions, EMS calls interrupted education 0-3 times (median: 0.5), with a loss of 2-10 participants (median: 3), for a range of 7-234 minutes (median: 44.5). All participants were able to complete the training portions of the program and no participant was lost to follow-up due to an interruption.

DISCUSSION

EMS clinicians are expected to provide expert care for all patients, but report feeling least prepared in the care of pediatric patients (3, 4, 7). Due to significant barriers surrounding time, funding, instructors, and accessibility, EMS agencies and educators need efficient and effective methods of training, ideally delivered on-site and during shifts (6, 8). In a prospective study of pediatric-focused SBT and simulated procedural outcomes for EMS clinicians, we were able to successfully enroll and educate clinicians on-site at urban, suburban, and rural agencies and incorporate remote, asynchronous, first-person-view video-based, procedural assessments. Pertinent to a defined need in EMS clinicians, we evaluated infrequently used, but critical, pediatric airway and vascular access procedures, requiring thoughtful selection and implementation of pediatric size-based equipment.

We found that our standardized, guidelines-based, on-site SBT curriculum was associated with improvements in simulated procedural performance of IO catheterization, BVM ventilation, and SGD placement, with improvement maintained over the study period. This concurs with prior evidence surrounding SBT efficacy, but adds further insight into the interval length of time between training events that may prevent skill decay (13, 23-25): while our initial protocol had proposed follow-up at 3-6 months, secondary to the unintended delays caused by COVID-19, we were still able to show improvements from baseline at a 9.5-month interval. We also demonstrated the potential use of head-mounted, first-person-view video-recording, allowing for the remote, asynchronous assessment of medical procedural performance by EMS clinicians, which had only been previously reported in the operating room setting (15-18). Lastly, we reconfirmed a continued desire for frequent pediatric-focused training in the EMS community.

While we were able to demonstrate a statistically significant improvement in overall scores across all procedures, between the pre- and post-intervention intervals, the absolute differences were small as the starting scores were generally high. This highlights the complexity of assessing experienced clinicians with high baseline skill levels and of using a dichotomously-rated training tool as an assessment tool, namely where all steps are equally weighted. While there is evidence for the use of global-assessment-scores, we decided not to add these given the prior validation of our selected instruments (27). Despite these challenges, our methodology was still able to detect statistical differences. Furthermore, the per-outcome-measure analyses provide interesting insights into the individual items that clinicians excelled at or struggled with. Many of these outcomes were particularly pertinent to pediatric-sized patients: IO items 6 and 7; BVM items 7, 9, and 10; and SGD items 2, 3, 4, 8, and 13 (Tables 4-6). Of these measures that began with pre-intervention scores less than

90%, each showed significant improvement at post-intervention; of those, IO 7 and SGD 4 maintained that improvement to follow-up.

These relatively small absolute differences bring into question the balance of effort and resources against the EMS clinicians' self-reported desire for continued, repeated training. Lammers et al. examined four training modalities of varying simulation fidelity, and found that a low-fidelity simulation-training group demonstrated the greatest improvement in clinical assessment module scores (13). While not directly addressing costs associated with higher fidelity SBT, their findings support that higher cost, higher fidelity simulators do not necessarily lead to better educational outcomes. Our protocol most aligned with the "lecture and procedure skills lab training" model, although we embedded the procedural training within a scripted clinical context. This incorporates the advantages of using a simulation-based scaffold while meeting the minimal requirements of the EMS for Children performance measures, providing one effective method for pediatric emergency care coordinators and EMS educators to have their clinicians "physically demonstrate the correct use of pediatric-specific equipment" (26).

Additionally, our use of a head-mounted, first-person-view, procedural assessment system presents new ways to overcome several obstacles to training EMS clinicians. Our experience suggests ease of use, unintrusive acceptance by participants, and high-quality data capture. Notably, when the role of the on-site educator can be split from the evaluator role, the focus of the educator can be purely formative, reinforcing psychological safety and improving buy-in from learners. Further, the off-site evaluator could be non-clinical staff who have undergone rigorous video reviewer training. In our own work, primary reviewer JB, who ultimately reviewed over half the videos, was a CRC without hands-on expertise in the assessed procedures. However, based on our reliability check protocol, she was found to be as consistent as GG, a senior pediatric emergency medicine faculty member with

extensive experience in video-review based research. Finally, the ability to capture and assess procedural skills asynchronously opens an avenue for remote training and evaluation, where EMS agencies and clinicians physically distant from academic centers could still receive individualized, focused, high-quality education. The validity and feasibility of such a program requires further study.

To maintain reliability in our assessment methodology, our data dictionary was as strict and objective as possible. To point, IO item 6 was narrowly defined by the study team per Arrow® EZ-IO® best practice guidelines. Even though a pink or blue sized catheter could technically be used with our task trainer, a point was only awarded if the participant visualized at least the final black line prior to initiating the drill. As another example, BVM item 6 mandated that the reviewer begin a stopwatch at the end of the scripted prompt and that a point should only be awarded if bagging began within 30 seconds. Our head-mounted, first-person-view, video-based methodology allowed for these types of granular assessment. Finally, we found during piloting that IO item 11 (confirming placement by easy flush or aspiration) could not be consistently assessed due to the way that the task trainer was built – this was the only measure where we needed a "Cannot Assess" option.

Our secondary outcomes were analyses stratified by agency setting. For the purposes of our study, we chose to distinguish agencies by their demographic environments based on the assumption that smaller agencies would have fewer opportunities to care for critically ill or injured children in the field, which would lower their exposure to the procedures of interest and accordingly lower both the pre-intervention and follow-up scores. We also stratified our other secondary, survey-based outcomes for the same reason: differences in exposure could affect a clinician's needs assessment. In line with our theory, but counter to our assumption, we found that the percentages of pediatric-aged EMS calls were similar for each agency, and both procedural outcomes across all time points and survey-based outcomes

were not significantly different. These findings reiterate that clinical exposure to pediatric patients is limited and that the educational needs of agencies are similar despite varied environments and levels of experience (28).

Limitations:

Our study has a few limitations. As with any simulation-based educational study, the validity evidence of outcome assessment and transfer to practice must be assessed. The IO catheterization and BVM ventilation assessment tools were created at our pediatric, academic, hospital-based simulation center and externally validated with peer simulation centers for use in procedural training. The SGD placement assessment tool was minimally adapted from the standardized psychomotor exam used by the National Registry of Emergency Medical Technicians to apply to pediatric-sized patients, with no better-described tool found in the literature at the time of study. By using these measures as a scaffold for training, applying them at three time points, and demonstrating improvement across time, we have demonstrated validity evidence at the single observation (scoring) and test setting (generalization) levels, as laid out by Kane's framework (29). This evidence is strengthened by the use of video recording, reviewer training, and co-reviews to improve reliability in the application of the measures. While transfer to practice in the real-life setting (extrapolation) level was not assessed in this study, the comprehensiveness of the steps as laid out in the assessment tools increases construct validity – put another way, the inability to perform any of the assessed steps would reasonably imply a lower ability to apply those skills in clinical practice.

Second, our study required two protocol deviations due to COVID-19. First, we were unable to assess for skill decay at our proposed 4-month follow-up interval, and most of the follow-up assessments occurred between 9-11 months. Second, changing clinical demands

required reallocation of videos between primary reviewers. As prior literature had demonstrated skill decay earlier than 9 months, it is unclear what proportion of the maintenance effect could be directly attributed to our training methodology (24, 30, 31). Notably, and likely due to the prolonged interval, about half of respondents who answered the survey reported having received interim procedural training between our initial and follow-up dates. While we could not perform a sensitivity analysis on this subset of participants, it is unlikely the education they received was pediatric-focused given the lack of other such programs in the local area. Appealingly, this could suggest that even intermittent, non-pediatric-focused training could help to prevent skill decay in the assessed pediatric-focused procedures, providing one workaround for agencies with limited access to pediatric experts. A future study could ideally test participants at multiple intervals, inclusive of differing forms of procedural training, to assess for dose effects and effects on skill decay.

The other protocol deviation required one primary reviewer, JB, to review a larger proportion of the procedural videos. We used block randomization to ensure that all reviewers would be at equal risk to be assigned each procedure, from each site, at each time point. Reassignment was done in sequential order, maintaining randomization as able. The effects of this on outcome measurement validity and reliability are unclear. In an ideal setting, a small pool of expert reviewers would co-review every video and resolve resultant discrepancies in a rolling fashion. This was not feasible for our study group and would be difficult to implement in a real-world setting. Nevertheless, our reliability checks demonstrated high reliability for each reviewer, and may have even improved overall reliability due to the accrual of experience by a single, non-clinical, primary reviewer. A future study may compare the validity and reliability of video-based outcome measurement by clinical versus non-clinical staff, which could inform the feasibility of similar training or research programs.

Lastly, this was a single region study of three local fire-based EMS agencies, which limits the generalizability of the results outside of our region. However, we obtained data from agencies located in three different community settings, with procedures typically within the scope of practice of EMS clinicians. Furthermore, while the years of experience for providers varied between sites, our findings were still significant, suggesting a positive effect for a wider demographic of clinicians.

CONCLUSION

In a prospective study of pediatric-focused SBT and simulated procedural outcomes for 127 EMS clinicians, with data extracted from 561 head-mounted first-person-view procedural videos, we found an overall improvement in IO catheterization, BVM ventilation, and SGD placement scores between the pre-intervention, post-intervention, and follow-up periods. These findings were consistent across urban, suburban, and rural sites. Participant surveys continue to emphasize a desire for more pediatric-focused training and highlight the low frequency of clinical exposure to procedures potentially needed in the care of critically ill or injured pediatric patients.

ACKNOWLEDGEMENTS

This work was supported by the Ohio Department of Public Safety Division of Emergency Medical Services Research Grant Priority 2-5.

DECLARATION OF INTEREST STATEMENT

The authors report there are no competing interests to declare.

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APPENDICES

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Table 1. Agency Characteristics

Agency	Urban	Suburban	Rural
Square miles of service	28.5	7.5	41.6
Size of population served	61,000	13,379	27,660
Total EMS calls (year prior to study start)	6,600	1,800	4,076
Number (percentage) of EMS calls for pediatric patients <16 years of age	430 (6.5%)	95 (5.3%)	223 (5.5%)
Number of paramedics on staff (full and/or part-time)	80	30	25
Number of EMTs on staff (full and/or part-time)	20	9	4

EMS: Emergency Medical Services, EMT: Emergency Medical Technician

Table 2. Participant Certification and Years Experience

			Site		
Time Point / Survey Question	**Certification of Clinicians**	**Overall**	**Urban**	**Suburban**	**Rural**
Pre-Intervention	Paramedic	93 (88.6%)	51 (87.9%)	22 (88.0%)	20 (95.2%)
	EMT	11 (10.5%)	7 (12.1%)	3 (12.0%)	1 (4.5%)
	Missing	1 (1.0%)	0	0	1 (4.5%)
Post-Intervention	Paramedic	90 (89.1%)	50 (86.2%)	22 (91.7%)	18 (94.7%)
	EMT	10 (9.9%)	7 (12.1%)	2 (8.3%)	1 (5.3%)
	Missing	1 (1.0%)	1 (1.7%)	0	0
Survey self-report of total years as EMT or paramedic (i.e., time since first/earliest certification) at post-intervention	< 1 year	1 (1.0%)	0 (0.0%)	1 (4.0%)	0 (0.0%)
	1 - 3 years	13 (13.4%)	5 (9.6%)	7 (28.0%)	1 (5.0%)
	4 - 6 years	14 (14.4%)	8 (15.4%)	2 (8.0%)	4 (20.0%)
	7 - 10 years	9 (9.3%)	2 (3.8%)	4 (16.0%)	3 (15.0%)
	> 10 years	59 (60.8%)	37 (71.2%)	10 (40.0%)	12 (60.0%)
	Missing	1 (1.0%)	0 (0.0%)	1 (4.0%)	0 (0.0%)
Follow-up	Paramedic	73 (81.1%)	36 (85.7%)	18 (69.2%)	19 (86.4%)
	EMT	17 (18.9%)	6 (14.3%)	8 (30.8%)	3 (13.6%)
Survey self-report of total years as EMT or paramedic (i.e., time since first/earliest certification) at follow-up	< 1 year	2 (2.4%)	0 (0.0%)	2 (8.7%)	0 (0.0%)
	1 - 3 years	12 (14.3%)	3 (7.7%)	7 (30.4%)	2 (9.1%)
	4 - 6 years	11 (13.1%)	4 (10.3%)	1 (4.3%)	6 (27.3%)
	7 - 10 years	8 (9.5%)	5 (12.8%)	1 (4.3%)	2 (9.1%)
	> 10 years	51 (60.7%)	27 (69.2%)	12 (52.2%)	12 (54.5%)

Table 3 – Procedure Outcome Model Results						
	Time Point Least Square-Means (95% CI)[a]			P-values[b]		
Procedure	**Pre-Intervention**	**Post-Intervention**	**Follow-up**	**Pre vs. Post**	**Pre vs. Follow-up**	**Post vs. Follow-up**
IO	9.5 (8.9, 10.2)	11.5 (10.7, 12.3)	10.5 (9.8, 11.2)	<0.0001	0.0040	0.0058
BVM	9.6 (9.3, 9.9)	11.0 (10.7, 11.4)	10.2 (9.9, 10.6)	<0.0001	0.0017	0.0004
SGD	11.6 (10.9, 12.2)	13.6 (12.8, 14.4)	12.4 (11.7, 13.1)	<0.0001	0.018	0.0010

[a] Each procedure was analyzed using linear mixed model with session as a fixed effect and sites as a random effect.

[b] Tukey's method was applied to adjust for multiple comparisons.

BVM: bag-valve-mask ventilation; IO: intraosseous catheterization; SGD: supraglottic device insertion

Table 4. IO Scores Percent Yes by Item						
	Percent of Yes[a]			Pairwise Comparisons[b]		
	Pre (N = 97)	Post (N = 95)	Follow-up (N = 65)	Pre vs Post	Pre vs FU	Post vs FU
1. Operator wears gloves	95 (97.9%)	95 (100%)	64 (98.5%)	--	0.9684	--
2. Identifies proximal tibia landmarks, defined as at least one finger breadth below proximal aspect on medial (flat) surface	87 (89.7%)	93 (97.9%)	58 (89.2%)	0.0869	0.9952	0.0906
3. Disinfects access site	78 (80.4%)	95 (100%)	64 (98.5%)	--	0.0237	--
4. Connects needle and drill	97 (100%)	95 (100%)	65 (100%)	--	--	--
5. Inserts needle into skin at 90 degree angle	92 (94.8%)	93 (97.9%)	65 (100%)	0.9999	--	--
6. Chooses appropriate needle size, defined as seeing black mark above skin prior to starting to drill	14 (14.4%)	83 (87.4%)	16 (24.6%)	<.0001	0.2393	<.0001
IO Needle Color[c]						
Pink	59 (60.8%)	6 (6.3%)	40 (61.5%)	<.0001	0.9954	<.0001

Table 4. IO Scores Percent Yes by Item						
	Percent of Yes[a]			Pairwise Comparisons[b]		
	Pre (N = 97)	Post (N = 95)	Follow-up (N = 65)	Pre vs Post	Pre vs FU	Post vs FU
Blue	38 (39.2%)	89 (93.7%)	24 (36.9%)	<.0001	0.9550	<.0001
Yellow	0	0	1 (1.5%)	--	--	--
7. Uses drill to insert catheter into marrow, defined as stops when resistance lessens	75 (77.3%)	89 (93.7%)	60 (92.3%)	0.0047	0.0452	0.8187
8. Disconnects drill from needle	93 (95.9%)	94 (98.9%)	65 (100%)	0.4793	--	--
9. Removes stylet from catheter	93 (95.9%)	94 (98.9%)	65 (100%)	0.4793	--	--
10. Attaches EZ-Connect tubing	88 (90.7%)	93 (97.9%)	61 (93.8%)	0.1255	0.7481	0.4269
11. Confirms placement, defined as aspiration of red fluid or easy flush without infiltration	71 (73.2%)	86 (90.5%)	50 (76.9%)	0.0072	0.9045	0.0368
IO Confirm Methods[c]						
Aspiration	13 (13.4%)	3 (3.2%)	4 (6.2%)	0.0496	0.3240	0.6465

Table 4. IO Scores Percent Yes by Item						
	Percent of Yes[a]			Pairwise Comparisons[b]		
	Pre (N = 97)	Post (N = 95)	Follow-up (N = 65)	Pre vs Post	Pre vs FU	Post vs FU
Flushing	7 (7.2%)	11 (11.6%)	10 (15.4%)	0.5597	0.2358	0.7649
Both	51 (52.6%)	72 (75.8%)	36 (55.4%)	0.0031	0.9344	0.0217
Cannot Assess	26 (26.8%)	9 (9.5%)	15 (23.1%)	0.0085	0.8545	0.0574
12. 'Push flush' with 5-10 mL NS	69 (71.1%)	89 (93.7%)	54 (83.1%)	0.0006	0.1979	0.0997

[a] The calculated raw percent of 'Yes' account for missing observations.

[b] P-values were calculated from generalized linear mixed model with session as a fixed effect and sites as a random effect. Tukey's method was conducted for multiple comparison adjustment.

[c] Included in data collection but not included in score calculation.

-- Model does not calculate a p-value for comparison including 1 or 0.

IO: intraosseous catheterization; FU: follow-up; NS: normal saline

Table 5. BVM Scores Percent Yes by Item						
	Percent of Yes[a]			**Pairwise Comparisons[b]**		
	Pre (N = 105)	**Post (N = 101)**	**Follow-up (N = 73)**	**Pre vs Post**	**Pre vs FU**	**Post vs FU**
1. Assess airway by determining if patent, partially obstructed, or completely obstructed	83 (79.0%)	100 (99.0%)	63 (86.3%)	0.0048	0.4358	0.0261
2. Check for breathing while checking responsiveness	47 (44.8%)	74 (73.3%)	44 (60.3%)	0.0002	0.1077	0.1710
3. Perform general airway maneuvers as defined as	45 (42.9%)	90 (89.1%)	50 (68.5%)	<.0001	0.0024	0.0043
4. Provide any oxygen support	102 (97.1%)	101 (100%)	73 (100%)	--	--	--
5. Provide optimal level of oxygen by providing high-flow oxygen of at least 10 liters via non-breather	101 (96.2%)	99 (98.0%)	69 (94.5%)	1.0000	0.9072	1.0000
6. Initiates positive-pressure ventilation in a timely manner, defined as less than 30 seconds after recognition that patient requires assisted ventilator support	64 (61.0%)	56 (55.4%)	41 (56.2%)	0.7029	0.7990	0.9951

Table 5. BVM Scores Percent Yes by Item						
	Percent of Yes[a]			Pairwise Comparisons[b]		
	Pre (N = 105)	Post (N = 101)	Follow-up (N = 73)	Pre vs Post	Pre vs FU	Post vs FU
7. Selects correct mask size, defined as creation of a seal around mouth and nose without placement of mask over the eyes	86 (81.9%)	100 (99.0%)	63 (86.3%)	0.0091	0.7799	0.0244
8. Demonstrates correct mask technique, defined as demonstration of one-handed (C-E) and/or two-handed (thenar) techniques	101 (96.2%)	101 (100%)	73 (100%)	--	--	--
9. Selects correct bag size for patient (only incorrect if selects a bag that is too small to ventilate manikin)	105 (100%)	101 (100%)	72 (98.6%)	--	--	--
10. Bag at appropriate rate of 12-20 breaths per minute (one breath every 3-5 seconds)	87 (82.9%)	101 (100%)	65 (89.0%)	--	0.3545	--
11. Obvious chest rise with each positive pressure breath (primary outcome measure)	101 (96.2%)	97 (96.0%)	72 (98.6%)	0.7352	0.6268	0.9481

Table 5. BVM Scores Percent Yes by Item						
	Percent of Yes[a]			**Pairwise Comparisons[b]**		
	Pre (N = 105)	**Post (N = 101)**	**Follow-up (N = 73)**	**Pre vs Post**	**Pre vs FU**	**Post vs FU**
12. Confirms efficacy by auscultation or looking at chest wall (self or directs team member)	97 (92.4%)	99 (98.0%)	70 (95.9%)	0.2213	0.6224	0.6771

[a] The calculated raw percent of 'Yes' account for missing observations.

[b] P-values were calculated from generalized linear mixed model with session as a fixed effect and sites as a random effect. Tukey's method was conducted for multiple comparison adjustment.

-- Model does not calculate a p-value for comparison including 1 or 0.

BVM: bag-valve mask ventilation; FU: follow-up

Table 6. SGD Scores Percent Yes by Item						
	Percent of Yes[a]			**Pairwise Comparisons[b]**		
	Pre (N = 105)	**Post (N = 101)**	**Follow-up (N = 73)**	**Pre vs Post**	**Pre vs FU**	**Post vs FU**
1. Opens the airway manually	94 (89.5%)	99 (98.0%)	67 (91.8%)	0.0643	0.8777	0.1700
2. Elevates tongue, inserts correctly-sized simple adjunct (oropharyngeal or nasopharyngeal airway)	89 (84.8%)	100 (99.0%)	66 (90.4%)	0.0162	0.5173	0.0755
3. Ventilates patient at a rate of 12-20/minute (1 ventilation every 3-5 seconds) with appropriate volumes.	88 (83.8%)	101 (100%)	64 (87.7%)	--	0.7545	--
4. Checks/prepares appropriate supraglottic airway device	57 (54.3%)	99 (98.0%)	61 (83.6%)	<.0001	0.0004	0.0104
5. Lubricates distal tip of the device [may be verbalized]	80 (76.2%)	75 (74.3%)	52 (71.2%)	0.9498	0.7209	0.8777
6. Positions head properly	28 (26.7%)	57 (56.4%)	28 (38.4%)	<.0001	0.2135	0.0591
7. Performs a tongue-jaw lift	36 (34.3%)	59 (58.4%)	26 (35.6%)	0.0020	0.9817	0.0099
8. Inserts device to proper depth	98 (93.3%)	95 (94.1%)	67 (91.8%)	0.9677	0.8983	0.7871
9. Secures device in patient [inflates cuff with proper volumes and immediately removes syringe or secures strap]	99 (94.3%)	98 (97.0%)	71 (97.3%)	0.3892	0.6280	0.9456
10. Ventilates patient and confirms proper ventilation	101 (96.2%)	99 (98.0%)	70 (95.9%)	0.4389	0.9945	0.4240

Table 6. SGD Scores Percent Yes by Item						
	Percent of Yes[a]			**Pairwise Comparisons[b]**		
	Pre (N = 105)	**Post (N = 101)**	**Follow-up (N = 73)**	**Pre vs Post**	**Pre vs FU**	**Post vs FU**
11. Verifies proper tube placement by secondary confirmation such as capnography, capnometry, EDD, or colorimetric device	84 (80.0%)	98 (97.0%)	64 (87.7%)	0.0035	0.2311	0.0953
12. Secures device or confirms that the device remains properly secured	93 (88.6%)	95 (94.1%)	70 (95.9%)	0.9996	0.7653	0.7761
13. Ventilates patient at proper rate and volume	85 (81.0%)	100 (99.0%)	64 (87.7%)	0.9998	0.7077	0.9998
14. NOT failure to enter the supraglottic device at a proper depth or location within 3 attempts	99 (94.3%)	96 (95.0%)	68 (93.2%)	0.9606	0.9314	0.8198

Table 6. SGD Scores Percent Yes by Item						
	Percent of Yes[a]			**Pairwise Comparisons[b]**		
	Pre (N = 105)	**Post (N = 101)**	**Follow-up (N = 73)**	**Pre vs Post**	**Pre vs FU**	**Post vs FU**
15. NOT failure to confirm that patient is being ventilated properly (correct lumen and proper insertion depth) by auscultation bilaterally over lungs and over the epigastrium	101 (96.2%)	100 (99.0%)	71 (97.3%)	1.0000	0.9207	1.0000

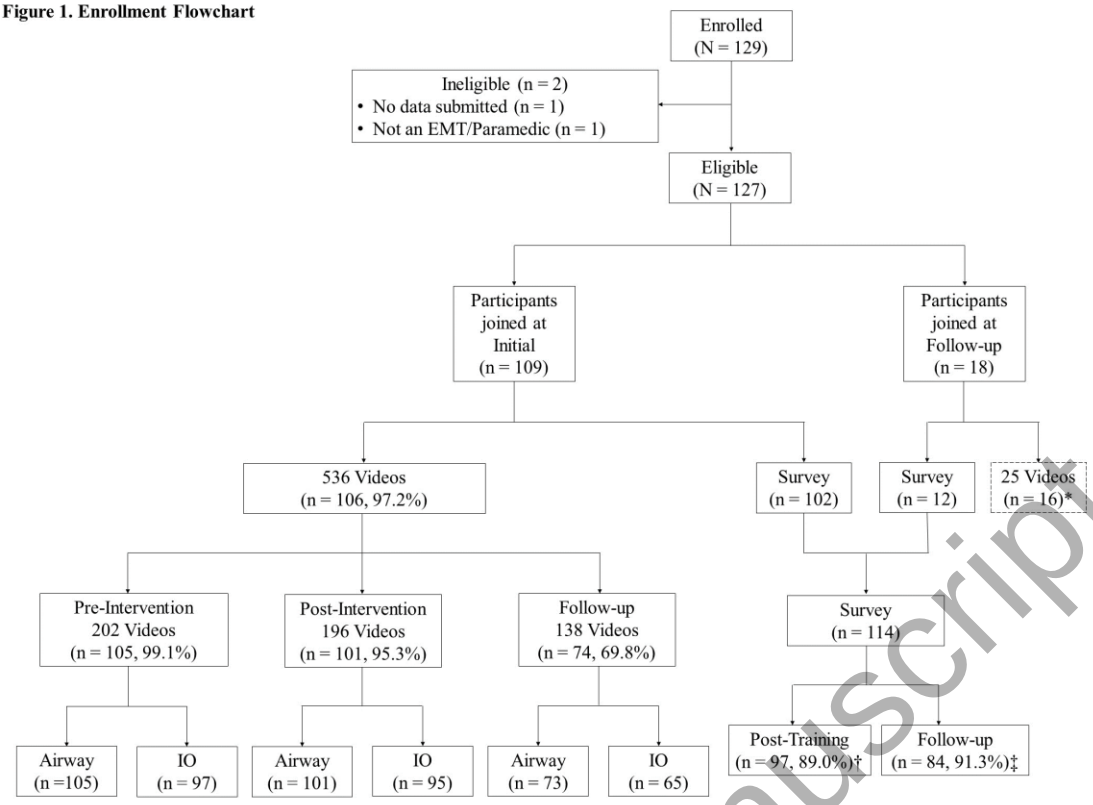
[a] The calculated raw percent of 'Yes' account for missing observations.

[b] P-values were calculated from generalized linear mixed model with session as a fixed effect and sites as a random effect. Tukey's method was conducted for multiple comparison adjustment.

-- Model does not calculate a p-value for comparison including 1 or 0.

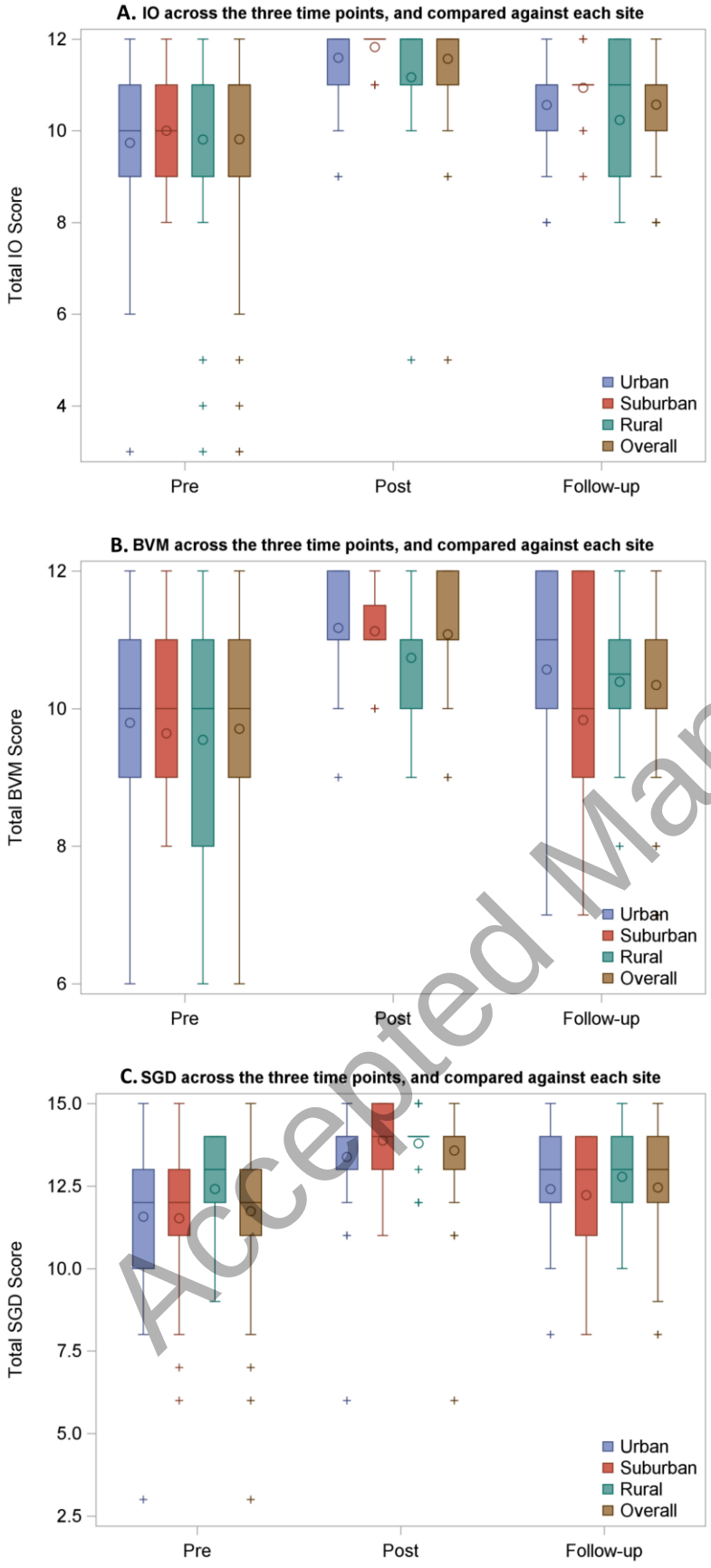
EDD: esophageal detector device; FU: follow-up; SGD: supraglottic device placement

Figure 1. Enrollment Flowchart



n = number of participants; *collected but not included in analysis; † % of 109 initial participants; ‡ % of 92 participants at follow-up

Figure 2. Procedure Outcome Scores Box Plots



BVM: Bag-Valve Mask; IO: Intraosseous; SGD: Supraglottic Device
O = Mean; Center Line = Median

Appendix A. Procedural Script

Check that:

1) Nobody else is in room and communicators are muted or set to low volume
2) Identifiers (logos, name badge) on participant are covered by tape
3) Wearing gloves
4) Participant ID number and trainer in frame on GoPro view

- **START recording on GoPro and read Intro**

Intro

"You have arrived on scene for a 7 yo who has drowned. Rescuers on scene have recovered him from the pool. Your Broselow tape indicates he is 22 kg. I will be your partner and can assist per your instructions.

Your first task will be managing this patient's airway using non-invasive techniques."

- **Step Back and Allow Participant to Proceed – do not answer questions other than repeating what is provided in prompt if needed**

BVM Script:

- *After participant applies BVM say:*
  - "We do not have an oxygen tank here, but if you were to hook it up, what flow of oxygen would you turn it to?"
- *If participant does not place oropharyngeal airway say:*
  - "You feel some resistance on bagging and decide to place an oropharyngeal airway."
- *If participant does not vocalize rate ask:*
  - "How many breaths per minute, or how many seconds between each breath, would you bag this patient?"
- *If participant does not vocalize that they are noting chest rise / lung inflation ask:*

- "How would you know you are delivering adequate breaths?"

➢ **Proceed to SGD after participant has attempted OPA placement and has answered questions regarding BVM**

SGD Script:

➢ **Read:**

"Medical control has been notified and they recommend placing a supraglottic device.

Your partner has taken over bagging so you can prepare your equipment."

➢ **Step Back and Allow Participant to Proceed – do not answer questions other than repeating what is provided in prompt if needed**

- *Once participant selects their SGD say:*
  - "This is the lubricating spray you should use – you only need 1-2 sprays and please do it over the garbage can."
- *If participant does not vocalize rate ask:*
  - "How many breaths per minute, or how many seconds between each breath, would you bag this patient?"
- *If participant does not vocalize that they are noting chest rise / lung inflation:*
  - "How would you know you are delivering adequate breaths?"
- *After SGD is placed ask:*
  - "What secondary method for confirmation of appropriate placement could you use?"
  - "How would you secure the device?"

➢ **<u>STOP</u> recording after participant has attempted SGD placement and has answered questions regarding SGD**

➢ **Move to IO station**

➢ **Have participant change gloves if needed**

- **START recording on GoPro and read prompt**

IO Script:

"Your partner takes over managing the airway and you decide to get access.

Your partner was unable to get a peripheral IV and you decide to place an IO."

- *For safety, if participant has hand underneath calf when about to drill:*

For safety, I'm going to recommend you not keep your hand there.

- **As participant aspirates after IO placement, push on "blood syringe" to check if needle is in the bone space**
- **STOP recording after participant has attempted IO placement**

General tips:

If a participant asks questions on the procedure:

That is a good question. As this is for training, we are asking participants to perform the procedure to the best of their ability. We will have opportunities for training and practice after this.

If a participant asks why there is no training during the assessment:

We're not trying to be frustrating, but we need to get an unbiased look at everyone's technique – this way, when we do the training and follow-up, we will know what to focus on.

Appendix B. Checklist for Intraosseous (IO) catheter placement

Task:	Yes	No	Reviewer comments/notes
Operator wears gloves			

Identifies proximal tibia landmarks, defined as at least one finger breadth below proximal aspect on medial (flat) surface			
Disinfects access site			
Connects needle and drill			
Inserts needle into skin at 90 degree angle			
Chooses appropriate needle size, defined as seeing black mark above skin prior to starting to drill			□ pink; □ blue; □ yellow
Uses drill to insert catheter into marrow, defined as stops when resistance lessens			
Disconnects drill from needle			
Removes stylet from catheter			
Attaches EZ-Connect tubing			
Confirms placement, defined as aspiration of red fluid or easy flush* without infiltration			□ aspiration; □ flushing □ both
"Push flush" with 5-10mL NS			

*Might be difficult to tell by video if the flush infiltrates, as the trainer does not allow visual edema

This modified checklist has 12 observable behaviors, scored as dichotomous outcomes of observed (yes) or not observed (no). Most importantly, the **primary outcome** for this

procedural skill is whether the resident is able to place a functioning intraosseous (IO) catheter on the manikin.

Appendix C. The Modified Scoring Checklist for Bag-Mask Ventilation Based on the Tool for Resuscitation Assessment Using Computerized Simulation (TRACS)

Task Group	Task	Y	N
Assessment	Assess airway by determining if patent, partially obstructed, or completely obstructed		
	Check for breathing while checking responsiveness		
Basic Interventions	Perform general airway maneuvers as defined as: (1) head tilt/chin lift maneuvers to open upper airway (2) external auditory canal and sternal notch aligned to maximize airway patency		
	Provide any oxygen support		
	Provide optimal level of oxygen by providing high-flow oxygen of at least 10 liters via non-breather		
Bag-Valve Mask Ventilation	Initiates positive-pressure ventilation in a timely manner, defined as less than 30 seconds after recognition that patient requires assisted ventilator support		
	Selects correct mask size, defined as creation of a seal around mouth and nose without placement of mask over the eyes		
	Demonstrates correct mask technique, defined as demonstration of one-handed (C-E) and/or two-handed (thenar) techniques		
	Selects correct bag size for patient (only incorrect if selects a bag that is too small to ventilate manikin)		
	Bag at appropriate rate of 12-20 breaths per minutes (one breath every 3-5 seconds)		
	Obvious chest rise with each positive pressure breath (primary outcome measure)		
	Confirms efficacy by auscultation or looking at chest wall (self or directs team member)		
Comments:			

Brett-Fleegler MB, Vinci RJ, Weiner DL, Harris SK, Shih MC, Kleinman, ME. A simulator-based tool that assesses pediatric resident resuscitation competency. *Pediatrics*, 2008. **121**(3):p.e597-603.
*no arrest scenarios were tested so compression:breath ratio removed

Appendix D. NREMT Advanced Level Psychomotor Examination – Supraglottic Airway Device

Task	**Yes**	**No**
Opens the airway manually		
Elevates tongue, inserts correctly-sized simple adjunct (oropharyngeal or nasopharyngeal airway)		
Ventilates patient at a rate of 12-20/minute (1 ventilation every 3-5 seconds) with appropriate volumes		
Checks/prepares appropriate supraglottic airway device		
Lubricates distal tip of the device [may be verbalized]		
Positions head properly		
Performs a tongue-jaw lift		
Inserts device to proper depth		
Secures device in patient [inflates cuff with proper volumes and immediately removes syringe or secures strap]		
Ventilates patient and confirms proper ventilation		
Verifies proper tube placement by secondary confirmation such as capnography, capnometry, EDD or colorimetric device		
Secures device or confirms that the device remains properly secured		
Ventilates patient at proper rate and volume		

Comments:

Critical Criteria:

Criteria	**Did NOT Fail**	**Fail**
Failure to enter the supraglottic device at a proper depth or location within 3 attempts		
Failure to confirm that patient is being ventilated properly (correct lumen and proper insertion depth) by auscultation bilaterally over lungs and over the epigastrium		
Comments:		

Appendix E. Post-Intervention Survey

Question 1. How long has it been since you personally cared for a critically ill or injured pediatric patient?
[ ] <3 months
[ ] 3 months – 12 months
[ ] 12 months – 24 months
[ ] >2 years

Question 2. How long has it been since you participated in hands-on, pediatric-focused, training?
[ ] <1 month
[ ] 1 – 6 months
[ ] 7 months – 12 months
[ ] >12 months

Question 3. How frequently would you ideally receive pediatric-focused training?
[ ] more frequently than once a month
[ ] once a month
[ ] once every 2 – 3 months
[ ] once every 4 – 6 months
[ ] once every 7 – 11 months
[ ] once a year
[ ] less frequently than once a year

Question 4. How long in total have you been a practicing EMT or Paramedic (i.e. time since first/earliest certification)?
[ ] <1 year
[ ] 1 – 3 years
[ ] 4 – 6 years
[ ] 7 – 10 years
[ ] >10 years

Question 5. How can we improve the experience you had today?
Free text:

Question 6. What is your biggest take-away from today's education?
Free text:

Appendix F. Follow-Up Survey

Question 1. How long has it been since you personally cared for a critically ill or injured pediatric patient?
[ ] <3 months
[ ] 3 months – 12 months
[ ] 12 months – 24 months
[ ] >2 years

Question 2. Have you performed bag-valve-mask (BVM) ventilation on a pediatric patient since our training session?
[ ] Yes
[ ] No

Question 3. Have you performed supraglottic device (SGD) placement on a pediatric patient since our training session?
[ ] Yes
[ ] No

Question 4. Have you performed intraosseous (IO) placement on a pediatric patient since our training session?
[ ] Yes
[ ] No

Question 5. Have you received any additional training on these procedures, either in adult or pediatric patients, since our training session?
[ ] Yes
[ ] No

Question 6. How frequently would you like to receive pediatric-focused training?
[ ] more frequently than once a month
[ ] once a month
[ ] once every 2-3 months
[ ] once every 4-6 months
[ ] once a year
[ ] less frequently than once a year

Question 7. How long in total have you been a practicing EMT or Paramedic (i.e. time since first/earliest certification)?
[ ] <1 year
[ ] 1-3 years
[ ] 4-6 years
[ ] 7-10 years
[ ] >10 years

Question 8. How can we improve the experience you had today?
Free text:

Appendix G – Post-Intervention Survey Results					
		By Site			
Questions	**Overall (n = 97)**	**Urban (n = 52)**	**Suburban (n = 25)**	**Rural (n = 20)**	**P-value**
Question 1: How long has it been since you personally cared for a critically ill or injured pediatric patient?					
					0.1230
< 3 months	15 (15.5%)	8 (15.4%)	3 (12.0%)	4 (20.0%)	
3 months - 11 months	33 (34.0%)	15 (28.8%)	9 (36.0%)	9 (45.0%)	
12 months - 24 months	24 (24.7%)	10 (19.2%)	11 (44.0%)	3 (15.0%)	
> 2 years	24 (24.7%)	18 (34.6%)	2 (8.0%)	4 (20.0%)	
Missing	1 (1.0%)	1 (1.9%)	0 (0.0%)	0 (0.0%)	
Question 2: How long has it been since you participated in hands-on, pediatric-focused, training?					
					0.0554
< 1 month	3 (3.1%)	0 (0.0%)	2 (8.0%)	1 (5.0%)	
1 - 6 months	18 (18.6%)	7 (13.5%)	7 (28.0%)	4 (20.0%)	
7 months - 12 months	32 (33.0%)	14 (26.9%)	10 (40.0%)	8 (40.0%)	
> 12 months	44 (45.4%)	31 (59.6%)	6 (24.0%)	7 (35.0%)	
Question 3: How frequently would you ideally receive pediatric-focused training?					
					0.1038
Once a month	10 (10.3%)	6 (11.5%)	2 (8.0%)	2 (10.0%)	
Once every 2-3 months	33 (34.0%)	16 (30.8%)	13 (52.0%)	4 (20.0%)	
Once every 4-6 months	25 (25.8%)	16 (30.8%)	5 (20.0%)	4 (20.0%)	
Once every 7-11 months	3 (3.1%)	3 (5.8%)	0 (0.0%)	0 (0.0%)	

Appendix G – Post-Intervention Survey Results					
		By Site			
Questions	**Overall (n = 97)**	**Urban (n = 52)**	**Suburban (n = 25)**	**Rural (n = 20)**	**P-value**
Once a year	24 (24.7%)	9 (17.3%)	5 (20.0%)	10 (50.0%)	
Less frequently than once a year	2 (2.1%)	2 (3.8%)	0 (0.0%)	0 (0.0%)	

Appendix H – Follow-up Survey Results					
		By Site			
Questions	**Overall (n = 84)**	**Urban (n = 39)**	**Suburban (n = 23)**	**Rural (n = 22)**	**P-value**
Question 1: How long has it been since you personally cared for a critically ill or injured pediatric patient?					
					0.0924
< 3 months	15 (17.9%)	3 (7.7%)	6 (26.1%)	6 (27.3%)	
3 months - 11 months	29 (34.5%)	15 (38.5%)	4 (17.4%)	10 (45.5%)	
12 months - 24 months	25 (29.8%)	12 (30.8%)	9 (39.1%)	4 (18.2%)	
> 2 years	15 (17.9%)	9 (23.1%)	4 (17.4%)	2 (9.1%)	
Question 2: Have you performed bag-valve-mask (BVM) ventilation on a pediatric patient since our training session?					
					0.3597
Yes	6 (7.1%)	4 (10.3%)	0 (0.0%)	2 (9.1%)	

Appendix H – Follow-up Survey Results					
		By Site			
Questions	Overall (n = 84)	Urban (n = 39)	Suburban (n = 23)	Rural (n = 22)	P-value
No	78 (92.9%)	35 (89.7%)	23 (100%)	20 (90.9%)	
Question 3: Have you performed supraglottic device (SGD) placement on a pediatric patient since our training session?					
					0.5366
Yes	1 (1.2%)	0 (0.0%)	0 (0.0%)	1 (4.5%)	
No	81 (96.4%)	38 (97.4%)	22 (95.7%)	21 (95.5%)	
Missing	2 (2.4%)	1 (2.6%)	1 (4.3%)	0 (0.0%)	
Question 4: Have you performed intraosseous (IO) placement on a pediatric patient since our training session?					
					0.4759
Yes	4 (4.8%)	3 (7.7%)	0 (0.0%)	1 (4.5%)	
No	79 (94.0%)	35 (89.7%)	23 (100%)	21 (95.5%)	
Missing	1 (1.2%)	1 (2.6%)	0 (0.0%)	0 (0.0%)	
Question 5: Have you received any additional training on these procedures, either in adult or pediatric patients, since our training session?					
					0.7242
Yes	42 (50.0%)	21 (53.8%)	10 (43.5%)	11 (50.0%)	
No	42 (50.0%)	18 (46.2%)	13 (56.5%)	11 (50.0%)	
Question 6: How frequently would you like to receive pediatric-focused training?					

Appendix H – Follow-up Survey Results					
		By Site			
Questions	**Overall (n = 84)**	**Urban (n = 39)**	**Suburban (n = 23)**	**Rural (n = 22)**	**P-value**
					0.6248
More frequently than once a month	4 (4.8%)	1 (2.6%)	2 (8.7%)	1 (4.5%)	
Once a month	15 (17.9%)	5 (12.8%)	5 (21.7%)	5 (22.7%)	
Once every 2-3 months	29 (34.5%)	11 (28.2%)	9 (39.1%)	9 (40.9%)	
Once every 4-6 months	21 (25.0%)	13 (33.3%)	5 (21.7%)	3 (13.6%)	
Once a year	14 (16.7%)	8 (20.5%)	2 (8.7%)	4 (18.2%)	
Less frequently than once a year	1 (1.2%)	1 (2.6%)	0 (0.0%)	0 (0.0%)	