Introduction

This document serves as the Final Report in completion of Ohio Department of Public Safety Division of Emergency Medical Services Research Grant Priority 2-5 of the 2019-2020 year, extended to 2020-2021 in light of the COVID-19 pandemic, for the project entitled "Development, Implementation, and Evaluation of an Innovative Pediatric Simulation-Based Curriculum for Emergency Medical Services."

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Abbreviations used throughout the report:

BVM - Bag-Valve Mask

CCHMC - Cincinnati Children's Hospital Medical Center

CSR - Center for Simulation and Research

EMS - Emergency Medical Services

EMSC - Emergency Medical Services for Children

EMT - Emergency Medical Technician

IRB - Institutional Review Board

IO - Intraosseous

PECC - Pediatric Emergency Care Coordinator

SBE - Simulation-Based Education

SBT - Simulation-Based Training

SGD - Supraglottic Device

Executive Summary

Our multi-professional group of pediatric emergency medicine physicians, a nurse, and a paramedic, along with supporting clinical research staff, successfully developed an innovative pediatric simulation-based curriculum for Emergency Medical Services (EMS) providers. We implemented this curriculum at three local fire departments, bringing both scenario-based and task-trainer-based education on-site to EMS providers across an eleven-month period (September 2019 – October 2020). During these training sessions, EMS providers practiced the management of a pediatric drowning victim using a scenario-based approach followed by debriefing, focusing on both technical and non-technical skills. They also submitted videos of task-trainer-based bag-valve-mask (BVM) ventilation, supraglottic device (SGD) placement, and intraosseous (IO) catheterization procedural training. Investigators then evaluated performance as captured on the videos using standardized assessment tools. The primary outcome measure was change in assessment tool scores as captured across three time-points: prior to training, within a few hours of training, and then on follow-up several months after training occurred.

Providers were enthusiastic in their involvement: 126 EMS providers participated (22 EMTs and 104 Medics). Only two providers declined participation in the research (recording) portion of the training. The initial training session ranged from 2-6 hours in length depending on the number of providers trained, and the follow-up sessions took 2-3 hours (not including travel, set-up, and breakdown time). The number of providers participating during a session ranged from 5-16 providers. We recorded 565 videos for data extraction. Due to COVID-19 related delays, data extraction is still ongoing – we have completed 409 of 565 videos at the time of this submission (72%). We anticipate that our findings will demonstrate a significant improvement in simulated procedural skill performance. However, even if a significant improvement is not found, we will submit manuscripts based on our research given its innovative approach and expected impact on the literature surrounding education delivery to the EMS community.

Qualifications of the Principal and All Co-investigators

Sang Hoon Lee, MD, MEd – Principal Investigator: Dr. Lee is a board-certified pediatrician, and fellowship-trained, pediatric emergency medicine (PEM) physician at Cincinnati Children's Hospital Medical Center (CCHMC). Outside of his clinical role, he regularly evaluates medical students, pediatric and emergency medicine residents, and pediatric emergency fellows as an Assistant Professor of Pediatrics at the University of Cincinnati (UC), College of Medicine. His academic interest during PEM fellowship focused on resuscitation science, specifically on the use of IO access in critically ill or injured children. He also received a Masters of Medical Education, completed a simulation fellowship at the CCHMC Center for Simulation and Research (CSR), and attained his Certified Healthcare Simulation Educator certification from the Society for Simulation in Healthcare. His simulation fellowship focused on the Mobile Simulation Lab and Outreach programs, teaching courses at local fire departments, community hospitals, and primary care offices. He is a certified Physician EMS Instructor, has taught for the Pediatric Education for Prehospital Professionals course, and is an active member of the Southwest Ohio Protocol Committee, which oversees development of regional EMS clinical practice guidelines.

Gary Geis, MD – Co-Investigator: Dr. Geis is a board-certified pediatrician (19 years) and board-certified PEM physician (16 years), who has accumulated significant amounts of clinical experience in the care of acutely injured and ill children. Beyond his clinical role, he routinely educates medical students, pediatric and emergency medicine residents, and pediatric emergency fellows as a Professor of Pediatrics at the UC College of Medicine. He has been actively involved in simulation-based training and research for 15 years; served as the Assistant Medical Director at our CSR for 4 years; and has been the Medical Director since July 2011. He currently directly oversees the development, medical content, delivery, and facilitation of 109 CSR courses. Relevant to this proposal, he has mentored many residents, fellows, and faculty on simulation-based studies over the last 12 years. These investigations leveraged simulation-based training to (a) improve non-technical skills of healthcare providers in high risk units, (b) probe functioning clinical units for latent safety threats and team-level knowledge deficits, (c) improved

bedside skill in invasive procedures, (d) develop new care teams in a "non-academic" pediatric settings and (e) develop interprofessional, multidisciplinary care processes for patients in need of critical airway management.

Shawn McDonough, EMT-Paramedic – Co-Investigator: Mr. McDonough holds a degree in Emergency Medical Services and is a certified Level III EMS instructor in the state of Kentucky, and an EMSI in the state of Ohio. He is a retired Firefighter/Paramedic with over 20 years' experience servicing a busy urban combination Fire/EMS Department. At CCHMC, he has served multiple roles, including: Critical Care Transport Paramedic; Extracorporeal Membrane Oxygenation (ECMO) and Transport Education Facilitator; and American Heart Association (AHA) Training Center faculty for Basic Life Support (BLS), Advanced Cardiac Life Support (ACLS), and Pediatric Advanced Life Support (PALS). He is currently employed at the CSR as an Education Specialist and co-leads the Mobile Simulation Unit and Outreach Program.

Brant Merkt, RN, EMT-Basic – Co-Investigator: Mr. Merkt has been an Education Specialist with the CSR since 2016. He graduated from Northern Kentucky University with a degree in nursing in 2008, and completed his national registry certification as an EMT-Basic in 2017. Prior to his time at the CSR, he worked for 7 years as a registered nurse in the CCHMC emergency department. There he filled multiple roles, including Education Committee Member, Trauma Core Nurse Chair, and Emergency Department Resource Nurse. He currently serves as AHA Training Center faculty for BLS, ACLS, and PALS. Combining his expertise, he is an Ohio EMS Continuing Education instructor and co-leads the CSR's Mobile Simulation Unit and Outreach Program, delivering pediatric simulation to regional EMS agencies, primary care physician offices, and community hospitals.

Lauren C Riney, DO – Co-Investigator: Dr. Riney is a pediatric emergency medicine physician and Assistant Professor of Pediatrics in the Division of Emergency Medicine at CCHMC. Dr. Riney completed the National Association of EMS Physicians (NAEMSP) Medical Directors Course and is an assistant medical director for Colerain Township Fire Department. She is a researcher in the field of

pediatric prehospital medicine and has conducted multiple studies involving implementation of prehospital protocols to develop and improve evidence-based care for children in the prehospital setting. Dr. Riney is currently the site PI for a large multi-institutional Pediatric Emergency Care Applied Research Network (PECARN) study developing and validating a risk assessment tool for pediatric cervical spine injury. Lastly, she is a member of the Southwest Ohio Prehospital Protocol Committee and Southwest Ohio Operations Committee.

Yin Zhang, MS – Statistician: Mr. Zhang is a Biostatistician at CCHMC and has coordinated with Emergency Medicine, Allergy and Clinical Immunology, Pulmonary, and Surgery Departments on several clinical research projects around infants, children, and adolescents. He is a PhD candidate of Biostatistics at the University of Cincinnati, with a focus on developing algorithms for machine learning models and causal inferences for understanding the mechanisms behind clinical outcomes. Additionally, he is a Biostatistical reviewer for both The Journal of Allergy and Clinical Immunology and The Journal of Allergy and Clinical Immunology in Practice.

Review of Pertinent Literature, Historical Perceptive, and Local-to-National Trends

Six percent of EMS runs in Ohio are for children under the age of 17 years.[1] At a national level, EMS providers are estimated to average 625 days, 958 days, and 1,087 days between care encounters for a critically ill or injured teen/preteen, child, or infant, respectively.[2] Stated another way, a typical Emergency Medical Technician (EMT) with 4-5 years' experience, or a Paramedic with 7-8 years' experience, may have previously cared for only one or two critically ill pediatric patients in their career prior to a pediatric run requiring immediate resuscitative care.[3] **Given the limited opportunity to maintain competence and confidence in the care of pediatric patients through clinical practice, EMS providers recognize a need for pediatric-specific continuing education to sustain expert skills.**

This training gap is further perpetuated by a lack of standardized certification and continuing education requirements.[4] A survey of Emergency Services for Children (EMSC) program managers found that only 41% of their states or territories define the number of pediatric training hours needed for initial certification; these range from 4-9 hours for EMT-Basics and 7-33 hours for EMT-Paramedics.[5] In a separate national survey, 76% of EMS providers, both volunteer and paid, across all service types, support adding mandatory continuing education in pediatrics.[6] Providers further identify "highly realistic simulation" as the preferred method of education.[7] Multiple needs assessments have uncovered specific high priority gaps in skills, including airway management and vascular access, as well as in knowledge, including the care of the newborn-to-toddler aged patient.[6,8-11] **Knowledge gaps are associated with differences in EMS providers' care, with pediatric patients receiving fewer necessary interventions compared to similarly ill or injured adults.**[12,13]

Around the same time as these surveys, the EMSC program established a timeline of nine "Performance Measures," setting national benchmarks around the improvement of prehospital pediatric emergency care.[14] Notably, Performance Measure 02 tracks "the percentage of EMS agencies in the state or territory that have a designated individual who coordinates pediatric emergency care," whose role includes "promoting pediatric continuing education opportunities." Performance Measure 03 targets "the percentage of EMS agencies in the state or territory that have a process that requires EMS providers to physically demonstrate the correct use of pediatric-specific equipment."

Simulation-based education (SBE) provides an optimal method to address the uncovered educational needs and the EMSC systems-based goals. However, there are few examples of EMS-specific, pediatric-focused, SBE in the literature, and they have difficulty spreading due to several barriers, namely cost, time, and accessibility.[2,5,15-20] Furthermore, while these educational interventions have demonstrated effectiveness in the simulation setting, demonstration of improvement in clinical outcomes is limited by the rarity of critical pediatric calls and difficulty in securing multicenter studies.

Therefore, there is a local, regional, and national need for more EMS-specific, pediatric-focused, SBE curricula that has been studied and shown to be effective.

Future Regional and National Trends

Given the low likelihood of being able to maintain procedural skills through clinical practice alone, EMS education will likely rely upon increasing amounts of simulation-based education and training. The barriers of cost, accessibility, and time, however, will remain. Our group will soon be studying an innovative next step: to have on-site Pediatric Emergency Care Coordinators (PECC) incorporate pediatric-focused SBE into their agency's routine training schedule, record procedural training as described in our curriculum, and send the videos off-site to our center where expert reviewers could grade the videos and provide feedback. This methodology would allow for an expert group of simulation educators to provide a high level of education to distant sites, even isolated locations or around-the-world.

Financial Issues and Considerations

Emergency Medical Services agencies should include resources for SBE into their annual budget. The budget for our project included both personnel costs and supplies costs. While our CSR typically charges per class, we were able to waive administrative fees as the grant paid for most of the costs associated with delivering the course. Personnel costs still outweighed supply costs. However, previous literature has found that even when EMS agencies have simulator equipment available, it is often unused due to a lack of training.[20] Therefore, while an EMS agency may consider purchasing their own simulator equipment and using their own educators to implement SBE, they should recognize that the costs of working with an experienced simulation center will assist in getting the full value of their capital investment cost.

Education and Training Issues and Considerations

Simulation-based education allows for the practice of low-frequency, high-acuity events and procedures. Our project focused on formative assessment, where the goal of providing feedback is to improve the

learner's abilities. This contrasts to summative assessment, which focuses on assigning a pass-fail grade. In formative assessment, learner psychological and physical safety is paramount: educators should ensure a safe learning environment where learners can make mistakes without fear of repercussion. This does not imply that there are no right or wrong answers; on the contrary, procedural training is best accomplished when there are objective, measurable criteria to differentiate a novice and expert proceduralist. Therefore, as demonstrated by our group, a successful SBE curriculum should include knowledgeable clinicians, members with first-hand knowledge of the learners' needs, and trained simulation educators who can give critical and constructive feedback within a safe learning space.

Legislative and Regulatory Issues and Considerations

Emergency Medical Services agencies should have a clear delineation of whether SBE will be used for formative or summative assessment. While the methods used in our curriculum could potentially meet the needs of high-stakes testing, our curriculum was conceptualized with the goal of being used primarily for formative assessment. As the Performance Measures set out by the EMSC group become increasingly tracked and enforced, our curriculum could be used to meet many of its requirements.

Data and Information Issues and Considerations

As participants in our curriculum recorded their procedures on videos, investigators rigorously ensured data safety. This was accomplished by quickly downloading videos onto password protected devices and deleting them from potentially unsecure memory cards; renaming video files in a way that would not reveal participants; and following our standard protocols for routine video deletion after research is complete. We also took significant measures to ensure that participants could not be readily recognized on the videos: the videos were recorded from the first-person perspective and so participant faces were not shown; participants wore gloves to hide any identifiable marks or jewelry; and masking tape was put over

badges or insignia. To promote learner safety, we notified the EMS agencies that they would not receive individual participant's scores, although aggregate data could be provided upon request. Lastly, we maintained any data collected in a secure database.

Research Findings Analysis

Due to the COVID-19 pandemic and its significant delaying of on-site training, we are still in the process of collecting data from the videos. At the time of report submission, the group has assessed 409 of 565 total procedural videos (72%). Once video review is complete, we will also analyze the results of surveys sent to participants, which assessed their self-reported experiences before and after training occurred.

Another aim of the project was to assess the efficacy and feasibility of an SBE curriculum provided on-site during EMS providers scheduled shifts. 126 providers participated (22 EMTs and 104 Medics). Only two providers declined participation in the research (recording) portion of the training. Eighteen new providers were enrolled during the follow-up sessions. The number of providers participating during a session ranged from 5-16 providers.

Initial training sessions occurred during November and December of 2019. The initial plan had been to complete the follow-up session between 3-6 months after the initial training sessions. We completed one follow-up session in March 2020, but due to COVID, could not continue follow-up sessions until August 2020, with the final session in October 2020. The initial training session ranged from 2-6 hours in length depending on the number of providers trained, and the follow-up sessions took 2-3 hours (not including travel, set-up, and breakdown time).

Every participant received a survey after both the initial training session and follow-up session. Of the 126 EMS providers surveyed, 97 completed an initial post-course survey, and 84 completed the follow-up survey.

Conclusions

Our multi-professional study group successfully developed and implemented an innovative on-site SBE curriculum for three local fire departments. While evaluation of its efficacy is ongoing, we were able to train EMS 126 providers, collecting 565 procedural training videos over 9 initial and 9 follow-up sessions, across an eleven-month training period.

Recommendations

Simulation-based education will have an increasingly important place in the training and continuing education of EMS providers. Continued grant funding is necessary, not only for EMS agencies to pay for classes delivered by expert educators, but also for those educators and their simulation centers to develop, implement, and evaluate more evidence-based, EMS-specific, pediatric-focused SBE curricula. Our summary of hours does not describe the months of development and planning required to create a robust curriculum. Dissemination and implementation of successful curricula regionally and nationally will require even more significant resources and commitments from granting agencies, educational institutions, and the EMS community.

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