Medical Emergency Management in the Dental Office (MEMDO): A Pilot Study Assessing a Simulation-Based Training Curriculum for Dentists

Jesse W. Manton, DDS, MS,*† Kelly S. Kennedy, DDS, MS,* Jonathan A. Lipps, MD,† Sheryl A. Pfeil, MD,‡§ and Bryant W. Cornelius, DDS, MBA, MPH*†

*The Ohio State University, College of Dentistry, Division of Oral and Maxillofacial Surgery and Dental Anesthesiology, †The Ohio State University, College of Medicine, Department of Anesthesiology, ‡The Ohio State University, College of Medicine, Medical Director–Clinical Skills Education and Assessment Center, and §The Ohio State University, College of Medicine, Department of Internal Medicine Division of Gastroenterology, Hepatology and Nutrition, Columbus, Ohio

In the event of a medical emergency in the dental office, the dentist must be able to identify a patient in distress, assess the situation, and institute proper management. This study assessed the impact of a simulation-based medical emergency preparedness curriculum on a resident's ability to manage medical emergencies. This interventional and pre-post educational pilot study included 8 participants who completed a standard curriculum and 8 who completed a modified curriculum ($N = 16$). The intervention consisted of a comprehensive medical emergency preparedness curriculum that replaced lecture sessions in a standard curriculum. Participants completed performance assessments using scenario-based objective structured clinical examinations (OSCEs) that were recorded and evaluated by calibrated faculty reviewers using a customized scoring grid. The intervention group performed significantly better than the control group on their summative OSCEs, averaging 90.9 versus 61.2 points out of 128 ($p = .0009$). All participants from the intervention group passed their summative OSCE with scores >60%, while none from the control group received passing scores. Completion of a simulation-based medical emergency preparedness curriculum significantly improved resident performance during simulated medical emergencies.

Key Words: Medical emergencies; Dental emergency training; Advanced dental education; Patient simulation; Patient safety.

The prompt recognition and management of an evolving medical emergency in the dental office is widely accepted to be a requisite skill for all dentists.[1–4] Continuing innovation and advancement of medical care and an aging population lead to patients presenting to oral health care settings with increasingly complex medical histories.[1,3,4–9] Some patients undergo invasive office-based dental procedures, which can be complicated by the delivery of local anesthetics with epinephrine and various levels of sedation and general anesthesia.[7–16] In 2018, Vaughan et al[1] looked globally at medical emergencies in dental practices and found a lack of preparedness toward medical emergencies despite universal recognition of its importance. They also found a universal desire among dentists to improve key medical skills.[1] Literature from the past 30 years regarding medical emergencies and adverse events in dental settings yields a consistent and repeated call for enhanced medical education and emergency preparedness across the profession.[1–6,10,14–21]

To gain advanced training, dentists may complete a postgraduate residency program such as a general practice residency (GPR). The Ohio State GPR program requires residents to complete the American Heart Association's Advanced Cardiac Life Support (ACLS) course, which provides advanced medical emergency preparedness training.[22] Residents also receive lectures on the dental management of medically complex patients. These experiences serve as evidence to demonstrate fulfillment of the Commission on Dental Accreditation Standard 2-4, which states that the program must provide training to ensure that upon completion of the

Received January 20, 2020; accepted for publication July 20, 2020.
Address correspondence to Dr Jesse West Manton, The Ohio State University College of Dentistry Division of Oral and Maxillofacial Surgery and Dental Anesthesiology, Postle Hall 305 W 12th Ave, Columbus, OH 43210; manton.16@osu.edu.

Anesth Prog 68:76–84 2021 | DOI 10.2344/anpr-67-04-04

Table 1. The MEMDO Curriculum*

Session	*Location*	*Session Topics*
1	COD	Objective structured clinical exam (baseline)
2	Sim Lab	Introduction to simulation, crisis resource management (CRM), basic life support, and intravenous and intraosseous access
3	COD	Electrocardiogram (ECG) interpretation and emergency medications, part 1
4	COD	Altered mental status (AMS) part 1: syncope, seizure, drug-induced AMS
5	COD	Altered mental status part 2: hypoglycemic/hyperglycemic crisis, stroke, falls
6	COD	Basic airway management and choking, foreign-body obstruction, aspiration, anxiety/hyperventilation, bleeding, secretions, nausea and vomiting
7	COD	Advanced airway management and mild allergy, asthma, bronchospasm, anaphylaxis, local anesthesia systemic toxicity, use of cognitive aids, CRM
8	Sim Lab	ECG review and dysrhythmia management, ISBAR handoff, emergency medications part 2, CRM, the office action plan
9	COD	Bradyarrhythmias, tachyarrhythmias, hypertensive crisis, use of cognitive aids, CRM
10	COD	Ventricular fibrillation, pulseless ventricular tachycardia, Hs and Ts, use of cognitive aids, CRM
11	COD	Pulseless electrical activity, asystole, acute coronary syndrome, Hs and Ts, use of cognitive aids, CRM
12	COD	MegaCodes, ACLS summary and course review
13	COD	Objective structured clinical exam (summative)

* MEMDO schedule for intervention arm with monthly session topics. ISBAR indicates identify, situation, background, assessment & action, response & rationale.

program, the resident is able to manage medical emergencies.[23] While didactic lectures and online education modules covering medical emergency management are a necessary supplement to development competence, the dynamic care of acutely ill patients must be regularly practiced to develop and maintain the essential skills, knowledge, and experience. Several undergraduate and graduate dental training programs have implemented simulation-based curricula for management of medical emergencies, reporting that participants generally enjoyed the training, believed it to be important to their education, and felt an improved confidence in their medical emergency management abilities.[24–28]

To our knowledge, no simulation-based experimental study has been conducted with GPR residents to investigate the effectiveness of medical emergency management training methods for improving performance in simulation-based objective structured clinical examinations (OSCEs). The principal objective of this pilot study was to determine if completion of a simulation-based medical emergency preparedness curriculum would yield improved performances by GPR residents managing simulated medical emergencies in a dental clinic setting.

METHODS

This study was approved by the Institutional Review Board (IRB) of The Ohio State University (OSU) before any study-related activities commenced (protocol 2018B0134). Interventional and pre-post experimental designs were employed. The OSU GPR is a 12-month hospital dentistry program with 8 residents per year. The 2018 class was assigned to the control arm, and the following 2019 class was assigned to the intervention arm (total $N = 16$).

In both arms of this study, residents initially completed an ACLS training program and a lecture series on intravenous (IV) sedation, physiologic monitoring, and emergency management during the first 2 weeks of residency. Residents received monthly lectures on emergency management as part of their weekly lecture series covering various dental topics by GPR faculty. Residents also gained experience during their clinical rotations and while providing patient care, which incorporated the use of sedation and general anesthesia for special needs patients in various dental clinics and operating room settings. For the intervention arm, 11 of the monthly emergency management lectures were replaced by simulation-based training sessions, which were used to deliver the Medical Emergency Management in the Dental Office (MEMDO) curriculum (Table 1).

Performance assessments were accomplished using a simulation-based OSCE. Each participant in the control arm completed a summative OSCE at the end of their residency. Each participant in the intervention arm completed a baseline OSCE at the beginning of residency (pre-MEMDO group) and a summative OSCE at the end of residency (post-MEMDO group). The control group did not complete a baseline OSCE because of the timing of IRB approval.

Figure 1. Standard OSCE setup in the dental operatory. The standard OSCE setup, including a SimMan3G, emergency equipment, and red emergency manual openly available on the countertops.

The MEMDO Curriculum

Didactic prelearning content, consisting of UpToDate articles, peer-reviewed journal articles, textbook chapters, and various online videos covering specified topics relevant to medical emergencies in dentistry, was distributed electronically for independent review by participants 2 weeks before each training session (Table 1). Sessions were facilitated by author J.W.M. with the support of trained simulationists, dental anesthesiology residents, and faculty from the OSU Division of Oral and Maxillofacial Surgery and Dental Anesthesiology.

Each training session lasted 3 hours and included modules that focused on hands-on procedural learning with partial task-trainers (ie, airway mannequins, IV and intraosseous access trainers), practice using medical emergency equipment, preparation and delivery of emergency medications, use of medical emergency cognitive aids, and formative experiences engaging in high-fidelity simulation scenarios using standardized patients and mannequin simulators. Sessions were conducted on site in the OSU College of Dentistry (COD) clinic operatories and patient waiting areas. Scenarios were designed to demonstrate real emergencies previously encountered in the dental clinic as well as published case reports from other dental environments. Residency staff members (front desk personnel, dental assistants, and dental hygienists) were included in the scenarios as often as possible to increase fidelity for the participants. Each scenario was followed by a combination of facilitated debriefing with video-review sessions and lecturettes focused around key learning points.

OSCE

The OSCE was designed to present 1 of 2 equally challenging clinical scenarios as in situ hybrid simulations within the COD. Both scenarios and the associated scoring grids were developed following best practices in scenario design and simulation-based research.[29–32] Each featured an adult male patient, represented by a patient simulator (SimMan 3G Laerdal Medical AS, Stavanger, Norway) positioned in a dental chair in an operatory (Figure 1). The simulator presented a patient experiencing signs and symptoms of either anaphylaxis or ST-elevated myocardial infarction (STEMI). Moulage was applied to the mannequin to improve crisis fidelity and consistency (ie, street clothes, Army veteran hat, hives, and diaphoresis).

Participants were randomly assigned an emergency encounter. Participants in the control group received either anaphylaxis or STEMI as their summative OSCE. Participants in the intervention group received either anaphylaxis or STEMI as their baseline OSCE and the alternate scenario 11 months later as their respective summative OSCE.

Before participating in the OSCE, each participant reviewed an introductory video that discussed IRB details, how to appropriately engage in mannequin-based simulation, relevant interactive functionality of the mannequin, details about the clinical scenario they were about to encounter, emergency equipment available for use, and the number and type of dental office personnel available for assistance in the scenario. After having any questions answered and verbalizing a willingness to voluntarily participate in the study, a consent form for audio/video recording and confidentiality agreement were signed.

Timing started upon entry of the participant into the OSCE operatory, and each scenario lasted a total of 10 minutes. In a sequence similar to that used in a study by Tan, the scenario consisted of three phases: early reaction (3 minutes), late reaction (3 minutes), and cardiovascular collapse (4 minutes).[24] The scenario ended with a programmed return of spontaneous circulation after 10 minutes, which was accompanied by spontaneous breathing, stable vital signs, moaning, and blinking. The subject was alerted to the patient's stabilized vital signs and that the scenario had concluded by a confederate actor. Physiologic and behavior changes in the mannequin were programmed to follow a rigid sequence of deterioration throughout the 3 phases regardless of the participant's decisions, actions, or interventions.

Confederates provided scripted information, responses, and technical assistance to the participants that were within the scope of a typical dental assistant trained in basic life support (BLS). Available equipment included recommended emergency medications, vital signs monitors, airway equipment, an automated external defibrillator, and a medical emergency cognitive aid that was discussed in the introductory video and openly available on the operatory countertops (Figure 1).[33–40]

Following completion of the OSCE, each participant completed a survey to collect individual demographic data. A 10-minute debriefing followed, provided by a member of the investigative team, that reviewed the appropriate algorithm for managing the medical emergency encountered as guided by the emergency manual available in the OSCE operatory (Figure 1).[37]

All OSCE scenarios were recorded by a digital single-lens reflex high-definition camera using a wide-angle fisheye lens with mounted high-fidelity stereo microphone. Video files were codified with a random 8-digit alphanumeric code starting with either A or M for scenarios of anaphylaxis or STEMI, respectively.

Scoring Grids

The 2015 ACLS guidelines, literature from perioperative and emergency medicine articles, along with published dental practice guidelines provided the support for action items that were included on each scoring grid.[1,3,5,14,22,37–40] Published scoring grids and crisis management checklists were examined, and a format similar to the scoring grids developed by Roy et al for their simulation-based medical emergency interventional study was used.[25,37] The scoring grids were designed to include all actions that would be optimally performed in a dental office by 1 ACLS-trained dentist and 2 dental auxiliary staff trained in BLS, prior to emergency medical services arriving and assisting with transfer of the patient to the nearest emergency department. Scoring grids included 38 action items and a total of 128 possible points (Figure 2). The OSCE score ("Grand Total Score A") equaled the sum of the section total scores (ie, $A_{STEMI} = B_{STEMI} + C_{STEMI} + D_{STEMI} + E_{STEMI}$). Action items were weighted, giving more points to the most critical actions in the management of the respective medical emergency. The scoring grids were reviewed and approved by consulting faculty members from various medical and dental services and a statistician.

OSCE Scoring

Pilot sessions were conducted and recorded prior to each OSCE date to facilitate calibration and consistency of the simulation team and confederate actors. Four faculty reviewers were recruited, a dentist anesthesiologist, an oral and maxillofacial surgeon, a physician anesthesiologist, and a physician gastroenterologist, who serves as the medical director of a clinical skills and assessment center (CSEAC). Faculty were calibrated using the recorded pilot session videos for both OSCE scenarios. After group viewing and independent scoring of each pilot video, the reviewers collectively discussed the scoring grids and their grading of the performance and deliberated over proper interpretation of each action item. After general consensus was achieved, the next pilot video was reviewed, scored, and discussed in the same manner.

Statistical Analysis

An envelope with blank scoring grids and a memory disk containing the 24 codified OSCE video files was provided to each reviewer for independent review and scoring. Following return of the populated scoring grids, the OSCE score for each sheet was documented manually and populated into a Microsoft Excel spreadsheet for statistical analysis. These data were subsequently analyzed via Wilcoxon rank-sum and signed-rank tests with an alpha of .05 using JMP 14 Pro (STS Institute Inc, Cary, NC). The assessment of consistency and reproducibility of scores from the reviewers was evaluated by calculating an intraclass correlation coefficient (ICC) using R version 3.6.0 (R-Project for Statistical Computing).

RESULTS

A total of 16 participants were enrolled, reflecting a diverse collection of undergraduate dental education programs from 14 dental colleges across the United States, Canada, and Puerto Rico. All residents entered the GPR program immediately after graduating from dental school. The average ages at the time of summative OSCE for the control and intervention arms were 28.5 and 26.6 years, respectively. The male to female ratios for the control and intervention arms were 3:5 and 4:4, respectively.

Performance scores out of 128 total possible points from each group were analyzed using both mean and median values, producing consistent statistical results (Table 2). The mean summative OSCE score for the post-MEMDO group (90.9 points, 71%) was significantly higher than that of the control group (61.2 points, 47.8%; $p = .0009$). For the MEMDO group, the mean

DATE:

Standardized scoring grid for the STEMI scenario (STEMI)

(Developed from from Roy et al., Tan et al., The OSU-Stanford Medical Emergency Cognitive Aid and 10-Minutes Saves A Life)

Sum score A_{STEMI} [0-128] = $B_{STEMI}+C_{STEMI}+D_{STEMI}+E_{STEMI}$ | **Video Identification Code:**

		degree of completion (point value)	Score
B	**Patient interview B_{ana} (0-8)**		
1	Inquires about medical history, medications, allergies	no (0), yes (8)	
		Section Total B_{STEMI} (0-8):	
C	**Situational awareness and emergency management C_{ANA} (0-96)**		
	Hazard Identification and protection		
2	Spaces objects that pose risk to patient	no (0), yes (2)	
	Clinical observations verbalized or acted upon		
3	Performs focused examination of patient	no (0), yes (2)	
4	Appreciates diaphoretic, chest wet with sweat	no (0), yes (2)	
5	Appreciates respiratory distress	no (0), yes (2)	
6	Appreciates chest discomfort	no (0), yes (4)	
	Evaluation of alertness and orientation (A&O)		
7	Verbal/physical stimulation	no (0), yes (2)	
	Oxygenation/Circulation		
8	Pulse oximeter utilized	no (0), yes (2)	
9	SpO2 value appreciated/acted upon	no (0), yes (2)	
10	Electrocardiogram utilized	no (0), yes (2)	
11	Tachyarrhythmia/Ischemic changes appreciated/acted upon	no (0), yes (2)	
12	NIBP utilized	no (0), yes (2)	
13	Hypotension appreciated/acted upon	no (0), yes (2)	
	Clinical awareness, deisions and actions		
14	Announces diagnosis/concerns to team, shared mental model	no (0), yes (2)	
15	Administers high flow 100% oxygen	no (0), suboptimal (4), optimal (8)	
16	Considers or delivers Aspirin 325 mg PO to chew and swallow	no (0), yes (4)	
17	Inquires about Aspirin allergy	no (0), yes (2)	
18	Considers or delivers of sublingual nitroglycerine	no (0), yes (4)	
19	Inquires about recent PDE5 inhibitor use	no (0), yes (2)	
20	Gains IV access	no (0), yes (2)	
21	Considers or delivers fentanyl/analgesic	no (0), yes (4)	
22	Appreciates clinical status changes	no (0), yes (4)	
23	Reassesses patient vital signs at least q5min	no (0), yes (2)	

DATE:

	Cardiopulmonary resuscitation (CPR) for Cardiac Arrest performed or coached		
24	Apnea appreciated	no (0), yes (2)	
25	Pulse check performed less than 10 seconds	no (0), yes (2)	
26	Patient positioned supine/low for optimal chest compressions	no (0), yes (2)	
27	Chest compressions delivered appropriately	no (0), suboptimal (3), optimal (6)	
28	Compression to ventilation ratio appropriate	no (0), yes (2)	
29	Delivery of meds (i.e. Epi) appropiate to clinical state	no (0), suboptimal (2), optimal (4)	
	Automated/manual external defibrilator use performed or coached		
30	AED utilized/applied to patient/turned on	no (0), yes (8)	
31	Appropriate coaching: clear to shock, immediately resume CPR	no (0), yes (2)	
	Ventilation support performed or coached		
32	Airway positioning: head tilt, chin lift, airway adjunct	no (0), yes (2)	
33	BVM properly assembled, positioned and deliver PPV	no (0), yes (4)	
34	Advanced airway implemented appropriately	no (0), yes (2)	
		Section total C_{STEMI} (0-96):	
D	**Call for help/activate emergency medical services D_{ANA} (0-16)**		
35	Call to 911/EMS	no (0), after arrest (4), before arrest (8)	
36	Pertinant patient information given for 911/EMS use	no (0), yes (2)	
37	Summon help to room from second assistant/office staff	no (0), yes (6)	
		Section total D_{STEMI} (0-16):	
E	**Utilizes a crisis resource management cognitive aid**		
38	Uses a cognitive aid	no (0), yes (8)	
		Section total E_{STEMI}(0-8):	
A	Grand Total Score A_{STEMI}(0-128) = $B_{STEMI}+C_{STEMI}+D_{STEMI}+E_{STEMI}$ =		of 128

COMMENTS:

Figure 2. OSCE scoring grid. Customized scoring grid for the STEMI OSCE scenario with 4 sections (B, C, D, E) for a total score of 128 possible points (A).

Table 2. Mean OSCE Performance Scores*

Group	*Mean OSCE Score (128 Total Points)*	*Score Percentage*
Control	61.2	47.8
Pre-MEMDO	54.0	42.2
Post-MEMDO	90.9	71.0

* Mean OSCE performance score for each group with respective score percentage. The post-MEMDO group performed significantly better than the control group ($p = 0.0009$), while the control group failed to perform significantly better than the pre-MEMDO group ($p = 0.2698$).

summative OSCE score increased significantly compared with the mean baseline OSCE score (+36.9 points, +28.8%; $p = .0039$). The mean summative OSCE score for the control group (61.2 points, 47.8%) was slightly higher than the baseline OSCE score for the MEMDO group (54 points, 42.2%), although that difference was not statistically significant ($p = .2476$). Data from the 3 groups are depicted below (Figure 3). An ICC was determined to be .9795, which reflects significant rater agreement well beyond chance, as an ICC greater than .75 is generally considered evidence of excellent rater calibration.

DISCUSSION

Experiential learning sessions that use immersive simulation and deliberate practice have shown great promise as training modalities to safely improve medical emergency management by health care providers and teams.[41,42] Clinical simulation pedagogy that incorporates formative and summative encounters with standardized patients and simulator mannequins has become standard across educational programs in medicine, nursing, and paramedic training.[43–49] A systematic review and meta-analysis by Cook et al[43] noted that in comparison to no intervention, simulation-based training was more effective at improving the knowledge, skills, and behaviors of health care professionals and moderate effects were appreciated for improving patient-related outcomes. A systematic review by Issenberg et al[45] concluded that high-fidelity medical simulations with mannequin simulators that demonstrate physiologic response capabilities are educationally effective and that simulation-based education complements medical education in patient care settings. In addition, the Association of American Medical Colleges and the Accreditation Council for Graduate Medical Education have endorsed the use of clinical simulation in both formative and summative assessments of trainee milestones pertaining to management of medical emergencies.[48,49]

During the OSCEs, study participants were confronted with a simulated medical emergency in the dental clinic setting. The group who completed the simulation-based MEMDO curriculum significantly outperformed the control group for their respective summative OSCEs ($p = .0009$). Notably, the lowest scoring resident in the post-MEMDO group outperformed the highest scoring resident in the control group as demonstrated by the lack of overlap in the score distributions for the control and post-MEMDO groups (Figure 3). Participants in the intervention (MEMDO) arm improved their OSCE scores by an average of 68.3%, had an average summative OSCE score of 71% (90.9/128 points), and received no failing grades (<60%).

In contrast, the average summative OSCE score for the control group was 47.8% (61.2/128 points). Remarkably, the control group, who was nearing completion of residency, failed to perform significantly better on their summative OSCE than the MEMDO group, who were recent dental school graduates, did on their baseline OSCE ($p = .2698$). This is evident by the significant overlap in score distributions for the control and pre-MEMDO groups (Figure 3). No participants in either the control or pre-MEMDO groups received passing grades on their respective summative and baseline OSCEs.

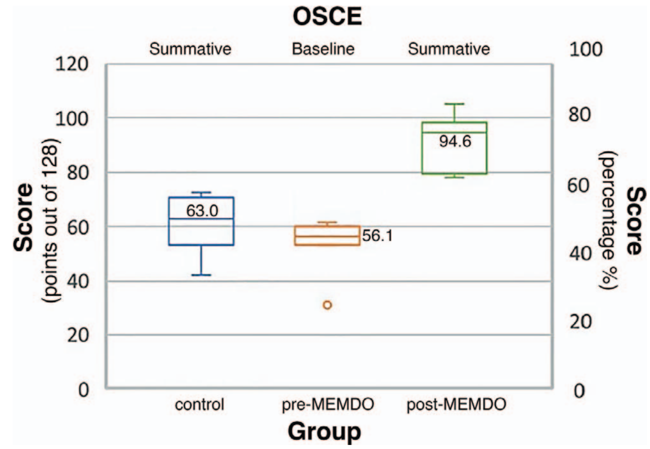

Figure 3. OSCE performance score distributions. Box and whisker plot depicting the distribution of OSCE scores by raw number and percentile horizontally and by group and OSCE type vertically. The boxes represent interquartile ranges with a central line for median scores labeled with their respective values. Whisker lines represent data ranges, and the circle represents an outlier. The post-MEMDO group performed significantly better than control group ($p = .0009$), with their score distributions lacking overlap. The control group failed to perform significantly better than the pre-MEMDO group ($p = .2476$), with noticeable overlap in their score distributions.

The standard approach to medical emergency preparedness training at the OSU GPR program has traditionally relied on completion of an ACLS course, content delivered through lecture-based education, and opportune clinical experiences. Results from this study suggest that this approach failed to provide effective training for residents to successfully manage simulated medical emergencies in a dental clinic setting. Residents who graduate lacking effective resuscitation skills may unknowingly endanger patients, particularly if using sedation with medically complex patients as they are no longer under the supervision of more capable faculty. Furthermore, it may be inappropriate to rely solely upon ACLS training programs for the delivery of substantial medical emergency preparedness and training for dental residents as the full application of ACLS treatment algorithms is not possible in the resource-limited dental clinical setting, where 12-lead electrocardiography, chest radiographs, arterial blood gas assays, and expert consultations are not readily available. The expansion of existing dental curricula to include simulation-based training methodology may be a more effective approach to better train dental health care providers to manage medical emergencies in a dental clinical setting.

In the effort to implement these types of training programs, dentist anesthesiologists and oral surgeons should serve as consultants/subject matter experts regarding resuscitation in the dental office setting. Collaboration with emergency physicians, physician anesthesiologists, emergency medical technicians, paramedics, and credentialed clinical simulationists can further aid in removing barriers to implement simulation-based training. The connections that GPR programs have with hospitals may prove to be uniquely valuable as many medical centers operate in-house simulation facilities to train their staff members.

Additional studies are likely needed to investigate best practices for implementing simulation-based medical emergency training across educational programs, as well as to measure the long-term retention of fundamental knowledge, skills, and abilities that are gained from these curricula.

Limitations

This study had several notable limitations. With simulation-based training and assessment, there is always the possibility that participants more experienced with the simulation environment may be more comfortable performing in a simulation-based OSCE. The control group was unable to complete a baseline OSCE because of the timing of IRB approval, which made it impossible to determine if the control group would have performed better if given a previous (baseline) OSCE. The number of participants ($N = 16$) was limited by the number of residents in the GPR classes studied. In addition, the dentist anesthesiologist who provided the IV sedation lecture series to residents in both the control and intervention arms served as 1 of the 4 faculty reviewers for this study and was not blinded to group designation of the participants in the OSCE videos.

Barriers to implementation of a simulation training program include the allotment of curriculum time, cost of technical equipment, implementation of faculty development for using simulation methodology, and availability of subject matter experts to design and facilitate sessions. The CSEAC provided access to simulation equipment, mannequins, and personnel free of charge for this study.

CONCLUSIONS

This pilot study adds to the growing literature supporting the effectiveness of simulation pedagogy within dental education. The completion of a simulation-based medical emergency curriculum significantly improved participants' performance in managing simulated medical emergencies in a dental clinical setting. Furthermore, standard training without regular simulation-based application failed to prepare residents effectively for managing simulated medical emergencies. GPR programs should consider implementing comprehensive simulation-based training curricula to enhance acquisition of the necessary knowledge, skills, and experiences that enable graduates to effectively manage medical emergencies.

ACKNOWLEDGMENTS

The authors give special thanks to the leadership and staff of the CSEAC who helped make this study possible and to faculty statistician John Draper, PhD. Thank you to the OSU Division of Oral and Maxillofacial Surgery and Dental Anesthesiology for the abundant support in resident and faculty time to help facilitate this study.

REFERENCES

1. Vaughan M, Park A, Sholapurkar A, Esterman A. Medical emergencies in dental practice—management requirements and international practitioner proficiency: a scoping review. *Aust Dent J*. 2018;63:455–466.

2. Johnson TM, Kurt-Gabel C. Compliance with and attitudes towards the management of medical emergencies in general dental practice. *Prim Dent J*. 2014;3:41–45.

3. Malamed SF. Managing medical emergencies. *J Am Dent Assoc*. 1993;124:40–53.

4. Clark MS, Wall BE, Tholström TC, Christensen EH, Payne BC. A twenty-year follow-up survey of medical emergency education in U.S. dental schools. *J Dent Educ*. 2006;70:1316–1319.

5. Boyd BC, Fantuzzo JJ, Votta T. The role of automated external defibrillators in dental practice. *N Y State Dent J*. 2006;72:20–23.

6. Pieren JA, Gadbury-Amyot CC, Kandray DP, Van Ness CJ, Mitchell TV. The attitudes of Ohio dentists and dental hygienists regarding the use of automated external defibrillators in the dental setting: a follow-up study. *J Dent Hyg*. 2013; 87:158–168.

7. Radfar L, Suresh L. Medical profile of a dental school patient population. *J Dent Educ*. 2007;71:682–686.

8. Nery EB, Meister F Jr, Ellinger RF, Eslami A, McNamara TJ. Prevalence of medical problems in periodontal patients obtained from three different populations. *J Periodontol*. 1987;58:564–568.

9. Rajeswari K, Kandaswamy D, Karthick S. Endodontic management of patients with systemic complications. *J Pharm Bioallied Sci*. 2016;8:32–35.

10. Bennet JD, Kramer KJ, Bosack RC. How safe is deep sedation or general anesthesia while providing dental care?. *J Am Dent Assoc*. 2015;146:705–708.

11. Campbell RL, Shetty NS, Shetty KS, Pope HL, Campbell JW. Pediatric dental surgery under general anesthesia: uncooperative children. *Anesth Prog*. 2018;65:225–230.

12. Chi SI. Complications caused by nitrous oxide in dental sedation. *J Dent Anesth Pain Med*. 2018;18:71–78.

13. Mortazavi H, Baharvand M, Safi Y. Death rate of dental anesthesia. *J Clin Diagn Res*. 2017;11:7–9.

14. Haas DA. Management of medical emergencies in the dental office: conditions in each country, the extent of treatment by the dentist. *Anesth Prog*. 2006;53:20–24.

15. Anders PL, Comeau RL, Hatton M, Neiders ME. The nature and frequency of medical emergencies among patients in a dental school setting. *J Dent Educ*. 2010;74:392–396.

16. Obadan EM, Ramoni RB, Kalenderian E. Lessons learned from dental patient safety case reports. *J Am Dent Assoc*. 2015;146:318–326.

17. Fast TB, Martin MD, Ellis TM. Emergency preparedness: a survey of dental practitioners. *J Am Dent Assoc*. 1986; 112:499–501.

18. Dennis MJ, Bennett JD, DeLuke DM, et al. Improving the medical curriculum in predoctoral dental education: recommendations from the American Association of Oral and Maxillofacial Surgeons Committee on predoctoral education and training. *J Oral Maxillofac Surg*. 2017;75:240–244.

19. Müller MP, Hänsel M, Stehr SN, Weber S, Koch T. A state-wide survey of medical emergency management in dental practices: incidence of emergencies and training experience. *Emerg Med J*. 2008;25:296–300.

20. Clark MS, Heine CS, Fryer GE Jr. Medical emergency education in American dental schools. *J Dent Educ*. 1985;49: 179–181.

21. Clark MS, Fryer GE Jr. A nine-year follow-up survey of medical emergency education in dental schools. *J Dent Educ*. 1993;57:363–365.

22. American Heart Association. *Advanced Cardiac Life Support Provider Manual*. Dallas, TX: First American Heart Association Printing; 2016.

23. Commission on Dental Accreditation. *Accreditation Standards for Advanced Education Programs in General Practice Residency*. Chicago, IL: American Dental Association; 2017.

24. Tan GM. A medical crisis management simulation activity for pediatric dental residents and assistants. *J Dent Educ*. 2011;75:782–790.

25. Roy E, Quinsat VE, Bazin O, Lesclous P, Lejus-Bourdeau C. High-fidelity simulation in training dental students for medical life-threatening emergency. *Eur J Dent Educ*. 2017;22:261–268.

26. Kalsi AS, Higham H, McKnight M, Dhariwal DK. Simulation training for dental foundation in oral and maxillofacial surgery: a new benchmark. *Br Dent J*. 2013; 215:571–576.

27. Newby JP, Keast J, Adam WR. Simulation of medical emergencies in dental practice: development and evaluation of an undergraduate training programme. *Aust Dent J*. 2010;55: 399–404.

28. Rubin ME, Hansen HJ. An emergency simulation course in a postdoctoral general dentistry program: the New York Presbyterian/Weill Cornell Medicine experience. *J Dent Educ*. 2017;81:1345–1350.

29. Cheng A, Auerbach M, Hunt EA, et al. Designing and conducting simulation-based research. *Pediatrics*. 2014;133: 1091–1101.

30. Lewis KL, Bohnert CA, Gammon WL, et al. The Association of Standardized Patient Educators (ASPE) Standards of Best Practice (SOBP). *Adv Simulat*. 2017;2:1–8.

31. International Nursing Association for Clinical Simulation and Learning Standards Committee. INACSL standards of best practice: Simulation^{SM} simulation design. *Clin Simul Nurs*. 2016;12:5–12.

32. McEvoy MD, Hand WR, Furse CM, et al. Validity and reliability assessment of detailed scoring checklists for use during perioperative emergency simulation training. *Simul Healthc*. 2014;9:295–303.

33. Becker DE, Rosenberg MB, Phero JC. Essentials of airway management, oxygenation, and ventilation part 1: basic equipment and devices. *Anesth Prog*. 2014;61:78–83.

34. Rosenberg MB, Phero JC, Becker DE. Essentials of airway management, oxygenation, and ventilation: part 2: advanced airway devices: supraglottic airways. *Anesth Prog*. 2014;61:113–118.

35. Rosenberg M. Preparing for medical emergencies: the essential drugs and equipment for the dental office. *J Am Dent Assoc*. 2010;141:14–19.

36. Becker DE. Emergency drug kits: pharmacological and technical considerations. *Anesth Prog*. 2014;61:171–179.

37. Stanford Anesthesia Cognitive Aid Group. *Emergency Manual*. 2016. Available at: emergencymanual.stanford.edu/. Accessed January 21, 2018.

38. Campbell RL, Li JTC, Nicklas RA, et al. Emergency department diagnosis and treatment of anaphylaxis: a practice parameter. *Ann Allergy Asthma Immunol*. 2014;113:599–608.

39. Malamed SF. *Medical Emergencies in the Dental Office*. 6th ed. St Louis, Mo: Mosby; 2007.

40. Reed K. Basic management of medical emergencies: recognizing a patient's distress. *J Am Dent Assoc*. 2010;141:20–24.

41. DeMaria S Jr, Bryson EO, Mooney TJ, et al. Adding emotional stressors to training in simulated cardiopulmonary arrest enhances participant performance. *Med Educ*. 2010;44: 1006–1015.

42. Ruesseler M, Weinlich M, Müller MP, Byhahn C, Marzi I, Walcher F. Simulation training improves ability to manage medical emergencies. *Emerg Med J*. 2010;27:734–738.

43. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA*. 2011;306:978–988.

44. Hayden JK, Smiley RA, Alexander M, Alexander M, Kardong-Edgren S, Jeffries PR. The NCSBN national simulation study: a longitudinal, randomized, controlled study replacing clinical hours with simulation in prelicensure nursing education. *J Nurs Regul*. 2014;5:3–40.

45. Issenberg SB, Mcgaghie WC, Petrusa ER, Gordon DL, Scalese RJ. Features and uses of high-fidelity medical

simulations that lead to effective learning: a BEME systematic review. *Med Teach*. 2005;27:10–28.

46. McKenna KD, Carhart E, Bercher D, Spain A, Todaro J, Freel J. Simulation Use in Paramedic Education Research (SUPER): a descriptive study. *Prehosp Emerg Care*. 2015;19: 432–440.

47. Kunkler K. The role of medical simulation: an overview. *Int J Med Robot*. 2006;2:203–210.

48. Obeso V, Brown D, Aiyer M, et al. Core EPAs for entering residency pilot program. In: *Toolkits for the 13 Core Entrustable Professional Activities for Entering Residency*. Washington, DC: Association of American Medical Colleges; 2017.

49. Hart D, Bond W, Siegelman JN, et al. Simulation for assessment of milestones in emergency medicine residents. *Acad Emerg Med*. 2018;25:205–220.