fortune Journals

Research Article

ARCHIVES OF INTERNAL MEDICINE RESEARCH

ISSN: 2688-5654

High-fidelity Simulation in Teaching Pediatric Critical Deterioration Events: A Learning Needs Assessment

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Abstract

Background: We introduced high-fidelity simulation (HFS) using mannequins to teach pediatric residents about critical deterioration events (CDE; respiratory failure, circulatory shock, or both) in pediatric patients over a 1-year period. For an effective HFS program, a learning needs assessment is required. We assessed pediatric residents' knowledge, attitudes, and perceptions of the new learning tool.

Methods: A 20-item paper-based questionnaire survey was completed by pediatric residents of a tertiary medical center who participated in the HFS program.

Results: Thirty-four (85%) of 40 pediatric residents responded to the survey. Their mean age was 29.35 ± 1.25 years, and 10 (29.4%) were male. The primary learning objective was the acquisition of technical skill. However, the residents considered HFS helpful for the acquisition of both technical and non-technical skills. A questionnaire with a seven-point Likert scale (1–7) was used to assess resident attitudes toward the HFS. The residents scored highly for active engagement with the HFS (mean score, 5.32 ± 1.45) and reported moderate stress levels (mean score, 4.35 ± 1.27). The residents (n = 34) considered HFS training before encountering a real patient with a similar presentation helpful (mean score, 6.32 ± 0.58), and also considered its future use for improving the management of CDE in pediatric patients important (mean score, 6.41 ± 0.7). The main barrier to HFS session attendance was lack of time (76.5%, n = 26).

Conclusions: HFS is helpful for residents learning about CDE in pediatric patients, and should be integrated into their training curriculum. Sufficient time is needed for effective HFS learning.

Keywords: High-fidelity; Simulation; Critical Deterioration Events (CDE); Needs Assessment; Pediatric

Abbreviations: HFS: High-fidelity Simulation; CDE: Critical Deterioration Events; CPR: Cardio-pulmonary Resuscitation; PEM: Pediatric Emergency Medicine; LFS: Low Fidelity Simulation; PICU: Pediatric Intensive Care Unit; CRM: Crisis Resource Management; ANOVA: Analysis of Variance

Background

High-fidelity simulation (HFS) using mannequins, which realistically emulates actual clinical events, is being increasingly used to train medical professionals [1-5]. HFS provides residents with experience of critical events, which can then be applied directly in their daily medical practice following a debriefing session [6]. HFS has a moderately positive effect on real clinical practice and patient-related outcomes [7]. For pediatric residents, HFS is particularly important as it offers an opportunity to learn about rare pediatric emergencies [2, 8, 9]. Simulations of critical pediatric scenarios have been shown to be beneficial with respect to resuscitation, including the application of oxygen, cardiopulmonary resuscitation (CPR), and defibrillation during actual clinical practice [10]. Supplementing pediatric resident training with HFS could improve residents' medical knowledge, clinical, procedural, and team-working skills, and ability to respond to deteriorating patients [4, 5, 11]. However, implementation of an HFS program requires a significant investment in space and equipment, and extensive faculty involvement [12]. Thus, if the training

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Citation: Jung Lee, Jainn Jim Lin, Shao-Hsuan Hsia, Jing-Long Huang, Cheng-Hsun Chiu, Min-Huey Lin, Cheng-Keng Chuang. High-fidelity Simulation in Teaching Pediatric Critical Deterioration Events: A Learning Needs Assessment. Archives of Internal Medicine Research 5 (2022): 340-345.

Received: June 16, 2022
Accepted: June 24, 2022
Published: July 19, 2022

Lee J et al., Arch Intern Med Res 2022
DOI:10.26502/aimr.0115

does not meet the residents' needs, it wastes resources. It is necessary for institutions to consider the cost of HFS; a learning needs assessment should be the first step in this regard [13, 14]. Exploring residents' opinions of HFS is helpful to identify program weaknesses, such that the institution can develop an effective HFS training program [15]. In this study, HFS was used to teach pediatric residents about critical deterioration events (CDE; respiratory failure, circulatory shock, or both) in pediatric patients over a 1-year period [16, 17]. We assessed pediatric residents' knowledge, attitudes, and perceptions of HFS, and the results would inform the creation of learning objectives that ensure a relevant and effective HFS training program [18].

Methods

A descriptive cross-sectional survey was conducted to assess the learning needs of pediatric residents following HFS exposure (see appendix 1: survey tool). All pediatric residents who participated in our HFS program at the Department of Pediatrics of Chang Gung Hospital, Taiwan, from September 2016 to August 2017 were included in this study and completed the paper-based learning needs survey. To ensure that the survey included appropriate items, it was designed according to guidelines for self-administered clinician surveys [19]. All survey items were generated based on a literature review and refined by an expert panel that included HFS researchers, pediatric emergency medicine (PEM) physicians, and medical education specialists. The 20-item English-language questionnaire was revised based on feedback from collaborators. The survey was tested in a pilot study, followed by a clinical feasibility test [19]. For consistency, operational definitions were provided to survey respondents, as follows. "High fidelity simulation (HFS)" was defined as simulation teaching which involves the use of computerized full-body mannequins programmed to simulate the physiologic conditions of various medical scenarios and responses to interventions; this is often delivered with experienced actors in real resuscitative environments. "Low fidelity simulation (LFS)" was defined as simulation teaching which involves the use of mannequins, materials and equipment which have little programming capabilities, and hence, limited ability to provide physical cues "(e.g., the "Annie" doll from pediatric advanced life support courses) (appendix 1).

The survey was anonymous and no personal information was collected. Informed consent forms and the paper-based survey were kept in different envelopes that were sent to pediatric residents after their HFS sessions. Residents read and signed the informed consent form after receiving an oral explanation of the study from the primary investigator. They were then asked to complete the survey, although this was not mandatory. Residents who did not consent to participate kept the survey and returned the blank informed consent form. All data were exported into Microsoft Excel (Microsoft Corp., Redmond, WA, USA) by a research assistant. As compensation for participation, a gift card worth $5 USD was sent to the participants. The primary site for data storage and analysis was the Department of Pediatrics of Chang Gung University. Ethics approval (No. 201601063B0) was obtained from Chang Gung University.

HFS setting

Participation in the HFS program was not mandatory and was not associated with any certification or job retention, to ensures residents' true opinions of HFS were captured. Two high-fidelity simulators were used (SIM-Baby and SIM-Junior; Laerdal, Stavanger, Norway). The HFS sessions of CDE were 45 minutes in duration (1 per week for 4 weeks). Residents performed different roles over the sessions, including team leader. The scenarios were designed based on the most common types of CDE encountered in the pediatric intensive care unit (PICU). The scenarios were refined by an expert panel comprising PEM physicians, HFS experts, medical educators, and other specialists. The carefully scripted scenarios focused not only on technical resuscitation skills [10], but also on non-technical skills related to the principles of crisis resource management (CRM), which requires behavioral skills, resource utilization, communication, leadership, teamwork and the ability to manage emergencies [20, 21]. The scenarios were brief (~10 minutes), and a detailed backstory including the ages of the patients was provided. A research assistant played the role of the family of the patient and communicated the residents. Scenarios were randomized and took place in a real clinical environment [22]. Doctors from emergency or intensive care pediatric wards facilitated the scenarios; they were provided with teaching materials before the start of the course, and conducted pre-briefing and debriefing sessions. To make the HFS scenario more realistic, the interaction of the facilitator with the participants was limited and only key patient medical history data were provided by the research assistant who played the role of the family of the patient [10].

Statistical analysis

Descriptive statistics were generated for demographic characteristics. Continuous variables (e.g., age) were subjected to univariate analyses and the data are provided as mean and standard deviation; for categorical variables (e.g., sex, the data are provided as frequencies and percentages. A seven-point Likert scale (1–7) was used for scoring questionnaire items. Student's t test and the Chi-square test were used for analyzing continuous and categorical variables, respectively. Analysis of variance (ANOVA) was also used to compare group means. The SPSS statistical software package (V24; SPSS Inc., Chicago, IL, USA) was used for all analyses, and $p < 0.05$ was taken to indicate statistical significance. The analysis was performed in consultation with an expert biostatistician from the Biostatistics Group of Chang Gung University.

Results

Demographics

Thirty-four (85%) of the forty pediatric residents who attended the HFS sessions responded to the survey. These included 8 (23.5%) second-year residents (R2), 15 (44.1%)

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DOI:10.26502/aimr.0115

third-year residents (R3), and 11 (32.2%) fourth-year residents (R4). Their mean age was 29.35 ± 1.25 years, and 10 (29.4%) were male. They specialized in advanced cardiac life support (41.2%, $n = 14$), pediatric advanced life support (94.2%, $n = 32$), neonatal resuscitation (97.1%, $n = 33$), and basic life support (58.9%, $n = 20$). They had experienced real CDE in pediatric patients 5.44 ± 3.39 times and attended HFS 2.5 ± 1.16 times over the past 12 months.

Knowledge (Table 1)

The top three learning needs identified by respondents prior to HFS for managing CDE in pediatric patients were "performance of emergent procedure(s)" (27/34, 79.4%) "understanding the management of critical events" (24/34, 70.5%), and "team communication, knowledge sharing" (13/34, 38.2%). Following the HFS program, these changed to "organizing a team and acting the role" (25/34, 73.5%), "understanding the management of critical events" (22/34, 64.7%), "recognizing deterioration and shout out for help" (12/34, 35.3%), "performance of emergent procedures" (12/34, 35.3%), and "providing a summary of the situation to the team" (12/34, 35.3%). Arrhythmia (supraventricular tachycardia, ventricular tachyarrhythmia, etc.) (18/34, 52.9%), cardiac arrest (17/34, 50%), and drowning (15/34, 44.1%) were considered desirable future HFS scenarios.

Attitudes (Table 2)

Generally, the residents scored highly for active engagement with HFS (mean score, 5.32 ± 1.45) and reported moderate stress during HFS sessions (mean score, 4.35 ± 1.27). Fear was reported regarding the management of real CDE in pediatric patients in the emergency department or hospital (mean score, 5.26 ± 1.23).

Perceptions (Table 3)

The residents ($n = 34$) indicated that practice with CDE in pediatric patients via HFS before encountering a live patient with a similar presentation was helpful (mean score, 6.32 ± 0.58). The residents also felt that HFS was more useful than low-fidelity simulation (LFS) for learning how to manage CDE in pediatric patients (mean score, 6.15 ± 0.7) and that it will be important to use HFS in the future to facilitate the management of CDE in pediatric patients (mean score, 6.41 ± 0.7). The greatest perceived barriers to engaging with HFS were as follows: "lack of time" (26/34, 76.5%), "intimidating environment" (16/34, 17.6%), "lack of a supportive climate" (9/34, 26.5%), and "unrealistic scenarios" (9/34, 26.5%) (Table 3). To improve HFS, "a more realistic simulation environment" (18/34, 52.9%), "more realistic scenarios" (18/34, 52.9%), and "more realistic actor performance" (18/34, 52.9%) were cited by the respondents (Table 3). Residents who had more real-life experience with CDE in pediatric patients showed a trend toward greater engagement with HFS (Pearson's correlation coefficient $[r] = 0.45$, $p = 0.07$). Other factors, including sex ($p = 0.278$), age ($p = 0.787$), seniority ($p = 0.88$), number of HFS sessions attended ($p = 0.726$), and stress level during real-life CDE ($p = 0.918$) and HFS CDE ($p = 0.774$) were not correlated with the level of engagement with HFS.

Table 1: Knowledge. 1) Which three aspects of managing pediatric critical deterioration do you want more information/training for? (choose your top 3). 2) Which three aspects of HFS do you find most helpful in your management of pediatric critical deterioration? (choose your top 3).

HFS exposure	Before	After
Recognize the deterioration and shout out for help	7	12
Organizing a team and acting the role	10	25
Team communication, knowledge sharing	13	10
Understanding the management of critical events	24	22
Performance of emergent procedure(s)	27	12
Finding needed equipment or medications	8	6
Summarizing the situation to team	5	12
Doctor-parent communication	3	1
Appropriate patient disposition	2	3
others	0	0

Table 2: Attitude.

	N	Mean	SD.
On average, how actively did you participate in HFS learning in the past 12 months? (1~7, never ~ totally)	34	5.32	1.45
Please rate your perceived stress when participating in HFS learning in the past 12 months? (1~7, Never ~ Always)	34	4.35	1.27
Please rate how frightened you felt when managing TRUE (not HFS) pediatric critical deterioration in your emergency hospital in the past 12 months? (1~7, Never ~ Always)	34	5.26	1.23

Table 3: Perception.

	N	Mean	SD.
How helpful do you think to practice pediatric critical deterioration HFS before a real patient with a similar presentation? (1~7, Definitely un-helpful ~ Definitely helpful)	34	6.32	0.58
Compared to LFS, how useful is HFS for you to manage a pediatric critical deterioration now? (1~7, Definitely un-useful ~ Definitely useful)	34	6.15	0.72
As a future clinical teacher, how important do you think it is to use HFS to teach pediatric critical deterioration event management? (1~7, Definitely un-helpful ~ Definitely helpful)	34	6.41	0.70

Discussion

The effectiveness of HFS in teaching residents about aspects of acute care is well-established [8, 23, 24, 25]. Unfortunately, most studies on simulations for learners only described their

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DOI:10.26502/aimr.0115

demographic characteristics without exploring their requirements with respect to this type of learning [26]. For a successful HFS teaching program, the learning objectives must align with the residents' needs, so that the full potential of the HFS program is realized and the institute receives an optimal return on their investment [14, 27, 28].

Knowledge

HFS is effective for improving medical knowledge and, in many fields, has been clearly shown to be associated with improved performance [7, 29]. It is particularly effective in improving high-level non-technical skills, such as decision-making and leadership, which could otherwise only be achieved through clinical experience, and aids in the identification of human error [30-35]. Non-technical skills important for CRM were addressed by our scenarios, and during debriefing. Before engaging with our program, residents did not have a good understanding of HFS; most of them expected to acquire technical skills related to the performance of emergency procedures. After the program, the residents indicated that both technical and non-technical skills were essential for HFS learning [27, 36]. This indicates that HFS may improve non-technical skills; thus, we believe that HFS could help prevent non-technical medical errors and thereby improve patient safety [21, 37].

Attitude

Research on adult learning generally emphasizes that active participation is an important factor [38]; adult learning outcomes are enhanced when they are actively engaged in the process [39]. Sometimes, residents may participate in teaching programs only because they are mandatory for recertification or job retention [26, 39]. In contrast, our residents participated in HFS voluntarily, and scored highly for active engagement with the program (mean score, 5.32 ± 1.45). The stress experienced during HFS, unfamiliarity with the equipment, and anxiety about being video recorded could limit residents' engagement with this learning modality [15]. Nevertheless, it has been argued that simulation-based education has the potential to change the culture of silence and blame that prevails when errors are made [40-42]. Our residents appreciated the less stressful learning environment of the HFS, where mistakes were permitted and reviewed rather than harshly judged and evaluated [43]. There was a positive correlation between the number of real-life critical events experienced and engagement with HFS, probably because residents who have experienced more of these events are likely to appreciate the reproducible, standardized educational experience provided by HFS [44].

Perception

Overall, our residents had a highly favorable view of HFS and reported high levels of engagement [20]. They indicated that encountering CDE via HFS before doing so in a live patient was helpful. Our results should help program designers to tailor HFS to the needs of individual participants [15]. Evidence supporting the use of HFS in favor of LFS in training programs for pediatric residents remains insufficient [20]. However, the residents in this study felt that HFS was more useful than LFS for learning about CDE in pediatric patients, and that HFS should continue to be used to improve management of CDE. Thus, educators should consider using HFS if sufficient resources are available [20]. A stressful/intimidating environment, fear of judgment by facilitators or peers, and concerns regarding whether performance accurately reflects clinical ability have been reported as barriers to HFS learning [43]. In our study, protected time for learning, in a realistic and safe environment, are needed for effective HFS programs.

Limitations

Our study had several limitations. First, there was no pre-HFS assessment, because we could not determine the residents' needs prior to their engagement with the new teaching method. Second, there was no control group, because we wanted to offer HFS to all residents. Third, the responses to the surveys may have been susceptible to recall bias because the residents had received the HFS training up to 12 months prior to completing the questionnaire.

Conclusion

HFS should be integrated into pediatric resident training programs because it facilitates the management of CDE in pediatric patients. It was shown that both technical and non-technical skills are essential for success in HFS, and sufficient time is needed for effective learning. Further research is required to assess the impact of this educational intervention on patient outcomes.

Declarations

Ethics approval and consent to participate

Ethics approval (No. 201601063B0) was obtained from Chang Gung University and written informed consent obtained from all the participants.

Consent for publication

The Author transfers to Medical Education on Line the non-exclusive publication rights and he warrants that his contribution is original and that he has full power to make this grant.

Availability of data and materials

The data from this research project are available upon reasonable request.

Competing interests

The authors declare no competing interests.

Funding

This study was supported by the Ministry of Science and Technology (MOST 106-2511-S-182A-004), and (MOST 107-2511-H-182A-002-MY2), Taiwan.

Authors' contributions

J.L., M.H.L. and C.K.C. conceived and designed the study. J.J.L. and S.H.H. interpreted the data, and participated in HFS teaching and data analysis. J.L. gathered the data. J.L. drafted the manuscript. J.L.H. and C.H.C oversaw the study and revised the manuscript. All authors have read and approved the final manuscript for publication.

Acknowledgements

The authors thank their expert panel, including Dr. Samina Ali, Dr. Carla Angelski, and Dr. Melissa Chan. The authors also thank to all the residents who took time from their busy schedules to answer this survey.

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