

High Fidelity Simulation Is Associated With Good Discriminability In Emergency Medicine Residents' In-Training Examinations

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Abstract

Background

In-training examinations (ITEs), arranged during residency training, evaluate the residents' performances periodically. The ITE usually consists of written and oral forms. There is limited literature focusing on the effectiveness of emergency medicine (EM) resident ITEs in the format of simulation-based examinations, as compared to traditional oral or written tests. Our primary objective is to compare high fidelity simulation with written and oral tests in the evaluation of the residents with different seniority in EM training programs.

Methods

During the 5-year study period, 8 ITEs were administered to 68 EM residents, and 253 ITE scores were collected. Different ITE scores were calculated and presented as mean and standard deviation. Discrimination of ITE scores between different training years of residency was examined using one-way ANOVA test.

Results

The high fidelity simulation scores correlated to the EM training year, and residents in their fourth training year (R4) had the highest scores consistently, followed by R3, R2, and then R1. The oral test scores had similar results but not as consistent as the high fidelity simulation tests. The written test scores distribution failed to discriminate the residents' seniority. The high fidelity simulation test had the best discriminative ability and better correlation between different EM residency training years comparing to oral or written forms.

Conclusions

High fidelity simulation tests had a good discriminative ability and were well correlated to the EM training year. We suggest high-fidelity simulation should be a part of ITE of EM training programs and maybe adopted in EM board certification examination in the future.

Introduction

The goal of postgraduate medical education is to facilitate the resident's acquisition of medical knowledge and clinical skills, and to support the achievement of the competency required to practice in a medical specialty(1). It is imperative to evaluate the residents' performance periodically, in order to facilitate them to overcome their weakness and to ensure the quality of the residency program. The Accreditation Council for Graduate Medical Education (ACGME) and the Council of Emergency Medicine Residency Directors (CORD) emphasize the value of practical and reliable assessment tools to evaluate the ability of residents and the effectiveness of the residency programs.(2-4)

In-training Examination (ITE), also known as in-service examination, was firstly introduced in 1963 to residents in medical specialty by the American Academy of Orthopedic Surgeons.(5) In either oral or written forms, ITE has been adopted by various medical specialties as a powerful and multi-functional assessment tool to measure the performance of residents.(6–9) For emergency medicine (EM) residents, the ITE is not merely a signboard of their current academic performance but also a chance to prepare for the board exam. The ITE offers an opportunity for them to review their deficiencies in medical knowledge and to improve themselves.(10) Prior studies have found a positive correlation between EM ITE scores and the American Board of Emergency Medicine (ABEM) written board certification scores.(11–13) Similar correlation of the ITE and board exam score was also documented in the field of internal medicine and its subspecialty of cardiovascular disease.(14, 15)

EM in-training examination, as well as board-certification qualifying examination, usually consists of written and oral tests.(6, 13) Some of these types of examinations measure the degree of medical knowledge and clinical skills, but may not correlate to the overall clinical performance in EM residency, which is supposed to advance with EM residency training year. Furthermore, clinical productivity (number of patient encounters per hour), as a "real-life" in the emergency department (ED), correlated poorly with academic performance when measured by oral ITE and oral/written ABEM scores.(13) ED is a complicated lieu, which is characterized by time limits, various independent tasks with undetermined priorities, a rapidly changing environment full of interruptions, and the need for education and training(12). The progress of multitasking ability by EM residency training year may not be directly reflected by written and oral test scores.

High fidelity simulations, using computer-controlled mannequins, are being used throughout medical education to emulate real patient encounters since the 1960s.(16, 17) In addition, simulation is increasingly being used as an assessment tool particularly for procedures.(18, 19) Simulation-based teaching was also integrated into the curriculum, including system-based practice and communication skill training course for EM residents.(20–22) Simulation-based assessment can be used to evaluate the EM residents' competency in differential diagnosis, resuscitation, procedures and the year-to-year progression of performance, both formatively and summatively.(23) Some literature supports the use of simulation-based assessment tools in the evaluation of residents, as in anesthesiology residency.(24–26) Some even advocated for the use of simulation-based tests in board certification exams.(19, 27, 28)

Currently, there is limited literature focusing on the effectiveness of EM resident ITEs in the format of simulation-based examinations, as compared to traditional oral or written tests. Our primary objective is to compare high fidelity simulation with written and oral tests in evaluation of the residents with different seniority in EM training programs.

Method

Study setting

This is a retrospective cohort study of EM resident physicians. The study was conducted at a university-affiliated tertiary teaching hospital with a 3,600-bed capacity and an estimated annual ED volume of 180,000 patient visits. There are 63 board-certified EM faculty members within the department. The residency program accepts 7–10 resident physicians each year. The study was approved by our institutional review board (IRB no.202000099B0).

Participants and data collection

Our EM training program administers in-training examination (ITE) to all residents biannually, usually in February and August. All residents needed to participate in the examinations unless specific conditions were met, such as severe illness. The first-year resident (R1) physicians would not take the examination in August because they usually registered in the same month. The ITEs were supervised by the residency program director and organized by the education committee within the department.

The ITE consists of 3 different forms: written examination, oral examination, and high-fidelity examination (oral and high-fidelity examination was canceled in 2018 due to equipment problems). Written examination involved multiple choice questions (MCQs) and short answer question (SAQ) stations. MCQs had mixed content of EM. SAQs stations included electrocardiogram (ECG) reading, image test (radiograph, computed tomography, ultrasound), and other different EM themes. Oral simulation tests included 2 to 3 stations with different EM topics, such as internal medicine, pediatrics, toxicology, emergency medical system (EMS)...etc. The examiner of each station was EM board certified faculty member. High-fidelity simulation was operated with computer-controlled mannequin and 2 designed scenarios with different topics were used in each ITE.

We collected five years of ITE data. Eight ITEs were included in the study. Only one ITE was administered in 2017 because of a change in the management level. Average scores from written, oral simulation and high-fidelity exams were calculated. The written test, oral test and high-fidelity examination scores were the mean scores across all stations.

Statistical analysis

Data were analyzed using SPSS software (version 13.0 for Windows; SPSS, Chicago, IL). In the descriptive analysis, categorical variables were presented as numbers and percentages. Different ITE scores were calculated and presented as mean and standard deviation. The reliability of ITE was evaluated using Cronbach's alpha coefficient. The discrimination of ITE scores between different training years of residency was examined using one-way ANOVA test. A p value < 0.05 was considered statistical significance.

Results

During the 5-year study period, 8 ITEs were administered to 68 EM residents training in our EM training program, and 253 ITE scores were collected. Table 1 reveals the characteristics of the ITEs and the participants. All 8 ITEs included written test, and 7 of them contained oral tests and high-fidelity

simulation tests. Examinations in February usually involved 35 or 36 EM residents, and examinations in August had 26 to 29 residents each time. The number of residents in each training year ranged from 7 to 10.

Table 1
Characteristics of the in-training exams (ITEs) and participants

Characteristics of ITEs		count		
Total tests		8		
Containing written test		8		
Containing oral simulation test		7		
Containing High fidelity simulation test		7		
Number of participating residents (lowest-highest)		26–36		
Gender of participants				
Male		55		
Female		13		
Participants' year of initiation	Male	Female	Total	
2012	1	0	1	
2013	8	1	9	
2014	9	1	10	
2015	8	2	10	
2016	8	2	10	
2017	7	3	10	
2018	8	0	8	
2019	6	4	10	

The analysis of ITE content was revealed in Table 2. All the stations of SAQs, oral tests and high-fidelity simulation tests were analyzed. The most discriminative subject is internal medicine (85.71%), followed by pediatrics (80%) and toxicology (60%). Other topics revealed diverse results. The internal consistency of the ITE was 0.95, which indicated a good reliability across different participants.

Table 2
List of domains of In-Training Exams

Domain of the test	Station Count	(%)
Written test stations	38	
MCQs	7	18.42
SAQs stations	31	81.58
ECG	8	21.05
Image	6	15.79
Ultrasound	6	15.79
Critical care medicine	4	10.53
Gynecology	2	5.26
Others	5	13.16
Oral test stations	15	
Internal medicine	5	33.33
Pediatrics	3	20
Toxicology	4	26.67
Other	3	20
High fidelity simulation stations	14	
Internal medicine	2	14.29
Trauma	6	42.86
Critical care	3	21.43
Pediatric	2	14.29
Toxicology	1	7.14

The written tests usually consisted of MCQs and several stations of SAQs. ECG reading and image tests are commonly covered in the SAQs each time. The most common topics of oral test were internal medicine and toxicology. Trauma and critical care most often appeared in the high-fidelity simulation tests. Table 3 shows the discrimination of the tests according to EM residency training year. Almost all oral and high fidelity simulation tests of each exam were discriminative except one. The discrimination of the written tests was poor. Although oral and high fidelity simulation tests were both discriminative, the scores distribution of these 2 kinds of tests were different. Figure 1 demonstrates the average scores of different EM training year residents in each ITE. The high fidelity simulation scores correlated to the EM training year and R4 had highest scores consistently, followed by R3, R2 and then R1 (Fig. 1c). The oral

test scores (Fig. 1b) had similar results but not as consistent as the high fidelity simulation tests. The written test scores distribution is lack of similarity (Fig. 1a). The high fidelity simulation test had the best discrimination and better correlation between different EM residency training years comparing to the other 2 test forms.

Table 3

Discriminability of in-training examinations, differentiated according to examination forms and test domains.

Discriminability according to different examination forms			
Examination	Written test	Oral simulation test	High-fidelity simulation
Test 1	p = 0.001*	p < 0.001*	p = 0.007*
Test 2	p = 0.967	p = 0.730	p = 0.249
Test 3	p = 0.733	p = 0.001*	p = 0.015*
Test 4	p = 0.384	-	-
Test 5	p = 0.084	p = 0.006*	p = 0.016*
Test 6	p = 0.032	p < 0.001*	p < 0.001*
Test 7	p = 0.261	p = 0.001*	p = 0.016*
Test 8	p < 0.001*	p < 0.001*	p = 0.004*
Discriminability according to test domains			
Test domain	Total stations	Discriminative stations	Discriminative prob (%)
Internal medicine	7	6	85.7
Pediatric	5	4	80.0
Toxicology	5	3	60.0
Mixed content(MCQ)	7	4	57.1
Critical care medicine	7	3	42.9
Trauma	7	3	42.9
Image	6	2	33.3
Sonography	6	1	16.7
ECG	8	1	12.5
Gynecology	2	0	(0)
* p value < 0.05			

Discussion

To our knowledge, this is the first study to evaluate the utility of high fidelity simulation in the in-training examinations of EM training programs. Our study demonstrated good performance of high-fidelity simulation test to discriminate the difference in competency of EM residents in different training year(s). It may not be surprising that high fidelity simulation tests had better results than written tests. Medical knowledge, as evaluated by written tests, can be obtained by greater efforts in reading textbooks and memorizing core contents. Consequently, as long as he/she studies hard, it is possible for a junior resident to outperform a senior one in a written test. Nonetheless, clinical experience, which was obtained at the bedside gradually with EM residency training years, cannot be rapidly obtained by goal-directed curriculum reading or short-term memory. Previous study also demonstrated improvement in written ITE scores after a structured board review program only in junior residents, but not senior ones.(29) With the accumulation of "real-life" experience, the medical knowledge should be integrated into the clinical scenario, including disease pattern recognition, application of relevant algorithm, and immediate interventions to treat patients properly and timely.(30) The clinical experience, as a basis of competence in patient care, is much more than a simple memory recall. Rodgers' study in an ACLS course concluded that written evaluation is a poor predictor of skill performance.(31) Other studies also fail to use ITE written and oral scores to predict residents' clinical performance.(6, 13, 30)

Oral tests also showed good discrimination in our study. The junior EM residents (R1) almost always had inferior scores comparing to senior residents. Whereas, the results were inconsistent in senior residents, and R2 or R3 physicians sometimes had better scores than R4 physicians in oral tests. One possible explanation is that oral tests may reflect some degree of both clinical experience and medical knowledge, but not as realistic as high fidelity simulation tests. Hence, the scores depended more individually in senior residents as long as they had a certain extent of clinical experience after completing first year EM training program. Alternatively, high fidelity simulation tests created a vivid scenario, which can evoke a physiologic response comparable to real-life clinical situation.(32) Therefore, the performance in high fidelity simulation tests correlated better to the extent of clinical experience than oral tests. According to our result, assessment by high fidelity simulation tests seems to be more appropriate to measure clinical competency of the EM residents.

The high fidelity simulation tests also had several advantages over traditional written and oral tests in assessing certain ACGME core competencies including interpersonal and communication skills, professionalism, patient care, and systems-based practice.(21, 22) The direct evaluation by medical educators through simulation-based assessment provides simultaneous evaluation of knowledge, clinical reasoning, and teamwork.(33)The standardization, fidelity, and reproducibility of medical simulation scenarios make it especially suited to be used in ITEs.(18, 23) With the aforementioned advantages, high fidelity simulation is possibly a better assessment tool for EM training programs.(34)

ITE in EM training program provides not only the evaluation of medical knowledge and clinical competency, but also an opportunity for the residents to know their advantage and deficiency.(10)

Contrary to text-based learning and written tests, EM residents prefer question-based learning, which can be evaluated by simulation tests.(10) Assessment by simulation had higher satisfaction rates when compared to written tests.(35) Although high fidelity simulation test is certainly more expensive than a standard written or oral test, it may be more cost effective than other commonly used methods of assessment like "standardized patient" in Objective Structured Clinical Examination (OSCE). Our study demonstrated the excellent discrimination of the high fidelity simulation tests in ITE of EM training programs. Although further study is needed, it should be considered as a part of EM board certification examination.

Limitations

Our study is a single-center study, the results may mostly reflect local situation. Additionally, the stations of in-training exam were drawn up by our EM faculty, which may not be generalizable to other specialties. Finally, the examiners of each ITE, which were our EM faculty, did not received additional training for each ITE, although the checklist of each station was provided and one station is scored by only one examiner.

Conclusion

High fidelity simulation tests used in ITE had good discriminative ability and well correlated to the EM training year. We suggest high-fidelity simulation should be a part of ITE of EM training programs, and may be used in EM board certification examination in the future.

Declarations

Ethics approval and consent to participate:

The study was approved by the institutional review board of Chang Gung Memorial Hospital (IRB no.202000099B0).

Consent for publication:

Not applicable.

Availability of data and materials:

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Authors' contributions

SYC contributed to the conceptualization, data collection and analysis, and draft writing of this research. CHC contributed to the research design, data acquisition, supervision of methodology, and data analysis. SRY contributed to the project administration, data acquisition, transcript coding, and participated in the analysis of themes. YCC contributed to the supervision of transcript coding and the emergence of themes. CJN contributed to the supervision of project. PL contributed to conceptualization of the research, software supervision and qualitative data analysis. All authors participated and contributed to the critical revision of the manuscript and gave final approval of version submitted for publication.

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Author contributions:

SYC contributed to the conceptualization, data collection and analysis, and draft writing of this research. CHC contributed to the research design, data acquisition, supervision of methodology, and data analysis. SRY contributed to the project administration, data acquisition, transcript coding, and participated in the analysis of themes. YCC contributed to the supervision of transcript coding and the emergence of themes. CJN contributed to the supervision of project. PL contributed to conceptualization of the research, software supervision and qualitative data analysis. All authors participated and contributed to the critical revision of the manuscript and gave final approval of version submitted for publication.

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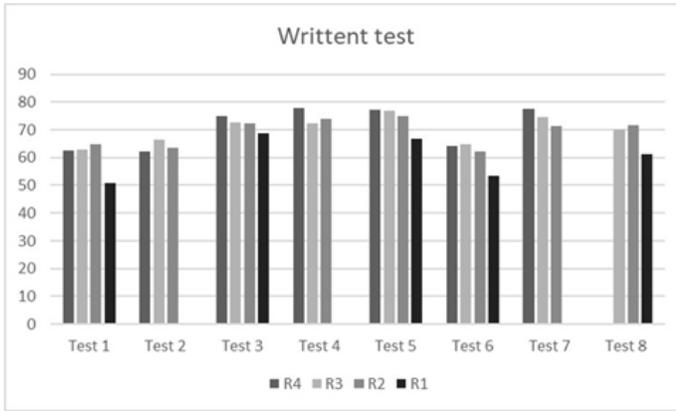
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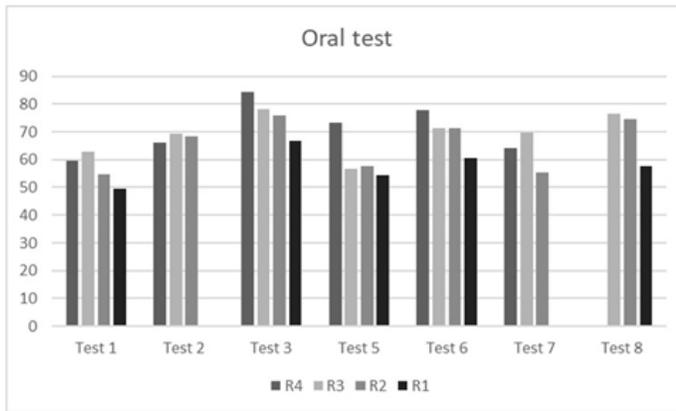
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Figures

(a)



(b)



(c)

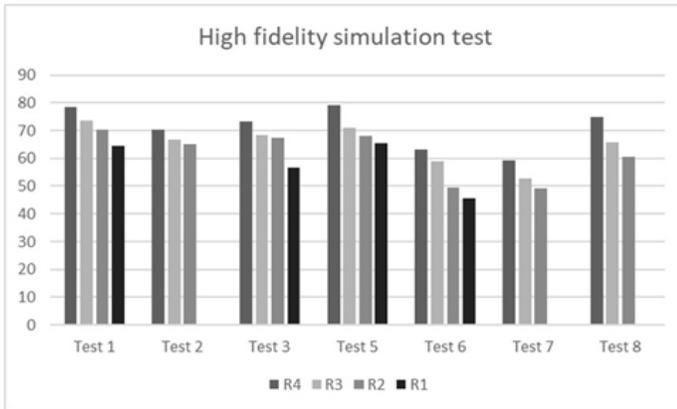


Figure 1

Illustration of test scores from (a) the written tests, (b) the oral tests, and (c) the high fidelity simulation tests of residents in different training years.