Journal of Advances in Medical and Pharmaceutical Sciences
12(4): 1-15, 2017; Article no.JAMPS.32234
ISSN: 2394-1111

SCIENCEDOMAIN *international*
www.sciencedomain.org

Role and Effectiveness of Simulation-based Training in Raising Family Medicine Residents' Clinical Resuscitation and Critical Care Skills

Majid Kh. Al Harthi[1], Raouf M. Afifi[2,3*], Mohamed A. Tashkandi[4], Ashraf E. Saad[4] and Yousef Afifi[2,3]

[1]Department of Family and Community Medicine, Medical Education Fellowship, University of Toronto, Canada.
[2]Community Health Research Institute, International Management-Health Services, Indianapolis, Indiana, USA.
[3]National Research Excellence Institute, Cairo, Egypt.
[4]Department of Preventive Medicine, Directorate of Health Affairs, Makkah, MoH, Kingdom of Saudi Arabia.
[5]Department of Preventive Medicine, Armed Forces Hospital, Wadi Al-Dawasir, Kingdom of Saudi Arabia.

Authors' contributions

This work was carried out in collaboration between all authors. Author MKAH designed the study, wrote the protocol, conducted literature search, data collection and preliminary analysis. Author RMA planned and conducted the analysis, results and discussion plan and wrote the first draft of the manuscript. Author MAT shared preliminary search, data entry and shared in analysis. Author AES shared in the analyses, results and discussion. Author YA shared in data management, manuscript drafts editing and referencing plan. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMPS/2017/32234
Editor(s):
(1) William Ebomoyi, Department of Health Studies, College of Health Sciences, Chicago State University, Chicago Illinois, USA.
Reviewers:
(1) Alberto Giuseppe Guido Piacentini, ASST Lariana, Como, Italy.
(2) Peter Laszlo Kanizsai, Semmelweis University, Budapest, Hungary.
Complete Peer review History: http://www.sciencedomain.org/review-history/18507

Review Article

Received 16th February 2017
Accepted 10th March 2017
Published 4th April 2017

**Corresponding author: E-mail: raoufafifi@hotmail.com;*

ABSTRACT

Background: Family medicine (FM) physicians are bound to providing healthcare services at a variety of clinical and community settings. They should be equipped to competently handle health emergencies in a multitude of professional procedures. Medical education on patients often raises safety issues; simulation-based medical education (SBME) was a solution enabling education in a risk free environment.
Aim: To analyze the impact of a SBME on Family medicine residents' performance in critical resuscitation procedures.
Methods: A systematic review of published articles between 1996 and 2016 was conducted. Systematized literature search through ranked search engines was done. All original research articles on SBME published between 1997 and 2012 were examined.
Results: The analysis included 6 relevant studies selected. The studies' venues included either academic or healthcare settings in Netherlands, Switzerland; Greece, and Canada. The studies' populations were mainly family medicine, and general practitioner, residents who participated in simulated resuscitation/life support educational activities. The number of participants in each SBMEactivity ranged between 28 and 72. The study of the Greekexperimentincluded 434 residents. An interventional design was advocated, and a self-reported questionnaire to evaluate participants' skills pursuant to SBME activities before and/or after the learning activities was unanimously utilized. The main SBME focus involved patient resuscitation and critical event care. Most studies came to significantly positive conclusions about SBME in raising residents' resuscitation knowledge, skill, and behavior.
Conclusions: The role of interactive SBM teaching in preparingFM residents to rescuing and resuscitating the critically ill independently is now sufficiently evident. Despite such success potential, methods to achieve improved critical care competence advocating low cost simulated medical education solutions in low economic circumstances should be sought.

Keywords: Medical education; family medicine; simulation-based; resuscitation.

1. INTRODUCTION

Clinical competence is a multidimensional concept and encompasses a variety of skills, including procedural, problem-solving and clinical judgment [1]. The initial stages of postgraduate medical training are believed to be a particularly important time for the development of clinical skill competencies. In practice, family physicians are called on to provide initial assessment and urgent care for patients with acute critical conditions, such as cardiac arrest, respiratory embarrassment, shock states, and other conditions necessitating immediate intervention. The critical nature of these conditions, when minutes or seconds count, urges medical education policy planners do their best to provide primary care cadres qualified enough to share the healthcare providers' community the responsibility of minimizing health and economic losses linked to unassisted critically ill patients. The family medicine junior staff and recent graduates often have to work independently, such as in rural or remote areas where a second opinion from experienced calibers is scarce. Given the change in lifestyle and reliance on technology in carrying out daily chores, todays' populations are growing physically inactive and obese, together with unhealthy diet; all are soil for developing chronic diseases of the time, such as diabetes and cardiovascular disease (CVD), especially myocardial infarction (MI) which is a frequent cause of death with around two-third deaths occurring outside hospital. Research evidence suggests that rapid initiation and a correct technique of cardiopulmonary resuscitation (CPR) are essential links in the chain of survival [2]. Since the majority of all deaths occur in the community, many lives could be saved if adequate CPR skills were present. Various studies have shown deterioration in CPR skills among physicians, even those who had successfully completed CPR training courses [3], indicating that proficiency in these skills is not maintained. Therefore, the importance of procedural skills training in the context of clinical competency has become recognized as an important component of residency in-training programs. In clinical medicine, many of the potentially life-saving interventions needed to care for patients require mastery of procedural skills. Although traditionally taught through a process informally referred to as "see one, do one, teach one," [4] educational opportunities to

perform such procedures during clinical rotations are limited. Inconsistent and inadequate exposure may lead to physicians lacking competence in their abilities to perform key procedures on completion of their residency.

The 1999 Institute of Medicine report entitled "*To Err Is Human"* [5] highlighted the diagnostic and cognitive aspects of medical error, and emphasized the role of simulation in procedural skills training [6]. Subsequent patient safety agendas, worldwide, have challenged licensing and governing bodies to improve physician competence and patient safety. In addition to concerns about patient safety, issues regarding liability of faculty, graduates and institutions have led to educational reform. Both the American College of Cardiology (ACC) and the American Board of Internal Medicine (ABIM) supported the American Medical College's Medical School Objective Project, which states, *"The successful medical school graduate should be able to effectively utilize various instructional tools including electronic tutorials and patient simulations"* [7]. Within this very context, research in simulation-based medical education (SBME) historically has been dominated by the fields of obstetrics and anesthesia, which have pioneered the use of simulation to improve performance while reducing patient risk [6]. Simulators allow trainees to acquire knowledge and competence in a controlled environment. They incorporate reality-resembling options, allow students to work through a clinical problem with limited direction, permit life-threatening mistakes to evolve without harming a real patient and provide immediate feedback on performances that are difficult to evaluate effectively in other circumstances. As such, SBME, such as acute critical event simulation (ACES), simulated CPR, simulated fiberoptic tracheal intubation, all could be part of several resuscitation and critical case management training programs, specifically designed to teach the basic competencies required to deal with critically ill patients in any of the aforementioned settings. However, such programs and embraced techniques should meet certain scientific and quality standards in order to be licensed for application [8]. In Canada, the College of Family Physicians of Canada (CFPC) [8] has set recommendation by that states the following: *"The CFPC's accreditation standards should require all family medicine programs to provide family medicine residents with the opportunity to acquire the acute care skills needed for both rural and urban inpatient hospital care."*Further, postgraduate specialty training leads to certification by either CFPC or the Royal College of Physicians and Surgeons of Canada (RCPSC). Postgraduate training is a particularly important phase of the medical education continuum and the first year of postgraduate training is believed to be of special significance in the development of the postgraduate trainee's clinical skills [9]. The assessment of clinical competence and feedback on performance are believed to be important strategies for enhancing clinical skills acquisition during this phase of medical education [10]. Clinical competence is a multidimensional concept and encompasses a variety of skill components including interviewing, interpersonal and physical examination skills, problem-solving and clinical judgment [1]. In order to assess competency in a valid manner assessment methods have to be authentic in nature, resembling the actual tasks to be performed by the independent physician. In effect, competency is related to the ability of the trainee to apply knowledge and comprehension appropriately in relevant situations and direct observation is a critical element in the assessment of competency. Sibert et al. [1] suggest that the methods for assessing clinical competence should be able to evaluate the skills required for successful clinical practice. Standardized patients (SPs) have been used for a number of years as a means of simulating the clinical encounter and enabling a valid and reliable assessment of clinical competencies. Ferrell [11] defines SPs as *"individuals who have been trained to portray a patient problem in a way that does not vary from learner to learner."* The use of SPs provides opportunities for assessments that are 'uncued, open-ended, standardized and more objective' than traditional paper-based assessment.

Overall, simulation in medical education, at its broadest, refers to the reproduction of something real by imitation, for the purposes of training or assessment. It has increasingly become part of mainstream postgraduate medical education. Especially family medicine and general practitioners (GPs) are prone to confronting emergency and critical cases at different clinical settings, the reason why they have to build up and maintain satisfactory critical care skills, which in turn help minimize errors and jeopardized patient's health and safety. Because medical learning through using the patient as a source of confrontation with actual disease experience is limited by patient's rights, discomfort, and risk of irreversible harm,

simulation provides an alternative solution for actual patient scenario. Simulation also replaces traditional forms of didactic learning, one that provides opportunity to learn from trial and error without risking negative outcomes for patients. It separates learning from the competing demands of service (for both the learner and the educator), allowing space and time for activities such as deliberate practice and a variety of methods of feedback and reflection. It is adaptive to the level of the learner. Although simulation is now largely being perceived as a cost-effectiveness approach for an efficient clinical training, the costs and experience needed for providing and adopting quality simulation-based education is often unaffordable, especially in places in limited resources situations. This review aimed toidentify and evaluate the outcomes of advocating simulation-based learning in family medicine residents' critical care and resuscitation practice. The following questions have been stipulated in order to specify the search mission and increase the potential of coming out with valid conclusions about the study findings: *a) what simulation-based training methods are available for family medicine practitioner in improving their resuscitation and critical care skills?" and b) how effective these methods in improving their resuscitation and critical care skills?*

2. METHODOLOGY

2.1 Data Sources

An extensive literature search was conducted on the effectiveness of simulation-based clinical education for teaching family medicine residents' resuscitation skills, to identify articles or reports published between 1996 and 2016 using Ovid MEDLINE, PubMed, Cochrane library, ERIC (Education Resources Information Center), and Google Scholar. A manual search of reference lists of original studies was searched. Key words in the search were combined together using Boolean operator [AND], (see Box 1).

2.2 The Study Selection Process

A total of 230 articles were identified in initial search. The titles and abstracts of all articles of potential interest were reviewed for inclusion and exclusion of studies. The criteria for selected studies aimed to include studies that indicated the effectiveness of SBME for teaching family medicine residents resuscitation skills. Studies from all locations and world countries were included. All the included studies were required to include family medicine residents, with or without general practitioners and medical students. If the selected studies were published in a scientific journal, such periodical should at least have an ISSN number with or without online ISSN number. Only studies published in English and where full manuscripts were included. Also there was not a restriction by sampling technique or sample size due to the limited numbers of studies meeting specified criteria. Importantly, all selected studies had to be based on simulation as the intervention interface of interest, without restriction to utilized technology, function or specific manufacturers. Finally, studies published in abstract form were excluded. A total of 45 full-text papers have been identified and further reviewed. Eventually, six articles were included in the review [12-17]. (Fig. 1 summarizes the selection process of the reviewed studies). Further selection criteria are summarized as follows:

2.3 Inclusion and Exclusion Criteria

Inclusion criteria included, a) published interventional, prospective, randomized or non-randomized studies, b) studies conducted between 1996 and 2016, c) detailed explanations of used continuous medical education (CME) methods, and d) outcomes include increased knowledge, change in practice behavior, and improved trainee's resuscitation and critical event care skills.

Exclusion criteria included, a) **s**tudies which have no family medicine physicians, b) studies published earlier than 1996, c) studies involving quality improvement projects, d) studies which do not address evaluation of educational or training interventions.

2.4 Data Abstraction and Quality Assessment

Data extracted for each study included study title, principal investigator (PI or first author), periodical/journal, study type, location/country, setting, year/duration, study context, study aim, methods, including study design, population/participant, inclusion criteria, sampling method and sample size, intervention method, outcome and evaluation/ assessment strategy, statistical analyses, results/ findings, and conclusion. Also compared and analyzed were strengths and limitations as addressed by each study or concluded by these investigators, and researchers' reflection, as concluded from the

original studies. Briefed tabulated findings for each study are showed herewith; besides detailed comparative discussion. A cumulative table including analyses of reviewed studies was also structured for itemized comparison. The main comparison headings as in original articles were used. (***NB.*** The quality of selected studies was assessed guided by the "Centre for Reviews and Dissemination guidelines") [18]. Since there were few papers that addressed the study questions, no studies were excluded for their qualities.

Box 1. Selected search terms

Simulation-based clinical teaching
1) "Simulation-based clinical teaching" OR "simulation based clinical teaching" OR "simulated clinical education" OR "simulated clinical training" OR "simulator-based clinical training: OR "simulation models clinical training"
Family medicine residents
2) "Family medicine residents" OR "Family medicine trainees" OR "family medicine practitioners" OR "general practitioners"
Resuscitation skills
3) "Resuscitation skills" OR "cardiopulmonary resuscitation skills" OR "critical resuscitation" OR "critical events resuscitation"
4) #1 AND #3
5) #2 AND #3
6) #1 AND #2 AND #3
7) #2 AND #3 AND #4

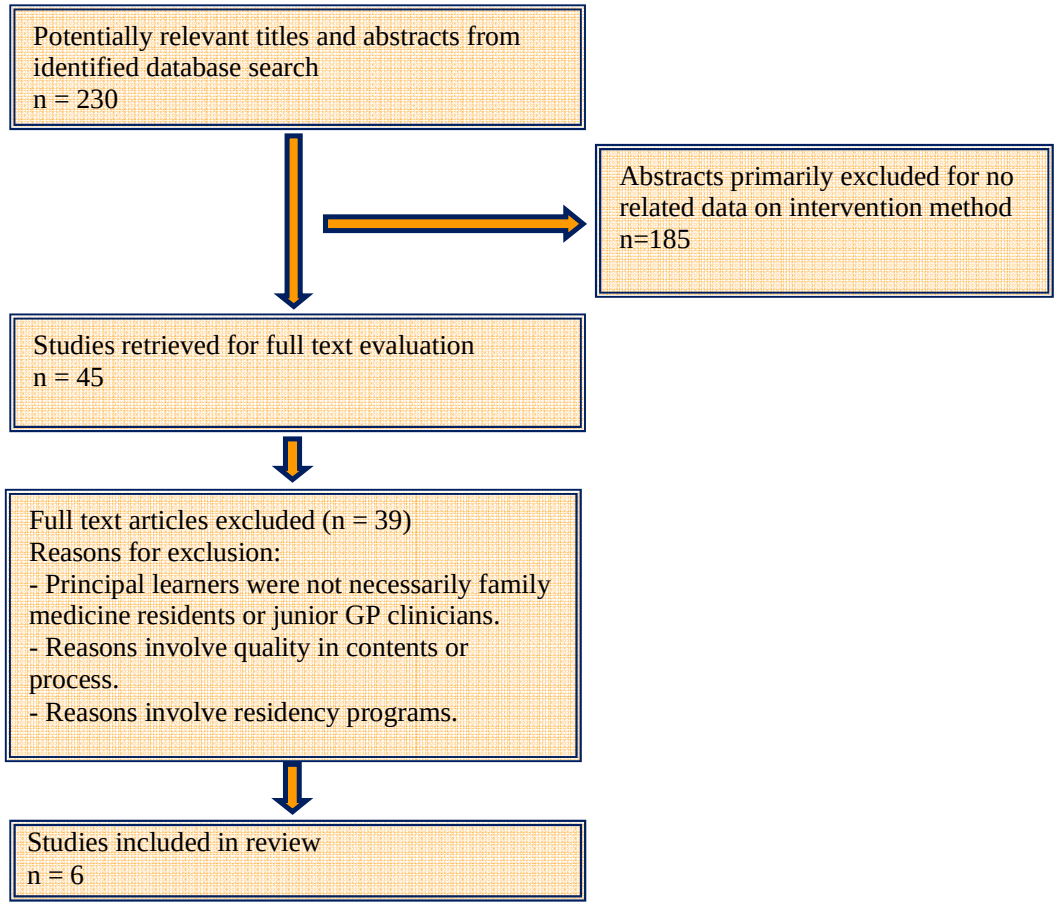

Fig. 1. Study selection process

2.5 Data Syntheses

A narrative synthesis was performed to identify the study question. It included describing all the included papers, summarizing the findings of the data extracted from each study, and exploring the relationships between the results of the different studies.

3. RESULTS

3.1 Study 1 Results and Conclusions

Physical exam and clinical skills in respiratory diagnosis were significantly correlated) (r=0.51, p=0.041). The "one sample paired t-test" of pre- and the post- course evaluations revealed significant difference in the mean scoresof 16 out of 25 different diagnostic skills tested in the six different clinical symptom scenarios relevant to the systems [cardiovascular system (CVS), respiratory system, central nervous system (CNS), musculoskeletal system(MSK), ear-nose-throat (ENT), and gastrointestinal system (GIT)] systems). Another paired t-test round showed significant differences in 2 out of 6 interview conducting abilities tested with certain history taking skills (past medical history, p=0 .010, history of life functioning with illness, p=0.016) (Table 1, Table 7a).

3.2 Study 2 Results and Conclusions

Mann-Whitney *U* testing to analyze Dutch residents' cardiac compression performance revealed a significant difference in the mean scores before and after training. Likewise, a significant difference in ventilation performance score levels before and after training was obtained ($p<0.05$ both tests; *U* statistic values were not given). Further analyses showed a significant difference in overall performance scores before and after the continuous medical education (CME) course ($p<0.05$). Interestingly, the study also provided variable levels of questionnaire's sensitivity 39%-98%, and specificity 39%-98% of the utilized checklist, compared to observer's notes. Importantly, a significantly variable range of correlation between checklist items & manikin strip recording output was found (r = 22%-79%, $p<0.05$). Ultimately there was also a significantly moderate correlation between checklist and general impression (r = 0,67, $p<0.05$) (Table 2, Table 7a).

3.3 Study 3 Results and Conclusions

Swiss medical students were significantly less likely to call for help in the initial phase of arrest (p=0.02). They were also less "hands-on" time during the first 180 seconds of CPR (p<0.0001).

Table 1. Study-1 (Curran, et al. 2012) (Original research paper. Newfoundland, Canada) [12]

Type, location/country	
Setting/context	Academic: Memorial University of Newfoundland. Clinical competence skills of postgraduate entry-level family medicine residents.
Aim/objective(s)	Evaluate OSCE* method as a means of assessment of clinical skill competencies of entering PGY1 family medicine residents. Also:a) identify competency gaps, b) provide immediate teaching and feedback, c) develop clinical skill training.
Population/participants	35 postgraduate (PG) family medicine (FM) residents, year 1 (Y1)
Intervention	SCE encompassing a realistic clinical encounter with a SP. Confronting OSCE with a standardized patient (SP): 4 clinical scenarios: a) back pain and work stress, b) hypertension (HTN) and diabetes (DM), cough/sinusitis and smoking, d) chest/ epigastric pain and CVS risk.
Outcome evaluation method(s)	Performance checklist (57- 69 items) to evaluate benefit from SCE via: • Pre-evaluation survey immediately after orientation. • Post-evaluation survey 3 months after experiment.
Conclusion	OSCE is a very positive educational experience for PGY1 family medicine residents.Areas for further improvement suggested through focus group analysis.

***** *OSCE: Objective structured clinical skills examination*

Table 2. Study 2 (Jansen et al., 1997) (Original research. Netherlands) [13]

Setting/context	Clinical service setting. CPR skills within physician practice environment.
Aim / objective(s)	Evaluation of general practitioners' (GP) performance in CPR. Evaluate checklist validity (sensitivity/specificity) v. recording strip (gold standard).
Population/participants	General practitioners (GP) in CME course, including CPR training.
Intervention	1 hour CME SB training on CPR attended by experienced CPR trainers.
Outcome evaluation method(s)	a) Validated instrument: checklist with 16 items in 10 scales (AHA standards), b) before and after instruction and compared checklist-based scores to mechanical recording scores to investigate which scoring method is preferable, c) compare self-reported behavior scores with manikin-generated strip record.
Conclusion	Assessment of CPR training of GPs using combined checklist assessment and recording strip of the manikin is highly recommended employed in most evaluation schemes.

Table 3. Study 3 (Lüscher et al., 2010) (Original article. Basel, Switzerland) [14]

Setting/context	Academic. Challenge new MD meet after graduation facing cardiac arrest situations.
Aim / objective(s)	CPR performance: newly graduated medical students vs. experienced GP.
Population/participants	Medical students and GPs: Matched 48 teams: a) 24 graduates teams (3 member/team = 72 students), b) 24 GP team (3 member/team = 72 GPs).
Intervention	Voluntary participation both of MD physicians immediately after graduation and GPs with ER experience in simulated patient resuscitation workshops, based on using advanced Human Patient Simulator (METIPediasim$^{(C)}$)* manikins (mimic human physiology and some MSK functions, talking impression), IV cannula route.
Outcome evaluationmethod(s)	a) Guidelines for CPR as reference to evaluate performance, b) spontaneous data recording (frame-in-frame technology of vital signs), c) behavioralratings, e.g., "d*ecision what should be done"; "decision on how thingsshould be done"; "direction/Command" were* rated as present if any utterance occurred, d) before and after workshop responses to study questionnaire.
Conclusion	MD students upon graduation have delayed life-support measures, less CPR support, compared to GP peers.

***** *METI: Medical Education Technologies Inc.*

Likewise, medical students, compared to experienced GPs had a delayed response in first defibrillation procedure (p<0.007) (Table 3, Table 7a).

3.4 Study 4 Results and Conclusions

The analysis in the fourth study showed a myriad of significant results associated with Canadian board resident residents' performance in Calgary and clinical competency in emergency situations within less error and risk environment through simulated training. Generally, there was a significant correlation between all self-assessed competence scores and corresponding OSCE scores. The residents showed a significant improvement in knowledge by advancement in the program years [F (2, 25) = 4.91, p< 0.01]. Also a significant improvement in clinical skills by postgraduate year (PGYs) was established [F (2, 25) = 10.89, p < 0.001]. Both PGY1 and PGY2 residents significantly had higher post 3-month score than beginning of course score, while PGY3 residents showed increased both knowledge and skills at 3-month follow-up. The checklist items and global rating scale points showed a significantly strong correlation (r = 0.78, p< 0.001). Expert assessment significantly correlated with both the residents' knowledge scores and their skills scores (r=0.40, r=0.51, respectively; p< 0.01 both) (Table 4, Table 7a).

Table 4. Study 4 (Langhan et al. 2009) (Original article. Calgary, Canada) [15]

Setting/context	Clinical. Improving residents' performance and clinical competency in emergency situations within less error and risk environment through simulated training.
Aim / objective(s)	To assess the impact of a simulation-based procedural skills training on residents' competence in the performance of critical resuscitation procedures.
Population/participants	Canadian board resident physicians.
Intervention	a) Attending 8-hour simulation-based course procedures, b) guided instruction to augment skill retention.
Outcome evaluation method(s)	Self-assessment questionnaire to measure pre-intervention self-assessed competence immediately after the course and post-evaluation: Immediately after 3 months. Directly observed performing skills by an expert observer (OSCE) station. After each station, formative feedback was provided to reinforce desired behaviors and to rectify incorrect or dangerous techniques.
Conclusion	Participating in a simulation-based resuscitation course helps improve residents' knowledge and skill competence of emergency and resuscitation procedures. The more residents' experience the greater competence build-up. More benefit matching the timing of clinical skills training to the clinical responsibilities of learners may well be obtained.

Table 5. Study 5 (Willett, Cardinal, & Karas, 2011) (Original research. Ottawa, Canada) [16]

Setting/ context	Academic. The need to build up competent clinical skills of managing critical and emergency cases among junior family physicians who often have to handle in challenging situations, such as remote or underserved areas, with a short residency duration to cover up all those skills.
Aim / objective(s)	a) Enhance the abilities of residents in family medicine to recognize signs of critical illness, b) teach competencies in the early resuscitation, c) safely and sound emergency care practice in a rural and remote setting, d) increase residents' confidence to include inpatient care in their practice, e) ultimately, improve recruitment, retention and overall professional satisfaction.
Population/participants	The 49 second-year family medicine residents. n = 37
Intervention	2-day Acute Critical Events Simulation (ACES) course: Lectures, case discussions, hands-on task training, a ½ day high-fidelity simulation.
Outcome evaluation method(s)	A post-course questionnaire, which included Likert-scale and open-ended questions, was distributed to all participants. No pretest
Conclusion	The ACES course achieved its aims; learners reported positive outcomes. This highly interactive program may help prepare residents for work in rural or remote communities with critically ill patients.

3.5 Study 5 Results and Conclusions

All 37 family medicine residents agreed that the course was relevant to their anticipated job-related needs, and 61% disagreed on *"there were not enough opportunities for me to solve patient cases."* Importantly, most agreed their technical skills improved because of the course (92%-97% improved breathing, circulation, and airway problems skills), and 90% indicated they planned to change practice because of the course. Moreover, 97% agreed they would recommend this course to colleagues. In this investigation, too, men were more likely to practice in tertiary/suburban settings; while women were more likely to practice in rural/remote settings (p = 0.006) (Table 5, Table 7a).

3.6 Study 6 Results and Conclusions

Among 434 respondents with valid questionnaire responses, male family medicine and GP residents accounted 68.9% of the study

population. All residents agreed and understood the role of simulation models in medical teaching. They generally did not like hand-made simulation models used in the courses. One-third of residents (33.3%) perceive the approach to the patient actually differs from simulation-based training (Table 6, Table 7a).

3.6.1 Publication year

The reviewed studies were published between 1997 and 2012. Oldest to publish was the Netherland study (#2), the rest were published between 2009 and 2012 (Table 7a).

3.6.2 Study location/ country

All reviewed works were carried out in western and industrial countries, namely, Switzerland (study 3), Netherlands (study 2), Canada (studies 1, 4, 5), and Greece (study 6).

3.6.3 Study setting

Expectedly, all acute critical care courses and training were delivered at clinical or medical educational settings. For instance, studies #1, 3, and 5 were conducted in the academic and educational institutions, such as "Memorial University of Newfoundland," Canada (study #1), "Basel University," Switzerland (study #3), and "University of Ottawa" (study #5), respectively (Table 7a).

3.6.4 Study population, sampling method and sample size

The general trend in recruiting participants of the reviewed studies was to utilize nonprobability sampling techniques. In the Swiss experience (study (#3), both the medical students and GPs were randomly allocated to a number of study teams (three members per team). Likewise, most studies tended to not adopt a comparative technique in evaluating candidates' performance on the resuscitation and critical case skills training they were challenged with. Again, the Swiss study was the only one designed as to consider GPs as a comparison group for measuring the students' performance before and after the attended workshop. The number of participants was mostly limited, e.g., ranging between 28-37 (Canadian studies [studies 13, 16, 17] and Dutch study [study 14]), moderate, as in the Swiss study (n = 72), and very large in the Greek study (n = 434) (Tables 1-6, Table 7a).

3.6.5 Outcome/ evaluation method(s)

According to the study aim, and as per the search strategy adopted to achieve this aim, all studies reviewed involved interventional research design approach. Such design enables better evaluation of the usefulness of using simulated based training in thrusting critical care and resuscitation skills and knowledge of family medicine residents, and equivalent specialty, clinicians. In our review, we found that all studies opted to utilize a self-reported questionnaire instrument to measure the performance and/or knowledge and behaviors associated with the clinical experiences targeted from the attended simulation opportunity. The Calgary Canadian board residents were further evaluated through "objective structured clinical examination (OSCE) approach during the course process. After each station, formative feedback was provided to reinforce desired behaviors and to rectify incorrect or dangerous techniques. Most (4/6=66.7%) studies used pretest and post-test evaluation approach. Two studies (33.3%), (the Calgary and the Greek's) used only post-test evaluation. Calgary study, instead, used two post-tests, one immediately after course and the other was the classical 3 month evaluation point, all other studies used to evaluate trainees after completing courses (Table 7a).

All studies advocated inferential statistical analyses, including parametric techniques (PMTs), and non-parametric techniques (NPMTs), where appropriate, and no breaching of PMT assumptions was observed by us during the review. All studies could achieve study goal and came to valid conclusions about the examined SBME technique. Moreover, most studies concluded the presence of a significantly useful effect of the utilized simulated education approach in raising the practitioners' resuscitation and life support management skills. Most studies revealed the limitations they were subject to down the road, and on our part, we could conclude areas of strengths embedded in some of these studies, as summarized in Table 7b.

4. DISCUSSION

The studies under review unanimously yielded significantly positive relationship between attending simulated training activities and enhancing the residents' resuscitation and critical care treatment skills. First, the statistical

techniques utilized in the set of evaluated researches were generally adequate for analyzing the exposure and observed variables against the outcome variables of interest. That said, both parametric techniques (PMTs), such as student t-test, and analysis of variance (ANOVA) test, and non-PMTs were used, where appropriate. Within the context of researching on critical health issues, the use of appropriate statistical methods to measure the degree and stability of the improvement of the targeted residents' skills is crucial. Pretty much of the statistical technique utilized in the experiments under our evaluation were sound enough for generating valid conclusions about the studied training - skill acquisition relationships.

4.1 Study Year

Almost all studies were conducted up to 2-4 years prior to publication. For instance, the Greek study (#6) [17] was carried out between 2006 and 2008 until published in 2009, and the Swiss study (#3) was conducted between 2004 and 2005 and published in 2010. Obviously, the difference between the publishing year and carrying out study represents the time needed to collect and analyze data, seek publishing prepare for publication).

4.1.1 Study location/country

Notably, three-out six (50%) studies reviewed were from Canada [12,15,16]. In our search we from Canada were open to including all countries and places all over the world; however, the bulk of Canadian studies under review perhaps would reflect the utmost attention Canadian medical education and health policy makers give to CME and junior primary care physicians' training [9]. Thrusting those physicians' skills in dealing with critical health situations on sound scientific and clinical basis assures highest patient safety standards and saves the losses incurred due to improper resuscitation practice. The issue is that death after some sudden conditions compromising respiratory and cardiac conditions is often preventable [3]. In fact, this attitude of care provided to junior physicians working in Canada is part of a broader success environment the healthcare system in Canada has been enjoying over the last four decades, in terms of overall health standard of the Canadian populations. The willingness of the Canadian society to invest in health is largely supported by the good healthcare outcome indicators achieved by the Canadian health system, e.g., compared to other western civilizations. For instance, the United States' per capita/year spending on health during 1992 and 2014 increased from USD3788 to USD9403 and the health outcomes, such as infant mortality rate (IMR), death from accidents, environmentally related diseases, were remarkably less favorable than those reported in Canada, which had spent almost half (USD1831 - 5292) of the USA budget during the same period yet achieved remarkably better health outcomes [19].

4.2 Study Setting

The experiences related to family medicine and GPs candidates either took place at such venues where the taught simulated resuscitation courses or CPR training were held. Obviously, 3/6 (50%) of the courses were at the setting of hospitals and healthcare facilities, and 50% were at medical education and academic institutions. Particularly the Swiss study [14] was held in the simulation center of the University of Basel, probably the most suitable place for CPR and life support raining; (however it was not clear whether or not the other studies were held in a similar facility specific simulation centers affiliated to the organizing institutions). In essence, specialized simulated medical education and critical care training could be handled in a verity of training settings ranging from ordinary primary healthcare institutions and hospitals, to highly specialized centers with digital simulator-operated technologies. The choice to embrace certain level of simulation education preparedness depends on clinical factors related to the depth of critical care scenarios and more importantly on financial and economic resources available [20].

4.3 Sampling Method and Sample Size

The tendency for the vast majority (5 out of 6) of simulation-based education experiences in this review to not adopt any probability sampling techniques [12,13,15,16,17], where not every member of the sampling population has an equal opportunity to be represented, can perhaps be because these works originally clinical educational opportunities devoted to junior family medicine and peer residents, most probably part of their training program objectives. In which case, all candidates are being recommended to take part of these educational experiences. The randomization in the Switzerland study [14] probably first was a midst the study and did not mean to be in the initial learners' enrolment

phase. Knowingly, randomization is a technique that occupies a top position on the list of methods to control for the effect of confounding in research work [21]. The presence of randomization, comparison group, and relatively large sample size qualifies the Swiss study [14] to be among the simulation-based resuscitation studies for junior medical candidates with most validity and reliability potentials. Validity emerges from minimizing bias as a result of confounding, as above. Reliability implies higher reproducibility potential and hence generalizability upon the general medical student and GP populations [22]. A comparative approach, e.g., comparing medical students whose cardiac resuscitation experience expectedly should be limited with GPs who were specifically selected from those who had such cardiac arrest previous experience was meant to measure the underlying knowledge and skills of cardiac resuscitation measures [14]. This is typically why the study was designed in a fashion where no formal previous training was required to participate and, during the workshop, no training or teaching was provided prior to the simulation. In which case, the evaluated knowledge and skills measurements would not be influenced by the confounding effect of having a previous exposure of similar knowledge or practice experience. This reflects adequate relevance between written self-reported evaluation and experienced observer's evaluation during OSCE rotations [15]. This denotes good validity of the instrument currently used by residents for self-evaluation.

Table 6. Study 6 (Christodoulou, 2009) (Original article. Greece) [15]

Setting	**Clinical setting: Greece hospitals**
Context	Given the difficulties in using the patient in medical teaching, and given the cost of high-tech simulator use in teaching resuscitation courses, and the obstacles to use actual alternative professionally designed "toys and dolls" can be introduced in low resourceful circumstances.
Aim / objective(s)	Identify and analyze: a) residents' opinion about the usefulness of simulation models in medical education, b) residents' opinion about the usefulness of simulation models at home, c) models' role in various stages of medical education, d) the usefulness of simulation models for special purposes (specialized questionnaire), e) residents' perceptions of future of medical education with or without simulation models.
Population/participants	GP and general surgery (GS) residents. n = 434
Intervention	Series of free courses using both professional and hand-made simulation models. *Professionally produced simulation models*: resuscitation manikins (adult, child and neonatal model); IVN (Hyper-alimentation) care, tracheotomy, fiberoptic tracheal intubation, other. *Hand-made simulation models used:* bleeding esophagus, thoracotomy model, other.
Outcome evaluation method(s)	Predesigned and validated questionnaire. After the end of the courses (2-7 days) response to distributed questionnaire was requested.
Conclusion	The cost of simulation models can be very low with the use of simple materials. Professionally made simulators are very expensive; however, models made by the instructors could help a lot. Many doctors depend on pharmaceutical industry to pay course fees. Culture plays an important role in doctors education. Family relationship and children of economically powerful families receive supreme education in comparison to the general "mass". Greek trainees are not organized in associations, so cannot demand their rights in a better education.

Table 7a. Comparative review of the included studies: study characteristics

Year(s)	Study types	Location/country	Setting	Sampling method	Sample size	Study design	Outcome/ evaluation method(s)
1997–2012	All original research	Europe, Canada	Either academic or clinical setting	All non-probability. One (#5) was randomized with a comparison group	28-72; one (#6) had 434 residents	All interventional, non-randomized and no comparison group; except one study (#3) was randomized.	- All, self-reported questionnaire. - One (#4) used OSCE via observer's evaluation. - Most used pretest/posttest; two (#4 Calgary, #6 Greek) used only post-tests. - One (#4) used two posttests, immediately after course and classical 3m evaluation point

Table 7b. Comparative review of the included studies: Study analyses and results

Statistical analysis	Results / Findings	Strengths	Limitations
All used statistical techniques with α level for significance	All came to positive conclusions about the usefulness of simulated education in raising residents' resuscitation handling skills.	Some had strengths, such as large sample size (Greek study), randomized and almost controlled design (Swiss study).	All had limitations, mostly small sample size, except the Greek study. This may well affect study power and hence, minimize generalizability

4.4 Study Outcomes and Evaluation Method(s)

In this review, we can realize that more than one evaluation measure were commonly used to assess the change in learners' experience and attitude toward the critical care area under improvement. First, questionnaires were used by all studies. A unified instrument where before the inquired performance and knowledge questions can be answered by the residents is mostly appropriate for measuring the impact simulated teaching on improving residents' skills of making sound decisions dealing with acute critical events needing immediate resuscitation and intensive life-saving measures. In the Calgary experience (study #4) [15] course planners deployed the "objective structured clinical examination (OSCE) approach, where independent expert observers were directly observing performing skills at each OSCE station. After each station, formative feedback was provided to reinforce desired behaviors and to rectify incorrect or dangerous techniques. The OCSE evaluation strategy is widely used in clinical medicine both at undergraduate and postgraduate education levels. It enables replacing traditional ward ratings and multiple-choice tests, which often do not reliably assess clinical competence [23]. Definitely, in-course evaluation using such reliable assessment method adds to the strengths the Calgary residents' critical resuscitation experience.

Among all studies reviewed, the Greek one [17] is a unique experience which emphasizes the economic, and also physicians' culture role influencing technology-driven medical education preference and utility. This very research was designed and conducted under resource-limited conditions, probably part of the general economic situation in the country. Culture was also another dimension to focus on. Therefore, the questionnaire items were set to address these areas of Greek medical education planners concern. For instance, items about "home practice" preference of simulation training using low-cost and handmade resuscitation dolls were proposed. Unsurprisingly, most Greek residents preferred home practice as the first choice for their training. In Greece, hospitals tend to use trainee physicians more for working than for receiving new knowledge [17], probably this is why training doctors would be much helped if they had the "luxury" of simulation models at home. The cost of simulation models can be very low with the use of simple materials, used in the everyday practice. Although professionally made simulation models are very expensive, simple models made by the instructors could help a lot. Even papaya was used efficiently as simulation model for training in uterine aspiration [24]. Simulation courses that use simulation models have 10-fold price, because these products are not available in shops in Greece. Except for the expenses, that some residents may pay, many Greek doctors become dependent on pharmaceutical industries because the companies pay for their participation fees. In fact, this trend of depending on pharmaceutical companies to "finance: and sponsor a significant portion of physicians' career promotion activities has always been a concern in health care because it often leads to conflict of interests between the physician's ethical obligation to provide the best, safest, and most beneficial service to the best interest of her or his patient [25]. The instinct that the approach to the patient does differ from simulation-based training, as declared by a considerable proportion of Greek residents raises the issue of advantages and disadvantages of simulation education, especially in medicine. In their systematic review on appraising the value of simulation-based medical education and whether the reporting of cost is sufficiently addressed [26].

5. CONCLUSION

Overall, the systematic review has achieved its goal, and research questions have been answered. Findings from the review support the benefits of simulation-based training for residents in the form of improved self-assessed theoretical knowledge and procedural skill competence. The best method for this was found to be through participation in simulation-based resuscitation education. Gains in perceived competence appear to be stable over time, with senior learners gaining further confidence upon post-training follow-up. While assigning a control group to "placebo" education in order to identify the effect of true education on subjects' resuscitation performance would be unethical, recruiting a comparison group instead, e.g., physicians with different acute care experiences or from a parallel discipline, was found to be a convenient solution, which assured maximum benefit of both the intervention and the comparison group. In the medical profession, continuous education dependence on simulation is becoming increasingly popular, particularly in improving experiential learning environments and developing simulation as a healthcare education

tool. Support for improved patient safety is one of the primary motivators behind the promotion of simulation in the healthcare arena. The general dissatisfaction toward the performance of unsatisfactorily-trained junior primary care providers attending acutely compromised health conditions may have led to a tangible increase of support for SBME, with health institutions and licensing bodies accepting it as a method of learning. Although many SBME trainees in this review tended to feel satisfied with the resources given to training, investing in innovating SBME, which can maximize both trainee skill improvement and victims' survivability and safety is mandated.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sibert L, Mariesse JP, Aulanier S, Olombel PL, Becret F, Thiberville J, et al. Introducing the objective structured clinical examination to a general practice residency programme: Results of a French pilot study. Medical Teacher. 2001;23(4): 383–8.
2. Meaney PA, Bobrow BJ, Mancini ME, Christenson J, de Caen AR, Bhanji F, et al. Cardiopulmonary resuscitation quality: Improving cardiac resuscitation outcomes both inside and outside the hospital. A Consensus Statement from the American Heart Association. Circulation. 2013; 128:417-435.
   Available:https://doi.org/10.1161/CIR.0b013e31829d8654
3. Seraj MA, Naguib M. Cardiopulmonary resuscitation skills of medical professionals. Resuscitation. 1990;20:31-9.
4. Norris TE, Cullison SW, Fihn SD. Teaching procedural skills. J Gen Intern Med. 1997;12(Suppl 2):S64-70.
5. Kohn LT, Corrigan JM, Donaldson MS, editors. To err is human: Building a safer health system. Washington (DC): National Academies Press; 1999.
6. Kneebone RL, Scott W, Darzi A, et al. Simulation and clinical practice: Strengthening the relationship. Med Educ. 2004;38:1095-102.
7. Newble DI. Assessing clinical competence at the undergraduate level. Med Educ. 1992;26:504-11.
8. College of Family Physicians of Canada (CFMPC). Family physicians caring for hospital inpatients. Discussion paper. Arch Fam Med. 2003;2:42.
9. Kramer AW, Jansen KJ, Dusman H, Tan LH, van der Vleuten CPM. Acquisition of clinical skills in postgraduate training for general practice. British Journal of General Practice. 2003;53:677–82.
10. Amin Z, Eng KH. Basics in medical education. New Jersey: World Scientific Publishing Company; 2003.
11. Ferrell BG. Clinical performance assessment using standardized patients: A primer. Family Medicine. 1995;27:14–19.
12. Curran VR, Butler R, Duke P, Eaton WH, Moffatt SM, Sherman GP, Pottle M. Assessment & evaluation in higher education, effectiveness of a simulated clinical examination in the assessment of the clinical competencies of entry-level trainees in a family medicine residency programme. Assessment & Evaluation in Higher Education. 2012;37(1):99-112.·
    DOI: 10.1080/02602938.2010.515009
    Available:https://eric.ed.gov/?id=EJ950345
13. Jansen JJ, Berden HJ, van der Vleuten CP, Grol RP, Rethans J, Verhoeff CP. Evaluation of cardiopulmonary resuscitation skills of general practitioners using different scoring methods. Resuscitation. 1997;34(1):35-41.
14. Lüscher F, Hunziker S, Gaillard, V, Tschan F, Semmer NK, Hunziker PR, Marsch S. Proficiency in cardiopulmonary resuscitation of medical students at graduation: a simulator-based comparison with general practitioners. Swiss Med Wkly. 2010;140(3-4):57-61.
    DOI: smw-12735
15. Langhan TS, Rigby IJ, Walker IW, Howes D, Donnon T, Lord JA. Simulation-based training in critical resuscitation procedures improves residents' competence. CJEM. 2009;11(6):535-9.

16. Willett TG, Kirlew M, Cardinal P, Karas P. An evaluation of the Acute Critical Events Simulation (ACES) course for family medicine residents. Can J Rural Med. 2011;16(3):89-95.
17. Christodoulou I. A questionnaire -based study on the use of medical simulation models by Greek General Practice and General Surgery residents; testing hand-made models as low-cost alternatives. Experimental Medicine. 2009;1(1):31-37.
18. Systematic Reviews. Centre for Reviews and Dissemination guidelines (CRD's) for Undertaking Reviews in Health Care, University of York, Centre for Reviews and Dissemination, York, UK; 2009.
19. World Bank. Health expenditure per capita (current US$). World Health Organization Global Health Expenditure database. Available:http://data.worldbank.org/indicator/SH.XPD.PCAP (Retrieved Dec. 2, 2016)
20. Qayumi K, Pachev G, Zheng B, Ziv A, Koval V, Badiei S, Cheng A. Status of simulation in health care education: An international survey. Adv Med EducPract. 2014;5:457–467. DOI: 10.2147/AMEP.S65451
21. LaMorte WW. Confounding and effect measure modification. Control of Confounding in Study Design; 2016. Available:http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704-EP713_Confounding-EM/BS704-EP713_Confounding-EM5.html (Retrieved Dec. 2, 2016)
22. Abella BS, Sandbo N, Vassilatos P, Alvarado JP, O'Hearn N, Wigder HN, Becker LB. Chest compression rates during cardiopulmonary resuscitation are suboptimal a prospective study during in-hospital cardiac arrest. Circulation. 2005; 111(4):428-434.
23. Sloan DA, Donnelly MB, Johnson SB, Schwartz RW, Strodel WE. Use of an objective structured clinical examination (OSCE) to measure improvement in clinical competence during the surgical internship. Surgery. 1993;114(2):343-50: 350-1.
24. Paul M, Nobel K. Papaya: A simulation model for training in uterine aspiration. Family Medicine. 2005;37(4):242-244.
Qayumi K, Pachev G, Zheng Z, Ziv A, Koval V, Badiei S, et al. A. Status of simulation in health care education: An international survey. Adv Med EducPract. 2014;5:457-67. DOI: 10.2147/AMEP.S65451
25. Coyle SL. Ethics and Human Rights Committee, and American College of Physicians-American Society of Internal Medicine. -industry relations. Part 1. Individual physicians. Annals of Internal Medicine. 2002;136(5):396–402.
26. Zendejas B, Wang AT, Brydges R, Hamstra SJ, Cook DA. Cost: The missing outcome in simulation-based medical education research: A systematic review. Surgery. 2013;153(2):160-76. DOI: 10.1016/j.surg.2012.06.025

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18507