Retention of Cardiopulmonary Resuscitation Knowledge and Psychomotor Skill Among Undergraduate Nursing Students: An Integrative Review of Literature

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RETENTION OF CARDIOPULMONARY RESUSCITATION KNOWLEDGE AND PSYCHOMOTOR SKILL AMONG UNDERGRADUATE NURSING STUDENTS: AN INTEGRATIVE REVIEW OF LITERATURE

by

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ABSTRACT

Purpose: The purpose of this integrative literature review is to explore the effectiveness of different training modalities on the acquisition and retention of CPR knowledge and psychomotor skill among undergraduate nursing students. **Background:** It is well known that standard CPR-training is ineffective at preparing nurses for the rigors of a cardiac arrest event. Survival rates for in-hospital cardiac arrests remain low and the proportion of neurobehavioral sequelae among survivors is very high. **Methods:** A review of relevant literature published between 2006 and 2016 was conducted using the CINAHL and MEDLINE databases. The following key terms were used in the search: 'student*', 'nurs* student*', 'cardiopulmonary resuscitation (CPR)', 'Basic Life Support (BLS)', 'Advanced Life Support (ALS)', 'Advanced Cardiac Life Support (ACLS)', and 'Retention'. **Results:** The initial database search yielded a total of sixty-seven articles; of which, nine articles met the inclusion criteria and were utilized in the final analysis. The articles analyzed explored the effectiveness of different training modalities including: self-directed, CD-based, low-fidelity simulation, high-fidelity simulation, collaborative high-fidelity simulation, and deliberate practice. **Conclusion:** Current training is ineffective both in promoting long-term retention and in delaying the decay of previously learned information. The most effective training modality identified was high-fidelity simulation in conjunction with deliberate practice. The use of collaborative simulation through 'mock codes' maximizes the acquisition and retention of CPR knowledge and skill by providing the highest degree of fidelity. Deliberate practice was the only modality, which resulted in improvement of knowledge and skill over time. The absence of individualized feedback diminishes the effects of

repeated practice. Practical experience is also susceptible to the detrimental effects exerted by the lack of feedback.

DEDICATION

For my beloved family whom I hope to see again soon,

For my husband and soulmate who weathered it all with me,

And for my ‘Belo’

Thank you.

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INTRODUCTION

The American Heart Association (AHA) estimates that approximately 209,000 individuals are victims of a cardiac arrest in U.S. hospitals every year (Mozaffarian et al., 2015). Nadkarni et al. (2006) and Mozaffarian et al. (2015) found that, even when efforts to resuscitate are performed by trained hospital personnel, the survival rates for adults suffering a cardiac arrest are only 18-25%.

Cardiopulmonary resuscitation (CPR) is a skill used in emergencies to manually restore oxygenation through the circulation of blood. CPR combines the use of chest compressions with artificial ventilation to preserve neurological function during a cardiac arrest. High-quality CPR is associated with improved outcomes when (1) it is initiated rapidly, (2) when compressions are executed "hard and fast", (3) when interruptions are minimized, and (4) when excessive ventilation is avoided (Meaney et al., 2013; Chan, Krumholz, Nichol, & Nallamothu, 2008). This review of literature explores the state of current research as it relates to the ability of nursing students to acquire and master CPR as a skill.

Main Components of Cardiopulmonary Resuscitation (CPR)

A number of resuscitation models have been developed to quantify the contribution of each component toward survival (Søreide et al., 2013; Valenzuela et al., 1997). Chest compressions and timing have proved to be the most vital in determining the extent to which the brain is subjected to the damaging effects of hypoxia (Saver, 2006). Further, animal models have shown that, of the two, timing is perhaps the most important component of CPR, with immediate, low-quality CPR resulting in better outcomes than delayed, high-quality CPR (Song et al., 2011).

Chest Compressions

There are two theories which explain the mechanism of circulation during chest compressions. The *Cardiac Pump* theory states that circulation is generated through the direct compression of the ventricles between the sternum and the vertebral column, creating a pressure gradient between the ventricles and the aorta which results in blood flow. Alternatively, the *Thoracic Pump* theory describes the mechanism responsible for blood flow as an increase in the Intrathoracic Pressure generated by chest compressions.

Despite technical distinctions between these two theories, both theoretical premises contribute to generating blood flow during CPR. However, anatomical differences between children and adults determine which theoretical premise drives circulation with regards to CPR. In children, the *Cardiac Pump* predominates; whereas in adults, the primary driver is the *Thoracic Pump* (Georgiou et al., 2014).

The American Heart Association (AHA) has recognized the presence of a strong correlation between high-quality CPR and survival. Over the years, CPR guidelines have been adjusted based on evidence supporting better outcomes. Most recently, several features of chest compressions were redefined to recommend a compression rate of at least 100/min, but no more than 120/min based on evidence suggesting inadequate depth with faster rates (Kleinman et al., 2015). In light of new evidence, the AHA stresses the importance of not exceeding 120 compressions per minute.

Another important change instituted in the 2015 CPR guidelines also restricts the depth of compressions. Kleinman et al. (2015) found that the use of excessive depth is detrimental because compressions that exceed the recommended range of 5-6cm carry an increased risk of injury.

Another common impediment to high quality CPR is residual leaning, defined as the act of leaning over the victim's chest between compressions (Meaney et al., 2013). During the decompression phase of CPR, the sternum springs back promoting venous return to the heart and significantly contributes to blood flow. Residual leaning impairs circulation by reducing blood flow to the brain, coronary arteries, and the overall volume of blood ejected from the left ventricle (Niles et al., 2011; Meaney et al., 2013). The most recent guidelines continue to emphasize the importance of enabling full chest recoil between compressions as it has been shown that leaning forces as low as 10% may reduce myocardial blood flow by up to 50% (Niles et al., 2011). The deleterious effects of residual leaning are more prominent in infants and children due to the reduced flexibility of their chest wall (Niles et al., 2011).

Ventilation

When the natural drive to breathe is lost during a cardiac arrest, oxygenation is sustained through artificial ventilation, also known as positive pressure ventilation (PPV). The most commonly used methods of positive pressure ventilation are: mouth-to-mouth, mouth-to-mask, bag-valve-mask (BVM), and endotracheal tube. Belying expectations, studies have failed to prove any correlation between improved outcomes and increasingly complex methods of ventilation (Link et al., 2015). Moreover, Meaney et al. (2013) suggest that the role of ventilation is only significant when asphyxia is the etiology of the cardiac arrest due to the fact that compressions-only CPR has yielded similar outcomes to standard CPR. Despite the need for evidence further clarifying the role of ventilation during CPR, the AHA continues to support its use. The most recent guidelines recommend a compression-ventilation ratio of 30:2 where the risk of hyperinflation is reduced by ventilations that generate minimal rising of the chest.

Timing

The last critical component in high-quality CPR is the reduction in down-time. During a cardiac arrest, compressions are the only mechanism generating blood flow (Meaney et al., 2013). Any task that necessitates cessation in compressions unequivocally halts circulation. Delays in the initiation of CPR, frequent interruptions, and prolonged pauses further reduce the chances of survival and decimate the likelihood of a good prognosis. Saver (2006) estimated that 2 million neurons are lost for every minute of brain ischemia. Hence, permanent brain damage typically ensues 4-5 minutes after cerebral circulation has ceased (Gutierrez, Rovira, Portela, Leite, & Lucato, 2010; Takahashi et al., 1993). For this reason, neurological outcomes hinge on the rapid initiation of resuscitative efforts by trained hospital personnel.

Post-Cardiac Arrest Encephalopathy

Post-cardiac arrest encephalopathy is an umbrella term used to encompass a wide variety of conditions resulting from decreased blood flow to the brain. It is estimated that 93-97% of cardiac arrest victims who experience return of spontaneous circulation will experience neurobehavioral-sequelae as a result of global ischemia (Geocadin, Koenig, Jia, Stevens, &

Peberdy, 2008). The areas of the brain that are responsible for arousal, awareness, and consciousness are vulnerable to decreased perfusion, and are primarily affected in a cardiac arrest. Hence, Coma, persistent-vegetative-states, and minimally-conscious-state are among the most severe and frequent cognitive impairments resulting from post-cardiac-arrest-encephalopathy (Xiong, Hoesch, & Geocadin, 2011); and are just as common as many other conditions, such as quadriplegia, language disorders, and/or impairments in the ability to process information (Anderson & Arciniegas, 2010).

CPR Training and Certification

The American Heart Association is the leading authority in resuscitation research and training. The AHA sets the standards for practice implemented during resuscitation for all laypersons, healthcare providers, and emergency service personnel. Training for healthcare providers is available in two modalities: Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS). Basic clinical knowledge is useful for successful completion of a BLS course but not required. In contrast, ACLS training does require competency in advanced clinical skills like interpretation of electrocardiographic rhythms, and the pharmacodynamics of drugs used to treat lethal dysrhythmias. Regardless of the modality of training, all courses build upon CPR as the fundamental principle of resuscitation. A valid BLS certification is required for most jobs in healthcare and educational programs whereas critical care setting (ER and ICU) ACLS is required.

In healthcare, certification is earned through an initial training session, and is maintained through subsequent retraining every two years. In addition to fulfilling an employment or educational requirement, a valid certification also implies that a provider is qualified to provide BLS and/or ACLS. Notwithstanding, few healthcare providers will encounter opportunities to revisit and practice these skills. Consequently, this information is briefly learned, forgotten, and relearned every two years.

Quality of Cardiopulmonary Resuscitation in Healthcare

Even though the focus of CPR is to save lives, poor resuscitation outcomes have been linked to significant deficiencies in the quality of cardiopulmonary resuscitation in hospital settings. Abella et al. (2005) found that 40% of hospital staff fell short of the minimum acceptable rate of 100 compressions per minute when performing CPR. Hunt, Alker, Shaffner, Miller, & Pronovost (2008) identified timing deficiencies in pediatric mock codes with 40% of participants beginning compressions within 3 minutes, and more than 13% of the participants delaying the start of compressions by 12 minutes or more.

While CPR skills might seem elementary, under stressful circumstances, people fail to respond adequately or in a timely manner. At St. Olav's University Hospital, Oslo, Skogvoll & Nordseth (2008) found that, in 16% of cases, CPR was not initiated until the rapid response team arrived on the scene. Among that group of patients, only 26% survived the episode.

Chan, Krumholz, Nichol, & Nallamothu (2008) analyzed data of patients (N= 6,789) who died due to cardiac arrest while hospitalized. The results not only identified a direct correlation between time-to-defibrillation and survival, but also uncovered factors associated with timing delays. Among these, it was reported that 30% of patients (n=2045) experienced delays in defibrillation beyond the recommended two-minute timeframe; and a further 9% of patients (n=888) were not defibrillated by the six-minute mark. Chan et al. (2008) reported that the following are risk factors to delayed defibrillation: (1) suffering a cardiac arrest outside of business hours, (2) suffering a cardiac arrest during a weekend, (3) suffering a cardiac arrest while hospitalized in a low acuity unit, and (4) suffering a cardiac arrest while being hospitalized for a medical diagnosis that is not of cardiac origin. Lastly, race was also reported as a risk factor with racial minorities of African origin being more prone to delays in defibrillation.

Recently, the role of nurses has come under scrutiny in non-critical care units. Borak et al. (2014) reported time delays in resuscitative efforts on medical-surgical (non-critical) units resulting from nursing performance. They determined that 85% of nurses responding to cardiac arrests did not utilize a defibrillator. Notably, BLS-trained nurses reported feeling uncomfortable and lacking confidence about their role as first responders (Borak et al., 2014).

Skill Retention in Cardiopulmonary Resuscitation

Skill decay is the process by which knowledge of a skill deteriorates following a period of nonuse. This process is particularly problematic in situations where individuals do not exercise the skill for extended periods of time after receiving initial training (Arthur, Bennett, Stanush, & McNelly, 1998). CPR is particularly susceptible to skill decay due to the prolonged length of time between initial training, implementation, and retraining.

Few healthcare professionals are faced with the prospect of providing CPR on a frequent basis which allows the skill to degrade between certifications. In addition, cardiac arrests are rare events in hospitals enabling most healthcare providers to not encounter a cardiac arrest for years (Wayne et al., 2006; Peberdy et al., 2003). The period of non-practice is known as the ‘retention interval’. As a general rule, the longer the ‘retention interval’ the greater the degree of skill decay (Arthur et al., 1998). For many healthcare providers, the retention interval for CPR skill and knowledge is approximately seven-hundred and thirty days, or two years.

In addition to the retention interval, there are other factors affecting skill retention, such as the nature of the skill itself and innate differences as individuals (Arthur et al., 1998). The interest lies in factors that promote retention in a long term basis. Creating a training environment that resembles reality is highly effective in promoting in vivo performance which helps to explain why simulation is very effective as an educational tool. Concerning CPR, simulation enables a higher degree of transfer-of-training between a cardiac arrest simulation and in vivo cardiac arrest in a hospital. Arthur et al., (1998) recommends that trainers ensure functional similarity between the training and the actual work environment to enhance the retention of skills in trainees.

Another factor affecting skill retention is the method of testing—how trainees are required to recall information after a training session. Most effective are methods which require the use of information for recognition of cues in the context of an environment or situation (Arthur et al., 1998). In this regard, simulation is highly effective at creating the opportunity for trainees to integrate a plain concept with its practical counterpart.

Performance Degradation in CPR

Performance degradation is the failure to execute a task or the inferior execution of a task. Notably, psychological stress inhibits performance by enabling a state of disorganized and erratic processing of information, ultimately resulting in impaired decision-making (Staal, 2004).

The role of psychological stress upon decision-making has been widely explored among high-risk professionals, such as police officers and military personnel.

Psychological stress is an unpleasant emotional state in response to an anticipated or an actual threat to the survival of the subject or someone for whom the subject is responsible (McKay, Buen, Bohan, & Maye, 2010). Without a doubt, a cardiac arrest constitutes an event which places high-levels of psychological stress upon the performance of healthcare providers. Consequently, reports of healthcare personnel freezing, or otherwise failing to perform under pressure, should come as no surprise.

Healthcare personnel view cardiac arrest simulations to be similarly stressful. Harvey, Bandiera, Nathens, and LeBlanc (2012), and Clarke, Horeczko, Cotton, and Bair (2014) have established a link between complex simulation scenarios and the physiological effects of high levels of stress which include: surges in cortisol levels, tachycardia, ventricular ectopy, as well as high levels of perceived stress. Likewise, nursing students also reported significantly higher levels of anxiety after the completion of a cardiac arrest simulation (Manderino, Yonkman, Ganong, & Royal, 1986; McKay et al., 2010).

Psychological stress prompts individuals to rely on well-rehearsed tasks where the character of the reaction is automatic and without conscious deliberation. These tasks only become implicitly encoded after deliberate practice and repeated exposure (Wilson, Sun, & Mathews, 2009; Staal, 2004; Bourne and Yaroush, 2003). Staal (2004) emphasized the pivotal role of high-fidelity emergency training stating that there is “no other way” that “novice operators safely garner emergency decision-making expertise” (p. 74).

Simulation

The origins of simulation date back to 1979 when the National Aeronautics and Space Administration (N.A.S.A) set out to explore the causes of air transport accidents (Helmreich, Merritt Ac Fau-Wilhelm, & Wilhelm, 1999). Originally created by N.A.S.A, Crew Resource Management is considered largely responsible for the reduction in air traffic disasters. N.A.S.A identified that interpersonal communication failures, errors in decision-making, and leadership issues are common to both air catastrophes and medical emergencies (Petrosoniak & Hicks, 2013; Helmreich, Merritt, & Wilhelm, 1999; Hunt, Walker, Shaffner, Miller, & Pronovost, 2008).

As a human-driven industry, healthcare must embrace a crucial premise that the aviation industry has already taken to heart: humans err. Because of this, the use of simulation in healthcare has become the standard for training and in the development of countermeasures to prevent, contain, and mitigate these errors. The National Council of State Boards of Nursing (NCSBN) has embraced simulation as a method of equal effectiveness to traditional clinical rotations in promoting competency among nursing students (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014).

PROBLEM

Currently, it is well established that the management of resuscitative events deviates from the recommended guidelines. It is also well-established that standard CPR-training is ineffective at preparing nurses for the rigors of a cardiac arrest event despite the relentless effort of the healthcare industry to reverse the trend. Amongst other training modalities, simulation is considered a viable, effective, and pragmatic solution. However, the effectiveness on skill retention of simulation and other training modalities remains unclear.

PURPOSE

The purpose of this literature review is to explore the effectiveness of different CPR training modalities on the knowledge and psychomotor skill acquisition of undergraduate nursing students. Factors intrinsic to each method will be analyzed in order to identify key components that reduce skill decay and promote retention.

METHODS

A review of literature related to the ability of nursing students to execute resuscitative measures and factors intrinsic to CPR training that promotes skill acquisition and retention was conducted. The literature reviewed in this article was established using the following databases: CINAHL and MEDLINE. Inclusion criteria for this paper consisted of peer-reviewed articles published within the last ten years (2006-2016) and articles that were written or translated into English. The keywords utilized to conduct this search include: ‘student*’, ‘nurs* student*’, ‘cardiopulmonary resuscitation (CPR)’, ‘Basic Life Support(BLS)’, ‘Advanced Life Support (ALS)’, ‘Advanced Cardiac Life Support (ACLS)’, and ‘Retention’. This study included only one sentinel study published in 1995 as it was the first to report exhaustive data on simulation and performance degradation in nursing students.

Articles which explored the retention of CPR knowledge and skills in populations other than nursing students were excluded, including lay-rescuer CPR and school-age children. In addition, articles that utilized multiplayer virtual world technology as a method of simulation were excluded as well.

Table 1: The Number Search Results from the Database Search

Database	‘Student’ and ‘Retention’ combined	‘Nursing Student’ and ‘Retention’ combined	Articles meeting inclusion criteria	Articles after elimination of duplicate results
CPR	(21) CINALH (44) Medline	(10) CINALH (13) Medline	10	6
BLS	(13) CINALH (28) Medline	(5) CINALH (4) Medline	5	3
ALS	(1) CINALH (3) Medline	(4) CINALH (0) Medline	0	1
ACLS	(6) CINALH (14) Medline	(8) CINALH (1) Medline	1	1

Table 2:Articles Included in the Integrative Review of Literature

Author	Title	p-value	N	n	Comments
Linnard-Palmer (1996)	The effect of a skills algorithm on nursing students' response rate, skill accuracy, and reported attention management during simulated cardiopulmonary arrests	N/A	N=5	N=5	"A repeated series to arrest simulations can lead student nurses to respond faster, more effectively, and with greater maintained attention" (p. 113).
Kardong-Edgren and Adamson (2009)	BSN medical-surgical student ability to perform CPR in a simulation: recommendations and implications.	N/A	N=32	N=32	"None of the groups performed the basic steps of CPR as defined by the AHA" (p. 81).
Ackermann (2009)	Investigation of learning outcomes for the acquisition and retention of CPR knowledge and skills learned with the use of high-fidelity simulation.	p=.002	N=65	n=24	"What do we do know? Few of them actually follow the correct steps of CPR even though they completed the AHA Basic Life Support for Healthcare Professionals training in order to participate" (p. 213).
Josipovic, Webb, and McGrath (2009)	Basic life support knowledge of undergraduate nursing and chiropractic students.	p=.001	N=130	N=130	"78.3% of respondents agreed they were prepared to perform CPR if required, yet 48% of respondents could not correctly identify the compression rate" (p.60-61)
Bruce et al. (2009)	A collaborative exercise between graduate and undergraduate nursing students using a computer-assisted simulator in a mock cardiac arrest	p=.000	N=118	N=118	"Competency scores increased but not significantly. Perhaps a more interesting research question is the following: Does competency improve if sessions are repeated" (p.27)
Oermann et al. (2011)	Deliberate practice of motor skills in Nursing Education: CPR as exemplar.	p<.005	N= 606	N= 606	"Motor learning is permanent. Learning a skill means it is retained and able to be performed at a later time" (p.314).

Sankar, Vijayakanthi, Sankar, and Dubey (2013)	Knowledge and skill retention of in-service versus preservice nursing professionals following an informal training program in pediatric cardiopulmonary resuscitation: a repeated-measures quasiexperimental study.	p=.03	N=74	n=65	"In-service nurses might have learnt incorrect skills during their nursing curriculum or service period, and it is much more difficult to change learned behavior than to learn completely new behavior" (p. 6)
Aqel and Ahmad (2014)	High-Fidelity Simulation Effects on CPR Knowledge, Skills, Acquisition, and Retention in Nursing Students.	p<.001	N=124	n=90	"It is noteworthy that CPR knowledge and skills were significantly decreased in both groups after three months of training" (p.398)
Mardegan, Schofield, and Murphy (2015)	Comparison of an interactive CD-based and traditional instructor-led Basic Life Support skills training for nurses.	p<.005	N=294	n=141	"Results indicate that there was very low retention of skill competency at eight weeks post-training with no statistically differences for the novice, practicing nurses, and when the cohorts were combined" (p. 164).
Hernández-Padilla, Suthers, Granero-Molina, and Fernández-Sola (2015)	Effects of two retraining strategies on nursing students' acquisition and retention of BLS/AED skills: A cluster randomized trial.	p<.001	N=177	n=154	"Students must actively participate in the process of identifying their learning needs, choosing learning outcomes, implementing leaning strategies, and reflecting on the acquisition of new competences" (p.32)

RESULTS

Simulation in Nursing Education

The first exhaustive study aimed at evaluating the performance of nursing students was undertaken by Linnard-Palmer in 1996. The study sought to assess performance and accuracy in the presence of environmental stressors which cleverly resemble stressors common to clinical setting (arguing physicians, distraught family members, hysterical colleagues, loud background noises, and strong environmental odors). Linnard-Palmer concluded that many nursing students were unable to perform basic CPR skills despite having a current CPR certification, and that environmental stressors reduced skill accuracy. However, Linnard-Palmer also concluded that the effects of environmental stressors were minimal once the nursing student had mastered the skill; a process which was accomplished through a 90-minute teaching session (Linnard-Palmer,1996).

Standard Training vs. Self-Directed Training

Technological advances have provided alternative methods of CPR training, but their effectiveness is largely unknown. Hernández-Padilla, Suthers, Granero-Molina, and Fernández-Sola (2015) conducted a study to compare the effects of self-directed versus instructor-directed training on BLS. In this study, the target population was not BLS-naïve, and had received BLS training three months before.

A total of nursing students (N=177) were randomized into two cohorts, but only a portion of the participants(n=154) completed the study entirely. The control group received structured training with well-defined "objective, teaching strategies, and learning outcomes" implemented by a certified trainer (p. 29). The experimental group received a lecture without defined structure where students freely selected the learning material based on their individual needs. In the experimental group, the role of the instructor was to individually support the process of skill acquisition.

Cognitive knowledge and psychomotor skills in BLS/AED were assessed before (pre-test) and immediately after training (post-test). Retention of knowledge and psychomotor skill was evaluated three months after training. Ten experts in emergency care and resuscitation training developed a multiple-choice questionnaire, and electronic mannequins were used to evaluate the psychomotor skill. The study found that participants in the self-directed group achieved higher competency levels and experienced better skill retention after three months of training. Overall, 89% of participants(n=66) in the experimental group demonstrated retention in knowledge and skill, in comparison to only 39% of participants (n=29 in the control group). Hernandez-Padilla et al.(2015) concluded self-directed strategies to retrain nursing students were more effective than instructor-directed methods. This study highlights the role of active ownership and reflection in the acquisition of CPR skills and knowledge.

Standard Training vs. CD-based Training

CD-based learning is an alternative approach to the traditional instructor directed training, but its effectiveness has yet to be adequately measured. Mardegan, Schofield, and

Murphy (2015) compared the effectiveness of a self-directed approach to the standard instructor-led training. The quasi-experimental study recruited novice nursing students (n=187) and practicing nurses (n=107) seeking certification; although, only a portion of the participants (n=74) completed the retention phase of the study. Participants were randomly assigned, and skill acquisition was tested both immediately after, one week, and eight-weeks after training.

Participants in the experimental group were assigned a computer and a mannequin that did not provide feedback on performance, but was used for practice while completing the CD BLS training program. In the control group, training and feedback was provided by the instructor. The results were disappointing and demonstrated low skill competence and retention in both groups. The researcher concluded that there were no significant differences between the CD-based and the standard training. After eight-weeks of initial training, only 41% of participants were deemed competent.

Simulation

Kardong-Edgren and Adamson (2009) conducted a study designed to evaluate the ability of nursing students to perform CPR. The study was not aimed at assessing the quality of CPR, but instead sought to determine the participants' ability to execute the basic steps of CPR. Twenty-two weeks after receiving initial CPR certification, nursing students (N=32) participated in the study. All participants attended a didactic lecture and received additional reading resources regarding the scenario and CPR one week prior to the execution of the simulation; and even then, all participants failed to correctly execute the basic steps of CPR, and only one-quarter activated the chain of survival.

Standard Training vs. High- fidelity Simulation

Ackermann (2009) conducted a quasi-experimental study designed to compare the impact of two instructional methods on the acquisition and retention of CPR knowledge. The study recruited nursing students (N=65), and all participants were certified in Basic Life Support. The first instructional method was the standard CPR training from the AHA which all participants received. The second instructional method was only provided to the experimental group, and consisted of participation is a simulated cardiac arrest. Data was collected in three intervals during the study: before training, immediately after training, and three months after training. Analysis of baseline data revealed participants who had previously performed CPR on a living person scored higher than their counterparts. Ackermann concluded that high-fidelity simulation was effective at promoting the acquisition and retention of CPR knowledge.

Standard Training vs. High-Fidelity Simulation - CPR-Naïve Sample

In order to maximize the acquisition and retention of a skill, the training must be conducted in a way that mirrors a real-life scenario as closely as possible. High-fidelity simulations are structured in a way that the scenario reflects a realistic situation. High-fidelity mannequins offer many benefits to CPR training through their ability to replicate human physiologic functions like pulse, breathing, cyanosis, blinking, and talking. Aqel and Ahmad (2014) sought to examine the effects of high-fidelity simulators on the acquisition and retention of CPR-skills.

The target population for this study was CPR naïve and did not have prior CPR experience or training. Nursing students (N=124) were enrolled, but only a portion of the participants (n=90) completed the study entirely. Participants were randomly assigned into two groups. The control group received traditional training which included demonstrations (low-fidelity) of CPR on a mannequin. The experimental group received additional training on a high-fidelity simulator.

Cognitive knowledge was evaluated through a multiple-choice questionnaire before training, immediately after training, and three months after training. Evaluation of psychomotor skill was conducted through observation and took place during a simulated scenario both immediately after and three months after training. The results revealed that the experimental group achieved higher scores across both timeframes. Aqel and Ahmad (2014) concluded that the use of high-fidelity simulators had a positive impact on acquisition and retention of CPR skill and knowledge with 85% of participants demonstrating competency after three-months.

Effects of Repeated Real Life Experience

Cardiac arrests continue to be a polemic topic which draws a lot of attention, but they are rare events that account for only ~2.85% per 1,000 admissions (Merchant, 2015). The lack of opportunities to participate in CPR is thought to contribute to the low rate of competency among healthcare providers, but data regarding competency among healthcare providers who participate in CPR frequently is scarce.

Sankar, Vijayakanthi, Sankar, and Dubey (2013) conducted a quasi-experimental study aimed at evaluating the impact of a training program on the knowledge and skills of in-service and pre-service nurses. Sankar and colleagues focused on pediatric CPR. Participants recruited for the study were composed of Registered Nurses (n=28) and nursing students (n=46). Only a portion of the participants(n=65) completed all the phases of the study. All participants recruited were assigned to the pediatric departments (ER and ICU) of a tertiary teaching hospital. The demographic data revealed that 62% of nurses had less than 1-year of experience working in pediatrics; 25% of nurses had 1-3 years of experience; and 20% of nurses had more than 3-years of experience. Half of these nurses had participated in fewer than 10 cardiac arrests whereas 48% had participated in more than 10 cardiac arrest in the last 6 months.

The study was designed to measure knowledge and psychomotor skills before, immediately after, and six weeks after initial training. Knowledge in pediatric-CPR was evaluated using a multiple-choice questionnaire; and psychomotor skills were evaluated using an electronic infant mannequin that provided objective feedback on performance i.e. ventilation volume, depth of chest compressions, and rate of chest compressions. Task sequence was evaluated by observation using a BLS checklist. The training program implemented consisted of a six-hour course that included lectures, video demonstration, and in classroom discussions. The baseline data was collected before, immediately after, and six weeks after implementation of the training program.

Pre-training data revealed that experienced nurses obtained higher knowledge scores but lower psychomotor scores in comparison to nursing students. Immediately following training, experienced nurses outperformed nursing students both in cognitive knowledge and psychomotor skills; but after six weeks of training, professional nurses experienced lower retention of psychomotor skills. Nursing students outperformed experienced nurses in performance of psychomotor skills by 37%. The researchers concluded that experienced nurses had a much more difficult time “changing learned behaviors” (Sankar et al., 2013, p.6).

Collaborative High-Fidelity Simulation (Mock Codes)

The emergency response system of a hospital is activated during a cardiac arrest or ‘code blue’. The system deploys the strongest members of the healthcare team (physicians, advanced practice nurses, anesthesiologists, and intensive care nurses) to the exact location of the emergency. The intricate process of leading the resuscitative efforts lies on the ‘code leader’, usually a physician or an advanced practice nurse. A ‘mock code’ is a high-fidelity simulation, also referred to as in-situ simulation, of a cardiac arrest where all the members of the team fulfill responsibilities respective to their roles. A ‘mock code’ reflects the highest level of fidelity in a simulation, and is only one step below an actual cardiac event.

Bruce et al. (2009) conducted a collaborative study between graduate and undergraduate nursing students through a mock cardiac arrest. The study aimed to determine the effectiveness of electronic mannequins on the knowledge and clinical competence of both graduate and undergraduate nursing students in the management of a cardiac arrest. More importantly, the study provided an opportunity for both groups to work as a team while simultaneously functioning within their role. The study enrolled nursing students (N=118), where a subset were students (n=17) were enrolled in a Nurse Practitioner Program, and students (n=107) were enrolled in a Baccalaureate Nursing Program.

The study was conducted at the simulation laboratory of the College of Nursing which is designed to resemble a hospital floor. The electronic mannequin utilized for the study displayed many physiological functions of the human body (pulse, respirations, blood pressure). The study measured the knowledge of both cohorts regarding the AHA protocol for cardiac arrest management, but only measured skill competency and confidence in graduate nursing students. To evaluate cognitive knowledge, a multiple-choice test was administered before, immediately after, and four-to-six weeks after the simulation. Bruce et al. (2009) reported the simulation significantly improved the knowledge scores immediately after, but its impact was diminished after four-to-six weeks. For Bruce and colleagues, the real question was: "Does competency improve if sessions are repeated after some time?" (Bruce et al., 2009, p. 27).

Deliberate Practice

Most studies have concentrated on interventions that reduce skill decay, but few have undertaken the goal of isolating specific interventions that can reverse the process. In 2011, Oermann et al., conducted a randomized control trial seeking to explore the effects of deliberate practice on CPR, a type of training modality aimed at improving the performance of a specific task through repetition and individualized feedback (Oermann et al., 2011; Hubbard, Parsons, Neilson, & Carey., 2009).

The study recruited nursing students (N=606) from 10 educational institutions in the U.S. The population sample contained a heterogeneous mix of nursing students enrolled in one diploma, four associate-degree, and five baccalaureate-nursing programs. The control group received a session of initial training, and the experimental group was required to practice for six-minutes every month. During the practice sessions, participants in the experimental group did not receive additional instructions other than the feedback provided by the voice-activated-mannequin. Every three-months, 20% of participants from both groups were sampled for one year until students completed another recertification course on BLS.

Oermann et al. (2011) reported a steady and progressive decline in the psychomotor skills among the control group which did not participate in monthly practice sessions. The experimental group not only maintained their psychomotor performance; but also improved their skills. They concluded that six-minutes of monthly practice was effective at maintaining and improving psychomotor skills when individualized feedback was implemented (Oermann et al.,2011).

CPR Knowledge vs. Self-Rated Ability

Josipovic, Webb, and McGrath (2009) explored two important variables: knowledge retention and perceived ability to perform CPR among chiropractic and nursing students. Researchers surveyed students (N=130) on their "self-perceived ability and knowledge of CPR/BLS" six-months after training. At the time of the study, all respondents held a valid CPR/BLS-certification, a standard requirement for enrollment in Nursing and Chiropractic programs. Despite the extended length since last training, 76.9% of respondents reported having practiced CPR within the last three months, and 13.2% reported having performed CPR on a real person (Josipovic et al., 2009). The researchers reported that 78.3% of respondents felt "prepared to perform CPR if required" yet 48% failed to identify the recommended compression rate, and 57% could not identify the recommended compression depth (Josipovic et al., 2009).

DISCUSSION

This integrative review of CPR related literature explored several modalities of training, specifically self-directed, CD-based, low-fidelity simulation, high-fidelity simulation, collaborative high-fidelity simulation, and deliberate practice. The pattern which emerged highlighted the failure to retain CPR knowledge and skill across target demographics. Worth emphasizing is the fact that this phenomenon can only be attributed to a lack of practice. The notion that competency in CPR can be achieved and maintained after a single training session is simply erroneous. The standard modality is ineffective both in the promotion of long-term retention and in delaying the decay of previously learned information. In order to improve performance and retention of CPR, healthcare providers need more frequent training.

In this review, high-fidelity simulation in conjunction with deliberate practice were the most effective set of modalities. Notably, 'deliberate practice' was the only approach that not only reduced skill decay, but also enabled improvement over time. The success reported by Oermann et al. (2011) was partly due to the feedback provided by the voice activated mannequin which targeted the participant's weakness. In the absence of feedback, the benefits of high-fidelity simulation are diminished.

The importance of feedback can be further substantiated by the results reported by Sankar et al. (2013). Prior to this study, a lack of real-world experience was considered partly responsible for the lack of CPR competency among healthcare providers. However, Sankar and colleagues (2013) demonstrated poor competency in psychomotor skills among practicing nurses despite adequate training and frequent exposure. This study captured the strong influence exerted by a skill that has become ingrained. Practicing nurses in this study were unable to override their CPR skills as they were too well-practiced. Consequently, novice nurses faced fewer challenges when learning CPR as a new concept than practicing nurses who had to alter their preexisting CPR skills.

The efficacy of high-fidelity simulation lies in its ability to engage complex reasoning by forcing leaners to recognize distress cues, recall concepts previously introduced, and integrate both processes in order to formulate an action plan (Arthur et al., 1998). In order to maximize the benefits of high-fidelity simulation, however, the scenario must present a high degree of realism where fidelity is maintained at all costs. Even slight disruptions to the CPR cycle can be carried into professional practice to its detriment.

Krogh, Høyer, Ostergaard, and Eika (2014) demonstrated the effects of shortening CPR-cycles during a simulation inadvertently carried over to evaluations, increasing hands-off time by 30%. In this regard, 'mock codes' offer additional advantages that promote rapid development of competency under very realistic circumstances. Some of the advantages provided by 'mock codes' include the opportunity for participants to rehearse a role that is within their scope of practice, develop efficient communication skills under stress, and become familiar the mechanics of a resuscitative event. Lastly, Josipovic, Web, and McGrath (2009) demonstrated that most individuals feel capable and prepared to provide CPR; however, they also largely overestimated their competence and knowledge. The notion of erroneous overconfidence is strongly linked to lack of individualized feedback where individuals are unaware of their limitations.

RECOMMENDATIONS

Nursing Faculty

Avenues to improve competency in resuscitation are limited to the standard training modality. To our knowledge, the option to participate in a high-fidelity simulation or a ‘mock code’ is only reserved for educational institutions and hospitals. The prospect of integrating ‘high-fidelity’ simulation as an adjunct to the standard training is enticing, and the incorporation of ‘mock codes’ is even better still. Through ‘mock codes’ institutions can promote competency of students in different disciplines from the undergraduate to the graduate levels. Another important intervention that may improve competency and retention of CPR skills among students enrolled in healthcare programs is a reduction in the length of certification to one-year instead of two-years. Educational institutions have a golden opportunity to conduct research and establish a new standard of practice where competency in CPR is defined by mastery and not mediocrity.

Learners

Accountability on behalf of healthcare professionals plays an important role. Healthcare providers must remember that a cardiac arrest can occur anywhere, and they must be prepared to rise to the occasion. As patient advocates, healthcare providers have a duty to raise the standards of care. My recommendation to learners and practicing healthcare providers is to seek yearly certifications and engage in learning opportunities, such as simulations and mock codes, which improve CPR competency and encourage professional development.

LIMITATIONS

The volume of literature regarding CPR, BLS, ALS, and ACLS in enormous; however, most studies that explored CPR knowledge and skill competency among undergraduate nursing students lacked strong objective data, and many report results on short retention intervals. Publications regarding the use of Deliberate Practice as an instructional modality in the field of nursing are scarce. This integrative review sought to select key representative studies in this subject, but it is plausible that other important publications were overlooked in the process, especially if unavailable in English. The use on only two databases, and a literature search that mainly focused on adult CPR constitutes another limitation as well.

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