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Review

Effectiveness of patient simulation in nursing education: Meta-analysis

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SUMMARY

Background: The use of simulation as an educational tool is becoming increasingly prevalent in nursing education, and a variety of simulators are utilized. Based on the results of these studies, nursing facilitators must find ways to promote effective learning among students in clinical practice and classrooms.
Objective: To identify the best available evidence about the effects of patient simulation in nursing education through a meta-analysis.
Methods: This study explores quantitative evidence published in the electronic databases: EBSCO, Medline, ScienceDirect, and ERIC. Using a search strategy, we identified 2503 potentially relevant articles. Twenty studies were included in the final analysis.
Results: We found significant post-intervention improvements in various domains for participants who received simulation education compared to the control groups, with a pooled random-effects standardized mean difference of 0.71, which is a medium-to-large effect size. In the subgroup analysis, we found that simulation education in nursing had benefits, in terms of effect sizes, when the effects were evaluated through performance, the evaluation outcome was psychomotor skills, the subject of learning was clinical, learners were clinical nurses and senior undergraduate nursing students, and simulators were high fidelity.
Conclusions: These results indicate that simulation education demonstrated medium to large effect sizes and could guide nurse educators with regard to the conditions under which patient simulation is more effective than traditional learning methods.

Introduction

With advances in science and technology, knowledge of health-related disciplines is continually expanding. After graduation, nursing students are required to solve complex clinical problems in real-life situations with multiple conflicting requirements. However, nursing education consists of classroom lectures and clinical instruction, and the ultimate goal of nursing education is to promote the application of theoretical knowledge to clinical practice (Bowers and McCarthy, 1993; Oermann and Gaberson, 2009). Therefore, facilitators need to provide their students with adequate clinical experience. However, the limited duration of clinical placement affects students' opportunities for clinical experience with real patients (Yuan et al., 2012). Nurse educators strive to promote competencies such as critical thinking skills, learning, and confidence through various teaching approaches because they cannot prepare nurses for every situation that the latter may encounter in clinical practice (Kaddoura, 2010). Fortunately, technological advances, such as simulation, are currently being used within nursing curricula (Norman, 2012). Simulation is an educational strategy that provides students with realistic clinical situations and allows them to practice and learn in a safe environment (Arthur et al., 2012).

The use of simulation as an educational tool is becoming increasingly prevalent in nursing education (Yuan et al., 2012). A variety of simulators are utilized, such as an anatomical model of the human body to perform a simple technique, and an artificial catheterization model or intravenous injection model to develop specific nursing techniques. Recently, human patient simulators have been found to lead to experiences that are more realistic, and have been used to offer students an opportunity to assess, intervene, and evaluate patient outcomes (Lee et al., 2007).

Simulation-based education has been substantiated to improve communication skills, the ability to collaborate with other members of a medical team, and the ability to manage complex situations (Bond et al., 2004; Norman, 2012), as well as increase self-efficacy (Kim and Choi, 2011), team efficacy (Kim et al., 2011), and understanding of interpersonal relationships (Kim et al., 2011). Reflective thinking during the debriefing steps has been found to effectively promote communication skills and confidence in nursing and medical education (Kneebone, 2003; Weaver, 2011). Through this process, attitudes regarding class

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and learning (Kim and Choi, 2011; Ko et al., 2010), class satisfaction (Kim and Choi, 2011), and aggressiveness in problem solving (Kim et al., 2011) have been improved.

The results of these studies indicate that nursing facilitators must find ways to promote effective learning among students in clinical practice and the classroom. A meta-analysis allows researchers to review and assess knowledge in important areas and facilitates evidence-based practice. Therefore, the use of meta-analyses has recently increased. This statistical technique allows researchers to derive comprehensive results and objectively verify the effectiveness of an intervention by statistically analyzing reported results of studies on that intervention (Borenstein et al., 2009). As a meta-analysis is a formal statistical analysis of data from various subgroups of pre-existing studies, it is conducted to obtain an overall estimate of the effectiveness of the selected subject/intervention.

Most published studies on simulation education have reported that it has positive effects on nursing students' knowledge, skills, and attitudes. However, there have been only a few attempts at a systematic review of these effects (Norman, 2012; Weaver, 2011; Yuan et al., 2012), and to our knowledge, no meta-analysis on the effects of simulation education for nursing students exists. Previous researchers summarized the results, but did not indicate the effectiveness of the intervention according to variables and effect size.

In this study, we provide scientific data for evidence-based education by conducting a comprehensive review and meta-analysis on the results of previous studies on the use of simulation in nursing education. The aim of this study was to identify the best available evidence about the effects of patient simulation in nursing education. We had the following research questions:

(a) What is the overall magnitude of the effect of simulation for nursing education associated with improved outcomes, in comparison with no intervention or traditional education?
(b) How do outcomes vary across evaluation outcomes?
(c) How do outcomes vary across learning environment variables (i.e., type of learners, course name, random assignment, and level of fidelity)?

Method

Meta-analysis is a statistical technique for combining the findings from independent studies (Borenstein et al., 2009). Therefore, it includes steps such as the formulation of a problem, collection of studies, and coding of data, as well as data analysis and interpretation (Cooper and Hedges, 1994).

Data Sources and Searches

In the collection of studies phase, a large number of potential studies were identified, and therefore, we decided to restrict our search. Our inclusion criteria were as follows: as simulation-based education has three levels of fidelity, categorized as low, medium, or high fidelity according to the rigorousness of the process models and the level of complexity, we included studies involving one or more of the following modalities: partial-task trainers, human patient actors (standardized patients), full body task trainers, or high fidelity mannequins. Thus, we did not include studies that involved computer-based virtual patients and computer software. Second, studies needed to have quantitative outcomes that focused on nursing student learning. Third, an experimental and quasi-experimental design that examined the effectiveness of simulation must have been used. Fourth, the subjects of the study had to be nursing students (college and university) or nurses in all the possible domains of interest related to nursing education. Finally, we focused on the international literature written in the English language in order to gain insights into the effectiveness of simulation within the domain of nursing education and without time limits.

The exclusion criteria were as follows: we excluded articles that did not report a control group, such as a one-group design, and studies that did not report results comparing a group that received simulation teaching with a control group. Non-empirical studies and literature reviews were not included in this analysis, as the outcomes also had to include enough data to calculate an effect size. Finally, qualitative studies were excluded.

We explored published quantitative evidence on the effects of simulation in nursing education by using the following electronic databases: EBSCO, Medline, ScienceDirect, and ERIC. There was no time limit for papers to be included in our analysis. The initial keywords that were used included "nursing education," "human patient simulator," and "simulation." We identified 2503 potentially relevant articles using the above search strategy. Therefore, we screened the studies according to the inclusion and exclusion criteria. The titles and abstracts were scanned in order to identify potentially relevant studies for which full reports were subsequently obtained. For abstracts that did not provide sufficient information to determine eligibility, 269 full-length articles were retrieved for more information. After a review of the full articles, 200 articles that did not meet the inclusion criteria, or that met the exclusion criteria were excluded. Sixty-nine articles remained and three articles were added through a manual search. Of these, we excluded 52 ineligible articles. Disagreement on inclusion or exclusion of articles was resolved by consensus among the researchers. Finally, 20 studies meeting the inclusion criteria were included in the analysis (Fig. 1).

Data Extraction

We extracted data from those studies that met our inclusion criteria. The study characteristics were coded to reflect the potential moderating variables for the effect of simulation on nursing education. The coded characteristics were as follows:

(a) Evaluation variables (i.e., evaluation methods, learning and reaction domains);
(b) Learning environment variables (i.e., type of learner, course name, random assignment, and simulator level of fidelity).

Kirkpatrick's (1994) four levels of evaluation, which consist of reaction, learning, transfer, and results, were used for a sub-group analysis to describe the type of evidence produced by different evaluation strategies. For this study, we categorized evaluations at the learning and reaction levels because both transfer, which evaluates how trainees apply the information, and results, which are the final products of training, were not used as outcomes in all studies. Evaluation at the learning level consisted of attempts to assess the extent to which learners acquire both knowledge and skills. The learning level was divided into three domains: cognitive, affective, and psychomotor. Evaluation at the reaction level measures how students react to, or are satisfied with a training program.

In terms of the level of simulator fidelity, simulation-based education using static models or task trainers were coded as low fidelity; full-body mannequins that have embedded software and can be controlled by an external, handheld device (Seropian et al., 2004) were coded as medium-fidelity; and simulators that were life-size computerized mannequins with realistic anatomical structures and high response fidelity (Alinier et al., 2006) were coded as high-fidelity.

Data were extracted independently by two researchers. A coding manual was developed in order to maintain the reliability of coding. The manual included information regarding effect size calculations and the study and report characteristics. Differences between coders were resolved by discussion until a consensus was achieved.

Data Synthesis and Statistical Analysis

All effect sizes were calculated using Comprehensive Meta-Analysis version 2 (Biostat, Englewood, New Jersey). Fixed effects models assume