Nurse Education Today 54 (2017) 6–20

Contents lists available at ScienceDirect

Nurse Education Today

journal homepage: www.elsevier.com/locate/nedt

Review

Simulation-based training for nurses: Systematic review and meta-analysis

Pål A. Hegland*, Hege Aarlie[1], Hilde Strømme[2], Gro Jamtvedt[3]

Western Norway University of Applied Sciences, Department of Health Studies, Norway – and – Centre of Evidence-Based Practice, Western Norway University of Applied Sciences, Norway

ARTICLE INFO

Keywords:
Simulation
Clinical competence
Quality improvement
Nurses
Knowledge
Skills
Systematic review

ABSTRACT

Background: Simulation-based training is a widespread strategy to improve health-care quality. However, its effect on registered nurses has previously not been established in systematic reviews. The aim of this systematic review is to evaluate effect of simulation-based training on nurses' skills and knowledge.

Methods: We searched CDSR, DARE, HTA, CENTRAL, CINAHL, MEDLINE, Embase, ERIC, and SveMed + for randomised controlled trials (RCT) evaluating effect of simulation-based training among nurses. Searches were completed in December 2016. Two reviewers independently screened abstracts and full-text, extracted data, and assessed risk of bias. We compared simulation-based training to other learning strategies, high-fidelity simulation to other simulation strategies, and different organisation of simulation training. Data were analysed through meta-analysis and narrative syntheses. GRADE was used to assess the quality of evidence.

Results: Fifteen RCTs met the inclusion criteria. For the comparison of simulation-based training to other learning strategies on nurses' skills, six studies in the meta-analysis showed a significant, but small effect in favour of simulation (SMD − 1.09, CI − 1.72 to − 0.47). There was large heterogeneity (I^2 85%). For the other comparisons, there was large between-study variation in results. The quality of evidence for all comparisons was graded as low.

Conclusion: The effect of simulation-based training varies substantially between studies. Our meta-analysis showed a significant effect of simulation training compared to other learning strategies, but the quality of evidence was low indicating uncertainty. Other comparisons showed inconsistency in results. Based on our findings simulation training appears to be an effective strategy to improve nurses' skills, but further good-quality RCTs with adequate sample sizes are needed.

1. Introduction

Healthcare services offer complex, and advanced treatment for patients. Therefore highly competent and skilled healthcare providers are needed to secure patient safety (Grol et al., 2008). Studies show that errors in healthcare are a risk for patient safety that in many cases can be prevented (Patel et al., 2015). Patient safety, and quality improvement are therefore important issues in today's society (Institute for Healthcare Improvement, 2015). There are several tools for quality improvement such as evidence-based guidelines, or clinical audits (Ivers et al., 2012; NICE, 2014). Another strategy used to improve performance among healthcare workers, and students, is simulation-based training.

Simulation-based training is practising realistic scenarios using a specialized manikin, computer software, or humans playing the role as patient (Society for Simulation in Healthcare, 2014; The International Nursing Association for Clinical Simulation and Learning, 2013). The setting can be high-fidelity, where manikins and equipment are advanced, also called technology-enhanced simulation. It can also be low-fidelity where the equipment is less advanced (Healthy Simulation, 2014; Salas et al., 2013). The most specialized manikins today simulate the physiology of humans with pulse, blood pressure, and secretion of sweat and tears. The facilitator has the ability to regulate the parameters according to the actions initiated by the health workers, using specialized computer software (Healthy Simulation, 2014).

Previously published systematic reviews on simulation-based training for students in health-profession education, showed large effects on students' knowledge and skills, and moderate effects on patient-related outcomes (Cant and Cooper, 2010; Cook et al., 2011). Simulation-based training for critical care nurses in continuing education programmes,

* Corresponding author.
E-mail address: pal.a.hegland@hotmail.com (P.A. Hegland).
[1] Second reviewer. Western Norway University of Applied Sciences, Bergen, Norway.
[2] Librarian, Norwegian Institute of Public Health, Oslo, Norway.
[3] Oslo and Akershus University College of Applied Sciences, Norway.

http://dx.doi.org/10.1016/j.nedt.2017.04.004
Received 14 June 2016; Received in revised form 28 February 2017; Accepted 7 April 2017

can improve adherence to recommendations about safe medication (Jansson et al., 2012). Further technology-enhanced simulation in emergency medicine seems to have effect on several outcomes (Ilgen et al., 2013). In addition, a qualitative study among midwifery students showed that simulation created links between theory and practice, and provided a safe learning environment (Lendahls and Oscarsson, 2017).

One systematic review that summarized evidence for graduated nurses separately found only one cohort study. Since this learning strategy is widely used for nurses, it is relevant to evaluate its effect. The aim of this systematic review is therefore to summarize the effect of simulation-based training on nurses' knowledge and skills.

2. Methods

2.1. Inclusion Criteria

To be considered relevant for inclusion in the systematic review, the studies had to be randomised controlled trials (RCT) evaluating the effect of simulation-based training for graduated nurses, or graduated nurses in continuing education. Skills and/or knowledge had to be the primary outcomes in the trials. The studies were eligible for inclusion if they were written in English, German, Norwegian, Swedish, or Danish.

2.2. Comparisons

Relevant comparisons for the systematic review were simulation-based training to other learning strategies, different simulation strategies compared to each other, or different organisation of the simulation training.

2.3. Identification of Studies

Systematic searches were performed in The Cochrane Database of Systematic Reviews (Wiley), Database of Abstracts of Reviews of Effects (CRD), Health Technology Assessment Database (CRD), Cochrane Central Register of Controlled Trials (Wiley), CINAHL (EBSCO), MEDLINE (OVID), Embase (OVID), ERIC (EBSCO), and SveMed +. Searches were performed 5 September 2014, with an update search 15 December 2016. Search strategies were reviewed by an experienced research librarian (Sampson et al., 2009). Search terms included 'simulation', 'technology-enhanced simulation', 'computer-based simulation', 'nurs*', 'skills', 'knowledge' among others (complete list in Appendix E). No limitations pertaining to language, publication year, or study design were applied. An example of a complete search strategy is presented in Appendix A, and complete search strategies are available upon request. Hand searches were performed in the journals Clinical Simulation in Nursing, and Simulation in Healthcare for the years 2013 to December 2016 as they were indexed in MEDLINE until January 2013 at the time of the primary search. Previously identified systematic reviews and primary studies were screened for relevant references. Experts in the field were contacted for additional published or unpublished research. Finally Clinical Trials (ClinicalTrails.gov, 2014) were searched with the text word 'simulation', to identify unpublished or ongoing studies.

2.4. Screening and Selection of Studies

Two review authors screened all titles and abstracts independently. The selection process was piloted by reading the first 50 titles and abstracts to calibrate understanding of inclusion and exclusion criteria (Higgins and Deeks, 2011, Ch. 7). We obtained full-text articles of all studies that did not clearly meet the exclusion criteria. The same two reviewers read all full-text articles for final inclusion. Disagreements in all stages were solved by discussion until consensus was reached (Higgins and Deeks, 2011, Ch. 7).

2.5. Data Extraction

A pre-defined data-extraction form was developed. Data from the included studies were extracted by one person, and quality checked by a second person. We extracted the following data: author name, publication year, number of participants, interventions and comparisons, outcomes, country, and effect measures.

2.6. Assessing Risk of Bias and Grading the Evidence

The Cochrane Collaboration's Risk of Bias Tool (Higgins et al., 2011, Ch. 8.5), was used to evaluate risk of bias in included studies. We used the Guideline Development Tool (GRADE Working Group, 2012; Guyatt et al., 2011) to assess quality of the evidence for the following comparisons: Simulation-based training versus other learning strategies, high-fidelity simulation versus other simulation strategy, and different organisation of simulation training. The grading was made per comparison for each outcome, and was assessed as high, moderate, low, or very low quality (Guyatt et al., 2008).

2.7. Data Synthesis

We planned to do a quantitative synthesis, by conducting meta-analyses when there was low clinical diversity in the studies (Deeks et al., 2011, Ch. 9). We also planned narrative syntheses, if meta-analyses were not possible to conduct. The statistical data were entered to Review Manager 5.3 (The Nordic Cochrane Centre, 2014).

For continuous measures we calculated Standardized Mean Difference (Inverse Variance, random effects model), and 95% confidence interval (CI), and for dichotomous measures we calculated Risk Ratio with 95% CI (Mantel-Haenszel, random effects model) (Deeks et al., 2011, Ch. 9).

In the meta-analysis, between-study consistency (heterogeneity) was calculated with I^2 statistics, which estimates the percentage of the variability not due to chance. An I^2 value > 50% indicates substantial heterogeneity. A *p*-value was also calculated, and $p < 0.05$ indicates significant between-study heterogeneity (Deeks et al., 2011, Ch. 9).

3. Results

3.1. Identification of Studies and Study Selection

Fourteen-hundred and seventy-five potentially relevant studies were identified through the database searches, hand searching, and screening of reference lists. After screening by two reviewers independently as described in the methods section, fifty-eight articles were selected for full-text review. Fifteen studies met the inclusion criteria, and were included in this systematic review, see Fig. A screening and selection process. Excluded studies are presented in Appendix B.

3.2. Study Characteristics

The fifteen included studies were published between 2005 and 2016, three of which before 2010. Nine studies were conducted in the USA (Arnold et al., 2013; Corbridge et al., 2010; Hebbar et al., 2015; Johnson et al., 2012; Keleekai et al., 2016; Maneval et al., 2012; Rutherford-Hemming et al., 2016; Schneider et al., 2006; Weiner et al., 2011), one in Australia (Cioffi et al., 2005), two in Belgium (De Regge et al., 2008; Monsieurs et al., 2012), one in Finland (Jansson et al., 2016), one in Singapore (Liaw et al., 2015), and one in Norway (Simonsen et al., 2014). The studies had enrolled a total of 852 registered nurses. Twelve studies were conducted in hospitals (Arnold et al., 2013; De Regge et al., 2008; Hebbar et al., 2015; Jansson et al., 2016; Keleekai et al., 2016; Liaw et al., 2015; Maneval et al., 2012; Monsieurs et al., 2012; Rutherford-Hemming et al., 2016; Schneider