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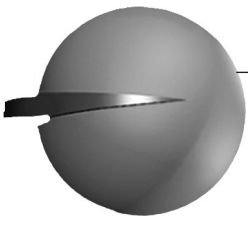
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Evidence Review

Does Simulation Training for Acute Care Nurses Improve Patient Safety Outcomes: A Systematic Review to Inform Evidence-Based Practice

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Key words

acute care, medical/surgical, RN training, patient safety, simulation, medication errors, patient outcomes, nurse education, patient care, systematic review

ABSTRACT

Background: Simulation is increasingly used as a training tool for acute care medical-surgical nurses to improve patient safety outcomes. A synthesis of the evidence is needed to describe the characteristics of research studies about acute care nurse simulation trainings and patient safety. An additional purpose is to examine the effects of acute care registered nurse (RN) simulation trainings on patient safety outcomes.

Methods: Five Internet databases were searched for articles published on any date through October 2018 examining the effect of RN simulation trainings on patient safety outcomes in the adult acute care setting.

Sample: $N = 12$ articles represented 844 RNs of varying experience levels and 271 interprofessional participants.

Results: Nine studies (75%) used high-fidelity scenarios developed locally about high risk but infrequent events. Five studies (42%) incorporated interdisciplinary team members in the scenarios and/or outcome evaluations. Outcome measures were self-reported, direct observation, or clinical indicators. All studies in this review achieved improved patient safety outcomes. It is unknown how outcomes vary for different groups of RNs because of insufficient gender, ethnicity/race, and age reporting.

Linking Evidence to Action: Findings support the design of simulation training research studies for patient safety outcomes and use of simulation training and research in acute care RNs. Additional high-quality research is needed to support this field. Future studies should include descriptors that characterize the sample (i.e., age, gender, education level, type of nursing degree, ethnicity or race, or years of experience); incorporate interdisciplinary teams; evaluate a combination of outcome measure types (i.e., self-report, direct observation, and clinical outcomes) both proximal and distal to the simulation; and that utilize standardized scenarios, validated outcome measure instruments, and standardized debriefing tools.

INTRODUCTION

Over half (61%) of all registered nurses (RNs) in the United States work in general medical-surgical acute care hospitals (U.S. Bureau of Labor Statistics, 2018), and the literature reports that 50% of newly licensed RNs are involved in patient safety events, which are defined as errors in patient care that may or may not result in an adverse outcome for the patient (Kim, Kim, & Kang, 2016). New RNs are more likely than experienced RNs to be involved in patient safety events, especially those who work the night shift (Kim et al., 2016; Saintsing, Gibson, & Pennington, 2011). While many RN training programs utilize simulation-based

training in combination with other training methodologies to improve clinical competence (Smiley et al., 2018), limited evidence exists about the relationship between simulations in adult acute care training and their connection to actual patient safety outcomes.

A synthesis of the evidence is needed to determine whether and how simulation-based training for nurses affects patient safety outcomes to inform future simulation design and evaluation. The purpose of this study was to describe the characteristics of studies about simulation-based training for nurses and patient safety and their relationship with patient safety outcomes. The research questions are as follows:

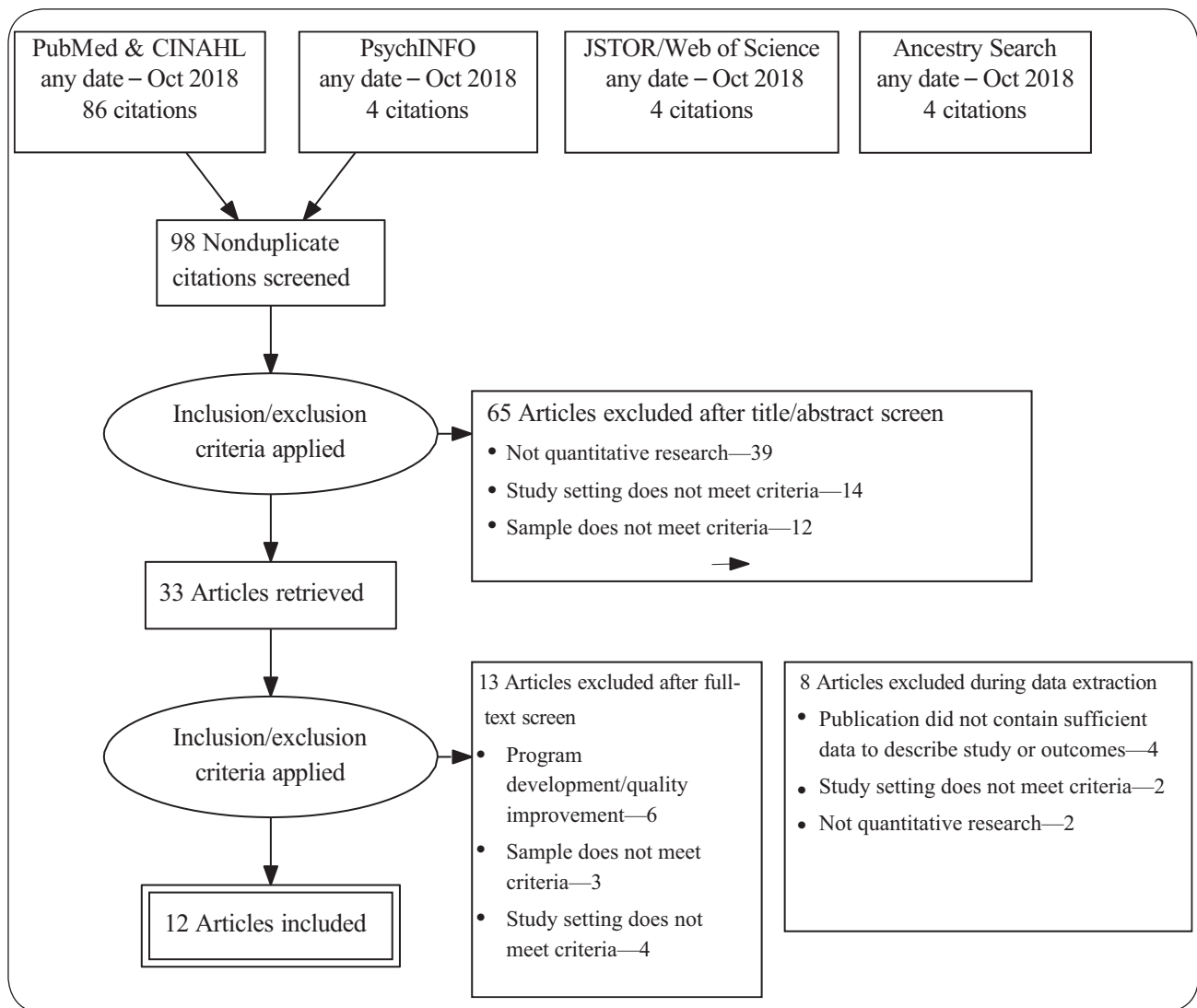


Figure 1. Simulation patient safety PRISMA diagram.

1. What are the characteristics of studies about simulation-based training for nurses and patient safety?
2. What are the relationships between simulation-based training for nurses and patient safety outcomes?

METHODS

The search strategy is summarized in Figure 1. As per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), peer-reviewed literature written in English and published on any date through October 31, 2018, was searched independently by two scholars in five Internet databases: PubMed, CINAHL, JSTOR, Web of Science, and PsycINFO. Searches were conducted using varying

combinations of the key words “Registered Nurse”; “RN”; “nurse”; “training”; “education”; “internship”; “mentorship”; “extended preceptorship”; “orientation”; “simulation”; “acute care”; “medical-surgical”; and “patient safety”. Ancestry searches were done to identify additional articles, and dissertation databases were searched to minimize publication bias.

After removing duplicates, inclusion and exclusion criteria were applied resulting in 12 articles in the final sample. Due to the paucity of research that was specifically about a nurse residency or first-year clinical nurse training, all quantitative research studies were included if they involved a simulation-based training session or program of sessions for any inpatient or hospital-based adult acute care nurse. Included studies also had a stated purpose of affecting one or more patient safety outcomes through simulation-based training or measured patient safety outcomes. Studies were

Table 1. Sample and Study Characteristics of the Articles Included in the Final Sample

Sample characteristic	Number of studies	Result
Age	8	Range 18–62 years
Gender	6	Female 50–100%
Ethnicity	0	Unknown
Nurse experience level	11	64%—mixed (<1 year to 25+ years) 18%—inexperienced or entry-level RNs only (<2 years) 18%—experienced RNs only (>2 years)
Study characteristic	Result	
Sample size	Range <i>N</i> = 6–247 RNs, mean <i>N</i> = 70 RNs	
Interprofessional teams	5 studies	

excluded if they involved operating room and surgical outcomes, labor & delivery, postpartum, pediatrics, or the emergency department.

Data Extraction

Data were extracted based on characteristics of the sample (e.g., age, gender, race or ethnicity, experience level of the nurse, interprofessional team members), study design, setting, simulation type (developed by study authors or site or commercially purchased products), content of simulation, type of simulation equipment, method of evaluation, simulation training group size, amount of time spent in simulation training, and measures for patient safety outcomes (including standardized debriefing tools). In addition, data were extracted about the relationships between patient safety outcomes and the simulation intervention.

A risk of bias analysis was conducted per the Cochrane Collaboration's recommended methodology (Higgins et al., 2011). Risk of bias was evaluated based on sample size, randomization, study design, study limitations as reported by study authors, and quality of the instruments used for measurement of outcome variables.

RESULTS

The final sample of articles was made up of 12 studies representing *N* = 844 participants. General characteristics of the studies included in the final sample are summarized in Table S1, and the data extracted from the studies are presented in Table 1.

Sample Characteristics

Participants' ages ranged from 18 to 62 years. Eight studies reported the age of the sample. Reporting format of experience levels was disparate. Eight studies included samples of nurses with varying experience levels, ranging from <1 year to over 25 years of experience (Ballangrud,

Hall-Lord, Hedelin, & Persenius, 2013; Gerolemou et al., 2014; Kim, 2014; Klipfel et al., 2011; Liaw et al., 2016; Pati, Cason, Harvey, Evans, & Erwin, 2012; Trbovich, Pinkney, Cafazzo, & Easty, 2010; Wilson et al., 2010). One study was limited to inexperienced or entry-level nurses with <2 years of experience (Roots, Thomas, Jaye, & Birns, 2011). Two studies were limited to experienced nurses, which they defined as more than 2 years of experience (Braddock et al., 2014; Raurell-Torreáda et al., 2015). The percent of participants who were female ranged from 50% to 100%. Kim (2014) was the only study that reported race (66.7% Asian/Pacific Islander). Ethnicity was not reported in any studies.

Study Characteristics

The study designs of the included research studies were pilot studies (Roots et al., 2011; Wilson et al., 2010), quasi-experimental study designs with either a one group pretest posttest design (Ballangrud et al., 2013; Braddock et al., 2014; Gerolemou et al., 2014; Klipfel et al., 2011; Liaw et al., 2016) or a nonrandom assignment to groups (Kim, 2014; Nevo et al., 2010; Pati et al., 2012; Raurell-Torreáda et al., 2015; Trbovich et al., 2010). Sample sizes ranged from *N* = 6 to 247 RNs, and the mean sample size was *N* = 70 RNs. Five of the studies were interdisciplinary (Braddock et al., 2014; Kim, 2014; Klipfel et al., 2011; Nevo et al., 2010; Roots et al., 2011) and contained additional participants from 1 to 76 doctors, medical residents, or clinical assistants. The other seven studies were not interprofessional, but one was unique in that it included 101 undergraduate nursing students as a comparison group (Raurell-Torreáda et al., 2015).

Simulation Interventions and Designs

Simulation type

Most studies' (nine) simulation scenarios were developed by the site or people associated with the study. Three studies

utilized commercially available simulation scenarios. One was called e-RAPIDS, which stands for Rescuing a Patient in Deteriorating Situations, developed by the National University of Singapore (Liaw et al., 2016). Another was simulation curriculum from the National League for Nursing (Raurell-Torreada et al., 2015), and the third was from Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS; Kim, 2014).

Simulation content

Simulation content in nine studies was focused around high risk, low frequency of occurrence events such as cardiac arrest or a clinically deteriorating patient requiring action by the RN. Two additional studies were unique in their content in that one study evaluated routine tasks (i.e., hand hygiene behaviors) through simulation (Nevo et al., 2010) and another evaluated how routine task safety behaviors varied based on the room configuration (Pati et al., 2012).

Simulation implementation

Group size was small (1–4 team members) in most studies. The duration and frequency of trainings ranged from 5 min once to two half-days spaced 2 weeks apart in the eight studies that reported session duration. A majority were 10–30 min long (Braddock et al., 2014; Kim, 2014; Klipfel et al., 2011; Nevo et al., 2010; Roots et al., 2011; Wilson et al., 2010) repeated once (Ballangrud et al., 2013; Klipfel et al., 2011; Liaw et al., 2016; Nevo et al., 2010; Raurell-Torreada et al., 2015; Roots et al., 2011; Wilson et al., 2010). Braddock et al. (2014) allowed one or more repetitions at the RN's discretion; 43% participated in two or more sessions over the intervention period. Gerolemou et al.'s (2014) study incorporated two repetitions. Both the headwall study (Pati et al., 2012) and the intravenous (IV) pump technology study simulations (Trbovich et al., 2010) were unique because simulations were repeated 27 times per nurse.

Equipment and technology

Nearly all studies used high-fidelity simulation mannequins or live actors, with one exception (Liaw et al., 2016) which used a web-based simulation training program. No other unique technology interventions were described in these studies (e.g., GoPro, Google Glass, or virtual reality).

Measures

The patient safety outcome measures identified in the studies were found to be in three major categories: Self-report, direct observation, or clinical patient safety outcomes. Seven studies included self-reported measures of skills or individual characteristics as proxy measures of patient safety, such as perceived confidence, teamwork, and communication skills (Ballangrud et al., 2013; Braddock et al., 2014; Kim, 2014; Klipfel et al., 2011; Liaw et al., 2016; Roots et al., 2011; Wilson et al., 2010). Nine involved direct observation of

behavior from peers, scored videos, preceptors, and educators (Ballangrud et al., 2013; Gerolemou et al., 2014; Klipfel et al., 2011; Liaw et al., 2016; Nevo et al., 2010; Pati et al., 2012; Raurell-Torreada et al., 2015; Trbovich et al., 2010; Wilson et al., 2010). Four included clinical patient safety outcomes such as rates of severe sepsis and septic shock, acute respiratory failure, transfers to higher level of care, catheter-related blood stream infections (CRBSIs), patient falls, or pressure ulcers (Braddock et al., 2014; Gerolemou et al., 2014; Kim, 2014; Liaw et al., 2016). Three of the studies that used surveys to measure outcomes developed the survey themselves and had not tested the instruments for reliability or validity (Ballangrud et al., 2013; Roots et al., 2011; Wilson et al., 2010). Two studies used the Agency for Healthcare Research and Quality's Hospital Survey on Patient Safety Culture (Braddock et al., 2014; Kim, 2014).

Debriefing and prebriefing

Debriefing and prebriefing sessions held in groups or individually were common and built into the simulation design. Although common to hold these sessions, most authors did not report using any standardized debriefing or prebriefing tools, although they may have reported using a standardized process among groups or using facilitators trained in debriefing (Braddock et al., 2014; Gerolemou et al., 2014; Kim, 2014; Klipfel et al., 2011; Liaw et al., 2016; Roots et al., 2011; Wilson et al., 2010).

Relationship Between Intervention and Outcomes

All studies achieved improvements in outcome measures. No category of outcome measure outperformed any other.

Risk of Bias

Many of the studies were found to have a moderate risk of bias inherent in the study design. Sample sizes were small and included convenience samples. Most were quasi-experimental design without randomization: pretest post-test design, or a control group without random assignment to groups. Some studies used measures with adequate reliability and validity, although many were developed for the purpose of the study and did not report reliability and validity testing.

DISCUSSION

Findings from this review describe the study characteristics found in the peer-reviewed literature about simulation-based training interventions for patient safety outcomes in the adult acute care nursing setting. It is impracticable to conclude that a single simulation-based training experience or series of experiences is the sole cause of a change in real-world patient safety outcomes, and if a causal relationship exists, to what extent it is the cause, because these outcomes are influenced by a variety of factors in the nonsimulated world. Through this review, the authors

found that to address this challenge, some studies measured other outcomes (i.e., self-report and direct observation of nurse behaviors and attitudes) as proxies for patient safety outcomes to discern the change in nurse behavior or attitude that ultimately leads to a change in patient safety outcomes. Figure S1 provides a model of these outcomes and their relationship to simulation training.

Further, the results of this review indicate that simulation-based training for acute care nurses improves all categories of self-report, direct observation, and clinical patient safety outcomes. These findings are consistent with conclusions from a meta-analysis of simulation studies for clinical deterioration that included undergraduate nursing students in the academic setting by Orique and Phillips (2017). Despite emerging evidence from research studies about simulation training, the field is largely still based upon best practice guidelines, expert opinion, quality improvement projects, and research with undergraduate nursing students in the academic setting. Additional high-quality research studies are needed to support this important aspect of nursing education.

Study Characteristics

Sample characteristics

There is a gap in knowledge about the characteristics of the samples studied, primarily due to inconsistent reporting. For example, a mean age was not able to be calculated because of inconsistent metrics across studies. The race and ethnicity were not reported. The experience levels varied widely, from undergraduate students enrolled in a nursing program, newly hired acute care nurses with simulation offered during week two of orientation, experienced medical-surgical registered nurses and experienced critical care nurses with experiences ranging from 2 to 20 years. As a result, it is difficult to determine whether or how the effects of the interventions may vary based on different groups of nurses. The samples were predominantly female, which is consistent with the general population of nurses, but little is known about the effects of the interventions on males. The gap in this area indicates an urgent need for more rigor in reporting sample characteristics in studies related to simulation training for nurses.

Study characteristics

A majority of simulation scenarios were created by the site or study team members. Some of the studies cited theoretical frameworks, national treatment guidelines and models, and hospital policies as a foundation for scenario development. Yet, many studies are utilizing scenarios that may not have been tested or developed with the appropriate scientific rigor. There is a need for standardization, incorporation of theory, national guidelines, and policies into the selection or creation of scenarios for training purposes. Consistency among studies and increased rigor in the scenarios used for training programs are needed as well.

The scenario content is mostly focused on high-risk, low-frequency situations such as cardiac arrest, pulmonary emergencies, septic shock, or other rapidly deteriorating patient care situations that require nurse interventions. Due to the risk inherent in the patient care, and the limited opportunity to practice these scenarios during a preceptor-based orientation, it is appropriate to practice these scenarios in simulated settings.

Yet, there is a gap in knowledge about how patient safety outcomes are affected by repetition of routine or high-frequency events. It is possible that by routinizing tasks like admissions and discharges that recur often and require time to become proficient (i.e., time-consuming tasks with many steps) that patient safety outcomes would be improved as a result of the enhanced cognitive capacity for critical thinking. Future studies should explore the relationships between such simulated training events and patient safety outcomes. Further, the types of technology utilized for simulations remain fairly constant with a majority using high-fidelity mannequins, standardized patients, and live actors. This indicates an opportunity for nursing to explore new technologies (i.e., virtual reality, robotics) to assist with simulated training research in this population.

The measurement of patient safety outcomes postsimulation training poses a challenge to investigators as observed in practice and supported by this review. Patient safety measures identified within this review fall into three categories: self-reported, direct observation (via preceptors, educators, or peers), and clinical outcomes. Most of the studies utilized self-reported confidence level, knowledge tests, critical thinking, or teamwork measures as a proxy for patient safety outcomes. This category of outcomes is easy to measure because it requires limited resources beyond the simulation setting; however, it is unknown how well self-reported measures translate to actual patient safety behaviors beyond the simulated setting and whether or not those measures deteriorate or improve over time after the simulation training. While commonly used as a measure for patient safety outcomes in simulation-based training, the authors recommend that future studies test the value of a combination of measures from more than one category (e.g., self-report, direct observation, and clinical outcomes).

Nine of the studies employed direct observation of behavior from peers, scored videos, preceptors, and educators. This review found that most of the studies looked at behaviors and skills that occur within the simulation itself. Rarely, verification was made to assess whether the newly acquired skills translated to the clinical practice environment. Future studies should consider incorporating direct observation measures both distal and proximal to the simulation training as well as observation in the clinical setting.

Four studies included and reported improvement in clinical patient safety outcomes (Braddock et al., 2014;

Gerolemou et al., 2014; Kim, 2014; Liaw et al., 2016). For example, the study by Gerolemou, et al. (2014) found an 85% decrease in CRBSI 12-month post-simulation-based intervention. Braddock et al. (2014) found a significant improvement in adverse sepsis-related and acute respiratory failure-related outcomes. Kim (2014) found that fall rates initially decreased by 27% following a TeamSTEPPS intervention and decreased by 67% at 3 months postintervention. Pressure ulcer rates increased 14% in the intervention group immediately postintervention, but rates fell to zero at three months postintervention. Finally, both Liaw et al. (2016) and Braddock et al. (2014) found that nurses flagged deteriorating patients for transfer to a higher level of care with greater frequency postintervention.

In summary, these four studies directly measured the outcomes most related to the stated purpose of the simulation trainings. However, patient safety events distal to a single simulation training could be affected by numerous factors that may or may not be related to the nurses who underwent the simulation training. It is difficult to discern whether the simulation training was the cause of the change in outcomes, and if it was, to what degree it influenced outcomes compared to other confounding factors. This finding is consistent with the conclusions of Kim (2014). Further, patient safety outcome reporting systems are varied and limited in their accuracy as well (Rosen et al., 2010). Thus, it is recommended that a combination of patient safety outcome measures both proximal and distal to the intervention be used in simulation training research.

Debriefing sessions were common, although four of the studies did not report any debriefing sessions as a component of the intervention (Gerolemou et al., 2014; Pati et al., 2012; Raurell-Torreáda et al., 2015; Trbovich et al., 2010). The duration and frequency of the interventions ranged broadly, but most of the studies were administered once and lasted from 10 to 30 min. Studies reported that the short duration was preferred to minimize cost, maximize efficiency, and enhance practical implementation for scheduling nurses.

Effects of the Interventions

Due to the disparate nature of the outcome measures, no comparison could be done across all studies. However, despite this inconsistency in measurement tools, the literature appears to support the notion that simulation-based training for nurses may positively affect patient safety outcomes because all studies reported an improvement on one or more patient safety outcomes postintervention.

Risk of Bias

The studies overall were found to have a moderate risk of bias predominantly due to a variety of contributing factors in the study design or execution: smaller sample sizes, higher attrition rates, failure to use valid and reliable

instruments, lack of randomization or control group, and insufficient description or homogeneity of the sample. Despite the risk of bias, these studies represent the best evidence available at this time to describe the state of the science, support decision-making, and plan future research.

Limitations of the Review

PRISMA guidelines for systematic reviews were followed to complete the analysis, and the Cochrane Collaboration's guidelines for risk of bias assessment were used in the interpretation of the findings, yet as with any study, there are limitations associated with this review. This review only considered and reviewed study articles available in English and all non-English language studies were excluded. Thus, there may be additional evidence written in another language that is not included in this analysis. However, the findings of this study summarize the state of the science to date and represent the best evidence available on this topic. Findings support and confirm the importance of additional high-quality, evidence-based, simulation-based training and research in nursing to confirm results of this review and to further support the relationship between simulation training and patient safety outcomes.

CONCLUSIONS

The findings from this study indicate that simulation holds significant promise for training current and future generations of nurses. However, more detailed, evidence-based simulated clinical scenarios with standardized, validated evaluation methods are needed to ensure their alignment with patient safety outcomes. There are gaps in our knowledge about how interventions affect different types of nurses because of underreporting of the sample demographics (e.g., age, race or ethnicity, experience level, gender). Further, although all studies achieved significant effects of the interventions on outcomes, the findings from the existing studies should be interpreted with caution due to design limitations. The field would benefit from standardization of simulation scenario quality, evidence-based study design, and reliable and valid outcome measures. Further, novel technologies should be developed and tested to improve both the experience for the nurse and the quality of the evaluation of the outcomes.

Despite its growing use, there is a paucity of rigorous, high-quality evidence supporting the use of simulation-based training for acute care hospital inpatient nurses to impact patient safety outcomes. It is crucial for nurses to understand how the critical thinking and decision-making skills learned during simulation-based activities have the potential to impact patient outcomes. Thus, additional research to improve and strengthen the design and implementation of simulation-based training for nurses is

warranted and serves as a foundation for ensuring quality care and patient safety. **WVN**



LINKING EVIDENCE TO ACTION

- When conducting future research studies, research scientists should include descriptors that characterize the sample (i.e., age, gender, education level, type of nursing degree, ethnicity/race, or years of experience), as well as incorporate interdisciplinary teams.
- To ensure scientific rigor during simulation training, clinicians need to develop standardized scenarios, use validated outcome measure instruments, and incorporate standardized debriefing tools.
- Healthcare teams should evaluate a combination of outcome measure types (i.e., self-report, direct observation, and clinical outcomes) both proximal and distal to the simulation, in an effort to establish evidence-based metrics for patient safety outcomes.
- To maximize cognitive capacity for critical thinking among RNs, clinicians should explore the use of novel technologies, such as virtual reality or robotics, in simulation training.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web site:

Figure S1. A proposed model of simulation based training for patient safety outcomes in acute care nursing.

Table S1. Characteristics of studies evaluating simulation based training for RNs and patient safety outcomes.