THE EFFECTIVENESS OF EDUCATION IN THE RECOGNITION AND MANAGEMENT OF DETERIORATING PATIENTS: A SYSTEMATIC REVIEW.

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Title: The effectiveness of education in the recognition and management of deteriorating patients: a systematic review.

ABSTRACT

Background: Survival from in-hospital cardiac arrest is poor. Clinical features, including abnormal vital signs, often indicate patient deterioration prior to severe adverse events. Early warning systems and rapid response teams are commonly used to assist the health profession in the identification and management of the deteriorating patient. Education programs are widely used in the implementation of these systems. The effectiveness of the education is unknown.

Aim: The aims of this study were to identify: (i) the evidence supporting educational effectiveness in the recognition and management of the deteriorating patient and (ii) outcome measures used to evaluate educational effectiveness.

Methods: A mixed methods systematic review of the literature was conducted using studies published between 2002-2014. Included studies were assessed for quality and data were synthesized thematically, while original data are presented in tabular form.

Results: Twenty three studies were included in the review. Most educational programs were found to be effective reporting significant positive impacts upon learners, patient outcomes and organisational systems. Outcome measures related to: i. learners, for example knowledge and performance, ii. systems, including activation and responses of rapid response teams, and iii.

patients, including patient length of stay and adverse events. All but one of the programs used blended teaching with more than 87% including medium to high fidelity simulation. In situ simulation was employed in two of the interventions. The median program time was eight hours. The longest program lasted 44 hours however one of the most educationally effective programs was based upon a 40 minute simulation program.

Conclusion: Educational interventions designed to improve the recognition and management of patient deterioration can improve learner outcomes when they incorporate medium to high-fidelity simulation. High-fidelity simulation has demonstrated effectiveness when delivered in brief sessions lasting only forty minutes. In situ simulation has demonstrated sustained positive impact upon the real world implementation of rapid response systems. Outcome measures should include knowledge and skill developments but there are important benefits in understanding patient outcomes.

Introduction

Survival to discharge from in-hospital cardiac arrest is between 16-20% globally (Cooper et al., 2006; Ebell and Afonso, 2011; Larkin et al., 2010; Peberdy et al., 2003; Sandroni et al., 2007). Clinical features, including abnormal vital signs, often indicate patient deterioration in the hours prior to cardiac arrest (Buist et al., 2004; Franklin and Mathew, 1994). These same indicators often precede severe adverse events and unscheduled intensive care admissions (McQuillan et al., 1998; Winters et al., 2007). One Australian multi-centred prospective follow-up study (Hillman et al., 2002) reported that

60% of 551 patients requiring unscheduled ICU admission had documented life-threatening observations in the eight hours preceding admission.

Ward doctors and nurses are responsible for the care of increasingly complex patients, identifying signs of physiological deterioration and managing deteriorating patients (Hodgetts et al., 2002; Jones et al., 2011; Odell et al., 2009). Patients are more demographically diverse and patients with high dependency needs are now cared for on general medical and surgical wards (McGillis Hall and Doran, 2007).

Ward nurses have been shown to have varying abilities to recognise, document, report and respond to physiological deterioration (Odell et al., 2009). Medical students and junior ward medical staff have also been shown to have significant shortfalls in the interpretation of the signs and symptoms of clinical deterioration (Smith and Poplett, 2002). Similarly experienced doctors can be underprepared to respond to medical emergencies and acutely unwell patients (Frankel et al., 2004).

For almost two decades Rapid Response Systems (RRS) have evolved to manage the prevention, recognition, and stabilisation of clinical deterioration (Winters and DeVita, 2011). The impact of Medical Emergency Teams (MET) upon the incidence of mortality has been debated since the landmark work of Buist et al. in 2002. During this time educational support for these systems has also developed to address the increasing demands upon potentially underprepared ward staff. These educational interventions have been applied nationally (Smith, 2003), at regional level and locally (Buykx et al., 2011; Liaw et al., 2011).

The efficacy of rapid response systems is topical, well documented and has been systematically reviewed (Odell et al., 2009; Ranji, 2007; Winters et al., 2007). The effectiveness of educational programs that have been designed to prepare health professionals for using these systems has not received the same attention. This review aims to identify: (i) the evidence supporting educational effectiveness in the recognition and management of the deteriorating patient and (ii) the outcome measures used to evaluate educational effectiveness.

Methods

A systematic search of the literature was conducted during January 2014. The search was conducted to identify peer reviewed quantitative, qualitative or mixed methods studies that measured the effectiveness of educating health professionals to identify and manage the deteriorating in-patient.

A 4 phase decision process including study identification, screening, eligibility and inclusion to the study was used (see PRISMA statement)(Moher et al., 2009) which is shown in Figure 1.

Databases searched included CINAHL Plus, Medline, Embase, Cochrane, Proquest, ERIC, Scopus and the search engine Google Scholar.

An initial search to identify relevant keywords, subject headings and MeSH terms was carried out on the following terms:

- Training OR Education AND Deterioration (deteriorat*)

This search yielded 6908 results. These articles were reviewed for further keywords and subject headings. The following searches were then performed on all databases.

- Training OR Education AND Deterioration (deteriorat*)

- Rapid Response Teams OR Critical Care Outreach Teams OR Medical Emergency Teams
- Early Warning Scores OR Modified Early warning Scores OR (track AND trigger)

A manual search of potentially eligible study reference lists, relevant article bibliographies, related journals and professional body websites was also performed. This manual search was combined with database functions such as CINAHL's "find similar articles" function and a citation tracking (snowballing) approach.

The initial broad Boolean/Phrase search was limited to peer reviewed papers published in English between 2002 and January 2014 and where abstracts were available. The year 2002 was chosen as it coincided with the emergence of literature describing the implementation and outcomes of RRSs (Buist et al., 2002).

All duplicates were then removed and the Major Subject Headings were identified from the initial search and used to narrow the results. The abstracts of the remaining 794 results were read to identify any potentially eligible studies applying the following inclusion criteria:

- peer reviewed
- published between 2002 – January 2014
- available in English language
- abstract available
- address the effectiveness of education in identifying and managing the deteriorating in-patient
- examine education provided to health professionals

INSERT FIGURE 1. HERE

The author and a second reviewer (JJ) read the resultant 47 studies. The second reviewer again applied the inclusion criteria. If there were conflicting opinions in the inclusion or exclusion of studies, the paper was discussed and the inclusion and exclusion criteria was re-applied. If the discrepancy was not resolved, expert third party (SC) opinion was sought. The process produced 23 studies for inclusion in the review.

26 studies were excluded. Some examples of the reasons for exclusion were:

- The study investigated the learners' perception of the education program and not the effectiveness of intervention
- The study was designed to evaluate the tool used in measuring the participants' knowledge or confidence
- The paper simply described the implementation of an education program with no evaluation of effectiveness
- The study compared the application of specialised skills following two different modes of education

The remaining studies (n=23) were categorised by overall study methodology. The categories included quantitative, qualitative and mixed methods. Data for each study is presented at tables 1, 2 and 3. The quality of the studies was evaluated based upon generalisability, reproducibility, relevance to the setting, appropriateness of sampling (size and methods) to study aim, risk of bias, use of validated measurement tools and appropriateness of the outcome measures. These quality indicators were guided by the Evaluation Tool for Quantitative Research Studies (Long et al., 2002b), Evaluation Tool for 'Mixed

Methods' Study Designs (Long et al., 2002a) and the Critical Appraisal Skills Programme (CASP, 2014) tool for the evaluation of qualitative research.

Results

The review included twenty quantitative studies (Buckley and Gordon, 2011; Cooper et al., 2013; Crofts et al., 2006; Crofts et al., 2007; Featherstone et al., 2005; Fuhrmann et al., 2009; Gordon and Buckley, 2009; Harvey et al., 2014; Jones et al., 2006; Kelly et al., 2013; Kinsman et al., 2012; Lewis, 2011; Liaw et al., 2011; Liaw et al., 2013; Lindsey and Jenkins, 2013; Ludikhuize et al., 2011; Sittner et al., 2009; Smith and Poplett, 2004; Straka et al., 2012; Theilen et al., 2013), two mixed methods (Hart et al., 2014; Wehbe-Janek et al., 2012) and one qualitative study (Unsworth et al., 2012). The study designs of the quantitative studies were predominantly quasi-experimental and prospective interventional with one time series analysis of patient records (Kinsman et al., 2012). There was also one randomised control trial (Liaw et al., 2011).

The mixed methods studies used a descriptive exploratory design of the qualitative data and a quasi-experimental model for the quantitative data (Hart et al., 2014; Wehbe-Janek et al., 2012). The single qualitative study used focus groups and participant observation to investigate the role and effectiveness of simulation in developing mental health nurses' ability to recognise and respond to patient deterioration (Unsworth et al., 2012). All studies had a focused research question except for Wehbe-Janek et al. (2012).

Effectiveness of the education program was measured using three types of outcome: learner outcomes, patient outcomes and system outcomes.

Nineteen studies (Buckley and Gordon, 2011; Cooper et al., 2013; Crofts et al., 2006; Crofts et al., 2007; Featherstone et al., 2005; Gordon and Buckley, 2009; Hart et al., 2014; Harvey et al., 2014; Kelly et al., 2013; Kinsman et al., 2012; Lewis, 2011; Liaw et al., 2011; Liaw et al., 2013; Lindsey and Jenkins, 2013; Ludikhuize et al., 2011; Sittner et al., 2009; Smith and Poplett, 2004; Straka et al., 2012; Wehbe-Janek et al., 2012) measured the intervention's impact on perceived or real knowledge or performance, nine (Cooper et al., 2013; Featherstone et al., 2005; Gordon and Buckley, 2009; Hart et al., 2014; Harvey et al., 2014; Kelly et al., 2013; Lewis, 2011; Liaw et al., 2011; Wehbe-Janek et al., 2012) measured human factors or non-technical skills such as confidence, teamwork, leadership and communication, while one study measured the situational awareness of a team leader in a simulated patient deterioration scenario (Cooper et al., 2013). Only two of the studies (Crofts et al., 2007; Sittner et al., 2009) measured retention of skills or knowledge. Four of the studies measured the impact on care (activation and responses of RRS, quality of patient assessment and documentation of care) or the impact upon patient outcomes (patient length of stay, patient mortality and ICU admission rates) (Fuhrmann et al., 2009; Jones et al., 2006; Kinsman et al., 2012; Theilen et al., 2013). Fuhrmann et al. (2009) were unable to show improvement in 30 day and 180 day mortality as a result of the education; while Jones et al. (2006) associated improved frequency of MET call activation to the education intervention. Theilen et al. (2013) prospective cohort study demonstrated positive impacts upon patient and system outcomes. These included reductions in the time taken to recognise signs of deterioration, increased frequency of consultant review and reduced time

taken to escalate care. They also demonstrated measurable patient outcomes including increased ward to HDU transfers and reduced PICU admissions. Their paediatric patients were also less sick on arrival in PICU. Finally Kinsman et al. (2012) attributed improvements in the quality of patient assessment (appropriate frequency and quality of vital signs observation) and documentation of care (pain scores) to their educational intervention.

Based on these outcome measures, tables 1, 2, and 3 show that most (21) of the educational interventions report positive impacts upon learner, patient and organisational system outcomes. The education proved to be effective in all outcomes measured with the exception of two interventions (Fuhrmann et al., 2009; Sittner et al., 2009).

The duration of the education interventions ranged from 25 minutes to 45 hours with a mean time of eight hours. Seven of the interventions ran for a traditional eight hour “training day” model.

Most studies were potentially reproducible based upon the descriptions of the methods, the settings were relevant to the aim and sampling methods appropriate to the aims of the study. Though the quality of the studies was overall quite high, 10 (Buckley and Gordon, 2011; Featherstone et al., 2005; Fuhrmann et al., 2009; Gordon and Buckley, 2009; Jones et al., 2006; Lewis, 2011; Ludikhuize et al., 2011; Smith and Poplett, 2004; Wehbe-Janek et al., 2012) were at medium risk of bias due to participant selection methods, participant attrition or potential for selective reporting.

All studies were appropriately undertaken in acute hospitals (15) or universities (9). The studies were predominantly carried out in the UK (7), the

USA (6) and Australia (6). There was one Dutch and one Danish study and two were from the same author at Singapore's National University.

INSERT TABLES 1, 2 & 3 HERE

Discussion

The evidence supporting educational effectiveness in the recognition and management of the deteriorating patient and outcome measures used to evaluate educational effectiveness was determined by a systematic a search and analysis of all current relevant research evidence. This review identified that a third of the outcomes measured were based upon participants' personal perception of knowledge, skills and technical improvements, while just over a third of the studies measured actual improvement in knowledge, skills and technical performance. Though these traditional outcomes are often applied to the evaluation of educational interventions, there is evidence that knowledge tests and self-rated confidence do not necessarily predict improved clinical management of deteriorating patients (Liaw et al., 2012). As such, the challenge is to demonstrate actual changes in behaviour that translates to sustained improvements in patient safety and quality patient care.

Two studies assessed the effectiveness of the education on measurable patient outcomes (Fuhrmann et al., 2009; Theilen et al., 2013), while three investigated the impact upon the triggering arm of the RRS or clinician behaviour (Jones et al., 2006; Kinsman et al., 2012; Theilen et al., 2013). Fuhrmann et al. (2009) attempted to associate measurable patient outcomes to the educational intervention. The study was not able to show any positive effect on patient mortality at 30 or 180 days as a result of educational intervention, nor was it able to improve nurses' awareness of the deteriorating

patient. The authors pointed out that education alone did not alter patient outcomes when applied to a multi-faceted and complex organisation system such as a RSS (Fuhrmann et al., 2009).

Fuhrmann et al. (2009) also suggested that it would be important to re-evaluate the process and outcomes measured to include social behaviour and interaction. Measuring such outcomes was a common omission from the included studies. Social behaviour and organisational culture such as territorialism, professional resistance to change or hierarchy within the system have been described as potential barriers to the implementation of RRSs (Devita et al., 2006). The impact that social behaviour and organisational culture has upon the both arms of a RRS is not well understood but there is emerging evidence that these complex interpersonal relationships and organisational factors can affect the triggering of and response to physiological deterioration (Fein et al.; Massey et al., 2014). Given the complexity of these variables, it is not surprising that most studies did not include these in their design and outcome measures.

In addition to social behaviour and organisational culture, there are a number of other organisational factors (e.g. patient condition, workload, skill mix and time of day) that may affect the escalation of care that the deteriorating patient requires (DeVita and Hillman, 2006). Where real world complications such as these are requisite when conducting simulation-based educational interventions (Cheng et al., 2014), the inclusion of these experientially realistic factors into the training can present design challenges and outcome dilemmas. The benefits of including this level of experiential realism into the simulation need to be weighed against the potential disadvantages.

Augmenting simulated clinical situations with real world distractors can stimulate stress responses in intervention participants (DeMaria Jr et al., 2010). The participant exposed to this type of high fidelity experiential realism can be at risk of reactive responses that rely upon learned behaviour at the expense of higher level critical thinking. On the other hand, this level of realism can support higher-level decision making, improvisation and long term learning benefits (Dieckmann et al., 2007). In situ simulation is defined as simulation that takes place in the participants' actual clinical environment (e.g. the Emergency Department) and can help to overcome some of the challenges of incorporating the organisational culture and reality into the intervention (Miller et al., 2008). In situ simulation was implemented by two of the included studies (Harvey et al., 2014; Theilen et al., 2013).

While Fuhrmann et al. (2009) demonstrate the difficulties of improving measurable patient outcomes, Jones et al. (2006) demonstrate the difficulty of connecting the educational intervention to the effectiveness of these complex systems. The aim of their study was to determine the effect of a detailed education program on the rate of MET call activations three and a half years after its introduction. Though the aims were clearly described, how much the educational intervention directly influenced the MET activations remains unclear. This highlights the fragmentary nature of relying solely upon education to ensure that multifaceted organisational strategies are well implemented, evaluated and sustained.

Theilen et al. (2013) did record a trend towards reduced paediatric intensive care admissions and length of stay; and while the implementation of a paediatric MET (pMET) coincided with a decrease in patient mortality, their

study was not specifically designed to measure the effect of the education on this outcome. The study demonstrated the effectiveness of regular long-term in situ education to recognise and manage real world patient deterioration. In situ simulation is an educational strategy where the simulated scenarios take place in the environment that care is actually delivered. This is a highly appropriate learning strategy when interprofessional teams are required to communicate and manage complex system processes that are impacted by organisational culture and environmental barriers (Rosen et al., 2012). Theilen et al. (2013) were able to show that in situ simulation training can reduce the time taken to recognise deterioration, time to and frequency of escalation of care as well as the frequency of consultant review in a paediatric hospital. Harvey et al. (2014) was another (pilot) study to demonstrate the additional benefits to teamwork and confidence when in situ simulation was applied to nurses' ability to recognise and act upon early warning signs incorporating TeamSTEPPS® training (King et al., 2008).

Kinsman et al. (2012) also reported improvements in the quality of real world nursing practice from a 90 minute simulation (FIRST^{2}ACT). Their interrupted time series analysis demonstrated an increase in the frequency of vital signs and documentation in the 10 weeks post intervention. It is tempting to interpret this outcome as an overall improvement in the quality of observation. However, it more likely demonstrates improvements in one aspect of nursing practice and does not necessarily indicate an increase in the quality of observation. Theilen et al. (2013) and Kinsman et al. (2012) highlight the feasibility of translational research in education by demonstrating clear links between educational interventions, patient safety and quality of care.

Various educational models were employed across educational interventions. All interventions included traditional didactic classroom teaching. This traditional model was blended with combinations of paper-based scenarios without simulation, e-learning, case studies and simulation. Medium to high fidelity simulation was used in more than 87.5% of the educational interventions.

The use of simulation is an educational strategy that has been widely applied to traditional uniprofessional and interprofessional undergraduate preparation, postgraduate education and ongoing professional development (Crofts et al., 2006; Fuhrmann et al., 2009; Witt et al., 2010). The review showed that simulation improves overall techniques and skills while medium to high fidelity simulation had additional benefits over low fidelity simulation. Knowledge and skill retention over time was one of the most encouraging outcomes of the Crofts et al. (2007) high fidelity simulation intervention.

Debrief and reflective review of participant video recorded performance was highly rated in one third of the simulated studies. This is a critically important element of the simulation process that requires further research to ensure the best standards of education (Neill and Wotton, 2011).

Simulation is often viewed as expensive, resource intensive and time consuming to implement (Jansen et al., 2010). While the mean duration of the educational interventions was just over eight hours, one of the most educationally effective simulation program was completed in forty minutes. However, it is important to note that most simulation sessions were blended with other educational approaches, therefore the outcomes could not be

attributed to simulation alone. All participants in both studies by Croft et al. (Crofts et al., 2006; Crofts et al., 2007) were given equal, pre-simulation education preparation. This ensured participant standardisation before their exposure to the high and low-fidelity simulation. Sittner et al. (2009) was the only study that included an 18-25 minute medium fidelity simulation intervention without blending any other learning mode. The aim of their pilot study was to assess the impact of the Simulation Training for Enhancing Patient Safety (STEPS) program on nurses' knowledge and clinical judgement as well as the feasibility of this approach for a larger investigation. However, no significant improvements in knowledge were identified which may indicate the need for a blended curriculum to improve the effectiveness of education in recognising and managing deteriorating patients.

Teamwork and leadership development was also a highly valued feature of the simulation programs where debrief and reflective review were included. Despite the rapid response system's reliance upon complex interprofessional interaction, less than a third of the education programs used an interprofessional learning approach. As such, there is a need for further development and evaluation of interprofessional educational programs to improve the effectiveness of recognising and managing patient deterioration. Future research should also include studies that are designed to measure the impact of education on the quality of patient care. Attention should also be focussed upon measuring retention of skills and knowledge in the recognition and management of the deteriorating patient.

Limitations

The systematic review should be interpreted in the context of the following limitations. Other than a single randomised controlled trial (level I evidence), most of the studies were quasi-experimental, prospective, pre- post-intervention studies that provide level III evidence or below (Council, 2000). However, despite the need for level I evidence, the design of the randomised controlled trial (RCT) may not support the context level adaptation required of education. For example, different learners and settings can require the education program to be flexible to the participant's style of learning or their learning environment. Sample contamination is also a high risk when employing an RCT to an educational intervention. The prospect of preserving a true control group with students or staff who interact between sessions and during the study is an unknown variable that does not suit the rigor required of an RCT. Dividing formed group learning relationships could also be considered fragmentary to the learning dynamics of an established learner group.

Given that the majority (21) of the included studies reported positive impacts upon learner, patient and organisational system outcomes, the findings of the review are also at risk of publication bias (Higgins and Altman, 2008) and/or reporting bias (Sterne et al., 2008). There were, however, no studies excluded based upon the impact of the intervention on outcomes. Small participant sample size (M = 73) was also a limitation of the review. Finally, the use of indirect outcome measures (e.g. self-rated improvements in confidence) in some studies may not provide reliable statistical evidence regarding the efficacy of the intervention. However, the review provides educators who are designing education to support RRSs an appraisal of the evidence supporting

educational effectiveness in the recognition and management of the deteriorating patient and the outcome measures used to evaluate educational effectiveness.

Conclusion

The available evidence supporting educational program effectiveness in the recognition and management of the deteriorating patient indicates that simulation improves overall techniques and skills while medium to high fidelity simulation has additional benefits over low fidelity simulation. There is evidence that high fidelity simulation does require a large amount of time and has demonstrated effectiveness when delivered in brief sessions as short as 40 minutes and that regular in situ simulation has demonstrated sustained effectiveness in the real world implementation of rapid response systems.

The outcome measures used to evaluate educational effectiveness in the recognition and management of the deteriorating patient comprise of indirect (perceptions of knowledge, skills, technical performance and confidence levels) and objective measures (e.g. pre- post- intervention) of knowledge, skills and non-technical performance. The impact upon RRS's triggering (afferent), and response (efferent) arms are also outcome measures that are used to measure the effectiveness of education supporting these systems. Measurable patient outcomes such as patient mortality, ICU admission rates and patient length of stay have been used to measure the effectiveness of education but given the amount and complexity of uncontrolled variables these outcomes are difficult to equate with education alone. However, the quality of patient assessment and documentation of care can be used as an

outcome measure to evaluate educational effectiveness in the recognition and management of the deteriorating patient.

Conflicts of interest

None

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Table 1. Included Quantitative Study Details

Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Buckley & Gordon[45] (2011) University Australia	The effectiveness of high fidelity simulation on medical–surgical registered nurses' ability to recognise and respond to clinical emergencies	Follow up survey FRQ: Yes	To evaluate registered nurses' ability to respond to the deteriorating patient in clinical practice following training using immersive simulation and use of a high fidelity simulator.	I: 2 x 3 hour high fidelity simulation workshop and 14 hours of traditional classroom teaching. C: No comparison	50 post-graduate nursing students Convenience No	None No	Medium	Classroom teaching combined with immersive simulation improves nurses' perceived ability to respond to real world patient clinical emergencies.
Cooper et al.[44] (2013) Rural Hospital. Victoria Australia	Managing patient deterioration: assessing teamwork and individual performance	Prospective, quasi-experimental pre-test and post-test design FRQ: Yes	To assess the ability of rural Australian nurse teams to manage deteriorating patients.	I: A 2-hour session comprising 3 Objective structured clinical examination video-recorded high-fidelity scenario, C: No comparison	44 Registered nurses Convenience No	Participant invitation No	Low	Observed Skill Performance Mean score across three scenarios (AMI, Shock, COPD) was 54% (SD 10.04) Situational Awareness Team leader scores = 50% 'Physiological perception' of team leaders averaged 38%, 'global perception' 24% and level of 'comprehension' 42% Projection' of the situation was 74% Higher situational awareness scores were observed in younger aged participants. Higher situational awareness scores were associated with higher knowledge scores. Team Performance Mean Total score = 44% • Leadership subscale: 55% (4.4/8, SD 1.69) • Teamwork subscale: 58% (16.3/28, SD 4.52) • Task Management subscale: 54% (4.3/8, SD 1.34) Self rated confidence and competence were positively impacted

* FRQ – Focused Research Question, I – Intervention, C – Comparison, Y – Yes, N – No

Crofts et al.[43] (2006) Hospitals United Kingdom	Training for shoulder dystocia: A trial of simulation using low-fidelity and high-fidelity mannequins	Randomised comparative Prospective interventional study FRQ: Yes	To compare effectiveness of training with low and high fidelity mannequins for the management of shoulder dystocia.	I: 40- minute practical workshop on the management of shoulder dystocia C: High fidelity and low fidelity simulation training.	140 Midwives and doctors working in birth units. Purposeful Yes	Baseline Randomisation to one of four training arms (1-day hospital course, 2-day hospital course, 1-day sim centre course or a 2-day sim centre course). Yes	Low	Overall, at 3 weeks post intervention, there was a statistically significant increase in simulated successful deliveries - pre 42.9%, post 83.3% ($p<0.001$). Statistically significant increases in all basic skills ($p<0.002$). Training with high fidelity manikins was associated with increased likelihood of successful delivery compared with training with low fidelity manikin ($p<0.002$). Training with high fidelity manikins also associated with improved delivery ($p<0.004$). Improved chance of delivering of the posterior arm ($p<0.001$) and with less total force applied ($p<0.006$). Training improved communication scores ($p<0.001$).

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Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Crofts et al.[42] (2007) Hospitals United Kingdom	Management of shoulder dystocia: skill retention 6 and 12 months after training	Randomised comparative Prospective interventional study FRQ: Yes	To estimate the decay of skills at 6 and 12 months after structured training for shoulder dystocia.	I: 40- minute practical workshop on the management of shoulder dystocia C: 1. Pre-training group who could effectively delivery. 2. Trained group who learned to deliver from training. 3. Trained group who were unable to deliver pre or post training.	118 Midwives and doctors working in birth units. Purposeful Yes	Selection and allocation based on performance in previous study (Crofts et al., 2006). Yes	Low	A 40-minute dystocia training workshop resulted in a sustained improvement in performance and skill retention over a 12-month period. Successful delivery: 49% pre training, 84% at 6 months, and 85% at 12 months. No significant decline in delivery times, maximum force used and communication. 17% failed to deliver at 6 and 12% at 12 months. This was predominantly represented by group 2 (learned to deliver post training)

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Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Featherstone et al.[41] (2005) ALERT™ Courses United Kingdom	Impact of a one-day inter-professional course (ALERT™) on attitudes and confidence in managing critically ill adult patients	Pre and post quasi-experimental evaluation design. Single study group FRQ: Yes	To evaluate the impact of ALERT™ course on the confidence and attitudes of healthcare staff in relation to recognition and management of the acutely ill.	I: Theoretical Inter-professional One-day interactive seminar with practical patient-based scenarios, e-learning, reference manual and slide presentation C: Pre and post-testing	131 Health care workers: Doctors (n=43) Registered nurses (n=80) Physiotherapists (n=6) Other (n=2) Convenience Yes	None Yes	Medium	Significantly improved confidence in the recognition ($p < 0.01$) and management ($p<0.05$) of acutely ill patients. Improved recollection of simple life saving procedures ($p<0.01$). Self reported increase in knowledge ($p < 0.01$). Reduced anxiety ($p < 0.003$). Improved confidence in working as part of a team. Improved confidence in approaching senior staff for advice ($p=0.05$).
Fuhrmann et al.[40] (2009) Hospital Denmark	The effect of multi-professional education on the recognition and outcome of patients at risk on general wards.	A prospective quasi-experimental before-and-after study. FRQ: Yes	To evaluate the effect of multi-professional full-scale simulation-based education of staff on the mortality and staff awareness of patients at risk on general wards.	I: 1 day inter-professional educational program incorporating lectures, case presentations, skills training, simulations and debriefing C: Pre and post-testing	1563 patients (690 pre-test, 561 post-test) Convenience Yes	All patients present on two wards every evening between 16:00hrs and 21:30hrs pre and post educational intervention. Patients allocated to “normal” or “abnormal” vital signs groups. No	Medium	The education program did not increase nursing staff awareness of patients at risk, did not improve patient mortality over 30 to 180 days and did not decrease patient length of stay. Nurses’ awareness of deteriorating patient was 41% pre and 39% post-education ($p=0.8$) 30 day mortality was 11% pre and 11% post-education ($p=1.0$) 180 day mortality was 29% pre and 28% post-education ($p=1.0$) Length of stay was 15 pre and 13 post-test ($p=0.11$)
Gordon & Buckley[39] (2009) University Australia	The Effect of High-Fidelity Simulation Training on Medical-Surgical Graduate Nurses' Perceived Ability to Respond to Patient Clinical Emergencies	Descriptive pre and post survey FRQ: Yes	To identify the effects of simulation on participant confidence in responding to the technical and non-technical skills needed to manage patient deterioration. A secondary aim was to identify the aspects of simulation that participants found most useful to their learning.	I: 2 x 3 hour high fidelity simulation workshop and 14 hours of traditional classroom teaching. C: Pre and post-course evaluation	50 Undergraduate nursing students No	None No	Medium	Significant perceived performance enhancement was demonstrated: Recognition of unstable patient ($p=0.02$). Prioritising ($p <0.0001$). Performance of technical interventions ($p < 0.0001$) All non-technical skills improved ($p<0.0001$) No statistical significant change to call for help

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Harvey et al. [38] (2014) Hospital USA	Comparison of Two TeamSTEPPS® Training Methods on Nurse Failure-to-Rescue Performance	Quasi-experimental, two-group comparison, pre/post intervention study FRQ: Yes	To compare the impact of two types of evidence-based training methods (simulation-based training [SBT] vs. case study review, both incorporating Team- STEPPS® training, on Progressive Care Unit RN knowledge of early warning signs of patient deterioration, confidence, and teamwork and emergency clinical skills.	I: 2.5-hour didactic educational program, titled 'ACT NOW (Alert-Communicate-Treat-Nurses-Observing for-Warnings) and 60-minute simulation-based training (SBT) or case study review (CSR) session. C: educational outcomes from 60-minute simulation-based training (SBT) versus case study review (CSR) session.	39 Registered Nurses No	Simulation-based training (SBT) or case study review (CSR) incorporating TeamSTEPPS® training. Session participants allocated according to their care unit. No	Low	Increased knowledge and teamwork skills after education were seen in both groups ($p < .05$). The SBT group showed greater improvement in all areas except knowledge, with greatest positive impact demonstrated in SBT teamwork skills ($p < .05$).
Jones et al.[37] (2006) Hospital Australia	Effect of an education program on the utilisation of a medical emergency team in a teaching hospital	Prospective interventional study FRQ: Yes	To determine the effectiveness of an educational program on the utilisation of MET system	I: Lectures. Tutorial. Interactive focus groups. Grand round presentations. C: Pre and post-course evaluation	109,250 consecutive medical and surgical admissions Yes	Not applicable Not applicable	Medium	A detailed program of continuing education was associated with a significant increase in MET utilisation over 3.5 year period. ($p<0.0001$)

Table 1. Included Quantitative Study Details

Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Kelly et al.[36] (2013) University Australia	Empowering the registered nurses of tomorrow: Students' perspectives of a simulation experience for recognising and managing a deteriorating patient	Descriptive pre and post test FRQ: Yes	To determine the impact of a deteriorating patient simulation in increasing senior undergraduate nursing students' ability to recognise and respond appropriately; and to examine the impact of programme of study on students' responses and performance during the simulation.	I: 3 hour Simulation C: No comparison	57 Nursing students. Final year Bachelor of nursing students (3rd year students, 2nd year Enrolled Nurses (EN) and Graduate Entry (GE) students) No	None No	Low	Positive impact upon self rated knowledge, technical and non-technical skills and confidence.
Kinsman et al.[35] (2012) Rural hospital Australia	The FIRST2ACT simulation program improves nursing practice in a rural Australian hospital.	Interrupted time series analysis FRQ: Yes	To measure the impact of the Feedback Incorporating Review and Simulation Techniques to Act on Clinical Trends ($FIRST^2ACT$) simulation program on nursing observations and practice relevant to patient deterioration in a rural Australian hospital	I: Two high fidelity simulated patient deterioration scenarios conducted in a 90-minute session. C: No comparison (not applicable)	34 Registered nurses Medical Record audits Pre: 258 Post: 242 Yes	None Yes	Low	Improvements in the applicable • Frequency of observations (β 2 = -0.112, t = -3.57, d.f. = 7, P = 0.009) • And pain scoring (β 2 = -0.179, t = -4.585, d.f. = 7, P = 0.003) Improvements in the administration of oxygen were not statistically significant (P = 0.143)
Lewis[34] (2011) University United Kingdom	Learning the 'SMART' Way... Results from a Pilot Study Evaluating an Inter-professional Acute Care Study Day	Pre and post quasi-experimental evaluation design. FRQ: Yes	To evaluate and inter-professional education program. SMART® (Student Management of Acute illness Recognition and Treatment)	I: One day Inter-professional theoretical and medium fidelity scenario based education program. C: Pre and post-course evaluation	88 Students Third year student nurses (n=72) Fourth year medical students (n=16) Convenience No	None Yes	Medium	The results indicated an overall increase in self reported clinical knowledge, confidence and comfort with inter-professional teamwork.

Table 1. Included Quantitative Study Details

Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Liaw et al.[20] (2011) University Republic of Singapore	Rescuing A Patient In Deteriorating Situations (RAPIDS): A simulation-based educational program on recognising, responding and reporting of physiological signs of deterioration	A prospective Randomised Controlled Trial with a pre- and post-test design. FRQ: Yes	To describe the development, implementation and evaluation of an undergraduate nursing simulation program for developing nursing students' competency in assessing, managing and reporting of patients with physiological deterioration.	I: 4 simulation scenarios in a 6 hour education session C: Non-trained group	31 Nursing students Randomised Yes	Intervention group (N=15) randomly assigned. Control group (N=16) assigned using fish bowl method????? Yes	Low	Improved recognition, management and reporting of patient deterioration. Reported course satisfaction and confidence in clinical application. Clinical performance improved (p<0.0001). Higher post-test reportage of deterioration (p<0.0001). Participants report satisfaction and increased self-confidence. There were no comparison results here with the non-trained group.
Liaw et al.[33] (2013) University Republic of Singapore	An interprofessional communication training using simulation to enhance safe care for a deteriorating patient	Prospective, quasi-experimental pre-test and post-test design Exploratory descriptive study was used to evaluate the students' satisfaction on the simulation learning. FRQ: Yes	1. To evaluate the outcomes of the Sim-IPE program on the students' confidence level in communicating about patient deterioration and perceptions towards interprofessional learning. 2. To evaluate student satisfaction with the simulation learning	I: 3 hour HF simulation based interprofessional session C: Pre and post-course evaluation	127 Pre-registration medical (4th year) and nursing (3rd year) students. Purposeful No	None Yes	Low	Self-rated confidence was positively impacted – Medical (M 7.18 (SD 5.17)), Nursing (M 6.37 (SD 4.99)) Participant perception was positively impacted – Medical (M 4.88 (SD 4.04)), Nursing (M 4.33 (SD 3.58)). Satisfaction with simulation learning was high Likert scale (1-5) Mean 4.46 (SD 0.37)
Lindsey & Jenkins[32] (2013) University USA	Nursing Students' Clinical Judgment Regarding Rapid Response: The Influence of a Clinical Simulation Education Intervention	Prospective, quasi-experimental pre and post-test design FRQ: Yes	To examine the impact of an educational intervention on student nurses' clinical judgment regarding the management of patients experiencing rapid clinical deterioration.	I: 1 day mixed mode lecture as well as simulated scenarios of patient deterioration. C: Non-trained group	79 nursing students Randomised Yes	Randomised intervention group No	Low	Overall greater positive impact on knowledge scores found in the intervention group (M = 90.91, SD = 8.73) over the control group (M = 64.80, SD = 19.69), t(77) = 7.65, (p<0.001)

Table 1. Included Quantitative Study Details

Author, year and setting	Title	Design Focused Research Question (FRQ*) (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Ludikhuize, de Jonge & Goossens[31] (2011) Hospital The Netherlands	Measuring adherence among nurses one year after training in applying the Modified Early Warning Score and Situation-Background-Assessment-Recommendation instruments	Quasi-experimental prospective comparison study. FRQ: Yes	To evaluate whether nurses trained in the use of MEWS and SBAR tools were more likely to recognise a deteriorating patient.	I: 1 hour interactive MEWS and SBAR training session enhanced with posters, feedback and face-to-face conversations. C: Non-trained group	95 Registered nurses Convenience Yes	None Yes	Medium	The trained nurses identified the deteriorating patient more frequently than non-trained nurses (p=0.026). Improved notification to the physician of patient deterioration (p=0.037) There was no significant Improvement in the trained group's implementation of SBAR and MEWS tools.
Sittner et al.[30] (2009) Hospital USA	Rapid Response Team Simulated Training for Enhancing Patient Safety (STEPS)	Prospective, quasi-experimental pre and post-test design FRQ: Yes	1. To assess the impact of the educational intervention on knowledge and clinical judgement. 2. To evaluate the protocol used in the study and it's feasibility in application to a larger study.	I: High fidelity Simulation and feedback (unknown length) C: Pre and post-course evaluation.	11 Registered nurses. Convenience. No.	All participants were enrolled through invitation Yes	Low	Statistically no significant positive impact on knowledge and knowledge retention over a 3-month period. Perception of and satisfaction with simulation was rated high to very high across all subscales measured.
Smith & Poplett[29] (2004) Hospitals United Kingdom	Impact of attending a 1-day multi-professional course (ALERT™) on the knowledge of acute care in trainee doctors	Quasi-experimental prospective comparison study. FRQ: Yes	To determine if and how the ALERT™ course had influenced the knowledge of acute care in trainees.	I: Theoretical Inter-professional One-day interactive seminar. The seminar was built around practical patient-based scenarios, e-learning, reference manual and slide presentation. C: Non-trained group.	118 Doctors (Senior House Officers). Convenience. No	36 ALERT™ trainees (post-test). 82 non-ALERT™ group (pre-test). No	Medium	Doctors knowledge of acute care can be improved by attending courses such as ALERT™ (p<0.05)

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Straka et al.[28] (2012)	The impact of education and simulation on pediatric novice nurses' response and recognition to deteriorating.	Pilot Quasi-experimental prospective comparison study. FRQ: Yes	To determine if the use of high-fidelity simulation with novice paediatric nurses influences their knowledge of deterioration symptoms and potentially affects adverse events on the inpatient units.	I: Lecture based learning, skill stations and simulated patient deterioration. C: Pre and post-course evaluation.	26 Registered nurses. Convenience No	None No	Low	Positive effect on knowledge. Pre- (71.15%) and post-(87.69%) test scores (p <.0001).
Theilen et al.[27] (2013) Hospital United Kingdom	Regular in situ simulation training of paediatric medical emergency team improves hospital response to deteriorating patients	Prospective cohort study. FRQ: Yes	To evaluate the impact of regular team training on the hospital response to deteriorating in-patients and subsequent patient outcome.	I: Ongoing weekly 2-hour medium fidelity in-situ simulation. C: Pre and post-course evaluation	7854 hospital admissions pre- and 8652 hospital admissions post- Purposeful. Yes.	None. No.	Low	Pre- and Post- Reduced Time to recognition of deterioration (pMET: median time reduced from 4 to 1.5 hours, p < 0.001), Increase in rate of consultant review (45%/76%, p = 0.004) Transfer rate to HDU increased (18%/37%, p = 0.021). Reduced Time to escalation of care to PICU (median time reduced from 10.5 to 1.5 hours p = 0.024) Trend toward reduced PICU admissions, patients were less sick at time of PICU admission and reduced PICU mortality. Hospital mortality reduced 31/7854 to 11/8652 (p < 0 001). This coincided with the implementation of the pMET and was not attributed to the education.

Table 2. Included Qualitative Study Details

Author, year and setting	Title	Design Focused Research Question (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Unsworth, McKeever & Kelleher[48] (2012) University {Unsworth, 2012 #956}United {Unsworth, 2012 #956}Kingdom	Recognition of physical deterioration in patients with mental health problems: the role of simulation in knowledge and skill development	Exploratory descriptive. FRQ: Yes	To develop simulation scenarios and to assist mental health nursing students to recognize and appropriately manage physical deterioration in patients with mental health problems. The specific objectives of the project were to: • introduce mental health nursing students to simulation using whole-patient mannequins; • develop the skills and knowledge of mental health nursing students regarding the identification and appropriate management of the deteriorating patient; • develop intermediate fidelity simulation scenarios which address those clinical circumstances where rapid physical deterioration may occur; • evaluate the use of intermediate fidelity simulation scenarios as an approach to developing the skills and knowledge of mental health nursing student to manage physical deterioration.	I: Medium fidelity simulation C: No comparison	15 Registered mental health nursing students Convenience No	None Yes	Low	Identified positive effects upon participants in four (4) learning domains as a result of the education intervention: 1. "Bridging the gap" between the need to develop skills in recognising and managing deterioration 2. Learning interprofessionally (student nurses and student mental health nurses) 3. Authenticity 4. Reflective learning

Table 3. Included mixed methods Study Details

Author, year and setting	Title	Design Focused Research Question (Y/N)	Aim	Intervention (I) Comparison (C)	Participants Sample method Power calculation (Y/N)	Selection and allocation Validation of instrument (Y/N)	Bias risk	Outcome
Hart et al.[47] (2014) University USA	Effectiveness of a structured curriculum focused on recognition and response to acute patient deterioration in an undergraduate Baccalaureate of Science in Nursing (BSN) program	Quantitative research was quasi-experimental. Qualitative research was descriptive. FRQ: Yes	1. Quantitative: To determine the effect of a structured education curriculum on under-graduate BSN students' levels of self-confidence, knowledge, perceptions of teamwork in acute patient deterioration situations. 2. Qualitative: To explore and describe the decision-making processes of students' in recognizing and responding to patient deterioration.	I: 45-hour program structured into four components: 1) didactic lectures, 2) skill labs, 3) medium-fidelity simulations as well as three high-fidelity simulations, and 4) facilitator-led guided reflection sessions (GRS). C: No comparison	48 Nursing students Convenience No	None Yes	Medium.	Quantitative: Significant positive effect upon self rated confidence ($F(2,92) = 292.99$, $p<.001$) Significant positive effect upon knowledge ($F(2,92) = 236.99$, $p<.001$) Significant positive effect upon perceived teamwork performance (TEAM scores) ($F(1.46,65.85) = 122.27$, $p<.001$) Qualitative: 7 categories emerged from the qualitative data analysis. These included sources of knowledge, knowledge as a person, knowledge as a group, reasoning under pressure, feelings, real person versus simulation, and values. There was an overall positive effect upon these categories midway and following the intervention.
Wehbe-Janek et al.[46] (2012) Hospital USA	Nurses' perceptions of simulation-based inter-professional training program for rapid response and code blue events	Mixed methods descriptive exploratory design using interpretive and iterative processes while the frequency of thematic emergence was quantified. FRQ: No	1. To examine the perspectives of hospital unit nurses who may be called on to perform in rapid response teams. 2. To examine nurses' perspectives of the value of simulation-based training for rapid response scenarios. 3. To implement a program evaluation for a simulation-based multidisciplinary training program.	I: 3 hour team simulation training once per week over 3 weeks. Simulation training was augmented with didactic, online and staff meeting training. C: No comparison.	203 Registered nurses and licensed vocational nurses Convenience No	None No	Medium	Results indicated satisfaction with the course and minimal effect upon knowledge, skills, and confidence. The relevance of the program to patient outcomes was reported by only 2.7% of the sample. Self reported increased knowledge (9.9%) Self reported increased confidence and comfort (7.1%) Reported improvement to patient outcomes (2.7%)