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The educational impact of web-based and face-to-face patient deterioration simulation programs: An interventional trial

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ABSTRACT

Background: There are international concerns relating to the management of patient deterioration. The "failure to rescue" literature identifies that nursing staff miss cues of deterioration and often fail to call for assistance. Simulation-based educational approaches may improve nurses' recognition and management of patient deterioration.

Objectives: To investigate the educational impact of the First2Act web-based (WB) and face-to-face (F2F) simulation programs.

Design & Setting: A mixed methods interventional cohort trial with nursing staff from four Australian hospitals.

Participants: Nursing staff working in four public and private hospital medical wards in the State of Victoria.

Methods: In 2016, ward nursing staff ($n = 74$) from a public and private hospital completed three F2F laboratory-based team simulations with a patient actor in teams of three. 56 nursing staff from another public and private hospital individually completed a three-scenario WB simulation program (First2ActWeb) [A 91% participation rate]. Validated tools were used to measure knowledge (multi-choice questionnaire), competence (check-list of actions) and confidence (self-rated) before and after the intervention.

Results: Both WB and F2F participants' knowledge, competence and confidence increased significantly after training ($p \leq 0.001$). Skill performance for the WB group increased significantly from 61% to 74% ($p \leq 0.05$) and correlated significantly with post-test knowledge ($p = 0.014$). No change was seen in the F2F groups' performance scores. Course evaluations were positive with median ratings of 4/5 (WB) and 5/5 (F2F). The F2F program received significantly more positive evaluations than the WB program ($p < 0.05$), particularly with regard to quality of feedback.

Conclusion: WB and F2F simulation are effective education strategies with both programs demonstrating positive learning outcomes. WB programs increase ease of access to training whilst F2F enable the development of tactile hands on skills and teamwork. A combined blended learning education strategy is recommended to enhance competence and patient safety.

1. Introduction

Hospitalised patients with complex health issues are vulnerable to rapid physiological deterioration (Buykx et al., 2012; Liaw et al., 2016). Nurses working in general wards tend to be the key primary responders (Cooper et al., 2011; Bogossian et al., 2014; Liaw et al., 2016) and the first line of management for hemodynamically unstable patients. However, early identification, appropriate management and applicable

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Fig. 1. Screen shot of First2ActWeb depicting action buttons and patient actor.

help-seeking behaviour continues to be of concern in the "failure to rescue" literature (Cooper et al., 2013; Waldie et al., 2016). Interventions are frequently delayed resulting in suboptimal care (Quirke et al., 2011; Kitto et al., 2015), and missed indicators of deterioration have also been noted (Endacott and Westley, 2006). Further evidence indicates that nurses are not always clear about when to call for assistance do not seek advice and fail to appreciate clinical urgency (Odell et al., 2009). With nearly 43 million adverse events occurring globally (Jha et al., 2013), early recognition and response to clinical deterioration is vital to optimise health outcomes (Australian Commission on Safety and Quality in Health Care, 2012a; Jones et al., 2013). These factors have led to a growing emphasis on the early identification and response to deteriorating patients, particularly with the more recent inclusion of consumers in call activation (Chung et al., 2016; Vorwerk and King, 2016).

Simulation based education programs have a significant impact on the recognition and management of clinical deterioration, particularly by nurses (Connell et al., 2016; Massey et al., 2016). Simulation enables safe practice in realistic situations with either simulated patients (actors), high fidelity computerized human simulators, or training mannequins (Cooper et al., 2012; Bucknall et al., 2016). Effective simulation programs do enhance skills and knowledge and significantly increase confidence (Buykx et al., 2012; Cooper et al., 2012; Liaw et al., 2012).

Screen based (or web based) simulation is an emerging form which is being embraced by health professionals for student and staff development (Kononowicz et al., 2014) with demonstrable improvement in practice (Liaw et al., 2016). Multi-media applications such as animations, video, graphics, text, vision and sound are used for simulated learner interactions, including goal-based role plays that use digital simulations (Cant and Cooper, 2014). The aim of such programs is to engage the learner in life-like clinical scenarios and to provide immediate feedback on performance (Durmaz et al., 2012; Cant and Cooper, 2015). Although screen based simulations are an emerging field there are known benefits including enhanced clinical practice (Liaw et al., 2012), better technical skills (Cook et al., 2012) and improved nontechnical (teamwork) skills (Rogers et al., 2012).

This study aims to address patient safety in relation to first responders' 'failure to rescue' deteriorating patients, with a focus on enhancing the assessment and management of clinical deterioration. Over the last seven years we have developed a face-to-face and a web based educational program known as FIRST^{2}ACT (*Web*) http://first2actweb.com/. This has had a positive impact on educational outcomes (Buykx et al., 2012), and in a preliminary study, a significant impact on clinical performance (Kinsman et al., 2012).

The overall objectives of the current study were to measure the educational impact of these face-to-face (F2F) and web-based (WB) simulation programs in the education of qualified nurses, and second, to compare cost-effectiveness and clinical impact. The full protocol for this study is registered at: https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=370425 (ACTRN12616000468426) and is available as Cooper et al. (2016). In this paper we report on the educational impact. Later papers and the final report (Cooper et al., 2017) will identify the economic and clinical outcomes.

2. Methods

2.1. Design/Methods

The design is a mixed methods interventional cohort trial. The research objective was to identify the educational impact of the WB and F2F simulation programs. The programs, though similar, use a different form of delivery and are in themselves not directly comparable. As such, the intention was to measure the impact of the two programs rather than compare the programs per se.

2.2. The Interventions

Over the last seven years some of the authors of this paper (SC, RC, LK) developed F2F and WB versions of the program known as FIRST2ACT (Feedback Incorporating Review and Simulation Techniques to Act on Clinical Trends). Both approaches and the measurements used have been widely evaluated and validated (e.g. Sparkes et al., 2016; Bogossian et al., 2014, 2015; Cooper et al., 2015; Endacott et al., 2014).

The web-hosted 'e-simulation' (screen based) version includes a range of pre- and post-course assessment and educational materials and three interactive scenarios (cardiac, shock and respiratory cases) which run over 8 min. A patient actor depicts a deteriorating patient who significantly deteriorates at the four-minute mark. Individual participants are required to 'click' on various actions – such as taking vital signs, inserting an IV line, recording an ECG or selecting a form of oxygen therapy – resulting in pop up videos of each action (Fig. 1). Detailed feedback on performance is provided at the end of each scenario and at the end of the program. In this study staff completed the program in their own time or were released from ward duties.

The F2F version mirrors the content of the WB program. Set in a clinical lab, it includes the same three scenarios which are also

Table 1
Program content for each intervention.

	First²Act Web (WB)	First²Act Face-to-face (F2F)
Introductory preamble	Short written introduction with explanation.	Short verbal introduction with explanation.
Demographics and pre-course MCQ	A demographics form and an 11 item multiple choice questionnaire (MCQ).	As in web-based.
Background material	An animated slide show – with voice over from an educator. A variety of styles include pop up illustrations, video links, clear transitions and summaries.	As in web-based.
Scenarios (skills)	Three interactive web-based scenarios (8 min each) Each scenario filmed using patient actors trained to simulate symptoms of deterioration and incorporating applicable moulage (e.g. cyanosis). At the mid-point of each scenario the 'patient' declines significantly. The technology support a variety of actions to be performed in real time, including pop up videos of vital sign recordings, drug administration, oxygen delivery, and bed position. Performance rated on line based on pre-determined criteria.	Three interactive scenarios (8 min each) conducted in a clinical skills centre using patient actors and video-recorded to enable participant review. At the mid-point of each scenario the patient deteriorates significantly. Performance rated by two researchers at the end of each scenario – using predetermined criteria/check lists (an OSCE format).
Feedback	The software gathered all performance data for automatized feedback at the end of each scenario.	Face-to-face feedback conducted with an educator using video and performance records.
Post-course MCQ	Repeat of the MCQ.	As in web-based.
Course evaluation	A course evaluation and reflective review of educational impact	As in web-based.
Certification	Download a course participation certificate	Issued with a course participation certificate.
Course manual	Download the course manual for reflection and review	Issued with the course manual for reflection and review
Time commitment	1 to 1.5 h	2 h

portrayed by a patient actor. Those who facilitated the scenarios (including the patient actor) were nurse academics with expertise in simulation education. Table 1 lists the detailed stages of both programs.

2.3. Population/Setting

All registered (RN) and enrolled nurses (EN) from a medical ward in four regional hospitals across the State of Victoria, Australia, were invited to participate. Two medical wards (one private, one public hospital) were assigned for WB trainees and two medical wards (again one private and one public hospital) were assigned for F2F trainees. This approach ensured that there was no contamination between homogeneous participant groups. We anticipated around 83% participation, as in a prior study (Kinsman et al., 2012).

2.4. Intervention Measures

2.4.1. Knowledge

A validated 12 item Multiple Choice Questionnaire [MCQ] (Cooper et al., 2010; Endacott et al., 2010) was completed by participants before and after the programs to measure patient deterioration management knowledge.

2.4.2. Skills

All participants completed the three simulation exercises in either the interactive WB or F2F versions. Each scenario was designed to mirror commonly occurring acute presentations (AMI, hypovolaemia, COPD). During each simulation, information was presented to clearly reflect the real world requiring participants to search actively for information (Patel and Groen, 1986). This approach enabled participants to develop their critical thinking in a more dynamic manner and thereby enhanced the ecological validity of the simulation (Cioffi, 2001). The degree of information provided and therefore the levels of uncertainty was varied within and between scenarios in order to match the dynamic and changing situations encountered in clinical emergencies (Cosier and Dalton, 1988).

2.4.3. Program Evaluations

Each program was evaluated by participants on completion using a mix of rating scales and open ended comment options.

2.5. Data Analysis

Electronic data were downloaded from the WB program website and were combined with the uploaded F2F data. Analysis was conducted using IBM-SPSS version 22 (IBM SPSS V22, 2013). Descriptive and inferential statistics were used to analyse participant demographics, knowledge, and simulation skill performance. The relationship between paired knowledge data was explored using Paired Samples *t*-test and similarly, for ranked evaluation data (e.g., competence, confidence). Wilcoxon Signed Ranks test, Independent samples *t*-test and ANOVA with post-hoc tests were used to test differences in performance scores. The Kruskal Wallis Test was used with dichotomous variables and Spearman's correlation co-efficients were computed. The magnitude of the effect was interpreted using Cohen's recommendations (*r* effects: small ≥ 0.10, medium ≥ 0.30, large ≥ 0.50) (Cohen, 1988).

3. Ethical Approval

Ethical approval was gained from the ethics committees at each of the hospital sites and from (anonymized) (15414L).Approval required consent and voluntary participation in the research components of the program.

4. Results

All participants completed their respective program in a five-month period between February and June 2016. Results for each group follow and are described separately.

4.1. Web Based Program Participants

Fifty-six (56) nurses from two hospital medical wards individually completed the WB program. Some participant data were missed owing to an electronic collection error, however no substitutions were made. All but one participant was female, with ages ranging from 21 to 62 years (mean 40, SD 11.9). Most spoke English at home 47/52 (90%) and regarding their qualifications, 18/50 (36%) were hospital trained, 28/50 (56%) had a Bachelor's degree in nursing, and 4/50 (8%) held a post-graduate qualification. Clinical practice experience ranged from 1 to 43 years (mean 15.2, SD 12.4) mostly in the acute medical field.

The median time taken to complete the program was 86 min (range 23–382 min), however one-fifth of participants completed in < 45 mins. There was a significant positive correlation between age and the

length of time it took to complete ($r = 0.36, p = 0.012$). In other words, older nurses spent longer on the program.

4.2. Knowledge Development

Participants completed the MCQ before and after the program with knowledge improving significantly (pre-test M = 7.56, SD 1.7; post-test M = 8.93, SD 1.7; $t\ (n = 43) = -5.990$, $p \leq 0.001$) and with medium effect size ($r = 0.37$). Eight of 12 knowledge items were significantly improved at post-test, in particular a marked change in an item that asked 'which are the six essential actions in the initial treatment of a deteriorating patient?' Bachelor-qualified nurses' knowledge improved most (pre 7.59 SD 1.65; post 9.00 SD 1.29; z ($n = 22$) = −3.671, p ≤ 0.001).

There was no correlation between participants' age and knowledge scores, however years of work experience was negatively correlated with post-test knowledge scores ($r = -0.38$, $p = 0.03$).

4.3. Skills Development

Participants completed the three screen-based scenarios with notable increases in scores between scenarios 1–2, 2–3, and 1–3 (ANOVA, $p \leq 0.05$). Performances improved from 61% in the first scenario to 74% in the third scenario (Table 2).

There was no significant correlation between participants' performance scores and length of experience, age, or qualification. However, performance scores were significantly correlated with post-test knowledge scores ($r = 0.37$, $p = 0.014$) with higher scores associated with higher knowledge levels.

4.4. Participant Program Evaluation

Seven evaluation questions asked about the relevancy, applicability and level of challenge. Participant evaluations were positive with an overall median rating of four from a possible five points with the program seen as appropriate, relevant, and stimulating. For example, the program 'Was challenging without being threatening' (M = 4.26) and "Provided effective feedback" (M = 4.23).

Participants' open-ended comments were generally positive with some suggestions for improvement. Issues raised related to software limitations – not being able to do more than one task at the same time, and no notable improvement in the patient's condition despite actions taken.

'*In a clinical situation, I would normally be asking the patient their past history and how they were generally feeling while I was taking their vital signs. It felt like time was ticking away while I slowly did one action at a time.*'

'*It was hard to know if the tasks I chose for management were effective until the end of each scenario.*'

'*This program is very helpful in improving the knowledge on what actions to do on deteriorating patients. It improves critical thinking, management and teamwork within the multidisciplinary team.*'

Table 2
Scenario performance scores in screen based program.

	1. Cardiac scenario	2. Shock scenario	3. Respiratory scenario
Mean score	18.33, SD 4.30	19.15, SD 4.44	22.31, SD 3.24
Median score	18.00	20.00	22.00
Range	2–29	7–28	15–28
Maximum possible score	30	28	30
Mean score	61.1%	69.6%	74.4%

Before and after the program participants self-rated their abilities to recognise a deteriorating patient, to manage emergencies, and levels of confidence and competence. All ratings increased significantly ($p \leq 0.001$) with, for example overall confidence increased (pre 2.96, SD 0.84; post 3.55, SD 0.68; z − 3.938. p ≤ 0.001) and with a medium effect size ($r = 0.37$).

Confidence ratings were also significantly correlated with years of working experience ($r = 0.49$, $p = 0.001$) and with skill performance scores ($r = 0.50$, p ≤ 0.001). Competence ratings were also correlated with years working in healthcare (pre $r = 0.42$, $p = 0.008$) and with skills performance scores ($r = 0.46$, $p = 0.020$).

4.5. Face-to-face Program Participants

Seventy-four (74) nurses from two hospital medical wards participated in teams of three in a clinical skills laboratory. The majority were female 69/74 (93%) with age ranging from 22 to 65 years (mean 37, SD 12.6). Most spoke English at home 59/68 (87%) and 23/74 (31%) were hospital trained; over half 47/74 (63%) had a Bachelor's degree in nursing, and 6/74 (8%) held a post-graduate qualification. Clinical practice experience ranged from 0 to 48 years (mean 12 SD 12.2) mostly in a medical or surgical field.

4.6. Knowledge Development

Participants completed the MCQ before and after the program with knowledge improving significantly (pre-test M = 7.4, SD 1.6; post-test 8.1, SD 1.6; $t\ (n = 74) = -3.991$, $p \leq 0.001$) but with a small effect size ($r = 0.21$). Six of 12 knowledge items were significantly improved at post-test, in particular a marked change in an item that asked 'which are the six essential actions in the initial treatment of a deteriorating patient?'

4.7. Skills Development

There was no significant improvement in performance scores for the teams of nurses who completed scenarios 1 (a mean score of 65.6%), scenario 2 (64.1%), or scenario 3 (65.8%).

4.8. Participant Program Evaluation

A set of seven evaluation questions were asked relating to the relevancy, applicability, level of challenge. Participant evaluations were positive with an overall median rating of 5 from a possible five points (and a mean of 32.1/35) - with the program seen as appropriate, relevant, and stimulating. For example, the program 'Encouraged me to think through a clinical problem' (M = 4.69) and 'Provided effective feedback' (M = 4.69). Participants' open-ended comments were positive:

"*I learnt how to work through situations as a team and build confidence to care for patient before MET team arrives.*"

"*Loved it! Oxygenation is vital and going back to nursing fundamentals is also important.*"

"*I found the verbal feedback very helpful, thank you.*"

Before and after the program participants self-rated their abilities to recognise a deteriorating patient, to manage emergencies, and their levels of confidence and competence. All ratings increased significantly ($p \leq 0.001$) with, for example overall confidence increasing (M = pre 2.81, SD 0.79; post 3.55, SD 0.77; z = −6.022. p ≤ 0.001) with a medium effect size ($r = 0.43$). There were no significant correlations with other variables such as age, length of experience, knowledge, or performance.

4.9. Overall Educational Program Outcome

4.9.1. Knowledge

Objective measures of knowledge were reported in each cohort showing that both programs improved participants' knowledge. When the increment was examined by cohort, a non-significant difference was found between groups, with the conclusion that both educational modalities were equally able to improve participants' knowledge.

4.9.2. Post-program Evaluation

The post-program evaluation ratings showed that the F2F program received significantly higher ratings overall on quality than the WB program ($p \leq 0.05$). Six of seven question items were rated significantly higher. For example F2F participants rated "provision of effective feedback" (M = 4.62) significantly higher than those in the WB program (M = 4.15) ($p = 0.005$). This pattern continued with the F2F program being 'appropriate to my level of training' ($p = 0.021$) 'challenging but not threatening' ($p = 0.001$); 'enabling me to integrate theory' (p = 0.005); 'stimulated my interest' ($p = 0.017$) and 'encouraged me to think through a clinical problem. (p = 0.001). It was noted that there was no difference between training modalities in regard to post-program ratings of recognizing or managing a deteriorating patient, nor confidence or competence levels.

5. Discussion

Patient safety is a contemporary international issue, with a specific focus in Australia relating to healthcare professionals' ability to recognise and respond to 'Clinical Deterioration in Acute Health Care' (ACSQHC, 2012a, 2012b). Simulation based education approaches are now integral to nursing education although web-based simulation is a contemporary approach with fewer evaluation studies (Cant & Cooper., 2010, 2014). This research contributes to the growing body of knowledge that simulation based education is an effective strategy in the development of clinical knowledge and the skills required to address patient safety concerns.

5.1. Knowledge Acquisition

Evidence indicates that simulation is a valid learning and teaching strategy (Cant and Cooper, 2015; Bogossian et al., 2015; Cant and Cooper, 2014; Cook et al., 2012). In this research, we were able to report positive learning outcomes for qualified nurses who participated in either the F2F or WB simulation programs. Similar significant gains were reported in previous studies (Bogossian et al., 2015; Cant and Cooper, 2010, 2014; Stroup, 2014) who identified that high fidelity simulation can benefit knowledge acquisition, skills development and critical thinking in nursing education.

Our study also found that initial knowledge scores for those who completed the F2F program was significantly negatively correlated with nurses' age and years of working experience, suggesting younger nurses achieved higher knowledge scores, as did less experienced nurses. This pattern was repeated post-program showing a small negative correlation between knowledge scores and years of experience and also in the web-based program, suggesting the intervention had a greater impact on less experienced nurses.

Worldwide, simulation-based education has become commonplace within undergraduate and post graduate nursing curricula (Buckley and Gordon, 2011) and the 'Net Generation' are digitally literate and well connected, are experiential visual and kinaesthetic learners, and social and prolific communicators, who learn well in teams and crave interactivity (Bogossian et al., 2015). Thus, simulation engages learners, especially those in the younger age brackets.

5.2. Skill Development

Simulation-based education, when compared with more traditional teaching strategies, is associated with superior outcomes (Cook et al., 2012). We found differences in participants' skill development across different modes of teaching. While nurses who worked in a team of three F2F had no significant improvement in performance scores across three scenarios, those who individually completed three WB scenarios did have performance increases. This may be due to the different training approaches used – the F2F scenarios being managed in teams of three rotating the leader and the WB approach being an individual screen based activity. As previous studies have identified, although web-based simulation programs may not be considered tactile, they do have a significant impact on the learning of the fundamentals of nursing (Cooper et al., 2015; Moreno-Ger et al., 2010). Computer-based simulation also provides an interactive, safe test environment which can be accessed at any time without requiring specialised equipment (Moreno-Ger et al., 2010) and can include gaming elements that engage participants and enhance their motivation to learn (Moreno-Ger et al., 2010).

5.3. Debrief and Feedback

Following best practice in simulation (Decker et al., 2013) both programs aimed to provide feedback to participants, with the F2F program offering a formal clinician-led group debrief assisted by video review (Bogossian et al., 2014). Post program evaluation ratings showed that the F2F program received higher ratings on quality and 'provision of effective feedback' than the WB program. This aligns with results by Buckley and Gordon (2011) who found that medical-surgical graduate nurses rated debriefing as the most useful aspect of high fidelity simulation in enhancing their responses to patient emergencies. Shute (2007) concurs stating that the quality of feedback provided to a learner about their performance not only assists in knowledge and skill development but can motivate further learning and influence participants' experience. Buykx et al. (2012) also suggests that self-assessment is more likely to be accurate and positive if conducted via open-ended video-review of a clinical encounter.

We conclude that the First2Act F2F version and the First2Act Web version both provide a pedagogical response to the challenges of improving nurses' response to recognition and escalation of care of the deteriorating patient. Our results suggest that both simulation programs can assist in supporting organisation-wide efforts to improve recognition and response systems for deteriorating patients.

5.4. Study Limitations

Recruitment of nurses for training was, of necessity, based on convenience, and may not have been representative of all nursing staff on each ward. We assert, however, that the sample of 91% was adequate to reflect a broad range of performance. While it was clear from our results that there were benefits to learning in both approaches, the magnitude of effect was small and impact may have been limited by the short time frame of the training programs 1.5–2 h. For nursing staff who completed the web-based program, some minor electronic data collection errors illustrate the hazards of this approach. Further, while we can report a trend in knowledge and skill gain, we are unable to substantively comment on retention. A longitudinal study is recommended to ascertain any longer terms benefits of training.

6. Conclusion

As this study demonstrates, simulation-based education provides health professionals with access to case-based scenarios that address international standards for patient safety. Nurses placed high value on both the face-to-face simulation and the web based e-simulation

programs, demonstrating improvements in knowledge, competence, and confidence and endorsing the quality of both programs. This study provides evidence that both the FIRST2ACT face-to-face version and FIRST2ACTWeb provide a pedagogical response to the challenge of managing a deteriorating patient. We recommend the use of a blended learning approaches for future staff training, with web-based simulations as preparation for face-to-face simulation, which will also enhance teambuilding. Further longitudinal research is needed to determine the ideal frequency of training for knowledge and skill retention in this important clinical domain.

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