BEME Systematic Review Protocol

TITLE OF REVIEW

A systematic review of interventions designed to teach medical students and residents early recognition and/or prompt escalation in acute clinical deterioration

NAME OF LEAD REVIEWER

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1. COVER SHEET

Abstract

The care of acutely unwell patients requires prompt recognition of deteriorating clinical situations and appropriate management. Medical schools teach 'life saving' skills through high-fidelity simulations and part-task training along with bedside teaching and lectures. However, hospital adverse events data have shown that there are challenges. These stem from difficulties faced by healthcare teams in identifying patterns of deteriorating clinical situations (situated cognition) and the resultant delays in 'pattern recognition' and 'prompt escalation'.

This BEME systematic review is aimed at appraising literature on the teaching interventions for medical students and postgraduates aimed to achieve early recognition and prompt escalation of deteriorating patients. The review focuses on existing teaching interventions on the effectiveness of these interventions in minimizing the morbidity and scale of the preventable events.

Team members

1. **Dr Ashokka Balakrishnan MBBS MD FANZCA MHPE** is an anaesthesiologist, medical educationalist and high-end simulation based educator for undergraduate & postgraduate education and multi-disciplinary team-basedtraining. He facilitates simulation support for strategic prevention of untoward outcomes movement of the National University Hospital, Singapore. This has led to this study, where hospital wide policies are being implemented to minimise preventable outcomes and existing teaching & learning systems are being appraised. He would be the lead reviewer for the study and will be the primary coder for the planned literature search.

2. **Dong Chaoyan, PhD** is a medical educator with experience in systematic review. She received her PhD in Educational Communication & Technology from New York University in 2008. Since then she has been working on medical simulation and education in USA and Singapore. Her recent systematic review includes: Beyond the simulation laboratory: A realist synthesis of clinical outcomes of simulation based mastery learning. *Academic Medicine*. 2015. She would be the second coder for the literature search, with additional roles during the synthesis of evidence from quantitative study data.

3. **Dr Shuh Shing Lee, PhD** is a medical educationalist with research expertise and coordinates research in teaching and learning for undergraduates and supports faculty development courses

for medical educators. She specialises in technology-enhanced learning and qualitative research. She graduated with a PhD in education from University Malaya, Malaysia. Her PhD focus was on student reasoning. She would perform the role of supervision of coding by the first two coders and for making decisions when it needs conflict resolution. She would provide additional expert support for synthesis of evidence from qualitative data.

4. **A/Prof Liaw Sok Ying, PhD,** is nurse educator and academic researcher who has expertise in reviews on teaching intervention in acute deteriorations and has developed a RAPIDS model (Rescuing A Patient In Deteriorating Situations) and has published on programmatic approaches towards it. Her research has identified early recognition and escalation or trigger requirements for deteriorating clinical events as two areas of practice improvement for nursing education to improve outcomes. She would provide inputs from her experience with her research in deteriorating patients from a nursing perspective.

5. **A/Prof Chen Fun Gee MBBS MMed FANZCA MHPE** is an anaesthesiologist and pioneer in simulation-based undergraduate and postgraduate training in Asia. He is the director of graduate medical services that overseas postgraduate assessments and outcomes of training and is the Co-Chair of specialist accreditation board that sets standards for deciding on practice readiness of trainees as independent specialists. His special expertise in work place based assessments adds strength to the evaluation of effectiveness of teaching interventions. He would provide the inputs on the direction of the research from his inputs on residency outcomes and hospital outcomes data.

6. **Dr Dujeepa Samarasekera MBBS FAMEE MHPE** is the Head of the Centre for Medical education at National University of Singapore with vast experience in coordinating medical education research. His role in quality assurance in assessment at the Ministry of Health, Curriculum review committee and graduate exit evaluations surveys will provide rich information on the existing systems of teaching interventions and the evaluation processes of the effectiveness of these methods. His inputs on overall outcomes of the review and experience from audit of the medical education system would help in completing the review efficiently

7. **Miss Annelissa Chin** is a senior librarian at the National University of Singapore Medical Library and has experience with guiding medical research literature reviews. She would provide support with regulating and formalising the search strategies and would continue to support the review team to refine and achieve a comprehensive search of relevant publications.

1. BACKGROUND TO THE TOPIC

Patient deterioration can be defined 'as an evolving, (un)predictable and symptomatic process of worsening physiology towards critical illness' (Lavoie, Pepin, & Alderson, 2016). Patient with *acute deterioration* refers to a patient who moves from one clinical state to a worsening clinical state in a short period of time, which dramatically increases their individual risk of morbidity, including organ dysfunction, protracted hospital stay, disability or death (Jones *et al*. 201, page, 1033). The intent of medical and healthcare professions training is 'practice readiness'. As interns, house officers, foundational year trainees and residents, junior doctors are expected to face patients who are acutely unwell and make the right assessments from the clinical cues and prompts received from the healthcare teams in order to arrive at the best course of action. It is known from published databases on acute audits that 'one in four admissions into ICU were without consultant intensivist's supervision or review 24 hours after that; initial treatment was delayed or inappropriate or both for those patients who died in ICU' (Adam & Odell, 2005). Precious time and muscle is lost when there are significant delays in recognition of worrying clinical features and more so if there are lapses in prompt escalation to appropriate specialist care or to higher levels of expertise (Huffington post, 2012).

Junior doctors when commencing independent work have known to be associated with 6% increase in preventable mishaps and the induction period to clinical work is widely known as the 'killing season'(Huffington post, 2012). Medical establishments strive to minimise and mitigate the potential for harm from the care of patient by the inexperienced. The inability to recognize acute illness and subsequent delay in prompt initiation of rescue measures, whilst awaiting senior assistance, thus is an area of concern. There is definitely a need for a systematic analysis of literature on relevant training programmes to summarize aspects that contribute to a successful acute care curricula/ programme that enable junior trainees' timely recognition of and response to clinical deterioration.

Problem statement

There are existing educational programmes such as the ACUTE and SMART that focus on providing a structured training system for the doctors in training to enhance the preparedness for acute care clinical work. ACUTE (Acute Life-threatening Events—Recognition and Treatment) course, is a 1-day multi-professional course designed to give newly qualified doctors and nurses greater confidence and ability in the recognition and management of adult patients who have impending or established critical illness (Smith & Poplett, 2004). The outcomes of these interventions were evaluated based on self-reported questionnaires measuring confidence. During actual practice, either there is problem in how the vital information for clinical decision making is processed or how it is synthesised or retrieval is achieved when needed at times of crisis.

A review by Liaw et al (2011) identified 3 roles of healthcare teams namely *recogniser, reporter and responder* that are vital in the chain of management of acutely deteriorating patients. Trained senior nursing staff, owing to the demand and nature of work are increasing reliant on healthcare assistants and other junior staff to be the first line in recognition of clinical signs of what could have devastating outcomes if left unattended or missed. The role of healthcare assistants (HCA) in recognizing acute deteriorations through 'recorder' and 'responder' functions are well documented (James et al, 2010).

Liaw et al (2011) showed the effectiveness of a simulation-based educational program, RAPIDS (Rescuing A Patient In Deteriorating Situations), in recognizing, responding and reporting of physiological signs of deterioration. The study involved a 6 hour simulation based intervention resulting in overall improvements in abilities in recognizing and escalating acute deteriorations. Liaw et al (2014) studied the role of a 3 hour simulation based interprofessional

module (sim-IPE) using a *presage-process-product* (3P) approach for pre-registration medical students and nurses and showed better preparedness for possible future management of deteriorating patients. Other published interprofessional training programs that address similar educational perspectives include the Multi-professional Full-scale Simulation (MFS) and COMPASS. These are inter-professional courses for both qualified medical and nursing staff working in hospitals (Liaw et al, 2011).

Fisher & King (2013) performed a systematic review demonstrating evidence supporting use of simulation in preparing nursing in confidence, clinical judgment, knowledge & competence in care of deteriorating patients with limited roles in recognizing and responding to the same. They identified six themes namely, 'transferability of simulation skills to clinical practice', 'exposure to broader range of experiences', 'confidence levels in relation to simulation training', 'competence/performance', 'clinical judgment' and 'student perceptions of preparedness for practice following simulation' as chief aspects that need to be reviewed when appraising literature on simulation and patient outcomes.

A systematic review done in 2007 showed that only 15 out of 374 studies (4%) demonstrated high quality evidence such as randomized controlled trials showing usefulness of educational interventions in undergraduate training (Smith et al, 2007). The study also highlighted that the evidence gathered in majority tend to stay on lower levels of evaluation of the Kirkpatrick's model such as 'reaction' or 'confidence/ behaviour' (Kirkpatrick, 1983). Not many studies show 'patient outcomes' (level 4) as the intended purpose of the studies or measured end points.

The '**effectiveness**' data that this review will focus is on 'information from published studies on *clinical practice standard improvements, workplace reviews of better quality of trainee doctors* such as 360degree reports and *higher ratings/ impressions of clinical supervisors, better patient care outcome indices* such as reduced morbidity and mortality data, better patient satisfaction scores, overall reductions of preventable errors or reduced events that usually arise from delayed recognition or poor escalation to appropriate cadres for care of deteriorating patients.

Theoretical perspectives

Managing acutely deteriorating clinical situations requires ability to process information rapidly in an intense atmosphere with multitude of inputs, roles and demands that requires *situated cognition*. Situated cognition refers 'to activity, context, and culture to solve problems (Brown et al). This process of *cognitive apprenticeship* where the expert scaffolds the learning of the novice on graded responsibilities and learning opportunities is one of the ways of enhancing situated cognition (Dennen &Burner, 2008). The learners are immersed in the progressively spiralling levels of difficulties, after ensuring there is deliberate practise to achieve mastery in performance. This relates to the *constructivist approach* of slowly introducing to the complicated unknown after reinforcing on the known clinical knowledge. The learning of management of clinical deterioration though could be structured through educational programs that incorporate simulation and inter-professional learning paradigms, when it comes to the actual management of patients in clinical situations, there are complexities (social learning theory, Bandura 1969) in how the learned clinical knowledge is applied and how this results in acceptable standards of necessary care.

Practical perspective

The National Safety and Quality Health Service (NSQHS, 2014) in Australia requires hospitals to develop systems and processes to recognise and respond to clinical deteriorations in acute healthcare with one required action. The clinical workforce is trained so they can provide appropriate care to patients whose condition is deteriorating. However, in teaching hospitals, the management of patients after office hours is handled by junior manpower such as house officers and transitional years medical officers or Postgraduate Year 1 (PGY1) residents with intermittent supervision by senior clinicians and clinical supervisors who regulate the safety of patient care.

Junior trainees' and nurses' pivotal role in recognising and responding to signs of patient deterioration in a timely manner is imperative for optimal patient outcomes (Purling & King, 2012). In a systematic review on readiness of undergraduates in acute care, Tallentire et al (2012) reported that graduates perceived themselves to be less prepared in managing acutely ill patients. In medical schools, acute care specialties such as emergency medicine, anaesthesiology and paediatrics provide domain-specific acute care teaching programs using didactic and simulation based approaches to build the foundation for postgraduates to enhance practice readiness towards the completion of training. Yet it is not clear whether these training programs prevent harm and adverse events or malpractice claims.

In simulated team training in emergency situations, there is evidence showing that there are significant differences between *leader and follower roles*. For example, Meurling et al (2013) showed that leader roles in simulation scenarios resulted in increased concentration, better communication and postulated the need for better training strategies if leader roles are to be expected of every participant of simulation training. Practice as house officers and junior doctors' mandates practitioners to function as leaders. This is true when they are presented with first-hand information in the chain of response (recognition, reporting, responding) by the nursing support staff in deteriorating patients.

Acute care training modules commonly include *deliberate practice* for psychomotor skills, *situated cognition* and team training through high technology simulations (Bond et al, 2008). Yet the lacuna is how the young practitioner independently applies critical reasoning skills to recognise and comprehend clinical deterioration and how he/she initiates appropriate management plans or escalates early. The present study aims to review teaching interventions designed to equip the young practitioners in preventing these adverse outcomes.

Preliminary data from the scoping search

The following were done by the review team to know the extent of articles that could be retrieved and adequacy of information that could be processed. The summary of the preliminary 20 articles that were refined from the scoping search are attached in Appendix A.

For the BEME review we will take note of the following:

- The literature review on medical and nursing educational interventions (CINAHL, MEDLINE, EMBASE, CINAHL, ERIC, PsychINFO, Scopus) as well as inter professional interventions

- The educational interventions include details of the three phases of acute deterioration: recognition, reporting and response

- Most studies include self-reported data on trainees' confidence and knowledge gain. So focus is needed to look at effectiveness data on skills transfer and patient care

- The search for the 'educational intervention' might have to stay broad as there is a large variation in how it is described:

    o teaching intervention,

    o educational program,

    o training program,

    o acute care training,

    o interprofessional education module etc

- Grey literature such as unpublished thesis or educational audit reviews reports have to be appraised to acquire data/ papers

The information/ insights gathered from the scoping review that will inform the systematic review is synthesised in Table 1

Table 1: Synthesised information from the scoping review that will guide the BEME review

1. The *intervention* needs to be looked in all these search words:
    a. teaching interventions
    b. teaching programs
    c. educational strategies
    d. educational interventions
    e. teaching techniques
    f. educational effect
    g. curriculum
    h. acute care teaching/ training
    i. actual names of the interventions:
        i. simulation
        ii. computer based
        iii. virtual
        iv. team-based learning
        v. crisis management course/ programs etc.
        vi. small group teaching
2. The outcomes of *patient deteriorations* to be appraised for the following terms:
    a. acute deteriorations
    b. patient deteriorations
    c. catastrophes
    d. sudden worsening
    e. acutely ill
    f. calamities
3. The **target group**- trainees needs to be widened to obtain elaborate information:
    a. trainees
    b. medical
    c. undergraduate
    d. postgraduate
    e. transitional year
    f. interns/ house officer
    g. foundational year
    h. resident

A glossary of key definitions and concepts clarifying the study themes is presented in table 2.

Table 2: Definitions of keywords and concepts

Definitions of keywords and concepts

1. **acute deterioration:** refers to a patient who moves from one clinical state to a worsening clinical state in a short period of time which dramatically increases their individual risk of morbidity, including organ dysfunction, protracted hospital stay, disability or death

2. **teaching intervention:** refers to any educational program or module or teaching methods that are intended to improve the process of process of imparting acute care knowledge

3. **effectiveness:** refers to the degree to which something is successful in producing a desired result or success. For this review that refers *to higher level* data such as clinical practice standard improvements, workplace reviews of better quality of trainee doctors such as 360 degree reports and higher ratings/ impressions of clinical supervisors, better patient management indices such as reduced morbidity and mortality data, better patient satisfaction scores of confidence in junior practicing doctors, overall reductions of preventable errors or reduced events and *lower levels* of effectiveness data such as self-reported confidence improvements, participant satisfaction and engagement

4. **medical students:** includes undergraduate medical students, house officers and interns who are yet to obtain their qualifications as a medical doctor

5. **residents, postgraduates, young practitioner, trainees**: refer to doctors in training; these are terms used interchangeably in various educational systems world over. In essence these are doctors who have not obtained specialist qualifications or certification for independent unsupervised practice from the respective medical councils

Relevance for future educational practice

The review focuses on educational interventions designed to prepare the graduates for independent practice. What is not known are the proven best practices in teaching interventions that ensure measurable impact on young practitioners so that they are enabled to promptly and effectively recognise potential catastrophic situations that can be escalated early to prevent calamities. The results will help health professions *educators* to develop training programmes with best practices and choose proper educational platform to equip the young practitioners for independent practice, help the educational *leadership* and curricular planning committees to allocate valuable funds and resources. Where appropriate, the review could inform the *areas of concern* in terms of catastrophic events prevention and need for a revised approach to acute care program implementation.

Expected outcomes for educational practice

The review would help educators to improve existing curriculum compared to the published literature on best practices. The review might guide educators to choose effective interventions for training medical students and residents. Ultimately the trainees will be able to manage unsettling situations to minimise the degree of patient harm.

The review would guide *deliberate individual cognitive training* to address areas of concern. This will also guide future research. This would also direct financial support systems on what to channelize the efforts of university and hospital teaching faculty so that there can be reduction in the preventable harm. The review might inform the educationalists to look beyond self-reported increase in confidence of the participants to tangible patient outcomes and reduction in morbidity indices.

2. REVIEW QUESTION(S)/OBJECTIVES, TYPE OF REVIEW AND KEYWORDS

The aims of the review are to:

1. Identify and summarize published teaching interventions or acute care training programmes for undergraduate medical students and postgraduates to recognize and respond to clinical deterioration

2. Critically review these training programmes by using the ADDIE instructional design model and to appraise outcomes data on effectiveness in learning early recognition and prompt escalation of acute clinical deteriorations

3. Identify gaps in the literature for guiding further research

The review questions are:

1. What are the interventions designed for undergraduate medical students and residents to teach early recognition and/or prompt escalation of acute clinical deteriorations?

2. How effective are these teaching interventions in training them in early identification of the clinical untoward events?

Type of review: A systematic descriptive and justification review

Keywords: Teaching interventions, acute deteriorations, acute/critical care, undergraduate and postgraduate training, trainee doctors (junior and senior house officers), medical education, health professions education, teaching effectiveness, teaching methods.

Stake holders (who would benefit from this review): healthcare trainees, curriculum planners, quality and safety committees, postgraduate teaching audit committees, patients and care teams

3. STUDY SELECTION CRITERIA

(For a detailed table in the PICO format please refer to table 3)

Table 3: Study selection criteria using the PICO format

Key Features	Inclusion	Exclusion
Study population	Undergraduate training House officers/ interns Senior house officers Junior residents Foundational years doctors Transitional year doctors Postgraduates	Exclusive training programs for non-medical and allied healthcare professionals that does not have a interprofessional component to include doctors in training
Teaching intervention	Educational programs Teaching methods Simulation and technology based blended learning programs	

	Multi professional training	
	Acute care training methods	
	Curricular modules that intend to provide training of acute care skills	
	In contact and virtual learning modules	
	Small group teaching/ training	
Comparator / control	Not applicable	Not Applicable
Outcomes **Effectiveness data:**	Student self-reports of confidence, better engagement, participation	
	Future readiness data	
	Teachers' account of student improvements	
	Clinical supervisors ratings	
	Patient outcomes or clinical acute care improvement data suggesting better care	
	Reduction in preventable harm/ morbidity indices etc	

4. SEARCH SOURCES AND STRATEGIES

Search resources:
- MEDLINE (via PubMed)
- Embase
- The Cochrane Library
- ERIC
- PsyINFO
- CINAHL
- ProQuest Dissertation Abstract

Search Strategies:
Search strategy targeted primary literature. Electronic database searched were Medline, ERIC, EMBASE, Cochrane and CINAHL.
The following search terms were included:
Population: undergraduates, medical students, post graduates, doctors in training, residents, trainees;
Intervention: teaching interventions, teaching programs, training programmes, simulation, acute care training, emergency preparedness
Outcomes: deterioration, worsening, acutely ill, catastrophes, preventable errors

Other resources searched include reference list of relevant papers, grey literature searched through proquest. The detailed search strategy is given in the Appendices. No language limitation was applied.

Time period of data to be searched: None

Limits of search: None

The information on studies looking at interventions for improving training on management of patient deterioration are in general limited in medical education and fairly well studied in the nursing education context. We aim to summarise the existing literature in medical education designed to improve early recognition and prompt escalation of acute clinical deterioration. Back searching from references of pertinent articles and direct communication with authors of some articles might be required as the generic search engine outputs are refined to the topic of the BEME review that we have resolved to pursue.

5. EXTRACTING DATA

AB and DC, the two coders will be primary coders for the articles. The two will appraise the articles using the data extraction form (attached) independently. For consistency of the coding process standard, every 5th article reviewed by the coders will be reviewed by SS, for reliability, consistency and presence of congruence and completeness. Any discrepancies will be resolved with open discussions among the three coders.

Data extraction will be recorded in Covidence ™ (Melbourne, Australia). Qualitative studies will be independently reviewed by the primary reviewers and information obtained will be collated through the data extraction form. The information will be used to answer the research questions in identifying teaching interventions, the domains that are taught and trained by it and where possible the data on effectiveness of these interventions.

6. APPRAISAL OF STUDIES

The studies would be appraised for rigor and quality of study design and analysis for inclusion in the review. We will use the criteria defined by the quality assessment tool (QATSSD tool) by Sirriyeh et al (2011) to ensure the quality of information collected. Studies with missing components of the subscales in this tool will be discussed by the research team and decision for inclusion will be made accordingly.

The components for the quality assessment tool (QATSSD tool) include:
1. Explicit theoretical framework

2. Statement of aims/ objectives in the main body of the report

3. Clear description of research setting

4. Evidence of sample size considered in terms of analysis

5. Representative sample of target group of a reasonable size

6. Description of procedure for data collection

7. Rationale for choice of data collection tool(s)

8. Detailed recruitment data

9. Statistical assessment of reliability and validity of measurement tool(quantitative only)

10. Fit between stated research question and methods of data collection(quantitative)

11. Fit between stated research question and format & content of data collection eg: interview schedule (qualitative only)

12. Fit between research question and method of analysis

13. Good justification of analytical method selected

14. Assessment of reliability of analytical process(qualitative only)

15. Evidence of user involvement in design

16. Strengths and limitations critically discussed

After extraction of information, the studies would be reviewed by the coders for consistency of the quality of the articles. Disagreement between the two primary coders AB and DC would be resolved by SS and a final decision would be made on inclusion/ elimination of the studies reviewed.

7. SYNTHESIS OF EVIDENCE AND TRANSFER TO RESEARCH AND PRACTICE

The methodology for the synthesis of information would be that of Mixed Treatment Comparisons modelling (MTC) for obtaining coherent picture of all intervention and possible effectiveness data where there is no direct randomised evidence (Sutton, Cooper, & Jones, 2009). The reason for choice of this process is that educational interventions are often multiple and direct comparisons are not always possible especially when several interventions are applied in acute care educational modules. Hence a combined analysis of relevant data is preferred for healthcare decisions.

The synthesis approach will provide *knowledge-support* which summarises the evidence as general background information for decision-making' (Pope et al, 2006). The decision in this review would be that of *'effectiveness of existing education interventions in preventing or preparing for management of acute deteriorations'.* This would inform the educators on areas where future teaching efforts and resources need to be channelized and what needs to be enhanced to achieve optimal patient outcomes. The approach to synthesize qualitative data is *content analysis* approach wherein "data would be categorised into themes which can then be counted and converted into frequencies to identify dominant issues across a number of studies" (Pope et al 2006).

To synthesize and summarize qualitative data we will collate evidence from the published studies and derive themes that relate to effectiveness of teaching interventions (Garside, 2015; Barnett-Page & Thomas, 2009). As the review might include studies exclusively for medical training and those for multi-professional training including nursing and allied healthcare, the synthesis will be done separately for the these two groups

Transferability to future research:

The review is planned to analyse teaching interventions designed to improve the healthcare practitioners' ability to recognise and manage clinical deteriorations. It would lead to further research the usefulness of individual vs group educational strategies, possibly more in detail on paper based, computer based, simulations and virtual learning platforms to achieve the educational goals.

Transfer to practice:

This could help in reforming acute care teaching curricula to better suit the present day needs of managing deteriorations and preventing major calamities. Use of faculty and time intensive teaching strategies can then be replaced with more productive and impactful teaching interventions that emulate individual practice readiness and be well equipped with mental dexterity for pattern recognition.

Project timetable

The critical stages identified would be protocol approval, data collection, coding, synthesis and BICC reviewers' appraisal. The study team hopes to complete the study over a span of one year after obtaining approval of the proposal. The Project timetable is shown in table 4

Table 4. Project timetable and planned dates for completion

	June - Oct 17	Nov 17	Dec 17	Jan 18	Feb 18	Mar 18	Apr 18	May18	June 18	July-Aug 18
Protocol	███									
Paper –data collection		███	███	███						
Paper coding			███	███	███	███				
Results					███	███	███			
Further Data					███	███	███			
Synthesis						███	███			
Write up			███	███	███	███	███	███		
BICC review								███	███	███
Resubmission										███
Publication										███

REFERENCE

Adam, S., & Odell, M. (2005). An acute problem? A report of the National Confidential Enquiry into Patient Outcome and Death. *Nursing in critical care*, *10*(5), 225-227.

Bandura, A. (1969). Social-learning theory of identificatory processes. *Handbook of socialization theory and research*, *213*, 262.

Barnett-Page, E., & Thomas, J. (2009). Methods for the synthesis of qualitative research: a critical review. *BMC medical research methodology*, *9*(1), 59.

Bond, W. F., Deitrick, L. M., Eberhardt, M., Barr, G. C., Kane, B. G., Worrilow, C. C et al . (2006). Cognitive versus technical debriefing after simulation training. *Academic Emergency Medicine*, *13*(3), 276-283.

Dennen, V. P., & Burner, K. J. (2008). The cognitive apprenticeship model in educational practice. Handbook of research on educational communications and technology, 3, 425-439.

Krist2366, "Situated Cognition (Brown, Collins, & Duguid)," in *Learning Theories*, February 2, 2017, https://www.learning-theories.com/situated-cognition-brown-collins-duguid.html. Accessed 9 july 2017

Fisher, D., & King, L. (2013). An integrative literature review on preparing nursing students through simulation to recognize and respond to the deteriorating patient. Journal of Advanced Nursing 69(11), 2375–2388. doi: 10.1111/jan.12174

Garside, R. (2015) Methods of qualitative evidence synthesis (Webinar). Accessed on 10 juyl 2017 from http://ktdrr.org/training/workshops/qual/session3/session3_031815.pdf.

Higgins, J., & Green, S. (2008). Guide to the contents of a Cochrane protocol and review. *Cochrane Handbook for Systematic Reviews of Interventions: Cochrane Book Series*, 51-79.

Hogan, H., Healey, F., Neale, G., Thomson, R., Vincent, C., & Black, N. (2012). Preventable deaths due to problems in care in English acute hospitals: a retrospective case record review study. *BMJ Qual Saf*, bmjqs-2012.

Huffington post: (http://www.huffingtonpost.co.uk/2012/06/23/nhs-to-end-junior-doctors-killing-season_n_1620656.html_accessed 30 june 2017.)

James, J., Butler‐Williams, Carole., Hunt, J., & Cox, H. (2010). Vital signs for vital people: an exploratory study into the role of the Healthcare Assistant in recognising, recording and responding to the acutely ill patient in the general ward setting. *Journal of Nursing Management*, *18*(5), 548-555.

Jones, L., King, L., Wilson. C. A literature review: Factors that impact on nurses' effective use of the Medical Emergency Team (MET). *Journal of Clinical Nursing* 2009;18:3379 3390.

Kirkpatrick, D. L. (1983). Four steps to measuring training effectiveness. *Personnel Administrator*, *28*(11), 19-25.

Lavoie, P., Pepin, J., & Alderson, M. (2016). Defining patient deterioration through acute care and intensive care nurses' perspectives. *Nursing in critical care*, *21*(2), 68-77.

Liaw, S. Y., Rethans, J. J., Scherpbier, A., & Piyanee, K. Y. (2011). Rescuing A Patient In Deteriorating Situations (RAPIDS): a simulation-based educational program on recognizing, responding and reporting of physiological signs of deterioration. *Resuscitation*, *82*(9), 1224-1230

Meurling, L., Hedman, L., Felländer-Tsai, L., & Wallin, C. J. (2013). Leaders' and followers' individual experiences during the early phase of simulation-based team training: an exploratory study. *BMJ Qual Saf*, bmjqs-2012.

Pope, C., Mays, N., & Popay, J. (2006, April). How can we synthesize qualitative and quantitative evidence for healthcare policy-makers and managers?. In *Healthcare Management Forum* (Vol. 19, No. 1, pp. 27-31). Sage CA: Los Angeles, CA: SAGE Publications. Accessed on 10july 2017 from http://www.academia.edu/1506825/How_can_we_synthesise_qualitative_and_quantitative_evidence_for_health_care_policy_makers_and_managers

Sirriyeh, R., Lawton, R., Gardner, P., & Armitage, G. (2012). Reviewing studies with diverse designs: the development and evaluation of a new tool. *Journal of evaluation in clinical practice*, *18*(4), 746-752.

Smith, C. M., Perkins, G. D., Bullock, I., & Bion, J. F. (2007). Undergraduate training in the care of the acutely ill patient: a literature review. *Intensive care medicine*, *33*(5), 901-907.

Smith, G. B., & Poplett, N. (2004). Impact of attending a 1-day multi-professional course (ALERT™) on the knowledge of acute care in trainee doctors. *Resuscitation*, *61*(2), 117-122.

Sutton, A. J., Cooper, N. J., & Jones, D. R. (2009). Evidence synthesis as the key to more coherent and efficient research. *BMC medical research methodology*, *9*(1), 29.

Tallentire VR, Smith SE, Skinner J, Cameron HS. The preparedness of UK graduates in acute care: a systematic literature review. *Postgraduate medical journal*. 2012;88(1041):365-71.

APPENDIX A: PubMed Search Strategy

Title: *A systematic review of interventions designed to teach medical students and residents early recognition and/or prompt escalation in acute clinical deteriorations*

P= undergraduate medical students/ doctors in training /junior medical trainees/ post graduates **I=** teaching interventions or acute care training programmes **C=** NIL **O=** improve ability of target group to effectively deal with patient deterioration/manage clinical deterioration **Database searched: PubMed** **Search results retrieved: 5077 hits** **Date of search: 27 September 2017**

Lists of search terms proposed
Population

Keywords doctor[tiab] OR doctors[tiab] OR physician[tiab] OR physicians[tiab] OR "house officer"[tiab] OR "house officers"[tiab] OR "medical officer"[tiab] OR "medical officers"[tiab] OR residen*[tiab] OR intern[tiab] OR interns[tiab] OR internist[tiab] OR internists[tiab] OR internship[tiab] OR internships[tiab]) (medical[tiab] OR clinical[tiab] OR medicine[tiab]) AND (undergraduate[tiab] OR undergraduates[tiab] OR graduate[tiab] OR graduates[tiab] OR postgraduate[tiab] postgraduates[tiab] OR clerkship[tiab] OR trainee[tiab] OR trainees[tiab] OR student[tiab] OR students[tiab]) **Mesh terms** ("Physicians"[Mesh] OR "Clinical clerkship"[Mesh] OR "Internship and Residency"[Mesh]) *To build the search statement for "P" term, combine the 3 search statements using "OR" operator (refer to search statement #1 listed in Table 1)*

Intervention

Keywords (education[tiab] OR educations[tiab] OR educational[tiab] OR program[tiab] OR programs[tiab] OR programme[tiab] OR programmes[tiab] OR training[tiab] OR training[tiab] OR course[tiab] OR courses[tiab] OR competen*[tiab] OR teaching[tiab] OR simulation[tiab] OR simulations[tiab] OR simulating[tiab] OR simulated[tiab] OR simulator[tiab] OR simulator[tiab]) **Mesh terms** ("Simulation Training"[Mesh] OR "Teaching"[Mesh] OR "Problem-Based Learning"[Mesh] OR "Clinical Competence"[Mesh] OR "Hospitals, Teaching"[Mesh] OR "Education, Medical"[Mesh]) *To build the search statement for "I" term, combine the 2 search statements using "OR" operator (refer to search statement #2 listed in Table 1)*

Outcome

Keywords (deterior*[tiab] OR exacerb*[tiab] OR worsen*[tiab] OR worse[tiab] OR worst[tiab]) *Refer to search statement #3 listed in Table 1)*

Developing Search strategy   (guide for the primary study authors)

To build your search strategy

Step1. Search "p" terms

Step2. Search "I" terms

Step3. Search "O" terms

Step4. Combine "P" AND "I" AND "O" with AND operator, i.e #1 AND #2 AND # 3 to give you the final search strategy (see #4)

Table 1: Search strategies for PubMed

No	Search Queries	Search results
1	((((doctor[tiab] OR doctors[tiab] OR physician[tiab] OR physicians[tiab] OR "house officer"[tiab] OR "house officers"[tiab] OR "medical officer"[tiab] OR "medical officers"[tiab] OR residen*[tiab] OR intern[tiab] OR interns[tiab] OR internist[tiab] OR internists[tiab] OR internship[tiab] OR internships[tiab]))) OR ((medical[tiab] OR clinical[tiab] OR medicine[tiab]) AND (undergraduate[tiab] OR undergraduates[tiab] OR graduate[tiab] OR graduates[tiab] OR postgraduate[tiab] postgraduates[tiab] OR clerkship[tiab] OR trainee[tiab] OR trainees[tiab] OR student[tiab] OR students[tiab]))) OR ("Physicians"[Mesh] OR "Clinical clerkship"[Mesh] OR "Internship and Residency"[Mesh])	728213
2	((((education[tiab] OR educations[tiab] OR educational[tiab] OR program[tiab] OR programs[tiab] OR programme[tiab] OR programmes[tiab] OR training[tiab] OR training[tiab] OR course[tiab] OR courses[tiab] OR competen*[tiab] OR teaching[tiab] OR simulation[tiab] OR simulations[tiab] OR simulating[tiab] OR simulated[tiab] OR simulator[tiab] OR simulator[tiab]))) OR (("Simulation Training"[Mesh] OR "Teaching"[Mesh] OR "Problem-Based Learning"[Mesh] OR "Clinical Competence"[Mesh] OR "Hospitals, Teaching"[Mesh] OR "Education, Medical"[Mesh]))	2313070
3	(deterior*[tiab] OR exacerb*[tiab] OR worsen*[tiab] OR worse[tiab] OR worst[tiab]	364979
4	((((((doctor[tiab] OR doctors[tiab] OR physician[tiab] OR physicians[tiab] OR "house officer"[tiab] OR "house officers"[tiab] OR "medical officer"[tiab] OR "medical officers"[tiab] OR residen*[tiab] OR intern[tiab] OR interns[tiab] OR internist[tiab] OR internists[tiab] OR internship[tiab] OR internships[tiab]))) OR ((medical[tiab] OR clinical[tiab] OR medicine[tiab]) AND (undergraduate[tiab] OR undergraduates[tiab] OR graduate[tiab] OR graduates[tiab] OR postgraduate[tiab] postgraduates[tiab] OR clerkship[tiab] OR trainee[tiab] OR trainees[tiab] OR student[tiab] OR students[tiab]))) OR ("Physicians"[Mesh] OR "Clinical clerkship"[Mesh] OR "Internship and Residency"[Mesh]))) AND (((((education[tiab] OR educations[tiab] OR educational[tiab] OR program[tiab] OR programs[tiab] OR programme[tiab] OR programmes[tiab] OR training[tiab] OR training[tiab] OR course[tiab] OR courses[tiab] OR competen*[tiab] OR teaching[tiab] OR simulation[tiab] OR simulations[tiab] OR simulating[tiab] OR simulated[tiab] OR simulator[tiab] OR simulator[tiab]))) OR (("Simulation Training"[Mesh] OR "Teaching"[Mesh] OR "Problem-Based Learning"[Mesh] OR "Clinical Competence"[Mesh] OR "Hospitals, Teaching"[Mesh] OR "Education, Medical"[Mesh]))) AND (deterior*[tiab] OR exacerb*[tiab] OR worsen*[tiab] OR worse[tiab] OR worst[tiab])	5077

LIST OF RELEVANT ARTICLES

(Obtained after refining initial search)

1. Boling, B., & Hardin-Pierce, M. (2016). The effect of high-fidelity simulation on knowledge and confidence in critical care training: An integrative review. *Nurse education in practice*, *16*(1), 287-293.

2. Brunette, V., & Thibodeau-Jarry, N. (2017). Simulation as a Tool to Ensure Competency and Quality of Care in the Cardiac Critical Care Unit. *Canadian Journal of Cardiology*, *33*(1), 119-127. **(review on simulation outcomes)**

3. Butcher, B. W., Quist, C. E., Harrison, J. D., & Ranji, S. R. (2015). The effect of a rapid response team on resident perceptions of education and autonomy. *Journal of hospital medicine*, *10*(1), 8-12. **(rapid response and residents)**

4. Cachia, M., Pace-Bardon, M., Balzan, G., Tilney, R., Micallef, J., & Balzan, M. (2015). simulation training for foundation doctors on the management of the acutely ill patient. *Advances in medical education and practice*, *6*, 657. **(foundational doctors training)**

5. Callaghan, A., Kinsman, L., Cooper, S., & Radomski, N. (2017). The factors that influence junior doctors' capacity to recognise, respond and manage patient deterioration in an acute ward setting: An integrative review. *Australian Critical Care*, *30*(4), 197-209. **(junior doctors and acute deteriorations)**

6. Cooke, J. M., Larsen, J., Hamstra, S. J., & Andreatta, P. B. (2008). Simulation enhances resident confidence in critical care and procedural skills. *FAMILY MEDICINE-KANSAS CITY-*, *40*(3), 165.

7. Eppich, W. J., Brannen, M., & Hunt, E. A. (2008). Team training: implications for emergency and critical care pediatrics. *Current opinion in pediatrics*, *20*(3), 255-260.

8. Hogg, G., & Miller, D. (2016). The effects of an enhanced simulation programme on medical students' confidence responding to clinical deterioration. *BMC medical education*, *16*(1), 161. **(medical students and clinical deterioration- simulation)**

9. Khanduja, P. K., Bould, M. D., Naik, V. N., Hladkowicz, E., & Boet, S. (2015). The role of simulation in continuing medical education for acute care physicians: a systematic review. *Critical care medicine*, *43*(1), 186-193.

10. Liaw, S. Y., Chan, S. W. C., Scherpbier, A., Rethans, J. J., & Pua, G. G. (2012). Recognizing, responding to and reporting patient deterioration: transferring simulation learning to patient care settings. Resuscitation, 83(3), 395-398. DOI: http://dx.doi.org/10.1016/j.resuscitation.2011.08.021

11. Liaw, S. Y., Scherpbier, A., Klainin‑Yobas, P., & Rethans, J. J. (2011). A review of educational strategies to improve nurses' roles in recognizing and responding to deteriorating patients. International nursing review, 58(3), 296-303.

12. McGaughey, J., Alderdice, F., Fowler, R., Kapila, A., Mayhew, A., & Moutray, M. (2007). Outreach and Early Warning Systems (EWS) for the prevention of intensive care admission and death of critically ill adult patients on general hospital wards. *The Cochrane Library*. **(early warning scores Cochrane review)**

13. Piquette, D., Moulton, C. A., & LeBlanc, V. R. (2015). Creating learning momentum through overt teaching interactions during real acute care episodes. Advances in Health Sciences Education, 20(4), 903-914.

14. Sam, J., Pierse, M., Al-Qahtani, A., & Cheng, A. (2012). Implementation and evaluation of a simulation curriculum for paediatric residency programs including just-in-time in situ mock codes. *Paediatrics & child health*, *17*(2), e16-e20. *(in situ simulation and residency)*

15. Schroedl, C. J., Corbridge, T. C., Cohen, E. R., Fakhran, S. S., Schimmel, D., McGaghie, W. C., & Wayne, D. B. (2012). Use of simulation-based education to improve resident learning and patient care in the medical intensive care unit: a randomized trial. *Journal of critical care*, *27*(2), 219-e7. *(residency-simulation based module)*

16. Smith, G. B., & Poplett, N. (2004). Impact of attending a 1-day multi-professional course (ALERT™) on the knowledge of acute care in trainee doctors. *Resuscitation*, *61*(2), 117-122. *(multidisciplinary post graduate training)*

17. Smith, C. M., Perkins, G. D., Bullock, I., & Bion, J. F. (2007). Undergraduate training in the care of the acutely ill patient: a literature review. *Intensive care medicine*, *33*(5), 901-907. *(summary of studies on acute care in undergraduates)*

18. Smith, M. B., Chiovaro, J. C., O'Neil, M., Kansagara, D., Quiñones, A. R., Freeman, M., ... & Slatore, C. G. (2014). Early warning system scores for clinical deterioration in hospitalized patients: a systematic review. *Annals of the American Thoracic Society*, *11*(9), 1454-1465. *(about early warning scores and clinical deteriorations)*

19. Wolbrink, T. A., Kissoon, N., & Burns, J. P. (2014). The development of an internet-based knowledge exchange platform for pediatric critical care clinicians worldwide. *Pediatric Critical Care Medicine*, *15*(3), 197-205. *(online platforms in educational outcomes)*

20. Gough, S., Hellaby, M., Jones, N., & MacKinnon, R. (2012). A review of undergraduate interprofessional simulation-based education (IPSE). Collegian, 19(3), 153-170. *(undergraduate IPE review)*