THE EFFECT OF CRISIS RESOURCE MANAGEMENT TRAINING ON ERROR IN THE EMERGENCY DEPARTMENT: A SYSTEMATIC REVIEW

by

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Abstract

Background

Emergency department clinicians confront problems that are often ill defined, rapidly evolving and have severe consequences. The propensity for error is, therefore, significant. Crisis Resource Management training has gained recent attention as a means of improving teamwork and reducing error in the emergency department.

Methods

A systematic review of the literature was conducted to determine the effectiveness of Crisis Resource Management training in reducing error in the emergency department. The following databases were searched: CINAHL, EMBASE, MEDLINE, PsycINFO, PubMed Central and Google Scholar. Published and unpublished, experimental and quasi-experimental studies were considered. Relevant studies were appraised using the Joanna Briggs Institute Meta Analysis Statistics Assessment and Review Instrument.

Results

The literature search yielded a total of 491 published studies. After screening and critical appraisal, two studies were included. The first, a quasi-experimental before and after study, reported an 18 percent decrease in patient safety events following the intervention, which was not significant (p=0.22). The second, a

quasi-experimental, non-randomised control, before and after study, reported an 85 percent decrease in observed errors following the intervention. When compared to the control group, however, this was not significant (p=0.140). Due to the number and heterogeneity of the included studies, the results were combined into a narrative synthesis rather than a meta-analysis. The review suffered from publication bias because no unpublished studies were located.

Conclusion

There is limited evidence that Crisis Resource Management training reduces error in the emergency department. Further research, utilising an experimental or mixed methods design should be carried out to measure the overall effectiveness of Crisis Resource Management training within the emergency department.

Keywords

systematic review, emergency department, emergencies, communication, education, teaching, cooperative behaviour

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Summary of thesis

The idea for this project arose during the researcher's work as a Registered Nurse in the emergency department of a large tertiary referral hospital. Here, the researcher observed, and indeed was involved in, several 'near misses' regarding patient care. Prior to entering the nursing profession, the researcher worked in the aviation industry as an Air Traffic Controller, where he completed Crew Resource Management training. Within aviation, the researcher witnessed substantial gains in teamwork, recognition of unsafe acts and accident prevention, as this training spread throughout the sector. Now working as a novice Registered Nurse, the researcher somewhat naively expected senior colleagues to already know how to communicate effectively, function within a team and take steps to minimise error. Unfortunately, many of them did not. The researcher wondered if the health care equivalent, known as Crisis Resource Management training, had a place in the emergency department and if so, could it contribute to error reduction?

The aim of this thesis then, is to investigate the effectiveness of Crisis Resource Management training as an intervention to reduce error in the emergency department. The choice of this clinical question, rather than a more general examination of the effect of Crisis Resource Management training on teamwork, for example, is deliberate. Error serves as a more recognisable and quantifiable 'bottom line' in critical care areas such as the emergency department, and as such has more influence over decisions to implement interventions like Crisis Resource Management training. While simulation technologies are sometimes

used in the delivery of Crisis Resource Management training, the effect of simulation on error has been studied elsewhere and is, therefore, beyond the scope of this thesis. Others have similarly reviewed the effect of Crisis Resource Management training on non-technical skills and problem-solving.

The thesis has three chapters. The first, a literature review, establishes the need for a systematic review to determine if there is any evidence that Crisis Resource Management training reduces error in the emergency department.

Chapter two presents a systematic review in a form suitable for submission to the Australasian Emergency Nursing Journal. The review borrows heavily from the methods used in Cochrane Reviews, Joanna Briggs Institute Systematic Reviews and the Centre for Reviews and Dissemination Systematic Reviews. It offers a concise synthesis of the available evidence, obtained and appraised according to an understandable and reproducible system. Variations to the Australasian Emergency Nursing Journal instructions to authors include minor formatting changes appropriate to presentation within a thesis, the use of the Harvard referencing system and the inclusion of tables and figures within the article. The authors' details have not been listed at the beginning of the article and the abstract has been moved to the front matter of the thesis. A copy of the instructions to authors is provided in Appendix C of the article.

Chapter three draws together each of the arguments presented in the thesis and lists implications and recommendations for practice based on the results of the systematic review. The recommendations are twofold: reduce emergency department workload and increase research around Crisis Resource Management

training. They apply to health care professionals within the emergency department and contiguous to it.

CHAPTER 1

Literature review

Table of contents

List of tables

Literature review

Introduction

A recent initiative by the Australian Federal Government to reduce waiting times in emergency departments (ED) to a maximum of four hours, has created a tension between improved efficiency and reduced standards of patient care. Already working in what has been described as ‘organised chaos’ (Sheehy 2011, p. 1), nurses may now be deciding what elements of patient care to leave out, as management struggles to design patient flow systems to meet the new target which is tied to significant funding increases. In a more likely scenario, nurses and doctors will continue to offer the same level of patient care but in a reduced timeframe, possibly leading to an increase in error and associated adverse events. Given that the new target has bipartisan support, and is therefore unlikely to be adjusted in the short term, this chapter argues for an interim intervention, Crisis Resource Management training. This will provide ED staff with a suite of skills designed to improve communication, teamwork and decision-making. Evidence from other industries suggests that this training translates well into practice and contributes to error reduction.

This chapter begins with an overview of EDs in Australia, leading into an exposition of overcrowding and access block. This is followed by an explanation of the four hour target, a discussion of barriers to teamwork inherent in the ED environment and an introduction to the study of error. Error mitigation strategies are then compared. A comprehensive case for the introduction of Crisis Resource Management training to the ED is then presented. The chapter discusses the

origins of the training, implementation in other health care disciplines, application to the ED and role in reducing error. The chapter concludes with a recommendation for a systematic review of the evidence to demonstrate the link between Crisis Resource Management training and error reduction in the ED.

Search strategy

The MESH database was searched to identify keywords associated with the clinical question: Does Crisis Resource Management training reduce error in the emergency department? The following keywords were elicited: emergency department, emergencies, communication, education, teaching, cooperative behaviour, medical errors. The following databases were searched: Cumulative Index to Nursing and Allied Health Literature, MEDLINE, The Cochrane Database of Systematic Reviews and the Joanna Briggs Institute Library of Systematic Reviews. The keywords were entered using various combinations of the Boolean operators AND, OR and NOT. The phrase ‘Crisis Resource Management’ was not used because it was considered too restrictive. No temporal constraints were placed on the search because the intervention is relatively recent. Supplemental pieces of grey literature were also searched. Only full text articles available from the University of Tasmania library website and the New South Wales (NSW) Ministry of Health Clinical Information Access Portal were accessed. Relevant articles were identified from title and abstract. No appraisal tools were used to select appropriate studies.

Emergency departments

EDs are busy places with complex problems. In the financial year 2010-2011, over 7.4 million Australians presented to an ED (AIHW 2011b). This figure represents an increase of nearly four percent since 2006–2007 and is over twice the number who presented in 1998-1999 (AIHW 2000, 2011b).

An Emergency Nurse assesses all patients presenting to the ED. Based on a range of factors, each patient is assigned a triage category in accordance with the Australasian Triage Scale (ATS) (ACEM 2005). Table 1 shows each of the ATS categories alongside the respective patient classification, response time and Australian HealthCare Standards (AHS) benchmark. Individual hospital performance against each of the ATS targets is reported on the Australian Federal Government's MyHospital website (AIHW 2012).

Table 1 Australasian Triage Scale and associated AHS benchmark

ATS category	Patient classification	Response time	AHS benchmark
1	resuscitation	immediate	100 percent
2	emergency	10 minutes	76 percent
3	urgent	30 minutes	50 percent
4	semi-urgent	60 minutes	56 percent
5	non-urgent	120 minutes	86 percent

In 2010–2011, only 70 percent of patients were seen within the benchmark times assigned to each of the ATS triage categories (AIHW 2011b). Between 2006-2007 and 2010-2011, the number of patients requiring admission increased by 3.2 percent (AIHW 2011a, 2011b). However, the number of hospital beds available to Australians has remained steady at approximately 2.6 per 1000 since 1998-1999 (AIHW 2000, 2011a). Additionally, many hospitals operate at or above 95 percent of capacity, leaving little or no room for admissions during periods of high demand (ACEM 2004). In short, there is an increasing disparity between the number of patients requiring admission to hospital and the number of beds available to treat them. Therefore, admitted patients are forced to wait in the ED for extended periods until a ward bed becomes available, a phenomenon known as access block (ACEM 2004).

Access block

Access block and overcrowding in Australian EDs was first observed in the late 1980s (ACEM 2004). One reason put forward for the surge in ED presentations, is an increase in the number of non-urgent cases, patients who could have consulted their local general practitioner, but chose not to because of lack of access or cost (ACEM 2004). However, this argument is disputed by the peak body representing Australian emergency physicians, the Australasian College of Emergency Medicine (ACEM) who argue that it is easy to determine where a patient should have gone after they have been diagnosed (ACEM 2004). Irrespective of the reason for overcrowding, a review of interventions designed to relieve access block concluded that the only sustainable solution to the problem was to provide more hospital beds (Forero et al. 2010). In part, this has been

addressed through recent Australian Federal and State Government health reform initiatives to provide more sub-acute beds by 2013-2014, and the introduction of the National Emergency Access Target (COAG 2011).

The National Emergency Access Target

Under the National Emergency Access Target (NEAT), 90 percent of all public ED patients will either physically leave the ED and be admitted to hospital, be transferred to another hospital for treatment, or be discharged within four hours by 2015 (COAG 2011). The goal is based on a similar target that has been in place in the English National Health Service (NHS) since 2004 (COAG 2011; Mortimore & Cooper 2007). However, the original choice of the English NHS target is unclear. The United Kingdom (UK) Department of Health based the four hour target on work by Cooke, Wilson and Pearson (2002). However, other authors have stated that this work was contextually different and have questioned why four hours was chosen over another benchmark (Mortimore & Cooper 2007).

There is a limited body of research into the four hour target. A systematic review of clinical outcomes associated with the four hour target in the UK, found that the time to see a treating clinician and hospital mortality were unchanged after five years (Jones & Schimanski 2010). In contrast, a quasi-experimental study conducted in three tertiary hospitals in Perth, Australia over two years, found that the implementation of a four hour rule was associated with reduced mortality (Geelhoed & de Klerk 2012). However, the authors acknowledged that the study was limited by being confined to larger hospitals. Given the broad range of

factors that can influence patient mortality, further research into the four hour target will have difficulty in isolating the effect of the intervention.

Several studies have explored the effect of the four hour target on ED staff. A qualitative, phenomenological study of Accident and Emergency (A&E) nurses in a UK district hospital concluded that while participants felt the four hour rule was a success, they had reservations about the arbitrary nature of the target and increased workload (Mortimore & Cooper 2007). Participants also reported a reluctance of ward staff to accept patients without the tests and documentation that had previously been completed within A&E when no target was in place (Mortimore & Cooper 2007). In a similar study, nurses reported uncertainty as to who owned the target (the UK Government, the hospital or A&E), increased bullying and a more tenuous relationship between patient safety and performance (Weber et al. 2011).

Barriers to teamwork and communication

The ED is a unique workplace where decision-making takes place on a background of ill-defined problems, conflicting stimuli, rapidly evolving situations, competing priorities, severe consequences and poor communication (Eppich, Brannen & Hunt 2008). An Australian study of communication in the ED identified three networks: problem-solving; medication advice-seeking and socializing (Creswick, Westbrook & Braithwaite 2009). The problem-solving network was clustered around senior clinicians such as the in-charge Registered Nurse and senior doctor. Doctors were central to the medication advice-seeking network, with few doctors seeking advice from nurses regarding prescribing. The

socialising network was described as tribal, with colleagues invariably remaining with professional boundaries. The study concluded that despite being viewed as a single workforce, the ED consists of three distinct groups: nurses, doctors and allied health professionals (Creswick, Westbrook & Braithwaite 2009).

A similar study was conducted in a United States (US) Intensive Care Unit (ICU) to determine the degree of similarity between doctors and nurses in attitudes to collaboration (Nathanson et al. 2011). Nurses consistently rated collaboration as poor between the two groups, while junior doctors were satisfied with the level. The study argued that the result had implications in the longer term as junior medical staff moved to more senior positions (Nathanson et al. 2011). Another study discussed the ad-hoc nature of health care teams in the ICU and ED (Sutton 2009). The study stated that the rapid formation and dissolution of teams in response to high-stakes demands had negative implications for performance and training (Sutton 2009).

Workload management during periods of stress is a key non-technical skill associated with safety in ED (Flowerdew et al. [Article in press]). A cross-sectional survey study conducted in a Dutch ED measured the effect of acute and chronic jobs demands on individual teamwork behaviour in medical emergencies (Gevers et al. 2010). The study found that acute emotional demands (such as arguments with colleagues) combined with the chronic emotional demand of working in the ED, affected teamwork behaviour during acute care episodes such as resuscitations (Gevers et al. 2010).

Another cross-sectional, descriptive study (N=2216) was conducted across four hospitals in the US to determine the predictors of missed nursing care in the general ward (Kalisch & Lee 2010). After adjustment for individual participant characteristics, the study demonstrated that when teamwork was stronger, less nursing care was missed and fewer adverse events occurred (Kalisch & Lee 2010)

To summarise so far, overcrowding due to access block has existed within Australian EDs for nearly 30 years. In an effort to address this issue, the Federal Government has introduced a length-of-stay target of four hours. This figure was derived from similar initiatives in the UK, which themselves were arbitrary. Barriers to effective teamwork and communication already exist within EDs. Overlaid with this new temporal constraint, ED nurses and doctors are faced with a decision to reduce their standard of patient care or compress their activities to within four hours. By intuition, this creates an environment that is conducive to error.

Adverse events and error

Adverse events occurring in the ED continue to attract media scrutiny. Such occurrences include medication errors, health care associated infections, missed diagnoses and delayed analgesia. There is no published data describing the rate of adverse events in Australian EDs. However, the overall rate of adverse events in Australian hospitals is approximately 4.9 events per 100 patients (AIHW 2011b). This figure correlates with the results of a prospective cohort study (N=292) of Canadian ED patients that reported a rate of five percent (Friedman

et al. 2008). At least one study has associated access block with an increase in adverse events in the ED (Richardson 2001).

Error is defined as the failure of a planned action to achieve the intended goal and can be classified by consequence (for example wrong-site surgery, medication error) or cause (for example attention failure, broken rule) (Reason 1995). In the case of a ‘near miss’, the error usually has no associated consequence. When it is viewed in terms of the potential outcome, however, the ‘near miss’ can be considered the same as that which causes an adverse event and should, therefore, be investigated (D'Addessi et al. 2009).

The Organisational Model of Error can be used to analyse incidents and describes three types of error (Reason 1995). Type One errors include execution failures such as slips and lapses that occur unconsciously. This level also includes rule and knowledge-based mistakes. Type Two errors include violations from standard operating procedures that become routine because the rule is viewed as ‘silly’, or to satisfy personal risk-taking needs due to boredom or necessary in order to get the job done in extraordinary circumstances. Both Type One and Type Two errors are termed active failures. Type Three errors remain dormant in the system and stem from decisions made by administrators and designers separated from the operator both temporally and geographically. These errors are termed latent failures (Reason 1995). The identification of active and latent failures can be used to design error controls (D'Addessi et al. 2009).

Error reduction

Several methods are available to minimise error in the ED. Incident reporting systems, which are used in all health jurisdictions in Australia, collect data regarding accidents, near misses and minor incidents in an effort to understand vulnerabilities in the health delivery system (Thomas et al. 2011). Simulators can also be used to expose error pathways (Hunziker et al. 2010). These types of systems allow controls to be identified, designed and implemented before a critical incident takes place. Both Reason (1995) and Thomas et al. (2011) argue that these whole-of-system risk management approaches appeal to highly trained personnel, encouraging compliance. However, a large qualitative study of ED nurses conducted across two US states (N=175), found that a majority of participants were unlikely to report an error if there was no harm to the patient (Hohenhaus 2008). This result was surprising given that a mandatory error-reporting tool existed in one of the states in question. In general, under reporting of incidents reduces the integrity of the data set, giving a false impression of the safety health of the system in question.

Patient flow initiatives are another method of improving service delivery and reducing error. One approach, known as ‘Lean Thinking’, adapts concepts from the production line of a leading car manufacturer in Japan to patient flow in the ED (Holden 2011; Sheehy 2011). A systematic review conducted by Holden (2011) of ‘Lean Thinking’ as an intervention in the ED yielded 18 articles. Nine studies reported decreased length of stay, however, only one study reported increased compliance with national waiting time recommendations. Similarly,

only one study reported reduced numbers of hospital-wide adverse events (Holden 2011).

Teamwork enhancement is another method to improve patient outcomes and reduce error in the ED. Teamwork is broadly defined as collaboration towards a common goal and provides compensatory mechanisms that improve overall performance in chaotic and stressful environments (Salas, DiazGranados, Weaver, et al. 2008). Team training is considered synonymous with teamwork training and non-technical skills training. However, a more specific type of intervention known as Crisis Resource Management training has gained recent attention as a means of improving teamwork and reducing error (Carne, Kennedy & Gray 2012).

Crisis Resource Management training

Crisis Resource Management has its origins in aviation. Cockpit Resource Management, as it was first known, concentrated on communication when it was discovered that a large number of aircraft accidents in the 1970s and 1980s occurred as a result of poor flight deck coordination (Salas et al. 2001). As the concept gained traction, it was renamed Crew Resource Management in recognition of the involvement of cabin crew, ground staff and Air Traffic Controllers in the overall aviation safety picture (Lynch & Cole 2006). One study described the training as something that began as a ‘one-off’ experience and grew into a philosophy that underpins flight-related training at every level (Helmreich, Merritt & Wilhelm 1999). The study went on to state that Crew Resource Management training translates into improved flight deck skills and

attitudes. However, the overall effectiveness of Crew Resource Management training could not be measured against accident rates because the overall number is so low (Helmreich, Merritt & Wilhelm 1999).

Aviation Crew Resource Management training includes initial psychological testing to identify personality type and communication style, group dynamics as applied to decision-making, and the study of error (Salas et al. 2001). These cognitive and interpersonal skills are deliberately taught without reference to the psychomotor skills required to operate in the aviation environment (Sutton 2009). Aircraft accidents are analysed in light of information presented during the course, with participants studying the transcripts of voice recordings obtained from an aircraft's 'black box' and brainstorming what went wrong. Simulation sessions are conducted towards the end of the training and are used as an opportunity to showcase skills learned during the course. Low-fidelity simulation exercises (conducted in the classroom) provide an adequate location to demonstrate Crew Resource Management techniques when compared to more costly, high-fidelity sessions (conducted in an aircraft simulator) (Salas et al. 2001).

Crisis Resource Management training in health care

The first adaptation of these principles to health care was reported by Howard et al. (1992), who coined the term Crisis Resource Management. The researchers administered didactic training in decision-making and human performance to anaesthetists and videotaped their performance in a simulated anaesthetic emergency. Although limited by size, participants reported the course as being

enjoyable and relevant (Howard et al. 1992). Another report argued that aviation-based Crisis Resource Management training was a natural fit for operating theatre personnel given the similarity between the two environments as both involve confined workspaces, established hierarchies and high-stakes decision-making (Marshall & Manus 2007).

Several studies have explored the effect of Crisis Resource Management training on adverse events in operating theatres (Gillespie, Chaboyer & Murray 2010; Ricci & Brumsted 2012). A systematic review of team training interventions by Gillespie, Chaboyer and Murray (2010) identified 12 studies that demonstrated statistically significant post intervention improvement in teamwork practices and secondary outcomes such as rates of complication. However, the review concluded that there was no improvement in the number of wrong site surgeries, length of stay, length of procedure and turnover time (Gillespie, Chaboyer & Murray 2010). The review was limited by a lack of empirical meta-analysis and a focus on team training, rather than decision-making, leadership and supporting behaviours.

In a more recent US study, operating theatre personnel (N=517) including nurses, surgeons, anaesthetists and assistants, completed mandatory Crisis Resource Management training (Ricci & Brumsted 2012). The study demonstrated improved compliance with pre-operative briefing requirements and a decrease in wrong site surgeries and retained foreign bodies, but was limited by being restricted to one location. The study also detailed an overall decrease in malpractice expenses within the department under review (Ricci & Brumsted 2012).

Research around Crisis Resource Management in the ICU has been focused on outcomes. One paper reviewed studies investigating teamwork in the ICU in order to develop a performance framework that could be used to measure the effectiveness of Crisis Resource Management interventions (Reader et al. 2009). The paper identified four team processes: communication, leadership, coordination and decision-making. These processes were found to have the greatest effect on ICU outputs which were classified as either patient or team outcomes (Reader et al. 2009). Patient outcomes included adverse events, mortality, quality of end-of-life care and compliance with protocols. Team outcomes included job satisfaction, staff morale, stress, burnout and staff turnover. The study also identified four data types used to measure teamwork in the ICU: self-report, observational, attitudinal and interview (Reader et al. 2009). To date, this has been the only study to address issues around measurement of effect with regard to Crisis Resource Management training.

Classroom-based Crisis Resource Management training interventions have also been reviewed in a multidisciplinary context (Rabøl, Østergaard & Mogensen 2010). The study by Rabøl, Østergaard & Mogensen (2010) concluded that overall, participants reacted positively to the training and this, in many instances, contributed to improved translation to the workplace. Once again, it was impossible to generalise clinical outcomes because of the heterogeneity of the studies selected. For example, of the 18 studies identified, only nine measured the effect of the intervention at an individual behavioural level. Of these nine studies, behavioural change was measured through four different outcomes: compliance with preoperative briefings; use of communication frameworks; use

of non-technical skills and willingness to report incidents (Rabøl, Østergaard & Mogensen 2010). The issues identified by Reader et al. (2009) and Rabøl, Østergaard and Mogensen (2010) would apply equally to studies conducted in the ED.

A final study recommended the application of Crisis Resource Management beyond the health care 'crisis' environments of ICU and ED (Sutton 2009). The study stated that within the general ward areas, the reach of the multidisciplinary team is broader, and opportunities for whole-of-team discussions and debriefing are restricted. This location also allows for more fluid leadership and less formal job definition, strengthening the argument for domain-specific Crisis Resource Management training (Sutton 2009).

Crisis Resource Management training in the ED

The introduction of Crisis Resource Management training to the ED has been focused on trauma management. Given the range and severity of trauma presentations, several authors stress the need for a structured approach, involving clear role identification, predictable organisation and standardised communication (Curtis et al. 2012; Frakes 2009). This includes pre-designed treatment algorithms for multidisciplinary personnel involved in the trauma presentation, wearing vests or labels that clearly identify roles and responsibilities, high-fidelity simulation and post-incident debriefing sessions (Frakes 2009; Harkins 2009).

An ethnographic study in the ED of a UK hospital identified what factors influence the culture of a trauma team (Cole & Crichton 2006). Participant

responses were categorised into five domains: leadership, which included responsibility, experience, status and development; role competence, which included expertise and familiarity; conflict; communication and environment. Participants viewed role competence not only in terms of task performance but also as role modelling for new team members. Although limited by a relatively small sample size and being confined to one centre, the study concluded that Crisis Resource Management training would adequately address each of these factors (Cole & Crichton 2006).

Medical residents were surveyed after completing Emergency Medicine Crisis Resource Management training that used an Anaesthesia Crisis Resource Management course as a template (Reznek et al. 2003). The course involved a didactic session, simulated ED crisis scenarios and instructor-facilitated debriefing. The participants reported that they found the course enjoyable, believed the course material would be useful in their work environment, and found the simulation sessions to be realistic and faithful to actual situations (Reznek et al. 2003).

Another study proposed an ED teamwork model that included planning and preparation processes such as mission analysis, goal setting and strategy formulation; action processes such as monitoring, back up and coordination; and reflection processes including debriefing (Fernandez et al. 2008). Supporting behaviours such as leadership, shared mental models and closed-loop communication underpin each of these processes (Fernandez et al. 2008). Once again, the findings equate with the objectives of Crisis Resource Management training.

In a single, crossover, blinded and controlled observational study of ED clinicians (N=20) including doctors, nurses and technicians, the intervention group received an eight hour intensive simulator session involving graded scenarios while the control group received no training (Shapiro et al. 2004). Both the intervention and control group had previously completed a classroom-based Crisis Resource Management course, and were considered identical at baseline. The study, however, only demonstrated a trend towards improvement in team behaviour (p=0.07) (Shapiro et al. 2004).

A systematic review into the role of teamwork and communication in the ED from a physiotherapy perspective identified 14 studies and concluded that teamwork and communication interventions improve patient and staff satisfaction, patient safety and contribute to improved patient flow (Kilner & Sheppard 2010). The introduction of Rapid Assessment Teams, which are mobilised to facilitate the discharge of less complex patients, was also found to contribute to reduced length of stay in the ED (Kilner & Sheppard 2010).

Finally, a recent literature review offered a comprehensive argument for the implementation of Crisis Resource Management training in the ED (Carne, Kennedy & Gray 2012). The review identified seven key principles of Crisis Resource Management as applied to the ED: know your environment; anticipate, share and review the plan; ensure leadership and role clarity; communicate effectively; call for help early; allocate wisely and avoid fixation; distribute the workload by monitoring and supporting team members. The review argued that application of these principles improves conflict management and enhances patient safety and job satisfaction (Carne, Kennedy & Gray 2012). This final

assertion is supported by another study, which demonstrated a positive correlation ($p<0.001$) between teamwork and job satisfaction in 80 inpatient nursing units in the US (N=3675) (Kalisch, Lee & Rochman 2010).

Crisis Resource Management training and error reduction in the ED

Crisis Resource Management training courses promote aviation-style methods for reducing error. Most aviation carriers invoke a 'sterile cockpit rule' during periods of high workload such as taxi, take-off and landing which involves restrictions on non-essential duties such as paperwork (Hohenhaus & Powell 2008). Similar conditions could be imposed in the ED during medication administration, for example. Another method involves the use of written checklists to minimise legal liability and improve patient care (Howie & McMullen 2010; Wolff, Taylor & McCabe 2004). This extends to electronic checklists, which are being used in a number of EDs in Australia and overseas (Eastes, Johnson & Harrahill 2010)

There is also medium level evidence of the effect of Crisis Resource Management training on error. A seminal study conducted in 2002 used a prospective, multi-centre, quasi-experimental, untreated control group design with pre and post tests to measure the effectiveness of an Emergency Team Coordination Course on team behaviours and observable clinical errors (Morey et al. 2002). Apart from a significant improvement in team behaviours ($p=0.012$), the study also demonstrated a significant ($p=0.039$) reduction in clinical errors within the intervention group following the training. Subjective workload was also measured following the intervention and was not affected by the

intervention (Morey et al. 2002). This could mean that participants have internalised the methodologies of Crisis Resource Management training relatively easily.

Conclusion

Crisis Resource Management training has been the focus of numerous studies in various contexts. A large number of those studies reported improved teamwork following the intervention. However, fewer studies reported a reduction in adverse events. Systematic reviews of Crisis Resource Management training are either: too broad (Salas, DiazGranados, Weaver, et al. 2008), examine another outcome (Salas, DiazGranados, Klein, et al. 2008) or address a different population (Kilner & Sheppard 2010; Rabøl, Østergaard & Mogensen 2010; Salas et al. 2001). This gap in the literature should be addressed. Despite being relatively low in number, adverse events continue to be the bellwether of an ailing health care system. Patients, clinicians, administrators and governments should, therefore, welcome the possibility of high level evidence of the effectiveness of an intervention to reduce error.

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CHAPTER 2

Paper for publication

Table of contents

List of tables

List of figures

The effect of crisis resource management training on error in the emergency department: a systematic review

Background

Emergency department (ED) clinicians face many challenges throughout the course of a shift. Presentations are diverse in terms of type and acuity. Many patients display generalised signs and symptoms, which increases the time to differentiate and subsequently treat their illness. Despite improvements in pre-hospital care, triage and patient flow, EDs remain overcrowded, with some admitted patients waiting several days for a bed in a hospital ward (ACEM 2004). These factors add layers of complexity to clinical decision-making that increases the likelihood of error (Croskerry & Sinclair 2001).

Rates of error have been measured at approximately five percent, which is significant given the large number of ED presentations (AIHW 2011; Friedman et al. 2008). Errors include misinterpretation of results, missed diagnoses, incorrect medication administration and incomplete handover (Croskerry & Sinclair 2001). Following analysis, many of these errors can be attributed to deficiencies in collaboration, supervision and communication both within and across professional boundaries (Creswick, Westbrook & Braithwaite 2009; Kalisch & Lee 2010). These skills, which are distinct from the technical ones required to operate effectively as a nurse or doctor, combine to form the broader notion of teamwork (Fernandez et al. 2008). Efforts to minimise error, therefore, often involve team training. A specific form of team training known as crisis

resource management (CRM) has gained popularity as a means of improving patient care in general and reducing error more specifically (Carne, Kennedy & Gray 2012).

The content of a typical CRM course is derived from training given to aviation personnel (Helmreich, Merritt & Wilhelm 1999). Initially, participants spend a period in the classroom covering aspects such as planning and problem-solving, communication strategies, leadership, workload management through delegation, and error recognition (Dynamics Research Corporation 2004). The class then complete graded exercises in either a simulated or actual work environment under the supervision of qualified instructors. Participants take on roles during these exercises that may be different from their actual qualification, to gain a sense of how other members of the multidisciplinary team think and perform (Dynamics Research Corporation 2004).

The effectiveness of CRM in the health care setting was first reported in 1992 when training was given to a small group of anaesthetists in response to an increase in malpractice claims resulting from medical error (Howard et al. 1992). Proprietary versions of CRM have been developed as turnkey solutions both within the ED and across the hospital system (Dynamics Research Corporation n.d.; US Department of Health & Human Services Agency for Healthcare Research and Quality n.d.). Localised adaptations of these programs exist within obstetric units, paediatric departments, operating theatres and intensive care units (Foot 2007).

It is unclear how CRM might work to reduce error in the ED. Two systematic reviews (Salas, DiazGranados, Klein, et al. 2008; Salas, DiazGranados, Weaver, et al. 2008) proffer alternate theories: (1) by improving collaboration, clinicians are making better decisions in the first instance, thereby reducing the chance of making an error and/or (2) by improving error awareness, clinicians are scrutinising their own and others actions more vigilantly, thereby recognising and preventing more unsafe acts. Kilner and Sheppard (2010) offer an alternative perspective by stating that teamwork and communication act through mutual reinforcement to reduce error in the ED.

Measurement of the overall effectiveness of CRM has tended to rely on participant reports (Grogan et al. 2004; Kalisch, Lee & Rochman 2010; Marshall & Manus 2007), patient narratives (Friedman et al. 2008) or observer assessment (Shapiro et al. 2004). Systematic reviews of the effect of CRM on teamwork have, therefore, suffered due to the heterogeneity of the included studies (Kilner & Sheppard 2010; Salas, DiazGranados, Weaver, et al. 2008).

A search of the Cochrane Library, Joanna Briggs Institute and Centre for Reviews and Dissemination databases found no systematic review that specifically studied the effect of CRM on error. The objective of this review, which addresses the gap in the literature, is to determine the effectiveness of CRM in reducing error in the ED.

The review begins by detailing the search strategy, inclusion criteria, methods of screening, critical appraisal and synthesis. The results of the study are then presented. The discussion analyses the results in the context of what is already

known about the topic and concludes with a summary of what this study has added and recommendations for future research in the area.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines define a systematic review as: '…a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review…' (Moher et al. 2009, p. e1000097). Statistical methods known as meta-analysis may also be used to summarise the results of the review. The decision to synthesise results in this way is based on the number, quality and heterogeneity of the studies included in the review (Moher et al. 2009). This review has been conducted in accordance with the PRISMA guidelines checklist (Moher et al. 2009), which is provided in Appendix A.

Search

A comprehensive search of the following databases was undertaken: CINAHL, EMBASE, MEDLINE, PsycINFO, PubMed Central and Google Scholar. No constraints were placed on the search, which allowed the widest range of literature to be retrieved. The following search strategy was utilised:

1. (crew OR cockpit OR crisis)
2. (resource management)
3. 1 AND 2
4. team*
5. 3 OR 4
6. (train* OR educat*)
7. 5 AND 6
8. error*
9. 7 AND 8
10. (emergen* OR accident*)
11. 9 AND 10

The search terms (crew OR cockpit OR crisis) were used in recognition of the aviation origins of the intervention. The search terms (emergen* and accident*) increased the sensitivity of the search. Wildcard characters (*) were used because not all of the databases performed automatic word stemming. The reference lists of articles retrieved in full text were searched for relevant studies. The authors of included articles were contacted for additional information. Relevant emergency medicine and nursing journals and the libraries of the author were hand searched.

Inclusion criteria

Published and unpublished, experimental and quasi-experimental studies were considered. Studies had to be situated in an ED. This included accident and emergency, casualty and trauma departments and/or centres. The intervention

had to be formalised training delivered according to a standardised syllabus including the following components:

1. communication;
2. teamwork;
3. error recognition and mitigation strategies, and
4. problem-solving and decision-making.

Training did not have to include simulation sessions, as there is some evidence that this type of instruction has little effect on overall outcome when compared to instruction based entirely in the classroom (Rabøl, Østergaard & Mogensen 2010; Shapiro et al. 2004). Error could be either a primary or secondary outcome of the study. Error could be measured by participant report, observation or retrospective analysis of patient and/or incident reports. No restrictions were placed on error typology or severity.

Study selection, critical appraisal, data extraction and assessment of risk of bias were carried out in conjunction with experts in the field.

Study selection

Studies were screened using a three-step process. First, study titles were examined for evidence of the participants and intervention of interest only. The outcome measure was not included at this stage of the screening because many studies have as a primary aim, the measurement of team outcomes, and as such only include this information in the title. Where there was any doubt about the relevance of a study, the abstract was reviewed. Studies deemed potentially

relevant proceeded to Step 2, which involved the retrieval of the full text for further review. Step 3 involved a final check that the study met the inclusion criteria with regards to participants, intervention and outcome. Studies meeting this requirement were then critically appraised.

Critical appraisal

A number of critical appraisal tools were trialled prior to the commencement of this study. The suite of tools available from the Joanna Briggs Institute Meta Analysis Statistics Assessment and Review Instrument (JBI-MAStARI) (Joanna Briggs Institute 2011) package were chosen because they best fitted the range of studies that were expected to be encountered. The critical appraisal tools used in this study are provided in Appendix B.

Study inclusion

The aim of critical appraisal was to determine the methodological quality of studies meeting the inclusion criteria. The critical appraisal tools had nine questions. No benchmark level of positive responses was set to determine if a study would be included. Rather, an overall decision was made about the quality of the study based on the individual answers to the questions.

Data extraction

The JBI-MAStARI data extraction tool (Joanna Briggs Institute 2011) was used to extract the following data: methods, participants, intervention, outcomes, and results. An extraction tool was used in this study to ensure that the same or similar types of data were recorded for each of the included studies. The tool

allowed discrepancies in data extraction to be resolved easily between reviewers and decreased the likelihood of bias towards certain results over others.

Risk of bias in individual studies

The Cochrane Collaboration tool was used to assess risk of bias within included studies (The Cochrane Collaboration 2011). Bias was reported across the following domains: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias. Bias was used in conjunction with methodological quality to rate the level of evidence provided by included studies.

Synthesis

Due to the heterogeneity and number of included studies, statistical meta-analysis would have been meaningless. The results were, therefore, combined into a narrative synthesis. Although there is a lack of conjecture regarding the approach to narrative synthesis, the Centre for Reviews and Dissemination (CRD) systematic reviews handbook (Centre for Reviews and Dissemination 2008, p. 48) recommends a framework consisting of the following elements:

1. a preliminary synthesis of findings of included studies;
2. a theory of how the intervention works, why and for whom;
3. relationships between studies in terms of aim, method and presentation of results, and
4. an assessment of the robustness of the synthesis itself.

In order to preserve the structure of this article, the elements of the narrative synthesis appear across both the results and discussion sections.

Results

The search yielded a total of 491 studies. Individual database numbers are provided in Table 1.

Table 1 Search results

Source	Number of studies
CINAHL:	75
EMBASE:	10
MEDLINE:	165
PsycINFO:	41
PubMed Central:	198
Google Scholar and Additional sources:	2
Total studies:	491

After duplicates were removed, 267 studies were screened. Two hundred and fifty nine of these were excluded after reading title and abstract, leaving eight studies to be retrieved in full text. Six of these studies were excluded following full text review (Barrett et al. 2001; DeVita et al. 2005; Hinske et al. 2009; Hohenhaus 2008; Jankouskas et al. 2011; Rudy et al. 2007). The two remaining studies were included in this review following critical appraisal (Deering et al. 2011; Morey et al. 2002). A flow diagram constructed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2009), which details the results of the search process, is provided in Figure 1.

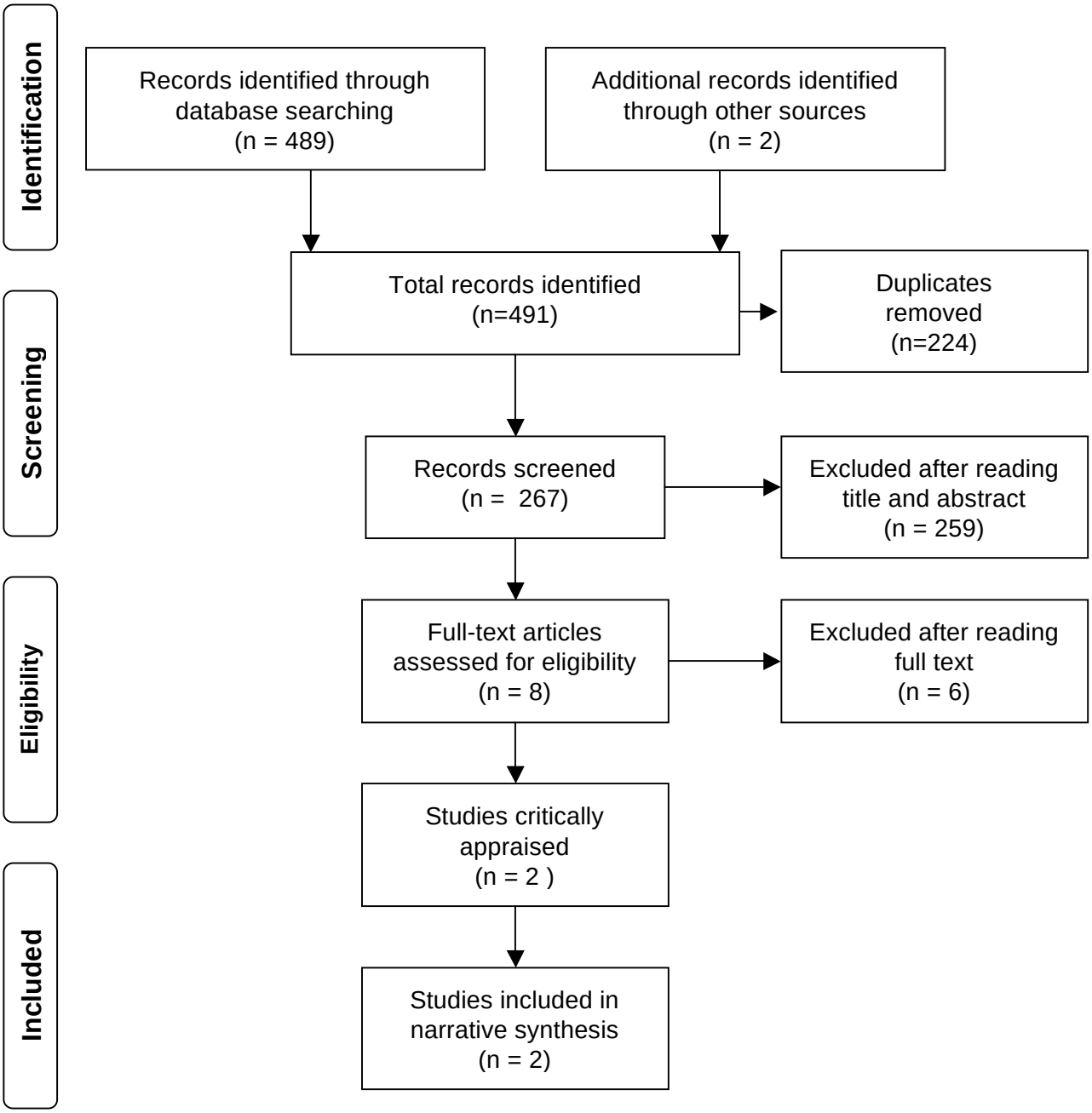

Figure 1 Flow diagram

Included studies

The included studies differed in terms of aim, method and presentation of results.

Aim

The primary aim of the study by Deering et al. (2011) was to measure the effect of a proprietary CRM program known as TeamSTEPPS (Team Strategies and Tools to Enhance Performance and Patient Safety) on error in a United States (US) military combat support hospital deployed overseas. Although the study was not based in an ED, it was included because of the similarity between the type and frequency of patient presentations to this unit and those of a large, inner city ED in the US. In all other respects, the study met the inclusion criteria.

The primary aim of the study by Morey et al. (2002) was to measure the effect of another proprietary CRM program known as the ETCC (Emergency Team Coordination Course) on the wider constructs of team behaviour, ED performance, and attitudes and opinions. The measurement of error only formed part of one of these domains – ED performance. The study was included because it met all of the inclusion criteria.

Method

Deering et al. (2011) analysed Patient Safety Event (PSE) reports over a 13-month period, seven months pre-intervention and six months post-intervention. The PSE data collection form was modified post-intervention to reflect four TeamSTEPPS competency areas: leadership, situation monitoring, mutual support and communication. PSE reports were analysed by two different

observers - firstly, by the patient safety committee at the time of the incident, and secondly, at the end of the 13-month period by a group of three health care professionals considered expert in delivering the intervention training. The health care professionals used a revised evaluation tool, which included the domains adopted by the patient safety committee in the final six months, as well as more specific questions regarding error causation.

The study by Morey et al. (2002) allowed self-selection into the experimental group (n=6). The control group was made up of two EDs that were unable to implement the intervention until it had been approved by hospital management, and one that enrolled late. Data collection began during a one-month period at the beginning of the study (Pre-test One) to establish a base-line level of knowledge. The intervention was administered to the experimental group over the next four months. Data collection resumed over the proceeding month (Post-test One). The intervention continued over the next four months for the experimental group. A further data collection period of one month concluded the study (Post-test Two). Post-test One was designed to measure the effect of the intervention, while Post-test Two was designed to test the effect of the intervention over time. Both the experimental and control EDs proceeded with the intervention following Post-test Two, however, no further measurement was undertaken.

Results

A total of 153 PSE reports were submitted during the total period of the study by Deering et al. (2011) – 94 pre-intervention, 59 post-intervention. When this data was normalised to represent inpatient census, there were 22.2 events pre-implementation and 18.2 events post-implementation. This decrease was reported as non-significant ($p=0.22$). When similarly adjusted, there was an 83 percent decrease in medication/transfusion errors ($p<0.05$) and a 70 percent decrease in needlestick injuries/exposures ($p<0.01$) post implementation. When analysed against the four TeamSTEPPS competency domains, the contributing factors with the highest frequencies involved situation monitoring (36 percent) and communication (27 percent). However, only events related to poor communication showed a significant decrease post implementation (65 percent decrease, $p<0.05$).

Within the study by Morey et al. (2002), one hospital in the experimental group did not supply Pre-test One observed error data and was therefore excluded from that part of the study. The mean observed error rate in the experimental group fell from 30.9 at Pre-test 1 to 4.4 at Post-test One. The observed error rate in the control group fell from 16.8 to 12.1 in the same period. However, when the experimental group was compared with the control group, there was no significant difference in the observed error rate from Pre-test One to Post-test One ($p=0.140$). There was no significant difference ($p=0.720$) in observed error rates between Post-test One and Post-test Two for the experimental group. A summary of the characteristics of the included studies is provided in Table 2

Table 2 Characteristics of included studies

	Methods	Participants	Intervention	Outcomes	Results	Risk of bias
(Deering et al. 2011)	Quasi-experimental, before and after analysis of PSE[a] reports	330 civilian and military health care professionals and ancillary staff of a combat support hospital	TeamSTEPPS[b]	(1) Total number of PSE reports pre and post intervention, normalised for inpatient census (2) Causes of PSEs classified according to TeamSTEPPS competencies (3) Numbers of individual causes of PSEs pre and post intervention (4) Types of PSEs pre and post intervention	(1) 18% decrease in PSE reports (p=0.22) (2) Situation monitoring = 36%, communication=27% (3) 65% decrease in communication-related events (p<0.05) (4) 83% decrease in medication/transfusion errors, 70% decrease in needlestick injuries	(a) Inadequate generation of randomised sequence (b) Inadequate concealment of allocations prior to assignment (c) Knowledge of the intervention by the participants and personnel in the study (d) Knowledge of the intervention by the reviewers

[a]PSE: Patient safety event, [b]TeamSTEPPS: Team Strategies and Tools to Enhance Performance and Patient Safety.

	Methods	Participants	Intervention	Outcomes	Results	Risk of bias
(Morey et al. 2002)	Quasi-experimental, non-randomised control, before and after study	Nine EDs (six experimental, three control) N=1058 (684 participants experimental, 374 participants control)	ETCC[c]	Observed errors pre and post intervention	Experimental: 85% decrease, control: 28% decrease (p=0.140)[d]	(a) Inadequate generation of randomised sequence (b) Inadequate concealment of allocations prior to assignment (c) Knowledge of the intervention by participants and personnel in the study (d) Knowledge of the intervention by the reviewers

[c]ETCC: Emergency Team Coordination Course, [d]paired t-test

Excluded studies

Studies were excluded because they were not available in English, not a research study, did not involve the population of interest (ED clinicians), did not study the intervention of interest (CRM), or did not measure the outcome of interest (error). A summary of the excluded studies is provided in Table 3.

Of the six studies excluded after full text review, three involved CRM delivered to participants outside the ED (DeVita et al. 2005; Jankouskas et al. 2011; Rudy et al. 2007), one measured ED nurses' experiences of error recognition and management without an intervention (Hohenhaus 2008) and two were opinion pieces (Barrett et al. 2001; Hinske et al. 2009). Those studies involving original research will now be discussed.

DeVita et al. (2005) administered in-house CRM to members of a hospital's Medical Emergency Team (MET) completing Advanced Cardiac Life Support (ACLS) training on human simulators. Although ED clinicians regularly perform ACLS, the study was excluded because it was not based in the ED. The authors measured 'patient' survival and task completion rate following three scenarios. ACLS team positions were rotated after each scenario. All 'patients' died during scenario one, with task completion rates ranging from 10 - 45 percent. At the completion of scenario three, 'patient' survival rate improved to 89 percent ($p=0.002$) and task completion rate rose to 80 - 95 percent ($p<0.01$).

In an experimental study by Jankouskas et al. (2011), the authors administered in-house CRM to groups of health care students completing Basic Life Support (BLS) training to measure the effect on overall error rate. The study was

excluded because the participants did not work in an ED. The study showed that there was no significant difference in error rate between the experimental and control groups post intervention (p=0.43).

A cross-sectional, mixed methods study conducted by Rudy et al. (2007) surveyed a group of health care professionals (N=53) to determine if they had used the content of a recently completed CRM course during clinical practice. The study was excluded because it was not based in an ED. Seventy one percent of participants felt more satisfied with their performance in a crisis after completing CRM and 84 percent of participants felt that communication was the most important concept taught during CRM.

Finally, in a study that surveyed ED nurses (N=175), Hohenhaus (2008) found that a majority believed errors related to medication administration were the most likely cause of mistakes in the ED. The study was excluded because it did not measure the effect of any intervention. Of note, 20 percent of participants reported that they had never made an error during their ED nursing practice. Given that the mean years of experience amongst the participants was 12.7 years, the author concluded that many nurses do not recognise when they have made an error because it is unlikely that any nurse could work for this long without making a mistake.

Table 3 Characteristics of excluded studies

Reason for exclusion	Number of studies
Not available in English	1
Not population of interest	105
Not intervention of interest	34
Not outcome of interest	16
Not a research study	109
Total number of excluded studies	265

Discussion

This section of the review will examine the quality of the included studies alongside their results, so as to provide an overall interpretation of the available evidence. This evidence will then be discussed in light of the findings of similar studies that fell outside the inclusion criteria, but nonetheless inform the clinical question. The discussion concludes with a summary of what this study has added to knowledge in this area, together with recommendations for an achievable next step in the research process.

Quality of included studies

The studies by Deering et al. (2011) and Morey et al. (2002) were both of low to medium level quality. The study by Deering et al. (2011) was biased on numerous levels. Because the study was quasi-experimental, there was selection

bias due to inadequate generation of randomised sequence and inadequate concealment of allocations prior to assignment. There was performance bias due to knowledge of the intervention by participants and personnel in the study. There was detection bias due to knowledge of the intervention by the reviewers. Although the study reported on TeamSTEPPS domains where there was no significant change in outcome, there were elements of selective reporting. Finally, while averaging PSE reports against inpatient census may have appeared to make the comparison pre and post intervention more reliable, it did not account for large influxes of patients during major casualty events. This is important because it is during such crises, that the residual effect of CRM training on behaviour is most tested. The study was also limited by being confined to one location.

The study by Deering et al. (2011) was, however, methodologically rigorous in many areas. The authors clearly defined the criteria for inclusion in the study and described their methods in detail. The outcomes of the study were measured reliably and appropriate statistical analysis was used to describe the results. While Deering et al. (2011) did not use a recognised tool to measure outcomes, they appeared to make a reasonable effort to standardise measurements among individual observers.

Although the study by Morey et al. (2002) was of a marginally higher quality than the study by Deering et al. (2011) due to the presence of a control, it was also biased in numerous ways. Participants self-selected into the experimental and control groups, which introduced selection bias due to inadequate generation of randomised sequence and inadequate concealment of allocations prior to

assignment. There was performance bias due to knowledge of the intervention by participants and personnel in the study. There was detection bias due to knowledge of the intervention by the reviewers. The study was also underpowered because of the small number of participating hospitals.

Both included studies reported isolated reductions in error post intervention, however, neither study was able to demonstrate significant reductions in overall error following CRM. In the case of Deering et al. (2011) the reductions were restricted to medication/transfusion errors ($p<0.05$), needlestick injuries/exposures ($p<0.001$) and communication-related errors ($p<0.05$), while Morey et al. (2002) reported a decrease in the clinical error rate from 30.9 percent to 4.4 percent in the experimental group only ($p=0.039$). Given that Morey et al. (2002) telegraphed the effectiveness of ETCC in reducing error via the title of their study, this later result was disappointing.

Main findings

The aim of this study was to determine the effectiveness of CRM in reducing error in the ED. In light of the number and quality of the included studies, and their lack of definitive evidence, it is impossible to say one way or the other whether this is the case. This may have been possible if a larger number of high quality studies were available, but they were not.

Other systematic reviews within the health care context have reported similar findings. A systematic review into the effect of CRM training on teamwork and clinical practice in operating theatres by Gillespie, Chaboyer and Murray (2010), found no significant improvement in wrong site surgeries. Another systematic

review by Kilner and Sheppard (2010) of the overall effect of team training in a multidisciplinary health care context was likewise unable to determine if there was any effect on error.

Outside of health care, no studies have specifically measured the effect of CRM on error. In an opinion piece advocating the merits of CRM in aviation, Helmreich, Merritt and Wilhelm (1999) stated that such a correlation would be difficult to prove because, overall, the accident/error rate is so low given the large number of aircraft movements worldwide. To some extent, this is also true in health care.

It is also difficult to demonstrate the effectiveness of CRM in reducing error because measurement of an outcome that is multifactorial and complex, can lead to both under and over reporting. As highlighted in the excluded study by Hohenhaus (2008), clinicians may be reluctant to report errors if the prevailing workplace culture encourages sanctions following workplace incidents. Studies using self-report of error may, therefore, be under estimating this outcome.

In contrast, studies which have as a primary aim the measurement of error, are likely to have participants that alter their behaviour because of the perception that they should do what the researcher wants – a phenomenon known as the 'Hawthorne Effect' (Wickström & Bendix 2000). Over-reporting may, therefore, result from concerted, system-wide interventions that involve continual reinforcement via posters, briefings and prompting from colleagues. This may have been the case in the study by Deering et al. (2011).

Neither included study provided definitive evidence of how CRM works to reduce error in the ED. By relating the data extracted from PSE reports to the specific TeamSTEPPS competencies, Deering et al. (2011) proposed a weak link between improved communication/cross monitoring and reduced error. Both included studies reported improved teamwork following the intervention. Systematic reviews by Kilner and Sheppard (2010), Salas, DiazGranados, Klein et al. (2008) and Gillespie, Chaboyer and Murray (2010), have previously demonstrated this relationship. Whether the interplay between teamwork and communication plays any part in the overall process of error reduction, remains in question.

What this review has added

Although this review was unable to provide a definitive answer to the original clinical question, the results are important for the following reasons. Firstly, this study found that despite ED practice remaining 'prone to error' (Croskerry & Sinclair 2001, p. 1), there has been limited research thus far to determine how many and what type of mistakes ED clinicians are making. Given the high volume and rapid turnover of ED presentations, this was not only surprising, but also alarming. This gap in the literature should be addressed.

Secondly, this study found that although considerable development has occurred in the area of health care CRM over a number of years, there is little high level evidence that this training works to improve teamwork or reduce error in the ED or elsewhere. Given the considerable commitment required to implement CRM in terms of cost, changes to work routines and additional training, this was

similarly unexpected. This does not mean that CRM is without utility, but rather that there should be more research done to demonstrate the value or otherwise of CRM in improving teamwork and reducing error.

Implications for research

The next step in the research process should be a study to identify the extent and nature of error in the ED. This should be followed with a study utilising an experimental or mixed methods design to measure the effectiveness of a 'CRM-like' intervention in reducing the errors identified in the initial study.

Strengths of this study

The strengths of this study lay in its methodological quality. The genesis of the study involved the formulation of a clinical question that was answerable and the design of a systematic review protocol that was robust. Searches were conducted across recognised databases containing the majority of published literature on the subject and a database of records identified including duplicates was maintained using the EndNote X5 reference management tool. The inclusion criteria were understandable and limited data collected to that which was able to answer the clinical question. A standard critical appraisal tool was used to establish the methodological quality of included studies. Data was extracted using a recognised tool and synthesised according to an acknowledged structure.

Limitations of this study

This study was limited by the number and quality of the included articles. No unpublished literature was retrieved, therefore, the study had a publication bias.

The JBI-MAStARI critical appraisal tools were chosen on the basis of which one best matched the aims of the individual studies. In the case of the study by Deering et al. (2011), this involved the use of the Descriptive/Case-series tool, and in the case of Morey et al. (2002), the Cohort (with control)/Case-controlled studies tool. Study results were not combined via a meta-analysis, and as such the synthesis had subjective elements.

Conclusion

Error mitigation remains an important goal of health care in general, and EDs in particular. However, the intervention cannot be recommended on the basis of reduced error alone. There may be a weak link between improved communication and reduced error. Whether targeted communication training would have the same overall effect as CRM training, however, remains unanswered. At this point, the decision to implement CRM training or similar team-oriented instruction should be based on broader systematic reviews that explore the effect on non-technical skills such as communication and problem-solving.

List of abbreviations

*****	Wildcard character
ACLS	Advanced Cardiac Life Support
AND	Boolean operator denoting logical conjunction
BLS	Basic Life Support
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CRD	The University of York Centre for Reviews and Dissemination
CRM	Crisis Resource Management
ED	Emergency Department
EMBASE	A database of biomedical literature
ETCC	Emergency Team Coordination Course
JBI-MAStARI	Joanna Briggs Institute Meta Analysis Statistics Assessment and Review Instrument
MEDLINE	United States National Library of Medicine bibliographic database

MET	Medical Emergency Team
OR	Boolean operator denoting logical disjunction
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSE	Patient Safety Event
PsycINFO	An abstracting and indexing database devoted to peer-reviewed literature in the behavioral sciences and mental health.
PubMed	A free bibliographic database developed and maintained by the National Center for Biotechnology Information at the United States National Library of Medicine
TeamSTEPPS	Team Strategies and Tools to Enhance Performance and Patient Safety

Definition of statistical terms

N	Population of the entire data set
n	Number contained in the sample
p	The estimated probability of rejecting the null hypothesis of a study question when that hypothesis is true
Paired t-test	A test that provides an hypothesis test of the difference between population means for a pair of random samples whose differences are approximately normally distributed

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Appendix A PRISMA guidelines checklist

Section/topic	#	Checklist item	Reported on p. #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	

Section/topic	#	Checklist item	Reported on p. #
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (I^2) for each meta-analysis.	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

Appendix B JBI-MAStARI critical appraisal tools

Cohort (with control)/Case-controlled studies

Q.1 Is the sample representative of patients in the population as a whole?

Q.2 Are the patients at a similar point in the course of their condition/illness?

Q.3 Has bias been minimised in relation to selection of cases and controls?

Q.4 Are confounding factors identified and strategies to deal with them stated?

Q.5 Are outcomes assessed using objective criteria?

Q.6 Was follow-up carried out over a sufficient time period?

Q.7 Were the outcomes of people who withdrew described and included in the analysis?

Q.8 Were outcomes measured in a reliable way?

Q.9 Was appropriate statistical analysis used?

Descriptive case series

Q.1 Was the study based on a random or pseudo-random sample?

Q.2 Were the criteria for inclusion in the sample clearly defined?

Q.3 Were confounding factors identified and strategies to deal with them stated?

Q.4 Were outcomes assessed using objective criteria?

Q.5 If comparisons were being made, was there sufficient description of groups?

Q.6 Was follow-up carried out over a sufficient time period?

Q.7 Were the outcomes of people who withdrew described and included in the analysis?

Q.8 Were outcomes measured in a reliable way?

Q.9 Was appropriate statistical analysis used?

In each case, the questions were answered Yes, No, Unclear or Not Applicable. A decision was then made to include the study, exclude the study or seek further information.

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Appendix C Instructions to authors (pp 68-73)

The original can be found at

Australasian Emergency Nursing Journal

http://www.aenj.org.au/authorinfo

CHAPTER 3

Conclusion and recommendations

Conclusion and recommendations

This chapter begins with a short discussion justifying the research project. This will include issues around motivation, possible sources of bias and the conduct of the literature and systematic review. This leads to implications and recommendations for practice centred around two themes: reducing workload in the ED to lessen the chance of clinician error, and improving the standard of research into Crisis Resource Management (CRM).

The aim of this project was to determine the effectiveness of CRM in reducing error in the ED. The clinical question was derived from the researcher's interest in safety and error prevention, which was cultivated in the high stakes environment of the Air Traffic Control tower. Two issues arise at this point: did the researcher's prior positive experience and understanding of the intervention influence the formulation of the clinical question and/or bias the interpretation of the results?

Having now completed the project, the researcher will concede that having a strong belief in the omnipotence of the intervention, albeit in another setting, may have influenced the formulation of the original clinical question, but only in terms of narrowing the outcome measure. As far as favourably biasing the interpretation of the results, this was anticipated and steps were taken to maximise transparency through the use of the PRISMA guidelines checklist (Moher et al. 2009).

The picture of the ED painted in the literature review, was that of an inherently complicated working environment struggling with a new administrative control

(the NEAT), which was designed to reduce waiting times and relieve access block. ED clinicians working under this new regime must either: work harder to complete their normal patient care duties in a shorter time frame to meet the new four hour target; work at the same rate but complete fewer of the normal tasks, delegating these to another unit or home carer; or maintain the status quo by working at the same rate as before, completing all of the usual tasks, resulting in fewer patients meeting the four hour target.

It was feasible to assume that in the first case, more errors would occur because the pressure on ED clinicians had increased. Staff would also turnover more quickly because such a routine was unsustainable. In the second case, it was also reasonable to assume that some care activities would be missed because the responsibility for patient care was now more dynamic than before, relying on accurate and timely handover. Pragmatically, however, the first and second cases would result in funding increases tied to the NEAT, but the final case would not.

The researcher's original hypothesis was that CRM could provide a 'safety net' of sorts during the NEAT transition period. This would arm ED clinicians with a suite of skills that would allow them to better analyse the working practices of themselves and others, ultimately reducing error. The first step in this process was to find evidence of the effectiveness of CRM in reducing error as a means of convincing decision-makers of the value of CRM in the ED.

The literature review yielded several opinion pieces that extolled the virtues of CRM in the ED (Carne, Kennedy & Gray 2012; Eppich, Brannen & Hunt 2008; Fernandez et al. 2008; Frakes 2009; Harkins 2009; Lynch & Cole 2006; Rosen et

al. 2008; Salisbury & Hohenhaus 2008; Wears & Perry 2002). However, there were only two studies involving error in the ED (Friedman et al. 2008; Hohenhaus 2008), two studies of the general effectiveness of CRM in the ED (Reznek et al. 2003; Shapiro et al. 2004) and only one study measuring the effect of CRM on error in the ED (Morey et al. 2002).

The narrow results of the literature review were reflected in the limited number of relevant studies subsequently located by the systematic review (Deering et al. 2011; Morey et al. 2002). But this does not mean that the choice of clinical question was misguided. The process used to identify relevant information was necessarily different for both the literature and systematic reviews. The purpose of the literature review in this case, was to elicit a manageable overview of information relevant to a clinical question that was formulated prior to the commencement of the project due to time constraints. It was not, as is sometimes the case, a means of identifying large bodies of information from which a clinical question can be formulated. This latter method can bias the subsequent systematic review towards meta-analysis/meta-aggregation because more studies are usually included. It can also yield answers to questions that are driven by the available research, rather than by a practitioner's need for reliable evidence of the effectiveness of an intervention.

The results of the systematic review were disappointing in that neither included study demonstrated a significant reduction in error following the application of CRM. Once again, this does not mean the review was without merit. The systematic review process provided an orderly, efficient and reproducible means of gathering and presenting evidence that could be used to answer a clinical

question and inform clinical practice (Moher et al. 2009). Without the systematic review process, the outcome would have lacked transparency and, therefore, authority. In short, the researcher suspected that there was little evidence of the effect of CRM on error in the ED following the literature review, but was unable to make such a claim without a subsequent systematic review of the literature.

Neither included study proffered a theory of how the intervention might work to reduce error. Systematic reviews by Salas, DiazGranados, Klein et al. (2008) and Salas, DiazGranados, Weaver, et al. (2008) both highlight the interplay between collaboration and error awareness in overall error prevention. They theorise that through a deeper appreciation of error pathways and improved teamwork gained during CRM, clinicians recognise errors in themselves and others more readily, and are prepared to speak up to prevent incidents (Salas, DiazGranados, Klein, et al. 2008; Salas, DiazGranados, Weaver, et al. 2008). However, the literature and systematic review did not locate any study that has demonstrated such a correlation.

The results of the systematic review cannot, therefore, be used to justify the introduction of CRM to the ED. There are, however, two significant implications for practice arising from this result, which will now be presented with associated recommendations.

Implication 1

Given that CRM is unlikely to be introduced to the ED at this stage, it is probable that the number of errors will increase until sufficient changes have been made to pre-hospital, treatment, transfer and discharge systems to accommodate the

requirements of the NEAT. Therefore, modifications should be made to each of these processes to reduce the likelihood of error.

Recommendations arising from implication 1

The recommendations for pre-hospital care involve the transfer of some of the duties of ED nurses and doctors, to paramedics in the field. This, however, should not be viewed as a cynical attempt to shift the problem away from the ED, but an endeavour to improve patient care and reduce duplication.

The tasks that could be delegated to paramedics include patient identification, history taking, assessment, treatment initiation and care planning. In NSW at present, there is no means of electronically transferring data collected by paramedics to computer systems in the ED. As such, identity information such as name, address and next of kin must be entered manually upon arrival at the ED. This similarly applies to medical history, allergies, medications and initial patient assessment. Whilst it is important to make regular assessments of a patient's condition, particularly during the emergent phase of the presentation, routine data collection such as this should be done once to avoid opportunities for errors in transcription and delays due to duplication.

There are also opportunities for paramedics to fully utilise, and in some cases extend their scope of practice. This could involve collecting routine pathology specimens such as blood, sputum and urine to speed the diagnosis of conditions such as myocardial infarction, respiratory and urinary tract infections (Shumaker et al. 2009). Although paramedics can already initiate fibrinolytics where myocardial infarction has been confirmed by electrocardiogram (Denktas et al.

2011), there is scope for paramedic-initiated hypothermia in suspected cases of cardiac arrest, stroke and traumatic brain injury (Cullen et al. 2011). Kessler et al. (2011) go so far as recommending the transfer of patients with suspected stroke direct to a dedicated stroke unit, bypassing the ED altogether. In each of these examples, paramedics are commencing clinical pathways in the field, expediting the flow of patients through the ED, and decreasing the time to effective treatment (Wolff, Taylor & McCabe 2004).

There remains room to streamline the treatment of patients within the ED. While the introduction of discrete treatment spaces such as chest pain assessment areas, sub-acute units, emergency short stay units, emergency medical units and medical assessment units have to some extent hastened the flow of patients out of the main acute treatment area of the ED, there is still a trend to use these outlying spaces as patient holding bays. In some cases, the transfer of patients to these areas is seen as meeting the requirements of the NEAT. This is clearly not the case when some patients spend several days waiting for further consultations and tests within these units. As such, there is a natural tendency to dismiss the needs of such patients, as being less than those deemed more acute. This has the potential to lead to missed medical and nursing care and, therefore, error.

There are also opportunities to rationalise the transfer of patient information between the ED and the wards. At present, this involves the collection and distribution of a considerable amount of paperwork including care plans, medication charts, orders, pathology results and in some cases x-rays. This information is easily misplaced within the frenetic environment of the ED,

sometimes leading to delays in transfer. This situation could be automated to the extent that much of this information can be stored online and printed locally.

The physical transfer of patients to the ward can also be condensed to free up resources in the ED. In many hospitals, it is considered good etiquette on the part of the ED nurse to call ahead to the ward to organise a suitable time to transfer the patient, which usually results in a request to delay the transfer due to staffing, bed cleaning or handover. Many ED nurses see this as a means of metering workload in the ward and become frustrated because no equivalent means exists in the ED. The flow of patients through the ED is then disrupted, causing friction between ED and ward staff. The ensuing handover is usually curt and lacks important information, which ultimately degrades patient care.

Handover can also be affected by workload, time of day, length of shift, experience, patient diagnosis and acuity. For these reasons, handover can be a haphazard episode, rather than a necessary, predictable and essential component of patient care. A qualitative study by Siemsen et al. (2012) of health care professionals (N=47) working in a Danish tertiary referral hospital, identified eight factors impacting on patient handovers: communication, information, organisation, infrastructure, professionalism, responsibility, team awareness and culture. The study also found that many participants did not view clinical handover as a critical safety juncture where information could easily be omitted or misunderstood, which was indicative of an immature safety culture within the hospital studied (Siemsen et al. 2012).

Wolff, Taylor and McCabe (2004) provide guidance as to how handovers can be improved. Standardised checklists and/or forms provide an easy and understandable means of conveying information. Dispatching ED personnel would be less likely to miss important and relevant information and receiving personnel know what information is coming and in what order. If pertinent information was missing, it would be more easily recognised and, therefore, sourced contemporaneously from the previous clinician. This could be achieved electronically if sufficient safeguards were built into the software handling the procedure. In the case of patients discharged directly from the ED, this could also be extended to referrals to the patient's own doctor or community health provider, which are at present mostly paper-based.

Implication 2

There is a gap in research with regard to error causation and prevention in the health care setting. The body of research describing the effect of CRM in health care is similarly limited.

Recommendations arising from implication 2

More research should be carried out into the size and nature of error in the ED. Although many health services already collect information about incidents through computerised safety management systems, much of this data remains out of the public domain due to confidentiality requirements and an understandable desire to project a positive safety image to the consumer. Such data sets are more or less useless, unless they are mined intelligently and analysed appropriately.

For example, there has been limited recent research into the effect of time of day on clinical error. In a study of anaesthetic adverse events, Wright et al. (2006) found that procedures conducted in the afternoon were associated with poorer outcomes. Silbergleit et al. (2006), on the other hand, found a slight increase (0.5 percent) in early mortality for those patients treated in the ED at night, but reported negligible differences in intubation attempts and time to thrombolysis. By contrast, and in keeping with the aviation flavour of this thesis, de Mello et al. (2009) found higher incidences of pilot error due to attention problems and fatigue in the early morning. Research in this vein could potentially affect staffing and rostering decisions in the ED, with more clinicians being available during periods when error was more likely.

The final recommendation concerns the intervention that has been central to this thesis – CRM. The literature to date has focused on what CRM is capable of delivering, rather than measurements of actual effect. There are two reasons for this: there is a poor understanding of how the intervention works, and there has been limited research into how the effect of CRM can be measured with any accuracy. Reader et al. (2009) went some way with this by developing a performance framework that could reliably measure outcomes such as team communication, team coordination and team decision-making in the ICU. However, the literature and systematic reviews contained in this thesis did not identify similar frameworks involving error in any other health care context.

The way forward will involve groundwork in the form of studies testing the reliability of outcome measures and theories of operation. Large scale, randomised controlled studies across numerous locations would provide the

highest level of evidence of the effectiveness of CRM, however, as revealed in the study by Hohenhaus (2008), qualitative methods may also have a significant role in this process. Only then will a systematic review similar to that conducted by Gillespie, Chaboyer and Murray (2010) into the effectiveness of CRM within operating theatres, be possible in the context of the ED.

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