Interventions to improve patient safety in the emergency department

Literature review for the Harm Prevention in the Emergency Department project

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Victorian Managed Insurance Authority (VMIA) acknowledges the Traditional Custodians of the land on which we do business and we pay our respects to Elders past, present and emerging. We acknowledge the important contribution that Aboriginal and Torres Strait Islander peoples make in creating a thriving Victoria.

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Document purpose

A deliverable of our Harm prevention in the Emergency Department (ED) project is a literature review to provide state, national and global perspective on what constitutes best practice, evidence-based initiatives to improve in ED care delivery and patient safety through a harm prevention lens.

This literature review provides a summary of available evidence specifically considering interventions to improve patient safety in the ED.

The review is intended to support decision-making for current project recommendations, and funding of future initiatives by VMIA and project partners. The information in this document will be considered in conjunction with findings from data analysis, health sector expert opinion, and client focus groups to determine final project recommendations.

Executive summary

EDs are characterised by a potentially challenging environment with a high risk of adverse patient safety events. Within Australia the rate of hospitalisations involving an adverse event in emergency admissions has remained at nearly 10% for the past several years.

Procedural, medication and diagnostic errors are all important areas of potential improvement for patient harm prevention. Researchers have found that diagnostic errors account for the largest fraction of medical indemnity claims, the most severe patient harm, and the highest total payouts. Diagnostic error occurs more frequently in EDs than the recorded 10–15% of adverse medical events for hospital inpatient care.

When considering diagnostic issues, it is important to recognise that, it is not always possible to make a definitive diagnosis in ED. The focus of ED is, based on the available information at the time, to identify serious illness and injury requiring emergency intervention and to, as much as is reasonably possible, rule out serious illness and injury. For rare conditions, this requires a risk balancing approach because the risks of pursuing a rare diagnosis can sometimes be higher than the risk of missing the condition. Clinicians operate within a complex, rapidly changing system with exposure to only a small part of a patient's journey and illness evolution. Patient safety improvements targeting clinical decision-making in this context aim to optimise diagnostic decision-making and appropriately manage risk rather than reduce diagnostic uncertainty to zero.

This report reviews the current literature specifically considering evidence for interventions to improve patient safety in the ED. The quality of literature on interventions in this field is limited. The few randomised trials are single centre based with findings which have not been replicated. As such the generalisability and effectiveness of any single intervention is likely to be limited in nature.

While the quality of literature in this field is limited, the best available evidence supports:

- Multiple interventions aligned and aimed at different levels e.g. care bundles for specific presentations or diagnoses that comprise of; standardised, clear care pathways for diagnosis, treatment and escalation, staff/team training and education, robust feedback and audit mechanisms and campaigns to increase awareness within the public and healthcare workforce.
- Interventions tailored or matched to best address the specific needs of the healthcare setting they target.
- A whole-of-system approach to address patient safety within the ED in a sustainable and meaningful way. Isolated interventions may be effective in the short term. However, they are likely to require significant effort and are unlikely to be sustainable once initial momentum wears off.
- Fostering a culture of safety, shared learning and focusing on communication and empathy in care delivery are necessary for any safety intervention to be effective and sustainable.

The available evidence can be categorised by the intended target of the intervention as follows:

Patient directed interventions

In the crowded and complex ED context, achieving patient-centred care is challenging but vital. Patient participation in reporting of adverse events, better communication, and collaboration to ensure accurate transfer of information and facilitate the assessment of safety interventions are important. A large proportion of adverse patient safety events have been attributed to failures in communication with patients. Shared decision-making with consumers is a critical practice when faced with diagnostic uncertainty.

Practitioner directed interventions

Human factors such as cognitive overload; the effects of stress, fatigue, distractions and interruptions; poor interpersonal communication; imperfect information processing; and flawed decision making are all known to contribute to errors in health care. Practitioner directed interventions such as targeting teamwork, clinical communication and diagnostic decision-making are currently recommended best practice.

System/Process level interventions

System level issues such as overcrowding, lack of resources or clinical support, workload, and process vulnerabilities such as unreliable referral pathways or follow up of abnormal results are some of the underlying factors leading to patient harm. Broad based interventions aimed at improvements at a system level are more likely to improve care and diagnosis and be sustainably integrated into ongoing practice than those with a narrow focus or targeting individual practitioners.

Interventions to improve patient safety in the emergency department

1. Background

1.1 Patient safety in healthcare

The patient safety movement emerged out of evidence from multiple studies that shined a glaring light on adverse events in health care across the globe.[1–3] [4] One in 10 hospitalised patients is believed to be affected by at least one adverse patient safety event (AE), with one out of 14 such events resulting in fatality and half of all cases considered preventable.[5] It has been estimated that AEs add 13–16% to hospital costs alone - at least one dollar in every seven spent on healthcare.[6] This figure does not include human costs such as pain and suffering or loss of independence and productivity for patients and their carers, or costs of litigation and settlement of medical indemnity claims.[7]

The resulting sustained focus on patient safety has resulted in some degree of success.[8] This has been achieved through calls for leadership and research, mandatory reporting systems, actions of oversight organisations, professional groups and the direct efforts of health care organisations to ensure safe practices at the delivery level.[9,10] However, there are ongoing concerns that hospitals have not become safer[11] and it has been observed that there is no silver bullet when it comes to improving care[12].

Within Australia the rate of hospitalisations involving an adverse event in emergency admissions has remained at nearly 10% for the past several years.[13] Widely publicised evidence from events that occurred in King Edward Memorial Hospital in Western Australia (2000)[14], Bundaberg Hospital in Queensland (2005),[15] Djerriwarrh Health service in Victoria (2014), [16] Bankstown-Lidcombe in New South Wales (2016)[17] and Oakden in South Australia (2017)[18] remind us that our health care services continue to be impacted by systemic issues where measurable and sustainable improvements in quality and safety are yet to be realised.[19] Multiple complex factors that vary between departments, hospitals, health systems and patient populations mean it is difficult to generalise the impact of targeted interventions from one area to another.

1.2 Patient safety in the emergency department

Patient safety has been defined as freedom from any harm associated with health care in clinical settings. The ED is regarded as a natural laboratory for the study of error due to its unique operating characterisitics.[20] The increasing number of elderly patients, those with injuries, mental health issues and substance abuse and increasing complications related to chronic medical conditions adds to the rising complexity of care in the emergency setting.[21] People with a lower socioeconomic status, people with disability, and Aboriginal and Torres Strait Islander people experience higher rates of illness, hospitalisation and death than other Australians.[22] The health challenges faced by rural and remote communities are significantly different from those that confront metropolitan Australia. The combined impact of fewer resources, poorer access to services, limited availability of key health professionals, poorer health due to a lower socioeconomic status, distance and travel all influence the experience of health consumers accessing services in these settings.

EDs are fast-paced health care settings with complex communication areas, and a high rate of work distractions and disruptions. In addition, health care providers are required to assess different types of patient presentations, treat conditions of varying severity with limited certainty of a final diagnosis. Therefore, EDs are characterized by a potentially challenging environment with a high risk of AEs.[23]

1.3 Established risk factors

Patient age and health care setting have been identified as risk factors for AEs, with the paediatric population seen in ED being particularly vulnerable to harm from medical errors[24]. Patient safety

studies in hospitalized patients have also identified older patients (>65) as high risk for AE [25] with prolonged length of stay in ED being linked to increased risk of in hospital adverse events in elderly patients.[26]

There is a direct link between **overcrowding** and the risk of AEs including those due to failure in patient assessment and follow-up care plan, delayed treatment, and an increased risk of preventable medical errors, including medication AEs.[27,28]

Communication failures related to poor staff communication are common findings in studies of AEs in hospitals and are even more evident in EDs. Examples include failing to communicate changes in vital signs to the attending physician, problems with the transfer of medical information and orders, delayed treatment of patients, and safety events associated with handoff communication failure.[23,28,29]

The difficulty in the timely recognition and treatment of **atypical or non-specific presentations** of a serious underlying disease[30–32] is made more complicated by the stress, interruptions, conflicting priorities, and acuity of presentations with limited and fragmentary patient information which is part of everyday work flow in the ED.

AEs often occur in a wide variety of emergency care aspects, including diagnosis, medication management, procedures, documentation, and communication.[33] Stang et al. (2013) reviewed AEs in ED and found that **management related events** (e.g. pulmonary oedema after excessively rapid infusion of normal saline) were the most common in 3 studies. They found **diagnosis related events** (e.g. renal failure following delay in diagnosis of abdominal aortic aneurysm) were the most common in two studies. Additionally, **medication related** events (e.g. anaphylaxis in patient with known codeine allergy prescribed codeine) were the most common in two studies and **procedural issues** (e.g. difficulty in obtaining IV access) were the most common in one remaining study.[34]

1.4 Uncertainty, diagnostic error and the emergency department

> "Medicineis a science of uncertainty and an art of probability"
>
> Sir William Osler

The National Academies of Sciences, Engineering, and Medicine defined diagnostic error as the failure to (a) establish an accurate and timely explanation of the patient's health problem(s) or (b) communicate that explanation to the patient.[35]

Patient surveys confirm that at least one person in three has firsthand experience with a diagnostic error[36]. Diagnostic error occurs more frequently in EDs than in the recorded 10–15% of adverse medical events for routine hospital inpatient hospital care[37]. There is often a higher rate of serious patient harm[1], mortality and length of hospital stay for patients who are misdiagnosed in the ED.[38] In Australia, an estimated 140,000 cases of diagnostic error occur each year, with 21,000 cases of serious harm and 2000–4000 deaths.[39]

Errors of diagnosis are multifactorial in origin and usually involve human and system related factors[37,40] that include a combination of cognitive load, authority gradients, poor team work and the work environment amongst other contributing factors. A large majority (up to 80%) of them are deemed preventable.[41]

In addition to physical harm to patients, diagnostic errors also have a significant impact on health care spending and the economy. Researchers have found that diagnostic errors - not surgical mistakes, or medication overdoses - account for the largest fraction of malpractice claims, the most severe patient harm, and the highest total of penalty payouts.[42]

In their 2015 report the National Academy of Medicine state that "The diagnostic process is a complex and collaborative activity that unfolds over time and occurs within the context of a health care work system. The diagnostic process is iterative, and as information gathering continues, the goal is to reduce diagnostic uncertainty, narrow down the diagnostic possibilities, and develop a more precise and complete understanding of a patient's health problem."[35]

It is important to recognise that, it is not always possible to make a definitive diagnosis in ED. The primary focus of ED is to identify or rule out serious illness and injury as much as reasonably possible, based on the

available information at the time, and to initiate required treatments in a timely and safe manner. For several presentations, this requires a risk balancing approach because the downstream risks of pursuing a diagnosis can sometimes be higher than the risk of missing the condition. An increasingly low tolerance for uncertainty has been linked to increased test ordering, failure to follow evidence-based guidelines, and fear of medical malpractice[44].

Providers tend to give excess weight to the benefits of diagnosis and intervention while underemphasizing potential harms.[45] One of the reasons is that adverse consequences from over testing, medication and hospitalization generally occur on a much longer timeline than the consequences of a missed diagnosis. A second cognitive error that can influence decision making is incorrect assumptions about patient preferences[46–48]

This emphasises the imperative to understand that decision-making is based on probabilities rather than absolutes and involves considering and managing risk, and the real harm of overdiagnosis[49]. As clarified by the 2015 IOM report, improving diagnosis should not imply the adoption of overly aggressive diagnostic strategies. **The goal of diagnostic testing is not to reduce diagnostic uncertainty to zero (an impossible task), but rather to optimize decision making by judicious use of diagnostic testing**[50,51].

1.5 Medication safety in the emergency department

Medication error has been defined as ‘a failure in the treatment process that leads to, or has the potential to lead to, harm to the patient’[52]. Earlier literature reviews of medication safety in Australia suggested the proportion of all hospital admissions that are medication-related is between 2 and 3%.[53] Other studies estimated medication-error rates varying from 4% to 14% to as high as 39% in paediatric ED settings[54,55].

Transitions from one health care setting to another are known to be a point of vulnerability for medication management[56] Literature suggests up to two errors per patient may occur in discharge summaries, with the highest rate reported for older patients being discharged from hospitals to aged care[57]. Multiple medicine use is now much more prevalent, leading to the potential for many more problems[58].

Strategies to improve safety must therefore consider the role of medication related events and assess the evidence to manage them within the ED.

1.6 Procedural safety in the emergency department

Procedures are commonly performed in the ED. In order of decreasing frequency these range from the administration of IV fluids (in 46% of visits), to splinting or wrapping, laceration and wound management, abscess drainage, foreign body removal and endotracheal intubation (from a survey of 117 million ED visits in the United States). Procedures such as lumbar puncture, central venous line placement, joint reduction and tube thoracostomy formed a sizeable category of “other procedures”.[59]

Although most ED procedures are minor, there is tremendous variation in the risk of complications for each procedure. The specific risks are dependent on many factors, including the inherent procedural risks, patient factors, the immediacy of the procedure, environmental conditions, the skill level and training of the provider performing the procedure, and the organizational context.[60]

Because of the wide variation in ED procedures and variable risks associated with each procedure, steps to ensure safety should be procedure specific. The literature on ED procedural safety is still in its early stages, and much of the foundational work has yet to be conducted. Despite the absence of definitive evidence, Quality Improvement and Patient Safety Organizations have recommended policies to be followed when procedures are performed in the hospital (including the ED).[61]

Noting the absence of definitive data demonstrating benefit of many recommendations, Pines et al. explore safety issues and propose a conceptual model for procedural safety. They categorised common ED procedures in the context of their respective hazards and potential interventions to help mitigate risk.[62]

2. Review objective

To review the evidence base for interventions that have been trialled within health care settings or in simulated environments with the objective of improving patient safety. Our focus was predominantly on improving assessment, diagnosis and included interventions that were aimed at the level of the individual, team and systems. We also broadly reviewed interventions that reduce or limit the effect of underlying systemic factors such as access block that have an adverse impact on safety.

3. Methods

Medline and CINAHL databases were searched using different combinations of terms such as “adverse events”, “Emergency Department”, “malpractice”, “patient safety incident”, “diagnostic error”. Relevant patient safety websites including those belonging to the Agency for Healthcare Research and Quality (AHRQ), World Health Organisation (WHO), Australian Commission on Safety and Quality in Health Care (ASQHC), Australasian College for Emergency Medicine (ACEM), Institute for Healthcare Improvement (IHI) and Society to Improve Diagnosis in Medicine (SIDM) were referred for content. The research cited in the Making health care safer reports from AHRQ were an especially valuable source of evidence for interventions as were the bibliographies from review articles, systematic reviews, and safety reports.

Studies with limited practical applicability to the emergency department or were not relevant to our setting were excluded. Additional studies were reviewed after feedback from our expert group.

4. Results

4.1 Patient directed interventions

Care delivery in the ED is driven by clinicians and protocols, with patients sometimes cast as passive consumers of care. In the ED context, achieving patient-centred care is challenging but vital.[63]

A large proportion of AEs have been attributed to issues in communication with patients and their involvement in their own care.[64–66] Therefore, safety initiatives should involve patient participation in reporting of AEs, better communication and collaboration strategies to ensure accurate transfer of information, prevent misunderstandings, and facilitate the assessment of safety interventions.

Physicians and patients often see the world differently, and clinicians need to avoid assuming understanding of the risk tolerance of their patients[67,68] A related incorrect assumption sometimes made by physicians is that patients want a “unilateral directive approach” in which the physician makes the decisions[69]. Most ED patients wish to have some involvement in medical decisions, especially in the case of more serious medical problems [70,71]. Thus, there is an urgent need to strengthen the practice of shared decision-making when faced with uncertainty[72,73]

Relevant literature describes how practitioners can better engage and empower patients when more than one reasonable care alternative exists. Two such examples are using evidence-based decision making tools to communicate diagnostic uncertainty[74] and providing necessary information to enable shared decision-making.[75]

Using trained interpreter services rather than untrained interpreters for patients with limited English proficiency has been shown to affect patient satisfaction, quality of care and outcomes.[76] Patient mediated strategies which enable patients to better report their health information, concerns or needs (usually via waiting room questionnaires) or that increase patient education may improve adherence to recommended practice guidelines according to a Cochrane review by Fonhus et al.[77]

In the case of paediatric patients, initiatives have targeted clinician communication with parents or carers.

A randomised trial reviewed by McDonald et al (2013)[78] in their systematic review of patient safety strategies targeted at diagnostic error found that parent education improved parents' ability to identify serious symptoms requiring a physician office visit.

For patient or caregiver education to be effective it must contain structured content, be presented verbally with written and visual cues to enhance recall and be provided in the patients language at an appropriate reading level.[79] Using a Teach-back method, [80] adding video or written information[80 81] to help ensure patient and family comprehension, and implementing a time-out at discharge for protected time to discuss discharge instructions have promoted safer and more patient oriented care.

4.2 Practitioner directed interventions

Human factors such as cognitive overload; the effects of stress, fatigue, distractions and interruptions; poor interpersonal communications; imperfect information processing; and flawed decision making are all known to contribute to errors in health care.[82] The following interventions are currently recommended best practice in practitioner directed interventions, grouped in domains of clinical processes in EDs.

4.2.1 Teamwork

The number one recommendation to address diagnostic error in the National Academy of Medicine report was to improve teamwork in the diagnostic process[83] with a focus on promoting awareness among team members of each other, in particular their identified roles/responsibilities and experience level.

Team training has been used successfully to improve the quality of team behaviours in the ED, as well as to reduce medical errors[84]. Current recommendations to improve teamwork in EDs include team huddles at key times to ensure communication of important information[85] and actively promoting multidisciplinary teamwork with initiatives **targeting high-risk conditions** like sepsis**,** stroke and trauma.[86 87]

Initiatives derived from high reliability organisations have been successfully adapted and incorporated within programmes to achieve better team behaviours, reduce errors and staff attitudes.[84,88,89] This has been shown in Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS), and Crew Resource Management (CRM) training. A comprehensive provider/team communication strategy includes multiple strategies that support better communication and teamwork (e.g. implementing a structured communication tool, a standardised escalation process, and team huddles) as demonstrated by Dingley et al.[90]

4.2.2 Safety checklists

The benefits of using checklists by teams involved in high-risk procedures has been clearly documented. Surgical checklists have been demonstrated to reduce morbidity and mortality across a variety of settings. In a worldwide study after the implementation of the WHO checklist, the complication rate was reduced from 11.0% to 7.0%, the surgical site infection rate from 6.2% to 3.4%, and the in-hospital death rate from 1.5% to 0.8%[91] These improvements have also been seen in other studies [92,93] Implementing the checklist includes potential impact through improved communication and aspects of safety climate such as the ability to speak up. In a collaborative cohort study in 108 ICUs predominantly in the US, Pronovost et al showed a significant reduction in catheter related blood stream infections from 2.7 infections per 1000 catheter days to 0 at 3 months after implementation of an evidence based intervention including a checklist to ensure adherence to infection control practices.[94]

Redfern et al describe the implementation of a checklist in a quality improvement programme and conclude that the implementation of **the ED safety checklist** was associated with improvements in key ED clinical performance indicators. There was improved management of time-critical conditions which included a mean increase of over 5% in CT scanning within an hour for patients with a suspected stroke. Additionally, there was a mean increase of 25% in hourly observations and Early Warning Score calculation with no clinical incidents relating to failure or delay in recognising a deteriorating patient. [95] This has now been adopted across all six hospital trusts and the ambulance service in the West of England.[96]

Performing ‘time-outs’ before a procedure is a component of the Universal Protocol along with a pre-procedure verification process and marking the patient site. These have been associated with improved reporting of equipment problems and lower rates of wrong-site surgical procedures [97,98] Although certain life and limb saving procedures should not be delayed by the requirements of a formal time-out process, pertinent safety issues can be addressed in preparation for the procedure. This may include pre-procedure role allocation, equipment checks, and discussion of back up plans. Post-procedure confirmation of placement and assessment for complications are recommended prior to use of material (e.g. central venous line placement, endotracheal tube confirmation).[99,100] Use of checklists in the emergency department has been associated with a reduction in complications and first pass success associated with intubation[100],[101] improved identification of deteriorating patients and clinical performance indicators[102] and have a potential to prevent diagnostic errors.[103]

4.2.3 Decision-making in the emergency department

Flaws in decision-making arise due to several individual, team and system factors. It is important to balance the pursuit of a final diagnosis when clinically indicated, with the harms of over investigation and unnecessary hospitalisations. As Platts-Mills affirm, *“for many clinical conditions, a period of observation is a safe and cost-effective diagnostic tool (“tincture of time”), however ED crowding and pressure to make decisions quickly to minimize ED length of stay make this approach less feasible. Expectations of referring, consulting, and admitting physicians can also put pressure on us to answer questions that sometimes don’t have to be answered”* [104]

Some of the interventions that are recommended to improve decision making within the ED are as follows.

4.2.3.1 Education

Education can support improvement interventions by engaging and familiarising clinicians with the justification for an intervention. However, especially passive education used on its own, typically delivers little value in improving diagnostic performance or patient safety.[105,106]

More useful would be tuition focused on scenarios involving frequently missed or wrongly diagnosed conditions, including vascular events, infections, cancer, and neurological disorders[107].

Education strategies that were reviewed include the following:

- Online modules coupled with performance feedback for targeted conditions.[108]
- Clinical reasoning education using virtual patients[109] and case-based learning.
- Workplace in-situ simulations[110] and integration of simulation training into educational curriculum[111].

An overreliance on educational interventions will likely fail to produce results if applied to problems that do not involve knowledge deficits, requires frequent repetition, or is impeded by external or system factors such as staff turnover.

General training in clinical reasoning

Cognitive factors in clinician decision making are primary or contributory causes of more than 75% of diagnostic errors, with system errors (e.g. missed communication or follow-up of a laboratory test result) being less frequent. [112] Accurate decision-making requires the ability to consider multiple diagnostic or management options, to use Bayesian (or probabilistic) reasoning and to override initial ideas in response to new information. Flaws in reasoning processes rather than knowledge gaps may underlie diagnostic errors.[113]

Cook et al. (2010) conducted a meta-analysis and systematic review of the effects on training outcomes of using virtual patients, including the effects on clinical reasoning. The main takeaway from this research was the use of virtual patients, is associated with large positive effects on clinical reasoning and other learning outcomes when compared with no intervention. Virtual patients were also associated with small effects in comparison with noncomputer instruction.[114]

Graber et al. (2012) performed a review to identify interventions that might reduce errors in clinical reasoning. Articles were classified into three categories:

1. Interventions to improve knowledge and experience, such as simulation-based training, improved feedback and education focused on a single disease.
2. Interventions to improve clinical reasoning and decision-making skills, such as reflective practice and active metacognitive review.
3. Interventions that provide cognitive 'help' that included use of electronic records, integrated decision support, informaticians, and facilitating access to information, second opinions and specialists.

Not all the suggestions had been tested, and of those that have, the evaluations typically involved trainees in artificial settings, making it difficult to extrapolate the results to actual practice.[115]

Hall et al[116] tested the effectiveness of cognitive aids provided in the form of simple, single step by step pathways in a randomised trial in Northern New South Wales, Australia. In a randomised trial, participants in groups were asked to manage four simulated emergency resuscitation scenarios with and without the use of the cognitive aid in the form of the Emergency Protocols handbook. Overall, scenarios using the handbook exhibited significantly lower estimated error rates: 17.9% versus 38.9%, for a relative reduction in error of 54.0% and an absolute risk reduction (ARR) rate of 21%. However, it is unknown whether interventions tested by simulation will perform in a similar manner during real clinical situations where responses depend on team composition, rural / metropolitan setting differences and other human factors that cannot be easily simulated.

Reilly et al. (2013) incorporated the promotion of reflection on past experiences where a cognitive bias led to a diagnostic error, as part of a longitudinal curriculum on cognitive bias and diagnostic errors for residents. Internal medicine residents who completed the curriculum significantly improved their ability to recognize cognitive biases when compared with their baseline performance ($p=0.002$), and when compared with the control group ($p<0.0001$). The study was limited in that it did not evaluate the impact of the intervention on diagnostic accuracy.[117]

Mohan et al. (2018) conducted a randomized controlled trial comparing two training interventions designed to improve the use of the representativeness heuristic to improve trauma triage by emergency physicians. The authors developed two serious video games to train in the use of the heuristic. Both games incorporated feedback on diagnostic errors and how they could be corrected. Results showed that both games had positive effects on trauma triage, whereas traditional medical education provided through an app had none.[118] The authors concluded that compared with apps based on didactic education, exposure of emergency physicians to a theoretically grounded video game improved triage decisions up to 6 months later. However, given that the entire study was performed online, the real-world efficacy of this intervention remains uncertain.

Scott and Crock suggest practical strategies including cognitive debiasing strategies and pedagogical methods to improve clinical reasoning.[119] Although intuitively this should improve diagnostic acumen, evidence of reproducible findings in the clinical setting are lacking.

Training and skill acquisition through simulation

Simulation-based learning is a widely accepted educational technique that does not put patients at risk and is supported by educational theory. The features of simulation which best facilitate learning include[84,120]

- The ability to provide feedback
- Repetitive practice
- Curriculum integration
- The ability to range the difficulty levels

It has been associated with improved patient outcomes, better teamwork and earlier identification of latent safety threats and system improvement.

In a single centre observational study from North America, Andretta et al showed that mock codes were correlated with a 50% increase in survival rates for paediatric cardio-pulmonary arrest. These rates were

significantly above the average national paediatric Cardiopulmonary arrest survival rates and held steady for 3 consecutive years, demonstrating the stability of the program's outcomes.[121]

In a before and after study involving didactic sessions followed by in-situ simulation, Steinmann et all showed improved teamwork ratings, task speed and task completion rates which were observed to translate into clinical practice.[122]

In a prospective cohort study, Thielen et al found significantly improved recognition and management of deteriorating in-patients with evolving critical illness after the introduction of a Medical Emergency Team and concurrent team training.[94]

Patterson et al found that a latent safety threat was identified at a rate of one in every 1.2 simulations performed in their study of 90 in-situ simulations in an urban ED over a 12 month period. [123]

Utilising simulated medication administration scenarios, a Queensland hospital examined the ability of nurses to identify medication errors. Nurses were presented with education about concepts of human error and risks, the systems in place in the hospital to prevent medication errors, roles and responsibilities in detecting errors and preventing harm. Results showed that the risk would have been identified and appropriate action taken in a median of 5 and average of 4 of the 6 scenarios.[124]

Other education/training interventions

Several other types of educational interventions targeting various consumers, doctors, nurses have been studied.

A quality improvement study assessed the impact of **feedback to emergency physicians** of telephone follow up outcomes of discharged patients, and **resident training about uncertain presentations** of serious disease and the need to use additional evaluation on selected patients.[125] Another investigated the value of **radiograph audit** involving both orthopaedic surgeons and radiologists in a formal daily conference run in an ED.[126] A prospective study on the benefits of **educating referring doctors** about sudden onset headache saw a 77% reduction in diagnostic error related to subarachnoid haemorrhage as a result of continuous interaction between neurosurgeons and local physicians.[127]

Feedback to clinicians on their errors has the potential to improve the overall diagnostic process and therefore patient safety.[128] Such feedback is important, as clinicians' self-assessment of their diagnostic accuracy is unreliable and their level of diagnostic confidence can be insensitive to both accuracy and case difficulty.[129] Organisational strategies to identify errors combined with reflection on identified errors ("cognitive autopsies") improve diagnostic performance.[128,130] Strategies include trigger tools within electronic medical records for identifying unexpected adverse events or unplanned readmissions, and systematic identification of errors within mortality and morbidity meetings.

The learning process of clinicians can be improved by changing the culture of organisations. This can be done through shifting the focus of feedback towards learning from diagnostic errors and improving the system rather than blaming the individual who made the error.[131] [132]

Several other studies in emergency settings supporting the utility of the **audit process** on reducing diagnostic errors were reviewed in a systematic review by Abimanyi-Ochomet et al.[133] Espinosa et al created a database (for use in teaching) of all clinically significant errors made by emergency physicians interpreting radiographs and implemented radiologist film review within 12 hours as a standardised control measure. In this longitudinal study, they showed a substantial reduction in error rates in interpretation of radiographs by emergency physicians. [134]

4.2.3.2 Decision support

Decision supports include the use of diagnostic checklists [135] easily available guidelines and protocols, clinical decision support systems, supervision, second opinions and referral pathways.

Diagnostic checklists

Checklists are considered a promising intervention for the area of diagnosis because they can support clinicians in their diagnostic decision making by helping them take correct diagnostic steps and ensuring that possible diagnoses are not overlooked.

Graber et al (2014) studied the use of a general and a **symptom specific checklist** in ED to reduce the likelihood of diagnostic error for patients presenting to the ED with undiagnosed conditions. Checklist use commonly prompted consideration of additional diagnostic possibilities, changed the working diagnosis in approximately 10% of cases, and anecdotally was thought to be helpful in avoiding diagnostic errors. The authors added that inconsistent usage and using the checklists privately, instead of with the patient, are factors that may detract from obtaining maximum benefit.[135]

Summarizing the current evidence on checklists in improving diagnostic reasoning however, Zwaan and Staal comment that "evidence that checklists improve diagnostic accuracy is mixed. Positive effects of checklists on diagnostic accuracy were mainly found in subgroups of cases (difficult cases) or clinicians (junior clinicians). Most studies that measure effects on accuracy were performed in controlled settings that do not resemble typical clinical practice, and even the modest benefits of checklists may therefore be overestimated."[113]

Additional review processes

Additional review processes have a positive impact on diagnostic accuracy. The most common intervention type evaluated was the review of test interpretation.[136, 137, 138, 126] Additional patient review was also studied in trauma patients[139,140] and found to be of benefit. In a before-after study the implementation of a dedicated paediatric trauma response team reduced the incidence of delayed diagnosis of injury from 4.3% to 0.46%.[139] Another study on the effect of implementing a paediatric trauma response team showed a significant reduction to treatment time and better survival of patients with severe trauma.[141] One study evaluating the utility of tertiary trauma surveys in adults showed a 36 % decrease in missed injuries post implementation of a routine trauma tertiary survey process.[142] Another study confirmed a 16% incidence of delayed diagnosis of injuries in children utilising an extended tertiary survey in paediatric trauma patients.[143] Both make a case for tertiary surveys being a routine part of ongoing evaluation of the trauma patient.

Computerised decision support

A clinical decision support system (CDSS) is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information.[144]

Over the last 20 years, there has been an explosion in the number of studies evaluating the role of CCDSS. There is a growing consensus that CCDSS have the potential to significantly improve health care[145]. CCDSS including computerised provider entry forms provide clinicians with timely electronic access to patient information and electronic decision support (e.g., alerts, reminders, order sets). However, Blumenthal's remarks on Electronic health records are applicable to the meaningful use of technology in health care in general - "by focusing on meaningful use, we recognise that better health care does not come solely from the adoption of technology itself but through the exchange and use of health information to best inform clinical decisions at the point of care."[146]

In their review of clinical decision support systems, Sutton et al. (2020) list several beneficial applications of CDSS but also caution against potential pitfalls and challenges. [147]

Bennet et al reviewed the use of computerised clinical decision support in emergency care and reported that the quality of research in most of the studies were poor. They found studies with a more robust design showed evidence of a positive impact of CCDSS on improving the process of care, with one study on improved mortality on patients with pneumonia.[148] Strategies to reduce medication errors commonly make use of CDSS. Errors involving drug-drug interactions (DDI) are cited as common and preventable[149]

Georgiou et al reviewing the effect of computerised provider order entry systems in ED noted increased time spent on computers but significant reductions in medication errors.[150] Mohoney et al. (2007) showed that other systems targeting patient safety in hospitals, such as electronic drug dispensing systems (EDSS) and barcode point of care (BPOC) medication administration systems can be combined with CPOE and CDSS simultaneously, with reduced prescribing error rates for drug allergy detection, excessive dosing, and incomplete or unclear ordering.[151] As with most CDSS, errors can still be made if providers omit or

deliberately work around the technology.[152] In their overview of systematic reviews of CDSS on medication safety, Jia et al. (2016) found that while a number of studies showed that CDSS significantly impacted and improved the process of care, the effect on improving patients safety was inconsistent.[153]

Differential diagnosis generators

Differential diagnosis (DDx) generators provide a list of potential diagnoses for consideration to improve diagnosis, sometimes in order of likelihood based on available information.

Riches et al. (2016) performed a **Systematic review and meta-analysis** which included 36 articles investigating the effects of 11 different DDx generators to retrieve accurate diagnoses (i.e. the correct diagnosis appeared in the list of possible diagnoses). With respect to the effectiveness of the DDx generators at retrieving accurate diagnoses, the authors concluded that the pooled accurate diagnosis retrieval rate was high, although with considerable heterogeneity. In the subgroup analyses examining the accuracy of individual DDx generators, 'Isabel', one of the tools under evaluation, outperformed all other tools, but again, the heterogeneity was considerable. When comparing the performance of the DDx tools to that of clinicians, the authors found that the DDx tools were associated with a nonsignificant increase in accurate diagnosis retrieval.

David et al. (2011) sought to prospectively determine the misdiagnosis rate of cellulitis among hospitalized patients and to determine if **a visually based computerized diagnostic decision** support system (VCDDSS, also named VisualDx) could generate an improved DDx for misdiagnosed patients. Among 145 subjects enrolled, misdiagnosis occurred in 41 (28%) patients. The diagnosis most frequently mistaken as cellulitis was stasis dermatitis (37%). At one centre, in cases that were misdiagnosed by the emergency department, the VCDDSS included the correct diagnosis in the DDx more frequently than the admitting team (18/28 cases (64%) compared to 4/28 cases (14%), p=0.0003).[154]

Kostopoulou et al. (2017) developed a prototype DDx generator integrated with a commercial electronic health record (EHR) system for use in general practice and tested it using high-fidelity simulation. As soon as the clinician enters the reason for encounter (RfE), the system generates a list of diagnostic suggestions based on the patient's RfE, age, and sex, and groups them according to published incidence rates (i.e., common, uncommon, and rare diagnoses). At the time of the study, the prototype supported three RfEs: chest pain, abdominal pain, and shortness of breath. Using standardized patients simulating 12 cases (4 cases per RfE), 34 general practitioners established their baseline performance with half of the cases and then used the DDX tool with the other half. Diagnostic accuracy improved significantly when using the tool, going from 49.5 percent to 58.3 percent accuracy ($p<0.003$)[155]

However, it needs to be acknowledged that a diagnosis being included in a diagnostic differential list does not necessarily translate to accurate diagnosis, efficient resource utilisation or appropriate risk balancing.

Specific diagnoses

Niemi et al. (2009) developed an automated clinical decision support tool that monitored the pharmacy information system, laboratory management system and radiology management system and applied rules for pneumonia and heart failure and generated an alert to the clinician if appropriate treatment had not been provided within a set time limit. In the ED, the sensitivity and specificity of the system to identify pneumonia was 89 percent and 86 percent, respectively, and in the inpatient setting it was 92 percent and 90 percent, respectively. For heart failure, the sensitivity was 94 percent and the specificity 90 percent as compared to the final diagnosis. In addition, the system allowed the hospital to increase compliance with national quality indicators for both of these conditions.[156]

Deleger et al. (2013) developed and tested an automated appendicitis (inflammation of the appendix) risk categorization algorithm for paediatric patients with abdominal pain, based on content from the EHR. They found this system to be comparable to use of physician experts.[157]

Kharbanda et al. (2016) developed and implemented an electronic clinical decision support tool for paediatric patients with abdominal pain. The tool included a standardized abdominal pain order set, a web-based risk stratification tool, and an ordering alert. Compared with in the pre-implementation period, the trend of computed tomography (CT) scan use during the implementation period decreased significantly each month (p=0.007). The study showed a 54-percent relative decrease in CT use in the post-implementation

period. The authors found that the decrease in CT use was not associated with the potential unintended consequences of decreased use of CT, significant changes to the rates of appendectomies or missed appendicitis cases.[158]

Electrocardiogram (ECG) interpretation

In the evaluation of cardiac health, 12-lead ECGs are accompanied by computer interpretations to assist the clinician with diagnoses. These interpretations have been shown to often be inaccurate, primarily because of noisy background signals that interfere with automated pattern recognition by the machine algorithms. However, four studies in this review evaluated ECG interpretations by automated systems, and all found that the systems were no better or worse than human performance alone.[159, 160, 161] Of concern the fourth study showed that a computer interpreted ECG failed to identify a significant number of patients with ST-Elevation Myocardial Infarction (STEMI). It found instead that the immediate review of ECGs by an emergency physician led to faster activation of the catheterization laboratory, and door-to-balloon times in patients with STEMI.[162]

In an **open randomised controlled trial**, Fitzgerald et al evaluated the **utility of computer-aided decision support** during the first 30 minutes of trauma resuscitation and the impact on error rate per patient treated as demonstrated by deviation from trauma care algorithms. They showed a significant decrease in error rates per patient and an increase in error free resuscitations from 16.0% to 21.8% during the first 30 minutes of resuscitation. They also concluded that using computerised decision support led to significant reductions in morbidity from shock management, blood use and aspiration pneumonia.[163]

Selker et al. (1998) tested whether computerized prediction of the probability of acute ischemia, used with electrocardiography, improves the accuracy of triage decisions in a **multicentre controlled clinical** trial. They concluded that using the Acute Cardiac Ischemia Time-Insensitive Predictive Instrument (ACI-TIPI) was associated with reduced hospitalisations among ED patients without acute cardiac ischemia[163]. This result varied according to the cardiac care unit (CCU) and cardiac telemetry unit capacities and physician supervision at individual hospitals. Appropriate admission for unstable angina or acute infarction was not affected. They surmised that If ACI-TIPI is used widely in the United States, its potential incremental impact may be more than two hundred thousand fewer unnecessary hospitalizations and more than one hundred thousand fewer unnecessary CCU admissions. However, the direct extrapolation of this finding to the Australian setting is limited due to differences in our health care systems and because ACI-TIPI is not used here.

In another **RCT performed under laboratory conditions** Tsai et al. (2003) studied the effect of computer interpretation of ECGs on accuracy of resident (non-cardiologist) reading ECGs.[164] They concluded that CCDSSs can generally improve the interpretive accuracy of internal medicine residents in reading ECGs. However, subjects were influenced significantly by incorrect advice, which tempers the overall usefulness of computer-generated advice in this and perhaps other areas.

Other decision supports

Ramnarayan et al. (2006) concluded that junior doctors used a **Web-based diagnostic reminder** system during acute paediatric assessments to significantly improve the quality of their diagnostic workup and reduce diagnostic omission errors. These benefits were achieved without any adverse effects on patient management following a quick consultation. They also stated that eliminating barriers to computer access is crucial for computerised assistance in clinical settings for the improvement in diagnosis[165].

Moore et al (2009) validated a **screening tool for early identification of sepsis** in their surgical ICU and concluded that implementation of this tool and their logic-based sepsis protocol had decreased sepsis-related mortality in their surgical ICU by one third[134].

The introduction of **standardised data collection forms and computer-aided diagnosis** has been found to be associated with improved diagnosis and management of patients with acute abdominal pain. Detailed analysis of 5193 patients presenting to one UK hospital by Wellwood et al[165] showed that the major benefit from such diagnostic aids was the accurate early diagnosis of non-specific abdominal pain by senior house officers in the ED. This in turn led to fewer admissions and fewer operations with negative findings.

More-advanced CCDSSs leveraging AI and machine learning have generated excitement over the potential to better augment clinician intelligence and support decision making. However, the research continues to be investigational in nature, with a lack of implementation and testing in real clinical settings.[166]

According to a 2014 Deeble institute brief commissioned by the Australian Healthcare and Hospital Association, “the potential effects of CDSS on variations in practice is not well understood, and CDSS are currently not a recommended means of improving evidence – based practice or patient outcomes, since the mechanisms of success and failure are not well defined and the potential impact on workflows and adverse events are poorly evaluated.”[167]

4.3 System/Process level interventions to improve safety

Breakdowns in patient safety occur due to failures during assessment, treatment, communication and teamwork. System level issues such as, lack of resources such as equipment, investigations, inavailability of clinical support, and process vulnerabilities such as unreliable referral pathways, or follow up of abnormal results are some of the underlying factors leading to ongoing patient harm. There is a close relationship between factors that impact ED performance and safety and quality of care afforded to patients. ACEM considers ED overcrowding and access block as critical indicators of health system dysfunction.[168] that have been associated with patient harm in numerous patient groups.[169] Studies performed overseas have shown poorer outcomes including delays to CT scanning[170] and increased mortality, complications and poorer recovery in patients with acute cerebrovascular accidents,[171] increased adverse events in patients with NSTEMI[172] and those admitted with chest pain,[173] and worse outcomes for critically ill patients held in ED for lack of bed space in the ICU.[174] It is also associated with increased medication errors.[175] Patients who are seen and discharged from the ED during periods of overcrowding have a higher risk of mortality and hospitalisation within 7 days.[176] Australian studies have also confirmed the association between overcrowding and mortality. [177,178] and the findings of a recent study from New Zealand suggest that system issues related to long ED stays may be most important in the link between ED crowding and mortality.[179]

Therefore, broad based interventions aimed at improving performance quality at a system level are more likely to improve care and patient safety, will be better received and more sustainable than those with a narrow focus or targeting individual practitioners.

Addressing underlying factors that lead to harm through reducing cognitive overload, targeting overcrowding through interventions at the whole-of-organisational level, improving workplace efficiency, workforce capability and resilience and targeting specific vulnerable points within the patients journey through the ED (such as patient discharge) are examples of system level recommendations.[180]

In a recent review of interventions to specifically improve ED performance Austin et al. (2020) categorised interventions into the domains of clinical practice and processes, and team compositon.[181]

The interventions listed below have been predominantly studied in relation to the impact on improving efficiency of care and are not directly shown to improve important clinical outcomes unless explicitly stated.

4.3.1 Triage interventions

Triage focused interventions that evaluated impact on efficiency include:

- **Personnel** – a systematic review of advanced nurse practitioners[182] in ED showed reduced waiting times in 5 out 9 included studies. Multiple studies have looked at the way physician involvement might occur in triage, and senior doctor triage to allow for rapid medical intervention and care escalation, initiate diagnostics, and treatment. Multidisciplinary assessment (dual doctor and nurse triage) reduced number of patients who left without being seen and provided one way of getting around access block and physical limitations in a tertiary referral hospital in Australia.[183]
- **Protocols** for specific symptoms, nurse-initiated ordering, including x-rays have been tried with mixed results.
- **Fast tracking** patients with less severe symptoms resulted in shorter waiting time and length of stay and fewer patients who left without being seen.[184]

- **Dedicated equipment and space** – e.g. use of ECG technician and machine and use of a dedicated room for test performance at triage.[185]
- **Triage education –** include staff education around atypical presentations, signs and symptoms. Chhabra et al reviewed interventions that led to improvements in door-to-ECG times for adult chest pain patients and found that most studies reported bundled interventions with most showing statistical improvement in door-to-ECG times. Effective bundled interventions included having a dedicated ECG technician, triage education, and better triage disposition.[185]
- **Triage system changes** – include process redesign based on task analysis and lean thinking approaches aimed at improving ED efficiency.

In their systematic review Harding et al. (2011) conclude that triage systems can improve patient flow across diverse healthcare settings. There was conflicting evidence concerning the benefits of basic triage systems and moderate evidence that managing less resource intensive cases or redirecting inappropriate referrals at point of triage could improve patient flow.[186] In a primary Australian study, Kelly et al. (2007) examined the effect of streaming in the different triage categories reported reduced wait time and shorter length of stay for patients in 2 of 5 triage levels. The ED was also able to fulfil a 4-hour goal of wait time to a greater extent with than without streaming.[187] However, Oreddson et al. (2011) in their systematic review of different models of streaming (not including fast track) found limited evidence of its effectiveness.[184]

4.3.2 Care transition interventions

Internationally, communication errors are a major contributing factor in sentinel events in health service organisations,[188] and the importance of effective patient-clinician communication is reflected across all of the National Safety and Quality Health Service (NSQHS) Standards.[189,190]

Information exchange in EDs is especially difficult due to challenges such as time pressure, multidisciplinary teams, high level of distractions, multiple handovers, high degree of nonverbal communications, and limited resources for documentation.[191]

Transfer of care between units faces additional obstacles including unstructured communication, interdisciplinary conflict, patient throughput pressures, and uncertain assignment of responsibilities. A patient admitted from the ED is not only changing health care providers but is also changing physical location, making this time especially vulnerable to miscommunication.

Improving handover of patient care between professionals is essential and can be achieved through standardised format and content, bedside handover, protected time and space.[192–198] In their systematic review on the role of standardised handovers between the ED and inpatient units Darcy et al (2019) [198] advocate face-to-face, verbal patient handoff. This was especially the case when both providers were able to review the patient and assess acuity, and with adequate training of staff in the proper use and reasoning behind the introduction of new tools to standardise handover.

There is substantial evidence that communication skills can be increased through appropriate training, and formal courses have been constructed to develop these skills, such as the physician-directed courses offered by the Bayer Institute for Healthcare Communication [199] or the Institute for Healthcare Improvement [200]

Practical measures to implement better communication during care transitions included handover tools to help standardise communication. Examples include ISBAR (Introduction, Situation, Background, Assessment, Recommendation) or SBAR-DR (Situation, Background, Assessment, Responsibilities and Risks, Discussion and Disposition, Read-back and Record) for verbal handover, hospital developed handover tools, as well as written handover, handover added to patient's paper chart, and an eSignout step added to the ED dashboard. A systematic review looking at the role of physiotherapists in the ED and how this impacts on teamwork and communication, Kilner et al. (2011) concluded that there was moderate evidence that multidisciplinary teams may be successful in reducing access block and demonstrated high levels of staff satisfaction with teamwork training interventions [60.]

Studies assessing the handover of care between paramedics and the emergency department staff have shown that having a structured handover (IMIST – AMBO)[166,167] improves effectiveness of care transition. Direct impact on clinical outcomes using these interventions has not been demonstrated.

In their systematic review on older adult's views of quality emergency care, Shankar et al. (2014) comment that effective communication improved the overall experience and decreased anxiety irrespective of whether the physician or nurse was the source of information. The transition after emergency care was a common concern and generated anxiety among many elders. patients with coordinated discharge plans viewed their care as high quality. The nurse discharge coordinator intervention involved discussing with the patient their health care needs, education, referral to outpatient facility, 24 hour nurse follow-up, back-up consultation one week after discharge.[203]

Crotty et al (2004) performed a randomised, single blind, controlled trial in South Australia to examine whether the addition of a pharmacist transition coordinator could impact medication management and health outcomes in older people undergoing transition from a hospital to a long-term aged care facility. It was limited by its small sample size but suggested that a transition coordinator could improve aspects of medication management during the transition from hospital to residential aged care. However, no impact on adverse drug events was demonstrated.[204]

4.3.3 Process redesign interventions

Process redesign interventions include updates to existing resources, or the introduction of evidence-based clinical practice **guidelines and protocols** for specific conditions or in pathology,[205] treatment,[206] and medication.[207,208]

In their review of interventions to improve patient satisfaction Boudreaux et al. observed wide variations in magnitude of impact.[205] They noted that all 3 studies looking at multicomponent interventions included:

- forming multidisciplinary teams
- implementing evidence-based guidelines
- a focus on system and process redesign (registration of patients and redesigning laboratory and radiology protocols).

Summarising organisational strategies to minimise medication errors Mieiro et al.(2019) note that *"fragile work processes are prone to medication errors. This means that in addition to the performance, skills and knowledge of people involved in processes, the systems in which they are inserted are directly related to the causes of errors."* They recommend protocols for the storage, prescription, dispensing, preparation and administration of high-risk drugs should be introduced with the aim of reducing variability in clinical practice and reducing the incidence of errors[205].

The National Medication Safety Breakthrough Collaborative was a key initiative of the former Australian Council for Safety and Quality. The Collaborative aimed to reduce harm from medications through "toolkits" to improve medication safety, including alert cards, incident report forms, education tools for staff and patients, communication tools and guidelines for high-risk medications (SQC wave 1, SQC wave 2, 2002). Reported achievements included more than halving the percentage of patients experiencing a high-risk adverse drug event (by the top 8 hospital teams), and an increase in the percentage of hospitalised patients who had medicines information communicated to their primary health care providers in a timely manner - from less than 30% to over 90% (by the top 8 hospital teams).[209]

Reviewing the literature on improving paediatric pain management in the ED. Williams et al. (2019) note that all 20 studies in their review adopted a multifaceted approach to organisational change. The studies bundled various interventions including pain assessment tools and management protocols, clinician education, nurse-initiated analgesia, feedback and family engagement[206]. They concluded that interventions that hold the most promise for optimised pain management if embedded in the workplace include nurse-initiated analgesia and family involvement at each stage of pain management in the emergency department.[208]

Organisational processes to enhance **procedural safety** are essential and include the use of clinical protocols for difficult airway and intubation, procedural sedation and central line insertion. These protocols incorporate administrative and clinical checklists as a method to ensure essential equipment and subprocesses are in place and being performed. These processes are backed up by quality assurance practices including evaluation of the facility, teams and individuals regarding procedural performance and safety.[209]

Patient assignment and referral processes

Patient assignment processes including alternating patient assignment to provider teams rather than zone or bed-based assignment[205] and referral processes. Managing non-urgent referrals to ED, ambulance diversion and destination control utilising internet-accessible operating information to redistribute ambulances are commonly studied solutions to crowding involving demand management. [210] In a recent review Kirkland et al (2019) concluded that there was no conclusive evidence regarding the impact of diversion strategies on ED utilisation and subsequent healthcare utilisation.

The overall quality of the research limited the ability of this review to draw definitive conclusions and more research is required prior to widespread implementation.[211]

Case management involves the identification of appropriate providers and services for individual patients based on a continuous, integrated medical and psychosocial model of care. It is a commonly cited intervention aimed at reducing ED utilization by "frequent users," a group of patients that utilize the ED at disproportionately high rates. Studies have investigated the impact of case management on a variety of outcomes in this patient population. Kumar et al reviewed studies investigating the impact of case management in the ED and conclude that case management interventions can improve both clinical and social outcomes with the strongest evidence for outcomes related to reduced visits and ED costs.[212]

Hughes et al. evaluated the presence of three key intervention components: assessment, referral plus follow-up, and contact both before and after ED discharge (“bridge” design) in studies of patients over 65 years of age in the ED. They concluded that using two or more intervention strategies may be associated with the greatest effects on clinical and utilization outcomes.[213]

Organisational processes

In their review of the evidence for trauma quality improvement, Juillard et al. (2009) note that the presence of a prehospital notification system and performance improvement programs were most associated with decreased risk-adjusted odds of death in the Canadian setting.[214] Multidimensional interventions resulted in a significant reduction in mortality.[215] The interventions included regular audit to identify issues in preventable deaths, and targeted interventions such as increased senior staffing during peak times, intra-hospital radio systems for communication, and a trauma registry for performance and quality monitoring. Gruen et al. (2006) reviewed deaths in a single mature trauma centre for quality-of-care concerns through a three-stage peer review. They found that 2.47% of deaths reviewed had recognized errors in care that contributed to death. These error-related deaths were organized into 14 error categories, four of which led to resultant changes in hospital policy. After these policy changes were made, the incidence of error-related deaths in trauma patients decreased for those categories of errors that had led to the changes.[216]

Other process interventions

Other process changes studied include communication and consultation intervention between radiologists and ED physicians to reduce patient call backs to the ED due to missed x-ray findings,[217] the addition of administrative, clinical and ancillary personnel, logistical changes in radiology and laboratory workflows, rearranging bed zones[205], and performance targets[218,219].

Introduction of the 4-hour rule in Western Australia led to a reversal of overcrowding in three tertiary hospital EDs. This coincided with a significant fall in the overall mortality rate in tertiary hospital data combined, and in two of the three individual hospitals.[220] However Perera et al. (2014) provide a more guarded opinion from their review of the National Emergency Access Target (NEAT) in the Victorian setting, they observed an improvement in waiting times and emergency length of stay but significant downstream effects including and increased inpatient length of stay. They conclude *“the implementation of the NEAT requires a system change rather than an isolated departmental change for full effect”*.[221] In their recent review on the impact of time based targets on quality of care Jones et al. found that in some settings reductions in mortality were seen in ED. Quality of care generally improved after targets were introduced and when compliance with targets were high.[222]

4.3.4 Technology interventions

Different types of mobile devices and workstations have been employed in ED including handheld personal digital assistant, wireless computers, mobile workstations and iPad® device. Dexheimer et al. (2015) note that there is very little research evidence that support the use of these mobile devices although it is inevitable that more decision support, charting and other activities will be performed on these devices. They also warned about the need to consider security of handheld devices and potential for data breaches.[223]

International evidence regarding medication safety has identified a number of tools or practices that may reduce medication incidents in healthcare. Computerised physician order entry coupled with CCDSS is amongst the most studied. These allow standardised online prescribing coupled to computerised advice to support prescribing decisions and can reduce adverse drug events in hospital settings.[209]

Barcoding and other scanning technologies to cross-check patient identification with the medication supplied for an individual patient at the point of medication administration have also been supported and advocated as a strategy to reduce medication error.[209]

Telecommunication technology

Telecommunication technology (transmission of video, images, radiological studies, physiological data, and pathology results) to provide care to a patient typically distant from the provider is an application with significant potential but still lacking evidence supporting improved patient outcomes. Advances in technology, combined with more attractive price-points have resulted in widespread interest and implementation around the world. Applications of this technology that are currently being studied include support for minor treatment centres, patient transfer decision-making, management of acutely ill patients and scheduled teleconsultations.[224]

Telehealth supports rapid access to specialists for patients in remote or rural locations e.g. in diagnosing stroke.[225] [226] Within Australia, it has been incorporated into efforts to managing time critical patients[227], [228] assisting with mental health reviews and providing emergency physician support to rural urgent care centres and other care facilities[229],[230].

eHealth records access

Electronic health records (EHRs) use health information technology to allow virtual health information management and exchange. A UK study evaluating shared electronic health records found that currently the evidence for benefits is weak. They assessed the impact of accessing primary care records on unscheduled care and concluded that well-designed shared EHRs should in principle be capable of improving the efficiency, quality and safety of unscheduled care. A striking feature was the near complete absence of data regarding system impacts on the quality and safety of unscheduled care, or economic outcomes.[231]

Systems for electronic sharing of patient health information, including medication information between different settings are currently under development and evaluation in various Australian jurisdictions. An ACQHC report summarised patient safety benefits of using National Electronic health records in Australian Emergency departments. They include access to critical information in an emergency situation, reduced duplication of diagnostic imaging and pathology and improved decision making. Improved workflows, documentation and sourcing of history and treatment would also result in more appropriate care and improved communication. However poor training and awareness, poor system interface between EHR and the local electronic medical record, lack of trust with content or poor accessibility including poor integration into workflow, lack of content would be significant barriers.[232] System and data security are important considerations for any electronic health record, as are processes for continuity of care delivery and system recovery should a breach occur.

Investigations and procedures

Point-of-care testing (POCT) has been used for a range of diagnostic tests including cardiac troponin[233] metabolic, urinalysis, pregnancy testing, cardiac markers, glucose, [218] influenza, and respiratory syncytial virus. POCT has been shown to increase the speed at which positive cases of ACS are accurately

identified, translating into decreased times to percutaneous coronary intervention and related treatment initiation.[234] Used wisely, it may play a significant role in early identification and reducing time to treatments especially in the overcrowded ED for other conditions like severe sepsis and stroke.[235]

Point-of-care ultrasound has been firmly established within the emergency department and has been shown to be related with reduced time and increased diagnostic accuracy across a range of presentations.[236] It is an established standard of care with various diagnostic and procedural applications.[237]

Technology for procedural safety includes the fibreoptic or video tools for intubation (Brown 2020)[238], end tidal and pulse oximetry for procedural sedation and post intubation monitoring (ACEM 2015)[239], and ultrasound for central line insertion and nerve blocks.

Artificial Intelligence

Artificial intelligence (AI) related research is rapidly increasing in emergency medicine. Studies show promising opportunities for AI in diverse contexts, particularly regarding predictive modelling for patient outcomes. In their recent review of AI in emergency medicine, Stewart et al. (2018) noted that of 24 studies with human comparators, AI interventions outperformed clinicians in 12 of them. In these studies, AI interventions were better able to diagnose acute cardiac events (including out-of-hospital cardiac arrest and myocardial infarct), identify hyperkalaemia, risk stratify patients in triage, identify participants, predict wound infection, predict mortality, predict patients for clinical trials, and read imaging (including intracranial haemorrhages, otoscopic imaging, and fractures).They were non-superior to humans in 3 (12.5%) studies that investigated triaging acute abdominal pain, detecting traumatic elbow effusions, and diagnosing chest x-rays. In one study, AI combined with physician judgment was superior to physician judgment alone when diagnosing myocardial infarctions via ECGs. However despite significant research successes, there remain very few instances of AI algorithms being successfully integrated into daily clinical practice in a complex and critical healthcare system.[240]

4.3.5 Team composition interventions

Different roles and specialties have been integrated into the ED. These included advanced nursing roles, physiotherapy, general practitioners, scribes, physician assistants, pharmacy, and mental health services.

Nurse practitioner (NP) models of care are now well established in Victoria and NPs have been successfully employed particularly in fast track for high volume departments. In rural areas, NPs are supplementing overextended physicians and allowing health centres to remain open when they might otherwise have to close. These strategies could improve access to care and patient satisfaction for selected urban and rural populations as well as make the best use of limited medical resources.[182,241]

From a review of physiotherapists in the ED it was evident that at patient level, there was high-level evidence of benefits in terms of improved pain control and reduced disability in the short term.[242] Summarising the results of a recent scoping review on physiotherapists in the ED Ferreira et al. conclude that *"available evidence suggests that physiotherapists may be as effective as other health providers in managing low-urgency musculoskeletal conditions in the ED. There is uncertainty about appropriate training and a lack of robust studies investigating the efficiency, safety and cost-effectiveness of this model of care."*[243] A recent pilot study looking at feasibility of vestibular physiotherapy in a metropolitan hospital in Victoria reported an improvement in the number of patients with undifferentiated diagnosis of dizziness, and a potential for a positive impact on patient care and adherence to evidence based practice.[244]

Studies looking at the scribes in the ED suggest that they do provide a significant role in allaying the burden of documentation experienced by doctors and can increase number of patients seen per hour.[245] An Australian RCT on scribes concluded that the greatest gains were achieved by placing scribes with senior doctors at triage.[246] While scribes may improve efficiency and positively impact patient and provider satisfaction, any impact on safety or clinical outcomes is yet to be established.[247]

Pharmacists in the ED are rapidly becoming a vital component of clinical service provision in the Australian ED and contribute significantly to medication safety and patient education.[248] The have also demonstrated a positive impact on patient-specific outcome measures, timely medication administration, optimization of therapy, and cost of care (Farmer 2017). A pre-test, post-test study examined the impact of an ED

clinical pharmacist on prescribing errors in a Victorian metropolitan teaching hospital. There was a relative reduction of errors rated as high/extreme (64% reduction), moderate (71% reduction) and minor (90% reduction) [249]. In a large study, clinical pharmacist interventions in eight major public hospitals over an average of 21 days were reviewed by an independent multidisciplinary panel. The clinical significance of the intervention was deemed to be life-saving in 15 (1.1%), major in 351 (25%), moderate in 535 (38%) and minor in 425 (30%)[249]

Liaison psychiatry models with mental health personnel integrated into the ED team or triage reduced patient waiting time to be seen, may reduce patients leaving without being seen and have high staff satisfaction.[250]

5. Discussion

5.1 Limitations

The quality of literature on interventions to improve safety, especially diagnosis related safety is limited. The few randomised trials are single centre based with findings which have not been replicated. Most of the positive outcomes in cognitive bias or educational interventions were seen in studies conducted in a laboratory environment. Research done in the clinical environment was predominantly conducted as part of local quality improvement initiatives with a focus on measuring performance or quality outcomes. As such the generalisability and effectiveness of any single intervention is likely to be limited in nature.

However, as concluded by Scott and Crock (2020), "*despite limitations in current research, the scale and harm of diagnostic error obliges clinicians to consider adopting preventive strategies that have reasonable face validity, are easily implementable in workplaces, and target individual decision making.*"[251]

It is important to be pragmatic in reviewing such literature, keeping in mind that no single intervention will make a sustained significant impact. The traditional approach to safety in healthcare is reactive in nature and relies on reliable reporting of errors and finding fault at an individual or system level. Significant efforts are made to collect information and analyse events, to learn from them. However, there is limited sharing of learnings or follow up on the outcomes of interventions based on recommendations from these adverse event analysis and similar events continue to occur.

The majority of recommendations focus on education and training. They may be largely ineffective or create further issues due to the mismatch between work as imagined and work as done. On the other hand, little is learnt from how things are done well. This type of thinking and sharing of best practice called Safety II needs to be incorporated along with traditional Safety I methodology.[252] Evidence based recommendations that make it easier to do the right thing instead of imposing additional tasks or documentation burdens are more likely to be successful. Embedding these initiatives into routine workflow is imperative to improve compliance and adherence.

5.2 Future direction

Improving safety in the ED is vitally important for the sake of patients, practitioners, and the health system. Increasing patient complexity, overreliance on technological solutions, widespread imbalances between demand for services and availability of resources, and ongoing challenges with training and equipping an engaged workforce are ever increasing challenges to providing access to safe, timely care.[253]

When developing the National Strategic Framework for Rural and Remote Health, it was noted that many excellent initiatives are driven by the personal commitment of individuals and health professionals in the community, rather than by any systemic planning at the local, regional, or state level. However without the support of appropriate service planning and delivery models, these efforts risk losing their ability to be sustained into the future.[254]Although targeted interventions may be effective in the short time, they are likely to require significant effort and are unlikely to be sustainable once the initial momentum wears off. Therefore, a whole-of-system approach is necessary to address patient safety within the ED in a sustainable and meaningful way.[255]

An increased support for the development and implementation of standardised pathways for high risk presentations has led to safer and more efficient care.[256] The introduction of care bundles for specific presentations or diagnoses has been shown to reduce mortality.[257] Groombridge et al. (2020) describe the role of a targeted bundle of airway initiatives including regular audit, feedback, education and an airway checklist on improving first pass success during emergency intubations[101]. The recent successful implementation of the Sepsis Bundle in Victoria is another example of a system wide approach to improving care.[258]

Significant efforts to address inequity in emergency care services are currently being undertaken in Victoria. Departmental projects are targeting education and empowering nursing staff in rural settings, supporting the role of nurse practitioners in urgent care centres and improving access to specialist care and advice through telehealth.[259–262] The Australasian College for Emergency Medicine continues to lead the way in providing training, setting standards of care for emergency departments and advocating for staff and patient safety.[263]

Within Australia, there have been several examples of significant inroads being made into improving patient safety through coordinated activity at a departmental level. Incorporating various system level interventions has enabled improvements in diagnostic and treatment support for a variety of emergency department presentations including clinical deterioration, suspected stroke, acute myocardial infarction, mental health and poisonings.[264–268]

The outcomes of these initiatives depend on a strong commitment to safety as core tenet. It is important at an organisational level, to foster a culture within which frontline staff are equipped to provide safe, equitable and empathetic care. Clinical and managerial leadership should empower staff and patients to escalate concern, focus on identifying policy gaps and process vulnerabilities before adverse events occur, address workforce needs and have a positive approach when faced with challenges.

Clinical leaders and supervisors should role model excellence in clinical reasoning, teamwork and communication. Teaching and training curricula for medical and nursing students should be designed to improve the transfer and testing of these core skills in order to assist individual practitioners in becoming better at clinical decision making. In their article titled “Zero harm in health care”, Gandhi et al. stress that *“a robust systems-focused approach to improving safety requires four interdependent elements: effectively managing change by tending to the psychology of change; creating and sustaining a culture of safety; developing and leveraging an optimal learning system; and engaging patients in the codesign of care and improvement.”*[269]

In conclusion, ongoing efforts are required at an individual, team, organisational and health department level to improve patient care. Fostering a culture of safety, shared learning and focusing on communication and empathy in care delivery are prerequisites for any safety intervention to be effective and sustainable. The recent past has seen a welcome shift in mentality from working in silos to teamwork and collaboration,[265] and while much remains to be done, we certainly appear to be headed in the right direction.

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