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The prevalence and management of deteriorating patients in an Australian emergency department

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Abstract

Background

Complex human and system factors impact the effectiveness of Rapid Response Systems (RRS). Emergency Department (ED) specific RRS are relatively new and the factors associated with their effectiveness are largely unknown. This study describes the period prevalence of deterioration and characteristics of care for deteriorating patients in an Australia ED and examine relationships between system factors and escalation of care.

Methods

A retrospective medical record audit of all patients presenting to an Australian ED in two weeks.

Results

Period prevalence of deterioration was 10.08% (n = 269). Failure to escalate care occurred in nearly half (n = 52, 47.3%) of the patients requiring a response (n = 110). Appropriate escalation practices were associated with where the patient was being cared for (p = 0.01), and the competence level of the person documenting deterioration (p = 0.005). Intermediate competence level nurses were nine times more likely to escalate care than novices and experts (p = 0.005). While there was variance in escalation practice related to system factors, these associations were not statistically significant.

Conclusion

The safety of deteriorating ED patients may be improved by informing care based on the escalation practices of staff with intermediate ED experience and competence levels.

Background

Physiological deterioration in patients is often indicated by clinical features such as abnormal vital signs and declining conscious state. Rapid Response Systems (RRS) have been used for nearly three decades to help recognise and stabilise patients experiencing clinical instability in general acute medical and surgical wards [1]. More recently, there has been an increasing uptake of emergency department (ED) specific responses to patient deterioration [2].

The last decade has seen the number of ED presentations increased between 23-49% globally [3-5]. The profile of the ED patient load is highly varied in age and complexity, and patients are often undiagnosed and unknown to ED staff. The workload demand is largely unpredictable, frequently overwhelming and highly susceptible to errors from interruption and decision overload [6]. There has also been zero growth of in-patient bed availability (2.6 beds per 1,000 population) in Australia since 2011/12, despite a 2.6% increase in patient presentations to the ED each year [7]. This has led to ED overcrowding and in turn impacted on the availability of treatment areas for assessing and treating ED patients.

A recent study has also found a higher prevalence of physiological deterioration in ED patients than that which is found on general acute wards, and over half of the acute ward Medical Emergency Team (MET) responses to physiological deterioration were for patients admitted via the ED [8].

Rapid response systems comprise of clinical policies, procedures and tools that equip frontline health care workers with a coordinated hospital wide process for responding to patients with signs of physiological deterioration. The systems are made up of two essential structural components, or limbs, which provide an overt set of guiding principles, communication processes, team roles and responsibilities for rescuing deteriorating patients

– the afferent limb and the efferent limb. In the afferent limb, ward doctors and nurses are provided with a set of physiological criteria and directives for reporting and escalating the care of patients with abnormal vital signs to a clinician or team of clinicians who can provide advanced care and expert consultation [9]. At a minimum, the criteria for escalating care often include assessment findings of the patient's pulse rate, respiratory rate, systolic blood pressure, oxygen saturation, conscious state or concern about the patient [10]. However calling criteria may also include other patient data such as decline in urine output, arterial blood gas data, haematology and biochemistry data, pain, seizure activity and concern for the patient reported by health care workers or patient family [11-16]. There are two main types of triggering criteria, single parameter track and trigger systems such as those used in Australasia, Canada and some European countries (e.g. MET) [16], and multiple parameter aggregated weighted track and trigger systems such as the National Early Warning Score (NEWS) used throughout the UK [17]. Both event detection systems have inherent strengths and weaknesses. For example, MET though easy to use, may be overly sensitive with up to a 15% higher triggering rate than NEWS [18]. An outcome which appears to be positive but is also associated with increased workload for staff and members of the response team [19]. Furthermore, multi parameter systems (e.g. NEWS) require some minor calculations which can be prone to user error up to 29% of the time [20].

While the implementation of RRS in the general ward area is well established, the application of a standard approach to a modified ED RRS is an emerging area of interest in the literature [8, 21-25]. Emergency care actions to incorporate modified alert criteria and responses to physiological deterioration since 2010 have been largely based on pre-existing ward RRS [26, 27]. That is, the overall functions of the afferent (monitoring and triggering), and efferent (response) limbs of the systems are based on the same principles of RRS described by Devita

and colleagues at the *First Consensus Conference on Medical Emergency Teams* in 2006 [28]. However, ED specific RRS in Australia and around the world demand differences in their structure and execution which are particular to this specialised area. These differences include, but are not limited to, modifications to the alert or triggering criteria (MET parameters), the process for escalating care of a deteriorating ED patient and the composition of the response team members. For example, unlike ward-based MET, where the rapid response team often include staff who work external to the deteriorating patient's ward (e.g. intensivist, ICU liaison nurse) [29], ED response teams are frequently made up of emergency staff, usually the doctor and nurse in charge of the shift [27].

Also, unlike ward based RRS which have been the subject of considerable investigation by patient safety and quality researchers, ED specific RRS have not received the same amount of scrutiny, and the factors that impact upon the activation of these systems warrant further exploration [2].

A number of patient and environmental characteristics can influence the frequency of ED responses to physiological deterioration. Some of these characteristics have been described in a point prevalence study designed to describe unrecognised physiological deterioration in ED [30]. Scott and colleagues (2015) found that physiological deterioration was more commonly under-reported when there were a higher number of older, sicker patients being cared for, and when ED occupancy was high. However, it is not known if research exists that describes the relationship between escalation of care of the deteriorating patient and dynamic factors in the ED such as workload, skill-mix and patient acuity.

Since their adoption in the early 1990s, RRS have supported frontline health care workers to recognise deteriorating patients and escalate their care to an expert response team. There

are, however, a number of intricate human and system factors (e.g. casemix, workload and skill-mix) that may impact upon the safe and effective implementation of these very same safety systems. The prevalence of deterioration and the effectiveness of ward based RRS are well documented in the literature [31-33]. However, the characteristics affecting failure to escalate physiological deterioration in ED specific RRS are largely unknown.

The primary aims of the study were to i) describe the period prevalence of physiological deterioration and the characteristics of care escalation for patients experiencing deterioration in a metropolitan ED in Australia, and ii) examine relationships between organisational factors (staffing levels, staff skill-mix, patient casemix, occupancy) and escalation of care in ED patients experiencing signs of deterioration.

Methods

Ethical approval was obtained from the study site Human Research and Ethics Committee (NMA HREC Reference Number: HREC/17/monH/510) and site-specific Assessment authorisation (NMA SSA Reference Number: SSA/17/monH/599) before the research project commenced. The aims of this study were addressed using a retrospective medical record review.

The sample comprised all patients who attended the ED requesting care at any time of day or night for a two-week period during July 2018. This included all adult and paediatric patients presenting with medical, surgical, mental health and behavioural problems.

Study Site

The study site was a metropolitan mixed (adult and paediatric) ED with 55 treatment areas in Australia which received just under 70,000 episodes of care in 2018. The study site hospital is

a general medical/surgical teaching hospital with adult and paediatric specialist services, maternity, orthopaedic, mental health and intensive care services.

To ensure that patients are treated in order of clinical urgency and allocated to an appropriate treatment area, the Australasian Triage scale (ATS) is used at the site. The ATS is a clinical triage tool comprising of 5 categories (1 – immediate, 2 – 10 mins., 3 – 30 mins., 4 – 60 mins. and 5 – 120 mins.) [34]. Site policy also required that all ED patients' condition and vital signs were reassessed hourly (including waiting room patients).

In an effort to identify and manage physiological deterioration, the study site introduced an ED specific mandatory alert criterion (MAC) in March 2012. The MAC is based upon the healthcare network's Adult MET calling criteria and includes a modified set of criteria to identify physiological deterioration in paediatric patients (supplementary file 1). Triggering of the alert criteria involves the person (usually a nurse) who documents the presence of any of the physiological or clinical mandatory alert signs, verbally informing both the ED Nurse and Doctor in-charge of the shift, then documenting this process in the patient notes. (defined as 'appropriate escalation' for this study). The Nurse and Doctor in-charge of the shift are then required to review the patient within 2 minutes and supervise the management of the patient. The MAC was specific to the site's healthcare network, and while it reflects similar ED RRS practices in Victoria, Australia [27], there was no nationally standardised ED RRS at the time of the study.

Nursing Staff Expertise and Experience

All ED nursing staff at the study site are mapped in a modified Benner's novice to expert clinical competence framework [35]. The framework documents a description of the skill level

of each nurse based on their progression to higher acuity areas of the ED (e.g. cardiac monitoring area to resuscitation cubicles) and skills competence completion. This provides a continuous standardised process to assess competency (beginner, intermediate and expert). A review of the map is completed quarterly and with the intake of new staff. The competence mapping process ensures that staff continue to develop professionally and informs the rostering process to ensure that the correct skill-mix is allocated to each shift.

Although experience is not an indicator of expertise, nurses' clinical competence advancement at the study site is often aligned with time spent working in the specialised emergency care setting. For example, novice and advanced beginners are typically nurses who have worked in the ED for approximately two years or less (figure 1).

Insert Figure 1 about here

Sampling

The medical record review sample included all patients who were cared for during the 2-week data collection period commencing July 16 2018. This ensured that a range of all ED occupancy levels, times of day and staff shift types were represented. No exclusion criteria were applied for the initial data collection.

Data Collection

Three separate web-based data analysis reporting tools were developed to identify the first episode of physiological deterioration of any patient who reached EDMA criteria during a two-week period, as well as the characteristics (patient casemix and occupancy) of the ED at the exact time that the patient exhibited signs of clinical instability. These tools (patient record audit tool, ED profile tool and ED workload tool) accessed source data from the ED patient electronic medical record (EMR) management system. The *Patient Record Audit Tool* was

accessed each day during the two-week data collection period. The *Patient Record Audit Tool* produced a record of every documented vital sign for each patient treated in the ED during the data collection period. This generated a report containing de-identified details about the patients' ED episode of care (box 1).

Insert Box 1 about here

The report was sorted by each vital sign and all patients with recorded vital signs that were found to meet the adult or paediatric early warning signs of the MAC were included for further data collection. Patients who had been categorised within the ATS as category 1 or 2 were not included for further data collection unless their initial vital signs returned to normal ranges for at least one hour. This decision made because category 1 and 2 patients are meant to be seen immediately, or within 10 minutes of their arrival respectively. Patients who had documented evidence of a treatment plan that included a *do not resuscitate* or not for resuscitation plan were not included for further data collection.

The *ED Profile Tool* reported on casemix, occupancy and acuity of the ED and generated a "snapshot" of the status of the ED at the time of each episode of deterioration. The report was accurate to the hour and shows the number of patients (paediatric and adult) being cared for in the ED, the triage category of each patient and the number of patients awaiting admission to the intensive care unit (ICU).

The *ED workload tool* produced a Microsoft Excel® spreadsheet with pivot tables designed to quantify how many new patients arrived each hour prior to the episode of patient deterioration and how many were awaiting transfer to ICU. The number of patients awaiting ICU transfer were a proxy for patients that required complex care and increased staff

resources (e.g. 1:1 staff to patient ratio). The ED arrivals per hour represents workload fluctuation in the hours preceding each episode of deterioration.

The ED staffing allocation logs were searched to describe the staffing levels, skill mix and staffing allocations present during each episode of deterioration were recorded, as well as the expertise and experience of the Nurse documenting observations for each patient included in the final sample (n = 110). Prior to analysis, data collected for the nursing staff levels and skill-mix were recoded as being either *below standard* or *at or above standard* indicating whether staffing numbers and mix of competence level were appropriate according to the standards set by the ED management team.

The retrospective medical record audit was carried out in a process that included 5 steps each day during data collection (figure 2).

Insert Figure 2 about here

Data Analysis

The medical record review data were analysed using the Statistical Package for Social Science (SPSS®) 2016 software [36]. Descriptive statistics such as frequencies, means and standard deviation were used to describe patient demographic data, characteristics of deterioration and the organisational characteristics of each episodes of deterioration.

Chi-square tests for independence were used to explore relationships between independent categorical variables (e.g. competence level) and dependant categorical variables (escalated or not escalated). Generalised linear mixed model regression analysis was used to examine the relationships between staffing levels, staff skill-mix, patient casemix, occupancy and escalation of care in patient deterioration.

Results

A total of 2668 ED patient records were searched; a final sample of 110 patients met all the inclusion criteria (Figure 2). The 2-week period prevalence of initial episodes of physiological deterioration was 10.08% (n = 269). Using the Wilson confidence interval method, there was 95% confidence that the prevalence of first signs of deterioration of all patients in the ED was between 9% and 11.28%. Prevalence and confidence intervals for all age groups are presented in table 1. The demographic data for these patients revealed that approximately half (*n* = 57, 51.8%) were male, mean age was 48.29 (SD 29.07) years and the majority (*n* = 88, 80%) were adults.

Insert Table 1 about here

More than half (n = 64, 58.2%) of the deteriorating patients were allocated an ATS category 3, followed by category 2 (n = 32, 29.1%), category 4 (n = 13, 11.8%) and category 5 (n = 1, 0.9%). There were no category 1 patients identified. Thirty-three different presenting problems were assigned to the 110 patients who met the study inclusion criteria. The top 3 were shortness of breath (n = 23), abdominal pain (n = 11) and febrile / pyrexia of unknown origin (PUO) (n = 10). The most common vital signs that met the MAC criteria during the first episode of deterioration were initial pulse rate (n = 34, 30.9%), systolic blood pressure (SBP) (n = 28, 25.5%), respiratory rate (n = 20, 18.2%), GCS (n = 15, 13.6%) and oxygen saturation (n = 13, 11.8%).

The prevalence of documented deterioration which was not escalated was 47.3% (n = 52).

There was a significant association between escalation practices and the area of the ED that the patient was being cared for when their first sign of deterioration is recorded, X^2 (4, n = 110) = 12.86, *p* = 0.01. The patients' care was more likely to be escalated when they were

located in the resuscitation cubicles (n = 15, 75%) and less likely to be escalated when they were located in the Waiting Room (n = 11, 84%) or the Short Stay Unit (n = 7, 63.6%) (table 2).

Insert table 2 about here

There was no significant difference between escalation practices when the ED contained no ATS category 1 patients and when there were one or more patients with this ATS category, X^2 (1, n = 110) = 0.13, *p* = 0.72. Similarly, there was no significant difference between escalation practices when the ED staff were caring for 1 - 10 ATS category 2 patients and when there were > 10 ATS category 2 patients in the ED, X^2 (1, n = 110) = 0.14, *p* = 0.91. The presence of patients who were waiting for transfer to the intensive care unit (ICU), also did not make a difference to escalation practices, X^2 (1, n = 110) = 0.35, *p* = 0.56 (table 2).

There were some differences in escalation practices when the ED workload varied. Two aspects were examined; occupancy levels and the number of patients arriving in the hour and the two hours prior to the episode of deterioration being documented. The most notable result was the escalation practices when the ED was between 75–100% occupancy, when just under 61% of deteriorating patient care was escalated, although the differences did not reach significance, X^2 (2, n = 110) = 3.01, p = 0.22 (table 2).

There was also no statistically significant difference between escalation practices when the ED received ≤ 5, between 6 – 10, 11 – 15 and > 15 patient arrivals in the hour that the episode of deterioration was documented, X^2 (3, n = 110) = 0.98, *p* = 0.81. Furthermore, there was no significant difference in escalation practices when the ED received 1 – 10, 11 – 20 or > 20 patient arrivals in the two hours prior to the documented episode of deterioration, X^2 (2, n = 110) = 0.94, *p* = 0.62 (table 2).

There was no significant difference between escalation practices when the ED is staffed at or above the standard set by management, X^2 (1, n = 110) = 0.11, *p* = 0.75 (table 2).

There was a significant difference between escalation practices and the competence level of the nursing staff who recorded the first episode of deterioration X^2 (4, n = 110) = 15.09, *p* = 0.005 with intermediately competent nurses significantly more likely to appropriately escalate care (table 2).

A generalised linear mixed model analysis was performed to assess the impact of 13 independent variables on escalation practices of Emergency Nurses when a first episode of physiological deterioration was documented. The model had a positive predictive value of 92.31%.

The strongest extrinsic predictor of appropriate escalation of patient deterioration was the competence level of the nurse who documented the deteriorating vital sign (intermediate competence level, *p*=0.037, OR 9.006) (table 3). However, the confidence interval was wide (95%, 1.148 – 70.636).

When the vital sign that indicated physiological deterioration was systolic blood pressure <90mmHg, the documenting nurse was significantly more likely to escalate care appropriately (OR11.9, 95% CI1.2 -118.7, *p* = 0.034) (table 3), again, with a wide 95% CI.

Insert Table 3 about here

Discussion

The results of this study show that the period prevalence of first episode late signs of physiological deterioration in the ED is 10.08%. This is consistent with the range of prevalence

demonstrated in Europe [37, 38], Australia [39], the UK [40] and North America [41] (10 – 27%).

Studies in Australian EDs have reported slightly higher prevalence (12.9% - 14.8%) [30, 42]. These results vary from the current study and may, in part, be attributed to the different study designs. Scott and colleagues (2015) used a prospective point prevalence study design which reported on the point prevalence of adult ED patients only (n = 186), while the cross-sectional design of the study by Considine et al. (2015) was limited to a sample (n = 600) of adult patients with shortness of breath, chest pain or abdominal pain. The results of the current study originate from a larger sample that included all adult and paediatric patients (*n* = 2668) that were cared for in the ED over a period of 14 days.

The prevalence of documented first episodes of deterioration, that were not escalated according to the health service's MAC, was 47.3%. This is greater than the 10 – 30% which has been reported in acute medical surgical wards[43-45] and ED [30].

Escalation of deteriorating ED patient care was not significantly impacted by fluctuations in workload, staffing levels/skill-mix or ED patient casemix. However, failure to escalate was significantly impacted by the experience and expertise of the person documenting signs of deterioration, the patient's vital sign (SBP) which indicated physiological deterioration and the ED area in which the patient is being cared for.

It is not surprising that novice ED workers are less likely to escalate care appropriately, a concern which has been self-reported by novice nurses when faced with managing deteriorating patients [46]. However, our data show, that there is not a linear relationship between experience, expertise and escalation practices, with expert ED nurses also significantly less likely, and intermediately competent nurses nine times more likely to

escalate care appropriately. To date, the evidence related to expertise and its association with escalation practices has been limited to nurses' level of education [47] and the effectiveness of educational interventions designed to improve escalation practice [48]. Whereas, the current study findings provide evidence directly related to staff expertise and clinical experience.

While it is distinctly possible that the expert nurses may have made decisions not to escalate care based on their emergency nursing expertise, intuition and skilled clinical reasoning [49, 50], it is not clear from the results of this study why nurses who are intermediately competent are more likely to escalate care appropriately. However, it is important to recognise that the intermediately competent group, who have between 2 – 5 years of ED work experience, are likely to have encountered physiological deterioration in at least 10% of the patients they have cared for and have experienced variation in escalation practice. Given the predictive strength of these Emergency Nurses to escalate patient care appropriately, there may be valuable lessons to be learned from their attitudes, beliefs and practice which could inform ED practice and policy change related to escalating care for deteriorating ED patients.

Though no association was found between the prevalence of failure to escalate and overall staffing levels, there was however a significant relationship between escalation practices and care areas that had different nurse-patient ratios and skill-mix requirements. In short, ED care areas with smaller nurse-patient ratios are more likely to escalate the care of deteriorating patients appropriately compared with areas with higher nurse-patient ratios. Two care areas of concern include the ED short stay unit and waiting room, which were prone to poor escalation practices at a rate of 63 – 84% respectively. In light of evidence that an increase of ward patient-nurse ratios by a single patient is associated with a 5 – 7% reduction in survival

from an in-hospital cardiac arrest [51, 52], the staffing levels and systems for managing increasingly overcrowded ED waiting rooms may not be providing a sufficient safety net for ED patients at risk from unrecognised deterioration. This is an especially important quality and safety issue in light of ED waiting room overcrowding and the undifferentiated nature (no provisional diagnoses) of the patients in the waiting room [53, 54].

In an attempt to overcome these challenges, EDs have modified the structure of their patient flow strategies [55], their triage and reassessment processes [56] as well as introducing nursing roles dedicated to waiting room patient care [57]. Though these interventions have demonstrated many positive patient outcomes (e.g. patient satisfaction, reduced 'did not wait for treatment' rates), efforts to improve the recognition and appropriate escalation of deteriorating patients still requires thoughtful evaluation and quality improvement strategies.

Limitations

There are a number of limitations to this study. The medical record review (MRR) was restricted to a single ED with a small sample size, limiting the generalisability of the results. However, the nurse competency framework used at the site and the live records of every staff member's clinical competence allowed detailed analysis. Without this stratified competency level data, many of the outcomes and conclusions related to experience and expertise would not have been possible. It was considered unlikely that different EDs would have competency level strategies and records that were similar enough to limit the heterogeneity of competence levels.

The period prevalence of deterioration was also limited to a distinct two-week period that did not control for seasonal fluctuations in ED presentations. And though the audit was

conducted during winter months (a time when ED presentation numbers are higher), scheduling data collection during winter and summer may have yielded a different, and perhaps more representative results.

The clinical significance and trajectory of deterioration should also be considered in the context of the study population and the alert criteria. That is, the patients in this study represent a wide range of presentation types and acuity, and the alert parameters were originally intended to identify deterioration in patients considered stable enough for general medical/surgical wards.

A decision was also made not to include patients with documented DNR or NFR orders. This was a deliberate design choice which was made due to the nuanced, and often undocumented decisions and care processes involved in caring for these patients. However, this research design choice does not indicate that escalating the care of these patients is any less important. Rather, we believe that research designed to describe the outcomes of patients with DNR/NFR orders who experience deterioration in the ED is important work which is long overdue.

Due to the retrospective nature of the MRR, there was also a possibility that care was, in fact, appropriately escalated for some of the episodes of deterioration but there was insufficient evidence of this in the documentation. Though all care was taken to identify any evidence that a doctor had been informed (e.g. administration of treatment that can only be ordered by a doctor), it is quite possible that some episodes may have been escalated.

Conclusion

The rate of failure to escalate care for patients experiencing physiological deterioration is a significant risk for ED patients who are being cared for in this overcrowded clinical setting.

Efforts to improve the safety and quality of care for ED patients, which staff are compelled to care for in inappropriate treatment areas (e.g. waiting rooms), may be augmented by preparing emergency clinicians to recognise and escalate care informed by the escalation practices demonstrated by nurses with intermediate ED experience and competence levels. Until government and health policymakers address systemic chronic access block, lower nurse-patient ratios can improve the safety net for ED patients at risk of unrecognised physiological deterioration.

Contributors I certified that all authors of this paper have made substantial contribution to the research article. CC has contributed to the: (1) conception design of the study, (2) acquisition of data, (3) analysis and interpretation of the data, (4) drafting the article and (5) critical revision of the article. SC has contributed to the: (1) conception design of the study, (2) analysis and interpretation of the data (3) drafting the article and (4) critical revision of the article. RE has contributed to the: (1) conception design of the study, (2) analysis and interpretation of the data (3) drafting the article and (4) critical revision of the article.

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References

1. Winters, B.D. and M.A. DeVita, *Rapid Response Systems: History and Terminology*, in *Textbook of Rapid Response Systems*, M.A. DeVita, et al., Editors. 2017, Springer International Publishing: Cham. p. 17-24.
2. Considine, J., E. Lucas, and B. Wunderlich, *The uptake of an early warning system in an Australian emergency department: a pilot study.* Crit Care Resusc, 2012. **14**(2): p. 135-41.
3. Hing, E., F.A. Bhuiya, and N.C.f.H. Statistics, *Wait Time for Treatment in Hospital Emergency Departments, 2009*. 2012: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.
4. Lowthian, J.A., et al., *Demand at the emergency department front door: 10-year trends in presentations.* Med J Aust, 2012. **196**(2): p. 128-132.
5. Pitts, S.R., et al., *National trends in emergency department occupancy, 2001 to 2008: effect of inpatient admissions versus emergency department practice intensity.* Ann Emerg Med, 2012. **60**(6): p. 679-686 e3.
6. Laxmisan, A., et al., *The multitasking clinician: decision-making and cognitive demand during and after team handoffs in emergency care.* International journal of medical informatics, 2007. **76**(11): p. 801-811.
7. Health, A.I.o. and Welfare, *Emergency Department Care 2016-17: Australian Hospital Statistics.* 2017.
8. Hosking, J., J. Considine, and N. Sands, *Recognising clinical deterioration in emergency department patients.* Australasian Emergency Nursing Journal, 2014. **17**(2): p. 59-67.
9. Soar, J., et al., *European Resuscitation Council Guidelines for Resuscitation 2015.* Resuscitation, 2015. **95**: p. 100-147.
10. Kellett, J., *The Assessment and Interpretation of Vital Signs*, in *Textbook of Rapid Response Systems*, M.A. DeVita, et al., Editors. 2017, Springer International Publishing: Cham. p. 63-85.
11. Mitchell, I.A., et al., *A prospective controlled trial of the effect of a multi-faceted intervention on early recognition and intervention in deteriorating hospital patients.* Resuscitation, 2010. **81**(6): p. 658-666.
12. Harrison, G., et al., *The prevalence of recordings of the signs of critical conditions and emergency response in hospital wards - the SOCCER study.* Resuscitation, 2005. **65**: p. 149 - 157.
13. Green, M., et al., *Comparison of the Between the Flags calling criteria to the MEWS, NEWS and the electronic Cardiac Arrest Risk Triage (eCART) score for the identification of deteriorating ward patients.* Resuscitation, 2018. **123**: p. 86-91.
14. Kipnis, P., et al., *Development and validation of an electronic medical record-based alert score for detection of inpatient deterioration outside the ICU.* J Biomed Inform, 2016. **64**: p. 10-19.
15. Moon, A., et al., *An eight year audit before and after the introduction of modified early warning score (MEWS) charts, of patients admitted to a tertiary referral intensive care unit after CPR.* Resuscitation, 2011. **82**(2): p. 150-4.
16. Smith, G.B., et al., *A review, and performance evaluation, of single-parameter "track and trigger" systems.* Resuscitation, 2008. **79**(1): p. 11-21.
17. Jarvis, S., et al., *Aggregate National Early Warning Score (NEWS) values are more important than high scores for a single vital signs parameter for discriminating the risk of adverse outcomes.* Resuscitation, 2015. **87**: p. 75-80.
18. Forbes, H. and E. Watt, *Jarvis's Physical Examination and Health Assessment*. 2015: Elsevier Health Sciences.
19. Herod, R., et al., *Long term trends in medical emergency team activations and outcomes.* Resuscitation, 2014. **85**(8): p. 1083-7.
20. Prytherch, D.R., et al., *Calculating early warning scores—A classroom comparison of pen and paper and hand-held computer methods.* Resuscitation, 2006. **70**(2): p. 173-178.
21. Alam, N., et al., *Exploring the performance of the National Early Warning Score (NEWS) in a European emergency department.* Resuscitation, 2015. **90**: p. 111-115.
22. Considine, J., D. Jones, and R. Bellomo, *Emergency department rapid response systems: the case for a standardized approach to deteriorating patients.* European journal of emergency medicine: official journal of the European Society for Emergency Medicine, 2013.
23. Corfield, A.R., et al., *Utility of a single early warning score in patients with sepsis in the emergency department.* Emergency Medicine Journal, 2013.
24. Griffiths, J.R. and E.M. Kidney, *Current use of early warning scores in UK emergency departments.* Emergency Medicine Journal, 2012. **29**(1): p. 65-66.

25. Spencer, W., et al., *Determination of the best early warning scores to predict clinical outcomes of patients in the emergency department.* Emergency Medicine Journal, 2019. **36**(12): p. 716.
26. Bingham, G., et al., *Clinical review criteria and medical emergency teams: evaluating a two-tier rapid response system.* Critical care and resuscitation : journal of the Australasian Academy of Critical Care Medicine, 2015. **17**(3): p. 167-73.
27. Considine, J., et al., *Systems for recognition and response to clinical deterioration in Victorian emergency departments.* Australasian Emergency Care, 2018. **21**(1): p. 3-7.
28. Devita, M.A., et al., *Findings of the first consensus conference on medical emergency teams.* Crit Care Med, 2006. **34**(9): p. 2463-78.
29. Shearn, D., F. Rubulotta, and M.A. DeVita, *Other Efferent Limb Teams: Crises that Require Specialized Resources*, in *Textbook of Rapid Response Systems: Concept and Implementation*, M.A. DeVita, et al., Editors. 2017, Springer International Publishing: Cham. p. 219-227.
30. Scott, B.M., J. Considine, and M. Botti, *Unreported clinical deterioration in emergency department patients: a point prevalence study.* Australas Emerg Nurs J, 2015. **18**(1): p. 33-41.
31. Jones, D.A.M.D.M.B.B.S., M.A.M.D. DeVita, and R.M.D.M.B.B.S. Bellomo, *Rapid-Response Teams.* New England Journal of Medicine, 2011. **365**(2): p. 139-146.
32. Chan, P.S., et al., *Rapid response teams: A systematic review and meta-analysis.* Archives of Internal Medicine, 2010. **170**(1): p. 18-26.
33. Maharaj, R., I. Raffaele, and J. Wendon, *Rapid response systems: a systematic review and meta-analysis.* Crit Care, 2015. **19**(1): p. 254.
34. Australasian College of Emergency Medicine. *Australasian Triage Scale*. 2014 [cited 2020 21/05/2020]; Available from: https://acem.org.au/Content-Sources/Advancing-Emergency-Medicine/Better-Outcomes-for-Patients/Triage.
35. Benner, P., *From novice to expert.* AJN The American Journal of Nursing, 1982. **82**(3): p. 402-407.
36. IBM Corp. *IBM SPSS Statistics for Mac*. [24.0] 2016.
37. Zegers, M., et al., *Adverse events and potentially preventable deaths in Dutch hospitals: results of a retrospective patient record review study.* Qual Saf Health Care, 2009. **18**(4): p. 297-302.
38. Marquet, K., et al., *One fourth of unplanned transfers to a higher level of care are associated with a highly preventable adverse event: a patient record review in six Belgian hospitalsx`.* Critical care medicine, 2015. **43**(5): p. 1053.
39. Harrison, G.A., et al., *The prevalence of recordings of the signs of critical conditions and emergency responses in hospital wards–the SOCCER study.* Resuscitation, 2005. **65**(2): p. 149-157.
40. Garry, D., et al., *A prospective multicentre observational study of adverse iatrogenic events and substandard care preceding intensive care unit admission (PREVENT).* Anaesthesia, 2014. **69**(2): p. 137-142.
41. Runciman, W.B., et al., *A comparison of iatrogenic injury studies in Australia and the USA. II: Reviewer behaviour and quality of care.* Int J Qual Health Care, 2000. **12**(5): p. 379-88.
42. Considine, J., J. Rawet, and J. Currey, *The effect of a staged, emergency department specific rapid response system on reporting of clinical deterioration.* Australasian Emergency Nursing Journal, 2015. **18**(4): p. 218-226.
43. Hillman, K., et al., *Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial.* Lancet, 2005. **365**(9477): p. 2091-7.
44. Johnston, M.J., et al., *A systematic review to identify the factors that affect failure to rescue and escalation of care in surgery.* Surgery, 2015. **157**(4): p. 752-763.
45. Kause, J., et al., *A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom--the ACADEMIA study.* Resuscitation, 2004. **62**(3): p. 275-82.
46. Della Ratta, C., *Challenging graduate nurses' transition: Care of the deteriorating patient.* Journal of Clinical Nursing, 2016. **25**(19-20): p. 3036-3048.
47. Massey, D., W. Chaboyer, and V. Anderson, *What factors influence ward nurses' recognition of and response to patient deterioration? An integrative review of the literature.* Nursing open, 2017. **4**(1): p. 6-23.
48. Connell, C.J., et al., *The effectiveness of education in the recognition and management of deteriorating patients: A systematic review.* Nurse Educ Today, 2016. **44**: p. 133-45.
49. Cader, R., S. Campbell, and D. Watson, *Cognitive Continuum Theory in nursing decision-making.* Journal of Advanced Nursing, 2005. **49**(4): p. 397-405.
50. Krishnan, P., *A Philosophical Analysis of Clinical Decision Making in Nursing.* Journal of Nursing Education, 2018. **57**(2): p. 73-78.

51. McHugh, M.D., et al., *Better Nurse Staffing and Nurse Work Environments Associated With Increased Survival of In-Hospital Cardiac Arrest Patients.* Med Care, 2016. **54**(1): p. 74-80.
52. Aiken, L.H., et al., *Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care.* BMJ Qual Saf, 2017. **26**(7): p. 559-568.
53. Carter, E.J., S.M. Pouch, and E.L. Larson, *The relationship between emergency department crowding and patient outcomes: a systematic review.* Journal of Nursing Scholarship, 2014. **46**(2): p. 106-115.
54. Guttmann, A., et al., *Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada.* Bmj, 2011. **342**(jun01 1): p. d2983-d2983.
55. Paul, J.A. and L. Lin, *Models for Improving Patient Throughput and Waiting at Hospital Emergency Departments.* The Journal of Emergency Medicine, 2012. **43**(6): p. 1119-1126.
56. Blank, F.S., et al., *Improving patient safety in the ED waiting room.* Journal of emergency nursing, 2007. **33**(4): p. 331-335.
57. Innes, K., et al., *Care of patients in emergency department waiting rooms-an integrative review.* Journal of advanced nursing, 2015. **71**(12): p. 2702-2714.

Table 1. Confidence interval for deterioration prevalence by age groups

Age group	Number of positive 1st episode of deterioration	Prevalence	Lower 95% CL	Upper 95% CL
Term – 12 months	6	0.0022	0.0010	0.0049
1 – 4 years	12	0.0045	0.0026	0.0078
5 – 12 years	1	4e-04	1e-04	0.0021
13 – 18 years	6	0.0022	0.0010	0.0049
Adult (>18 years)	244	0.0914	0.0793	0.1010

Confidence level (CL) - 0.95, Confidence interval method - Wilson

Table 2. Association between escalation of deterioration and ED care area, casemix, occupancy, skillmix and nurse competency

Characteristic	Variable and category		Escalated	Not Escalated	*p*
ED care area association with escalation of patient care		Resuscitation	15 75.0%	5 25.0%	0.01
		General Cubicles	33 56.9%	25 43.1%	
		Fast Track	4 50.0%	4 50.0%	
		Waiting Room	2 15.4%	11 84.6%	
		Short Stay Unit	4 36.4%	7 47.3%	
ED Casemix association with escalation of patient care	ED triage category 1 status	No category 1 patients	43 51.2%	41 48.8%	0.72
		≥ 1 category 1 patients	15 57.7%	11 42.3%	
	ED triage category 2 status	1 - 10 category 2 patients	24 54.5%	20 45.5%	0.91

Characteristic	Variable and category		Escalated	Not Escalated	*p*
		> 10 category 2 patients	34 51.5%	32 48.5%	
	ED patients waiting ICU admission status	No patients waiting ICU admission	42 55.3%	34 44.7%	0.56
		≥ 1 patient waiting ICU admission	16 47.1%	18 52.9%	
ED Occupancy association with escalation of patient care		<75% occupancy	11 55.0%	9 45.0%	0.22
		75 - 99.9% occupancy	26 61.9%	16 38.1%	
		100 – 150% occupancy	21 43.8%	27 56.3%	
ED arrivals in Hour/s of deterioration association with escalation of patient care	ED Arrivals in same hour of deterioration	0 – 5 arrivals	20 58.8%	14 41.2%	0.81
		6 – 10 arrivals	17 51.5%	16 48.5%	
		11 – 15 arrivals	15	17	

Characteristic	Variable and category		Escalated	Not Escalated	*p*
			46.9%	53.1%	
		> 15 arrivals	6	5	
			54.5%	45.5%	
	ED Arrivals 2 hours prior to deterioration	1 – 10 arrivals	16	11	0.62
			59.3%	40.7%	
		1 – 20 arrivals	19	16	
			54.3%	45.7%	
		> 20 arrivals	23	25	
			47.9%	52.1%	
ED staffing and skillmix association with escalation of patient care	Staffing and skillmix at or below standard	Above standard	34	33	0.75
			50.7%	49.3%	
		Below standard	24	19	
			55.8%	44.2%	
Nurse competence association with escalation of patient care		Beginner	13	16	0.005
			44.8%	55.2%	
		Intermediate	23	18	
			56.1%	43.9%	
		Expert	12	18	

Characteristic	Variable and category	Escalated	Not Escalated	*p*
		40%	60%	
Total		**58**	**52**	
		52.7%	**47.3%**	

Note: ICU - Intensive Care Unit, ED – Emergency Department

Table 3. Fixed variable correlation with escalation practices

Variables	Groups	Coefficient	*p*	Exp. (Coefficient)	95% Confidence Interval for Exp. (Coefficient)	
					Lower	Upper
Gender	Female	.118	.861	1.125	.295	4.297
	Male	0[a]	.	.	.	.
Age groups	Adult	-.152	.885	.859	.106	6.981
	Paediatric	0[a]	.	.	.	.
Triage Category	Category 3	.381	.629	1.464	.307	6.976
	Category 4 &5	-.282	.794	.754	.088	6.426
	Category 2	0[a]	.	.	.	.
Deteriorating vital sign	Glasgow Coma Scale	.467	.683	1.595	.166	15.321
	Peripheral oxygen saturation	-1.308	.294	.270	.023	3.176
	Systolic Blood Pressure	2.484	.034	11.993	1.212	118.665
	Respiratory rate	1.099	.332	3.000	.320	28.114
	Pulse	0[a]	.	.	.	.
ED care area	Short stay unit	1.456	.282	4.290	.296	62.270
	Waiting Room	-1.972	.164	.139	.009	2.266
	Resuscitation cubicles	.451	.628	1.570	.248	9.917

Variables	Groups	Coefficient	*p*	Exp. (Coefficient)	95% Confidence Interval for Exp. (Coefficient)	
					Lower	Upper
	Fast track & general cubicles	0[a]	.	.	.	.
Competence level	Expert	.868	.439	2.383	.259	21.924
	Intermediate (Competent & proficient)	2.198	.037	9.006	1.148	70.636
	Beginner (Novice & advanced beginners)	0[a]	.	.	.	.
Patients waiting ICU admission	1 or more patients awaiting ICU	-1.093	.172	.335	.069	1.625
	No patients awaiting ICU	0[a]	.	.	.	.
Skillmix and staffing levels at/above or below standard	Below standard	.272	.722	1.312	.290	5.944
	At or above standard	0[a]	.	.	.	.
ED triage category 2 status	> 10 category 2 patients	-.147	.866	.863	.153	4.876
	1 - 10 category 2 patients	0[a]	.	.	.	.
ED triage category 1 status	≥ 1 category 1 patient	.653	.486	1.921	.300	12.303
	No category 1 patients	0[a]	.	.	.	.
Patient arrivals in hour that deterioration was documented	> 15 arrivals	-1.358	.373	.257	.013	5.229
	11 - 15 arrivals	-1.525	.167	.218	.025	1.916

Variables	Groups	Coefficient	*p*	Exp. (Coefficient)	95% Confidence Interval for Exp. (Coefficient) Lower	Upper
	6 - 10 arrivals	-.030	.975	.971	.150	6.277
	0 - 5 arrivals	0[a]	.	.	.	.
Patient arrivals in 2 hours prior to deterioration	> 20 arrivals	.127	.920	1.135	.094	13.778
	11 - 20 arrivals	.491	.634	1.634	.212	12.594
	1 - 10 arrivals	0[a]	.	.	.	.
ED Occupancy	100 - 150% occupancy	.645	.616	1.906	.149	24.330
	75 - 99.9% occupancy	1.208	.277	3.347	.372	30.124
	<75% occupancy	0[a]	.	.	.	.

Generalised linear mixed model regression analysis

[a] Coefficient set to zero because it is the contrast group and therefore redundant.

Note: ICU - Intensive Care Unit, ED – Emergency Department