The uptake of an early warning system in an Australian emergency department: a pilot study

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ABSTRACT

Objectives: To evaluate the uptake of an emergency department early warning system (ED EWS) for recognition of, and response to, clinical deterioration.

Design, setting and participants: A descriptive exploratory study conducted in an urban district hospital in Melbourne, Australia. Systematic sampling was used to identify every 10th patient for whom the ED EWS was activated from May 2009 to May 2011.

Main outcome measures: Patient characteristics, ED system data and ED EWS activation characteristics.

Results: ED EWS activation occurred in 1.5% of ED patients; 204 patients were included in this pilot study. The median age was 65.1 years (interquartile range [IQR], 47.8–77.5 years), 89.2% of patients were classified as triage category 2 or 3, and 82.4% of patients were seen by medical staff before ED EWS activation. Hypotension (27.7%) and tachycardia (23.7%) were the most common reasons for ED EWS activation. Median duration of clinical instability was 39 minutes (IQR, 5–129 minutes). Nurses made 93.1% of ED EWS activations. Median time between documenting physiological abnormalities and ED EWS activation was 5 minutes (IQR, 0–20). Most patients (57.8%) required hospital admission: 4.4% of patients required intensive care unit admission.

Conclusions: The ED EWS resulted in at least two formal reports of clinical deterioration in ED patients per day, indicating reasonable uptake by clinicians. A greater understanding of clinical deterioration in ED patients is warranted to inform an evidence-based approach to recognition of, and response to, clinical deterioration in ED patients.

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There is a clear relationship between physiological abnormalities and serious inhospital adverse events, such as unexpected death, cardiac arrest, medical emergency team (MET) activation and unplanned intensive care unit admission.[1-4] The antecedent signs of serious inhospital adverse events mean that these events are often predictable and therefore preventable. This notion has been the impetus for the development of patient safety systems aimed at preventing serious inhospital adverse events by the early recognition of, and response to, clinical deterioration.[5-7] The terminology used to describe such systems is highly variable and includes terms such as rapid-response systems, rapid-response teams, early warning systems (EWSs), medical emergency response teams, METs, patient-at-risk teams, or critical care outreach teams.[8] In this article, the term EWS will be used.

Although EWSs are common in general wards of most major hospitals,[9] most emergency departments (EDs) manage patients in deteriorating conditions within their own resources and do not use formal EWSs. Despite an early study by Lee and colleagues demonstrating that 62% of MET calls were to the ED (compared with 29% to the general wards), widespread implementation of EWSs in EDs has not progressed.[10]

The lack of formal systems for the early recognition of, and response to, the ED patient in a deteriorating condition highlights several risks. First, the absence of objective, consistent criteria by which to define clinical deterioration increases the risk of unrecognised deterioration — failure to recognise the significance of physiological abnormalities is a recurrent theme in the adverse events literature.[11,12] Second, a structured process for reporting recognised deterioration is a valuable patient safety strategy that overcomes reluctance to report due to inexperience or authority gradients.[13] Finally, the effective management of clinical deterioration requires experienced personnel with advanced decision-making and problem-solving skills, so reporting clinical deterioration to inexperienced medical staff may result in delays to management or undertreatment.

To facilitate the early recognition of, and response to, clinical deterioration, the ED at the Northern Hospital, Northern Health, Melbourne, Victoria, Australia, introduced an EWS comprising clinical instability criteria and an escalation protocol in 2009. The aim of this study is to evaluate the uptake of this ED EWS.

Methods

Study design

A descriptive exploratory design was used. The project was approved by the Northern Health Human Research and Ethics Committee (approval no. A50/10).

Table 1. Emergency department clinical instability criteria (adults)

Criterion	Details
Airway/ breathing	Stridor, upper airway obstruction, or threatened airway
	SpO_2 < 90% (on oxygen 10 L/min via mask)
	Arterial blood gases: pH < 7.20
	Respiratory rate < 10 breaths/min or > 30 breaths/min
Circulation	Heart rate < 50 beats/min or > 120 beats/min
	Systolic blood pressure < 90 mmHg or > 200 mmHg
	Urine output < 20 mL/h or < 100 mL/6 h
Disability	Sudden decrease in consciousness (fall in Glasgow Coma Scale score > 2)
	Repeated or prolonged seizures
Worried?	Patients who may not meet the above criteria but have a sudden deterioration in their medical condition, requiring urgent medical review

Table 2. Emergency department clinical instability criteria (children)

Criterion	Details	
Airway/ breathing	Stridor, upper airway obstruction, or threatened airway	
	SpO_2 < 90% (on oxygen 10 L/min via mask)	
	Arterial blood gases: pH < 7.20	
	Tachypnoea (breaths/min)	
⩽ 3 months	> 60	
4–12 months	> 50	
1–4 years	> 40	
5–12 years	> 30	
> 12 years	> 30	
Circulation	**Hypotension (mmHg)**	**Heart rate (beats/min)**
⩽ 3 months	< 50	< 100 or > 180
4–12 months	< 60	< 90 or > 180
1–4 years	< 70	< 80 or > 160
5–12 years	< 80	< 60 or > 140
>12 years	< 90	< 100 or > 130
Disability	Sudden decrease in consciousness (fall in Glasgow Coma Scale score > 2)	
	Repeated or prolonged seizures	
Worried?	Patients who may not meet the above criteria but have a sudden deterioration in their medical condition, requiring urgent medical review	

Setting

The study was conducted from 1 May 2009 to 31 May 2011 at the Northern Hospital, a 300-bed urban district hospital that managed 63 584 ED attendances in the 2009–10 financial year.[14] At the time of the study, registered nurse (RN) staffing comprised 16 RNs on a morning shift (minimum of four RNs with postgraduate qualifications in emergency nursing), 18 RNs on an evening shift (minimum of five RNs with postgraduate qualifications in emergency nursing) and 13 RNs overnight (minimum of four RNs with postgraduate qualifications in emergency nursing). Medical staffing comprised nine doctors on a morning shift (including minimum of two emergency physicians), 13 doctors on an afternoon shift (including minimum of two emergency physicians) and four doctors overnight (including a senior registrar with on-call emergency physician support).

Intervention

In response to several cases where clear evidence of clinical deterioration was not reported or reported but undermanaged, an ED EWS comprising activation criteria (termed clinical instability criteria) and an escalation protocol were implemented. The clinical instability criteria were based on organisational MET criteria with a lower threshold for activation for tachycardia (120 beats/min), based on the undifferentiated nature of ED patients and research suggesting that a heart rate over 120 beats/min increased the likelihood of critical care admission in ED patients[15] (hospital MET is activated for a heart rate greater than 140 beats/min).

The clinical instability criteria aimed to increase recognition of clinical deterioration (Table 1 and Table 2). If a patient met any of the clinical instability criteria during an ED assessment, the escalation protocol required a report be made to the nurse and emergency physician in charge of the shift and the patient was reviewed by the emergency physician (or senior registrar overnight) within 5 minutes of notification. The aim of this escalation protocol was to ensure a timely assessment by senior medical staff. There were ED EWS log books at each of the two major staff bases in the ED. After an ED EWS activation, the person making the activation placed a patient sticker in the ED EWS log book, noted the date and time of activation, and ticked the ED EWS criterion that resulted in the activation.

Population

Patients for whom the ED EWS had been activated were identified from the ED EWS log book and systematic sampling was used to select every 10th patient. Given that the ED EWS log book registers consecutive patients in whom the ED EWS was activated, and there is no specific order to ED EWS activations, systematic sampling was deemed an appropriate sampling technique to

Figure 1. Relationship between emergency department (ED) attendances and ED early warning system (EWS) activations

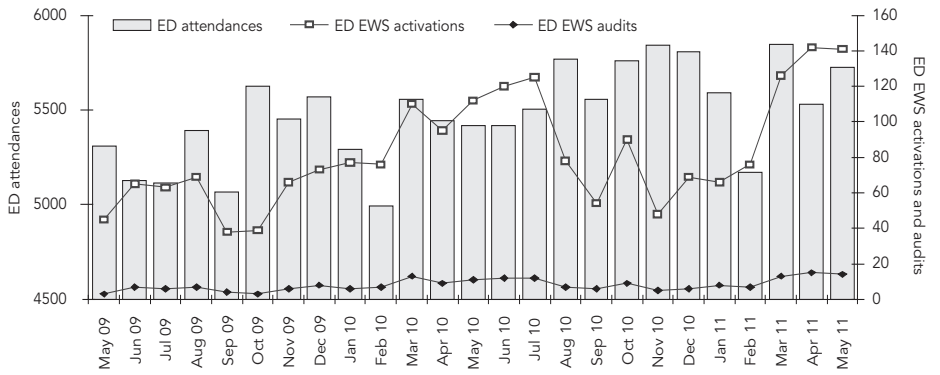

Table 3. Presenting problems of study sample

Presenting problem	No. (%)
Respiratory	51 (25.0%)
Cardiac	46 (22.5%)
Gastrointestinal	30 (14.7%)
Neurological	31 (15.2%)
Musculoskeletal	11 (5.4%)
Genitourinary	5 (2.5%)
Mental health	7 (3.4%)
Febrile/sepsis	11 (5.4%)
Other	12 (5.9%)
Total	**204 (100.0%)**

ensure the study sample was spread across ED presentations each month.

Measurements

Data were collected using medical record audit, specifically the ED nursing observation chart and medical notes. A prescribed data collection tool was used for each patient and the study data were collected by a single researcher (E L) within 8 weeks of the ED EWS activation. The data collected from each patient included in the audit were:

- patient characteristics (age, sex, Australasian Triage Scale [ATS] triage category [category 1, seen immediately; category 2, treatment within 10 minutes; category 3, treatment within 30 minutes; category 4, treatment within 60 minutes], presenting problem);
- ED system characteristics (waiting time, length of stay, discharge destination); and
- ED EWS activation characteristics (designation of staff initiating activation, reason for activation, interventions required, duration of clinical instability).

Data analysis

Data were analysed using SPSS, version 17.0 (IBM, Armonk, NY, USA). Descriptive statistics were used to summarise the study findings. As the study data were not normally distributed, median interquartile range (IQR) are presented. As this was a pilot study, associations between patient and ED system characteristics and clinical deterioration were examined for exploratory purposes using χ^2 test and Pearson R correlation. Statistical significance was set at $P < 0.05$.

Results

There were 136878 ED attendances (median, 5505 attendances/month [IQR, 5300–5674]) and 2072 ED EWS activations (median, 76 activations/month [IQR, 64–111]) in the study period. Children younger than 16 years comprised 15.9% (21820) of presentations and the admission rate was 27.5%, including short-stay unit admissions. Overall, 1.5% of ED patients required ED EWS activation (median, 1.3% [IQR, 1.2–2.0]); however, there was no significant correlation between the number of ED attendances and EWS activations (R = 0.264, $P = 0.2$) (Figure 1).

Patient demographics

A total of 204 patients were included in this pilot, representing 9.8% of ED EWS activations; 103 (50.5%) were male. The median age was 65.1 years (IQR, 47.8–77.5 years), and 16 patients (7.8%) were younger than 16 years. Ambulance transport to ED occurred in 125 patients (61.3%). The ATS category distribution was: category 1, 4 (2.0%); category 2, 88 (43.1%); category 3, 94 (46.1%); and category 4, 18 (8.8%). The median waiting time (from arrival to assessment and treatment) was 13 minutes (IQR, 7–24 minutes) to be seen by emergency nursing staff (excluding triage) and 22 minutes (IQR, 9–49 minutes) to be seen by medical staff. Most patients (168; 82.4%) had been seen by medical staff before requiring ED EWS activation. The most common presenting problems of patients requiring ED EWS activation were respiratory (shortness of breath, dyspnoea) and cardiac (chest pain, palpitations) complaints (Table 3).

Emergency department early warning system activations: location, personnel and criteria

The location of ED EWS activations was varied: 110 activations occurred in monitored cubicles (53.9%), 59 in general adult cubicles (28.9%), 14 in resuscitation cubicles (6.9%), 15 in paediatric cubicles (7.4%), and three in the ED fast-track area (1.5%). The location of activation was missing in

three cases (1.5%). Seven activations in the paediatric cubicles were for children younger than 16 years and the remainder were for adult patients who were cared for in the paediatric area. Just over one-quarter of ED EWS activations (25.5%; 52) occurred overnight (22:00–08:00). During the study period, 24.1% of ED presentations occurred overnight, so the proportion of ED EWS activations seems commensurate with the proportion of ED attendances occurring overnight.

Nurses made 190 (93.1%) ED EWS activations and medical staff made two (1.0%) EWS activations; the personnel making the ED EWS activation could not be determined in 12 cases (5.9%). Of the 190 ED EWS activations made by nurses, 152 (80.0%) were made by nurses without postgraduate qualifications in emergency nursing. The median time between documenting physiological abnormalities and ED EWS activation was 5 minutes (IQR, 0–20 minutes).

There were 224 reasons for ED EWS activation in 204 patients. Hypotension, tachycardia, bradycardia and tachypnoea were the most common reasons for ED EWS activation and clinical instability was resolved in 131 (64.2%) cases (Table 4). Clinical instability was more likely to be resolved when ED EWS was activated for blood pressure abnormalities and less likely to be resolved when activated for bradycardia or tachypnoea (Table 4).

Investigations and interventions

The investigations and interventions that followed ED EWS activation are shown in Table 5.

Disposition and patient outcomes

The median duration of clinical instability (period of time during which the patient fulfilled the clinical instability criteria) was 39 minutes (IQR, 5–129 minutes). Most patients had one ED EWS activation (187; 91.7%), but 16 patients (7.8%) had two ED EWS activations and one patient (0.5%) had three ED EWS activations during their episode of emergency care.

Median ED length of stay was 10.0 hours (IQR, 7.1–14.1 hours) for admitted patients and 7.1 hours (IQR, 4.3–10.2 hours) for non-admitted patients. Most patients (118; 57.8%) were admitted to general wards. Thirty-one patients were admitted to the short-stay unit (15.2%), eight were transferred to the coronary care unit (3.9%), three required transfer to another hospital (1.5%), and nine were admitted to the ICU (4.4%). One patient left against medical advice (0.5%) and 34 patients were discharged home (16.7%). MET activation after leaving the ED occurred in 20 patients (9.8%), and two patients (1.0%) experienced an inhospital cardiac arrest after leaving the ED. The median time between ED discharge and MET activation was 36 hours (IQR, 6.4–103.4 hours). Seven MET activations on the wards (35%) occurred within 24 hours of ED discharge and three MET activations on the wards (15%) occurred within 4 hours of ED discharge. Both cases of cardiac arrest occurred within 24 hours of ED discharge (1.95 hours and 20.43 hours). Five patients died during hospital admission (2.5%). One patient died after an inhospital cardiac arrest but the other four patients did not have an inhospital cardiac arrest or a MET activation after leaving the ED.

Discussion

Our study had several important findings. First, there was no significant correlation between the number of ED EWS activations and ED attendances, suggesting that the prevalence of clinical deterioration in ED patients is unrelated to ED demand. Second, the most common reasons for ED EWS activation were hypotension and tachycardia, both of which are known predictors of clinical deterioration, and clinical instability was resolved in over two-thirds of patients by simple interventions (intravenous fluids and supplementation oxygen). It stands to reason that intravenous fluids were a common intervention, given that hypotension was the most common reason for ED EWS activation. These results suggest that early recognition of, and response to, clinical deterioration results in restoration of physiological normality in most patients. Third, most ED EWS activations were by emergency nurses, most of whom were novice emergency nurses. Finally, one in 10 patients who required ED EWS went on to require MET or cardiac arrest team activation after leaving the ED.

The most common reasons for ED EWS activation were hypotension and tachycardia. Studies of general ward patients show that hypotension increases the odds of inhospital cardiac arrest by a factor of 19.9 (95% CI, 9.5–41.8; $P < 0.001$) and was present in almost four times as many cardiac arrest patients as controls ($P < 0.001$).[16] Heart rate abnormalities increase the odds of inhospital cardiac arrest by a factor of 4.07 (95% CI, 2.0–8.31),[16] and sinus tachycardia was the most common cardiac arrhythmia preceding inhospital cardiac arrest.[17] Although the relationship between physiological abnormalities in ward patients and serious inhospital adverse events is well documented,[1-4] there are few published studies of the relationship between physiological abnormalities in ED patients and adverse outcomes. Patients with hypotension (systolic blood pressure, < 100 mmHg) in the ED were more than twice as likely to die in hospital and 10 times more likely to suffer sudden and unexpected death.[18] There are no specific ED studies related to the predictive value of tachycardia; however, it is known that heart rate abnormalities at triage and first

Table 4. Reasons for emergency department early warning system activation

	All patients ($n = 224$),* no. (%)	Resolved ($n = 131$), no. (%)	Not resolved ($n = 73$), no. (%)	$P^{\dagger}$
Systolic blood pressure < 90 mmHg	62 (27.7%)	50 (38.2%)	12 (16.4%)	0.001
Heart rate > 120 beats/min	53 (23.7%)	39 (29.8%)	14 (19.2%)	0.098
Heart rate < 50 beats/min	39 (17.4%)	11 (8.4%)	28 (38.4%)	< 0.001
Respiratory rate > 30 breaths/min	24 (10.7%)	11 (8.4%)	13 (17.8%)	0.046
Systolic blood pressure > 200 mmHg	21 (9.4%)	18 (13.7%)	4 (5.5%)	0.030
Oxygen saturation < 90% (on oxygen 10L/min via Hudson mask)	14 (6.3%)	11 (8.4%)	3 (4.1%)	0.246
Sudden decrease in the level of consciousness (fall in Glasgow Coma Scale score > 2 points)	4 (1.8%)	3 (2.3%)	1 (1.4%)	0.549‡
Clinician concern	6 (2.7%)	4 (3.1%)	2 (2.7%)	0.632‡
Urine output < 20 mL/h or < 100 mL/6 hours	1 (0.4%)	0	1 (1.3%)	na
Seizures	0	na	na	na
Stridor, upper airway obstruction, or threatened airway	0	na	na	na
Respiratory rate < 10 breaths/min	0	na	na	na
pH < 7.20 on blood gas analysis	0	na	na	na

na = not applicable. * Some patients had more than one indication. † χ^2 test unless otherwise indicated. ‡ Fisher's exact test.

nursing assessment were both associated with increased odds of critical care admission,[15] and abnormal heart rate in ED patients increased odds of inhospital mortality by a factor of 2.5.[19]

In our study, emergency nurses initiated most ED EWS activations and most patients (82.4%) had been seen by medical staff before requiring ED EWS activation, highlighting the importance of ongoing physiological surveillance by nurses. Other studies confirm the finding that nurses most often activate EWS: the published literature to date shows that nurses activate over 80% of MET calls.[6,20] In our study, most nurse-initiated ED EWS activations were by novice emergency nurses (less than 12 months experience in emergency nursing) or nurses without postgraduate qualifications in emergency nursing. This finding is in contrast to other studies of nurses' MET activation, which show an association between years of clinical experience and confidence in decisions to activate METs.[21-23] The reason for this disparity is unclear, but it may be proposed that the close working relationship between emergency nurses and emergency physicians and the strong culture of reporting clinical instability at the study site facilitated ED EWS activation by less experienced nurses. Another possible explanation is that inexperienced nurses rely on rule-based decision making.[24] The ED EWS is a core element of orientation for new staff and, for novice nurses, rule-governed behaviour is an advantage in this case, as their interpretation of the clinical instability criteria is very literal and increases their consistency in activation of the ED EWS.

Finally, one in 10 patients who required ED EWS went on to require MET or cardiac arrest team activation after leaving the ED. There was significant variability in the length of time patients were on the ward before their conditions deteriorated to the point of requiring MET or cardiac arrest team activation; however, one-third of MET activations occurred within 24 hours of leaving ED. The relationship between physiological instability in ED and significant deterioration on the wards following ED discharge warrants further investigation.

The following limitations should be considered when interpreting our study findings. First, this pilot study was a single-centre study using a retrospective design, so generalisability to other EDs may be limited. Second, the study was based on a sample of patients in whom the ED EWS was activated: it was beyond the scope of this study to ascertain the prevalence of unreported clinical instability; however, further evaluation of the ED EWS requires that the prevalence of unreported clinical instability be established. Third, the sample size was relatively small; however, the use of stratified sampling was a deliberate choice to ensure the study sample was representative of patients in whom ED EWS was activated. Failure of the subanalyses to reach statistical significance may also be related to inadequate sample size. Fourth, the sensitivity and/or specificity of the ED clinical instability criteria is unknown, particularly in relation to prevention of adverse outcomes such as mortality, ED representations in discharged patients, and cardiac arrest, MET activation or unplanned ICU admission in admitted patients.

Table 5. Investigations and interventions following emergency department early warning system activation

	No. (%)
Investigations	
Electrocardiography	28 (13.7%)
Pathology	19 (9.3%)
X-ray	7 (3.4%)
Arterial blood gases	3 (1.5%)
Computed tomography	3 (1.5%)
Interventions	
Intravenous fluids	87 (42.6%)
Oxygen	46 (22.5%)
Change of location within emergency department	40 (19.6%)
No intervention	32 (15.7%)
Analgesia	16 (7.8%)
Antibiotics	14 (6.9%)
Nitrates	8 (3.9%)
Limitation of treatment	5 (2.5%)
Inotropes	5 (2.5%)
Intensive care unit referral*	2 (1.0%)
Indwelling urinary catheter	4 (2.0%)
High-dependency unit (HDU) referral*	4 (2.0%)
Non-invasive ventilation	1 (0.5%)
Basic life support	1 (0.5%)
Defibrillation	1 (0.5%)
Revised clinical instability criteria	0
Endotracheal intubation and mechanical ventilation	0

* ICU/HDU referral made as a result of early warning system activation (patients who already had ICU or HDU plan in place are not included).

The results of this pilot study suggest that physiological normality in ED patients suffering clinical deterioration can be restored relatively quickly with early recognition and simple interventions.

Early recognition of, and response to, clinical deterioration is a major issue in the safety and quality of health care agenda. In general ward settings, advances in patient safety have been made at system level through objective definition of clinical deterioration and clear escalation of care directives. Given that ED EWS activation occurred in only 1.3% of ED patients, equity in health care mandates that ED patients are entitled to the same level of protection at a system level, and that widespread implementation of ED EWS would not be overly burdensome for ED staff. Further, ED EWS also enables inexperienced or non-permanent ED staff to rapidly recognise deteriorating patients and easily elicit a timely response by senior personnel.

The results of this pilot study have highlighted several areas for further research. A better understanding of the balance between early recognition of, and response to, the deteriorating patient and unnecessary activations that may be counterproductive to busy ED staff (particularly emergency physicians) is needed to optimise ED EWS sensitivity and specificity. Controlled studies of the impact of ED EWS on patient outcomes are needed to determine whether ED EWS are effective in decreasing adverse events after the patient has left ED. Patients in whom clinical instability was not resolved or who required recurrent ED EWS activations require further investigation to determine if physiological abnormality is a normal state for these patients as a result of comorbidities or is the result of acute illness so warrants more aggressive management.

Conclusion

Implementation of a structured ED EWS with objective criteria and an escalation protocol has resulted in at least two formal reports of clinical deterioration in ED patients per day suggesting reasonable uptake in a busy ED. This evaluation of ED EWS activations has enabled the collection of objective data about the most common reasons for activation and the most common interventions required. However, a greater understanding of the most common reasons for, and outcomes of clinical deterioration in ED patients is required to inform an evidence-based approach to clinical risk management and physiological surveillance in EDs. Very few patients required ICU admission in this study; however, the outcomes of patients who suffer clinical deterioration in ED warrants further investigation and controlled studies are necessary to determine if ED EWS decreases ICU adverse events after the patient has left the ED.

Competing interests

None declared.

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