Bourke-Matas, Bosley, Gowens, Smith, Bowles. Can we define and recognise clinical deterioration in the prehospital setting? A systematic scoping review. https://doi.org/10.32378/ijp.v5i1.245

Can we define and recognise clinical deterioration in the prehospital setting? A systematic scoping review.

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Accepted for publication in Irish Journal of Paramedicine, Vol 5, Issue 1. This is the accepted version of the article, post peer-review. A final publisher version will be provided in due course.

Abstract

Introduction

Early identification of high-risk patients in the prehospital environment is crucial as it enables early intervention, transportation, and may determine the trajectory of future care. Although early warning systems (EWS) in-hospital are well established, it remains unclear whether adaptations of these systems can be extrapolated to prehospital care. This scoping review aims to explore how the current literature defines and recognises clinical deterioration in the prehospital setting.

Methods

In December 2019, a systematic search of five databases using a combination of terms describing ‘paramedic’, were integrated with terminology relating to ‘recognition’ of ‘clinical deterioration’. Additional reference chaining was also undertaken.

Results

A total of eight papers met the inclusion criteria. Seven out of eight studies included a definition, however these were primarily ad-hoc and fundamentally formed to support the creation of varying EWS. The prevalence of prehospital clinical deterioration is poorly explored in the literature, with only two studies discussing the frequency deterioration (5.1%). Furthermore, two studies reported that paramedics were suboptimal at identifying clinical deterioration due to medical aetiology by comparison to trauma. Additionally, an

article reported an association between clinician experience and recognition of clinical deterioration. As the topic of prehospital clinical deterioration has rapidly moved to focus on the potential implementation of EWS, there is limited literature that provides a fundamental description of the concept and its characteristics.

Conclusion

This review has found that there is no standardised definition of prehospital clinical deterioration. The development of a definition is crucial to assessing clinical deterioration and improving the efficacy of EWS. Not only could this lead to improving early identification of risk factors, but it can lay the foundations for consistent research which is imperative for the development and evaluation of an effective EWS.

Key Words

clinical deterioration; critical illness; early warning system; prehospital care; recognition.

Background

In recent years, clinicians have become increasingly interested in the deteriorating patient. In 2012, the Australian Commission on Safety and Quality in Health Care (ACSQHC) established clinical deterioration as one of ten key National Safety and Quality Health Service Standards[1]. However, identifying those that are declining into a critically ill state can be challenging[2,3]. In the prehospital environment, early identification of high-risk patients is crucial as it enables early intervention, transportation, and may determine the trajectory of future care[4,5]. There are established ambulance guidelines to diagnose specific conditions such as myocardial infarction, stroke and major trauma. However, there is a lack of knowledge surrounding clinical deterioration for the broader, more diverse general population[6].

A number of studies, completed as early as the 1990s, identified consistent aspects relating to the detection of clinical deterioration[7]. Schein first demonstrated that the majority of cardiopulmonary arrests were preceded by a period of physiological abnormality[7]. This is echoed in contemporary literature[2,8,9]. While patient vital signs have been shown to be the most accurate predictor of deterioration[10], a comprehensive patient assessment is not to be undervalued as it could detect subtle changes in a patient's condition[11]. Additionally, other factors such as increasing age and co-morbidities have also been associated with risk of deterioration[9,12]. By continuously monitoring patients, clinicians can make informed clinical decisions as to whether prompt action is required[13]. Failure to recognise and respond appropriately to clinical deterioration can result in increased mortality, resuscitative measures, implementation of higher level of care and prolonged hospital admission[14,15].

To date, the majority of studies have focused on in-hospital clinical deterioration[9,10,12,16]. Little research has been conducted in the prehospital space, which is one of high-risk, uncontrolled environments and rapid evolution[17]. Prehospital care has transformed from a simple transport model to one that is an integral component of the healthcare system[17]. Paramedics are often the first point of contact, and thus have the ability to influence patients' future care pathways[18]. The scope of practice for paramedics has expanded substantially over the last decade to include complex interventions[19].The deteriorating patient presents challenges to paramedics, who operate as autonomous practitioners in a high-risk environment. Thus, it is crucial to have a comprehensive understanding of what constitutes clinical deterioration to aid early recognition and guide appropriate management.

In 2016, an Australian study reported an association between repeated clinical exposure of paramedics and improved patient outcomes[20]. Dyson et al. reported that patient outcomes from out-of-hospital cardiac arrest (OHCA) improved if it had been less than six months since the paramedics last attended an OHCA and attempted a resuscitation[20]. However, exposure to deteriorating patients, especially for base-level paramedics (e.g. Advanced Care), varies. A policy report undertaken in the United Kingdom (UK) during 2005 identified only 10% of emergency calls are life-threatening, demonstrating an increased demand on ambulance services for lower acuity care[21]. A recent study confirmed this, finding a steep annual growth of 6.7% in patients not requiring medical interventions from paramedics[22]. Not only does this demonstrate the diverse nature of prehospital callouts, but it highlights the importance of paramedics being equipped with the knowledge and evidence-based tools to assist them in distinguishing varying levels of illness and deterioration. This is particularly significant in the context of potentially low rates of recent clinical exposure to high-acuity presentations.

While it is common for clinicians to associate deterioration with high-acuity cases, the seemingly lower acuity calls can also harbor complex presentations of sick patients with the potential to rapidly deteriorate. One such example would be the "lift assist" call. A "lift assist" occurs "when a person calls paramedic services and requests assistance to get up or mobilise, usually after experiencing a fall"[23 p.233]. Leggatt et al. concluded "these calls may be early indicators of problems requiring comprehensive medical evaluation"[24 p.560]. Similarly, elderly patients can be difficult to diagnose due to atypical presentations and underlying co-morbidities, while serious pathology can also present in a non-specific way[25,26]. Due to these complexities and the diverse nature of prehospital callouts, cognitive biases may impact the ability of paramedics to effectively identify a deteriorating patient.

The literature currently lacks a robust evidence base and there is no standardised operational definition of prehospital clinical deterioration. We conducted a scoping review to explore how the current literature defines and recognises clinical deterioration in the prehospital setting. This will assist in future development and evaluation of tools or procedures aimed at detecting deterioration. The review questions investigated were:

a. How is prehospital clinical deterioration defined?
b. What is the reported prevalence of clinical deterioration in the prehospital setting?
c. How do paramedics currently recognise clinical deterioration?

Methods

Protocol

The review protocol was derived from a methodological framework initially proposed by Arksey and O'Malley[27], and later advanced by the Joanna Briggs Institute[28,29]. Ongoing feedback from the research team was also incorporated.

Study identification

A comprehensive search strategy was developed in consultation with all authors. Firstly, keywords relating to the main research questions were identified. In order to establish this, the Population-Concept-Context (PCC) framework recommended by the Joanna Briggs Institute[28] was utilised as follows:

- P – Population: This review included patients attended to by paramedics in the acute prehospital environment.
- C – Concept: The included studies report on paramedics' attempts to use clinical judgement to recognise clinical deterioration. The use of scores or tools alone will be excluded, unless compared to the use of clinical judgement.
- C – Context: To further broaden the search, all types of clinical deterioration were included. There was no restriction on aetiology and thus the studies could be trauma or medical related.

Finally, a sequence of keywords expressing the concept of 'paramedic' were combined with terminology used to describe 'recognition' of 'clinical deterioration' (see appendix A: search strategy).

A total of five electronic databases were searched from inception to 22nd December 2019: MEDLINE (OvidSP), CINAHL (Cumulative Index to Nursing and Allied Health Literature) (EBSCO), The Cochrane Library (Wiley), EMCARE (OvidSP) and EMBASE (OvidSP). Additionally, a hand search of grey literature was completed. There were no limitations placed on the search. The reference lists of included studies were also screened to identify additional relevant studies.

Study selection

We included studies that reported on clinical deterioration for all aetiologies in the acute ambulance environment. The exclusion criteria are as follows:

- Participants <16 years of age due to paediatric patients having physiological differences when compared to adults
- Patients in cardiac arrest on ambulance arrival
- Interfacility transfers
- Developing countries where health facilities/systems are not comparable to those in Australia
- Validation, hypothetical or condition specific studies
- Studies in languages other than English
- Conference abstracts
- Full text not available.

Prior to screening, a pilot was conducted to ensure understanding of eligibility criteria among authors. This pilot consisted of two authors (EBM, PG) independently assessing the same twenty papers and reviewing the consistent interpretation of the eligibility criteria. Once the criteria was refined, two authors (EBM, PG) independently screened all potentially suitable titles and abstracts to establish study eligibility. Conflicts were resolved through consensus, or if necessary, a third author was consulted. For full-text screening the same process was adopted.

Levels of Evidence

Primary author (EBM) graded all papers in line with the National Health and Medical Research Council (NHMRC) levels of evidence[30]. This was checked by a second author (KAB) with any conflicts discussed until resolution was met.

Data extraction

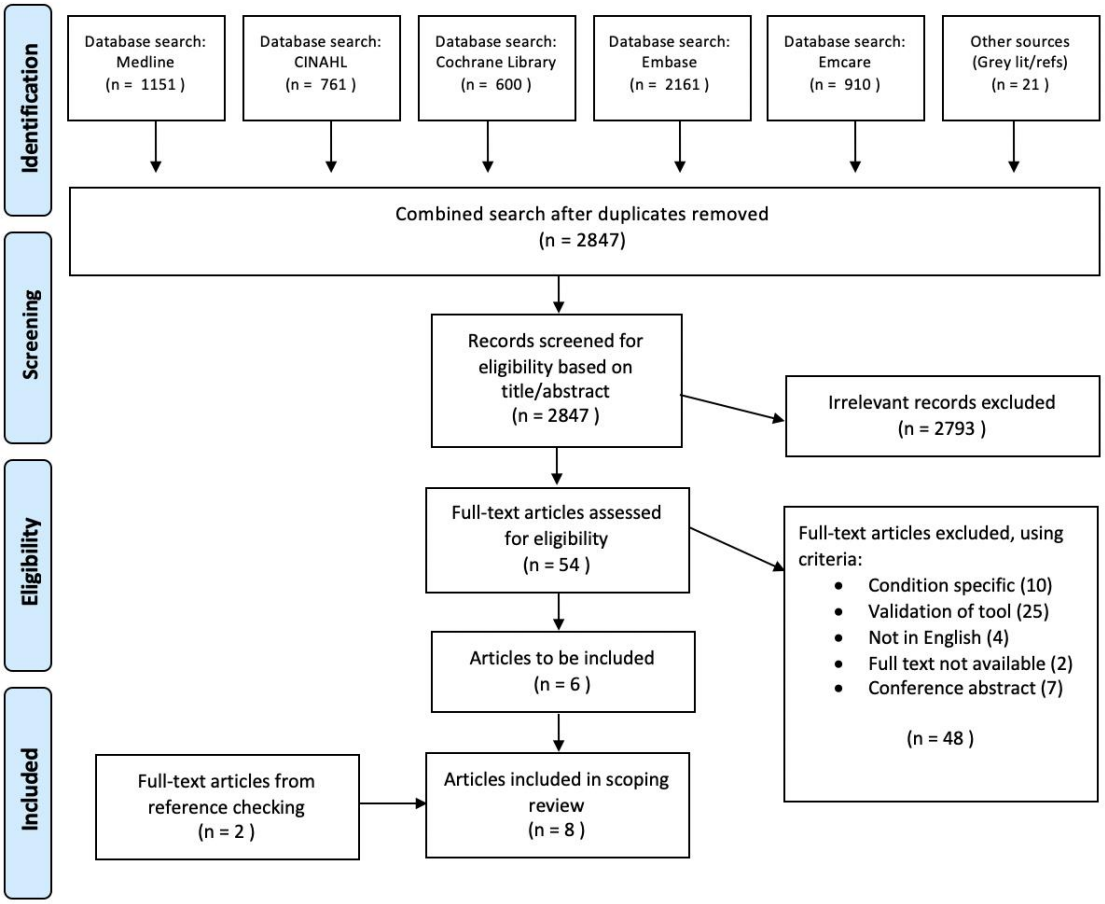
The data relevant to the research questions was extracted by one author (EBM) using a standardised data collection table created for this purpose (Appendix B). All data extracted was checked for completeness and accuracy by a second author (KAB).

Results

PRISMA

The search produced 2847 articles. Of these, 54 were manually screened for full-text eligibility, with a total of 8 studies included for review (Figure 1).

Figure 1: PRISMA


Identification
Screening
Eligibility
Included
Database search: Medline (n = 1151)
Database search: CINAHL (n = 761)
Database search: Cochrane Library (n = 600)
Database search: Embase (n = 2161)
Database search: Emcare (n = 910)
Other sources (Grey lit/refs) (n = 21)
Combined search after duplicates removed (n = 2847)
Records screened for eligibility based on title/abstract (n = 2847)
Irrelevant records excluded (n = 2793)
Full-text articles assessed for eligibility (n = 54)
Full-text articles excluded, using criteria:
Condition specific (10)
Validation of tool (25)
Not in English (4)
Full text not available (2)
Conference abstract (7)
(n = 48)
Articles to be included (n = 6)
Full-text articles from reference checking (n = 2)
Articles included in scoping review (n = 8)

Overall search and selection results

An overview of included studies (n = 8) can be seen in Table 1.

Table 1: Selected studies

Author	Year	Title	Aim	Sample Size (n =)	Journal	Country
Booth SM, Bloch M.	2012	An evaluation of a new pre-hospital alert guidance tool	To investigate the impact of a new pre-alert tool on current altering practices and evaluate its ability to take the place of a prehospital early warning system.	104	Emergency Medicine Journal	UK
Boyle M, Smith E, Archer F.	2008	A review of patients who suddenly deteriorate in the presence of paramedics.	To identify the number and outcomes of patients who suddenly deteriorated in the presence of paramedics.	2,893	BioMed Central	Australia
Brown E, Bleetman A.	2006	Ambulance alerting to hospital: the need for clearer guidance.	To evaluate the efficiency of current alerting practices and assess the need for objective guidelines.	454	Emergency Medicine Journal	UK
Brown R, Warwick J.	2001	Blue calls – time for a change?	To identify whether the current method of prior alert in the London Ambulance Service results in inappropriate deployment of hospital staff and if so, whether this occurs from inaccurate message relay or incomplete information.	189	Emergency Medicine Journal	UK
Fullerton J, Price C, Silvey N, Brace S, Perkins G,	2012	Is the Modified Early Warning Score (MEWS) superior to clinician judgement in detecting critical illness in the pre-hospital environment?	To compare the predictive accuracy of the Modified Early Warning Score with current clinical practice when identifying individuals at risk of clinical deterioration in the pre-hospital environment.	3,057	Resuscitation	UK
Seymour C, Kahn J, Cooke C,	2010	Prediction of critical illness during out-of-	To determine the out-of-hospital clinical predictors of critical illness and	144,913	Journal of American	USA

Watkins T, Heckbert S, Rea T.		hospital emergency care.	characterise the performance of a simple score for out-of-hospital prediction of development of critical illness during hospitalisation.		Medical Association	
Singh J, MacDonald R, Bronskill S, Schull M.	2009	Incidence and predictors of critical events during urgent air-medical transport.	To determine the incidence of in-transit critical events and identify factors associated with these events.	19,228	Canadian Medical Association Journal	Canada
Suffoletto B, Frisch A, Prabhu A, Kristan J, Guyette FX, Callaway CW.	2011	Prediction of Serious Infection During Prehospital Emergency Care	To determine the incremental predictive value of provided judgement in addition to prehospital physiologic variables for identifying patients who have serious infections.	199	Prehospital Emergency Care	USA

Characteristics of included studies

The search returned studies published between 2001 until 2012 (Table 1). The majority (4/8) were conducted in the UK. Five studies included all patient aetiologies, and the remainder limited focus to trauma, non-trauma (author defined) or sepsis. The aims of the studies varied across three domains: exploring pre-alerting practices, creating early warning systems (EWS) and evaluating clinical judgement when identifying critically ill patients. Five studies discussed the benefits of implementing an objective EWS in paramedic practice[3,5,31,32,33]. The most common study design was a retrospective cohort study (5/8)[3,5,32,34,35,36], while the others were prospective[31,33]. According to the National Health and Medical Research Council (NHMRC) levels of evidence, all studies would be classified at approximately level III-3[30]. Moreover, the sample sizes varied; with the exception of two large studies (n = 144,913[32] and

19,228[36]), the samples were relatively small (between 104 and 3,057). Missing data was noted as a limitation in four studies[3,32,34,35].

Review questions

a. How is prehospital clinical deterioration defined?

Only one study provided a clear definition of clinical deterioration[34]. This definition was ad-hoc, created by the authors for trauma patients within their study, and was neither consensus nor evidence-based. The definition provided detailed vital sign ranges, however it did not consider deterioration to be a concept beyond physiological abnormalities. Physical examination was limited to uncontrollable haemorrhage and cardio-respiratory arrest. Other patient characteristics were not considered. The remaining studies included adaptions of clinical deterioration in the form of critical illness, critical event, clinically critical, adverse events, and serious infection. One study failed to provide a definition[31]. As a result, it is difficult to draw comparisons, but it is clear that there is no recognised standardised definition.

b. What is the reported prevalence of clinical deterioration in the prehospital setting?

Only two studies, Boyle et al.[34] and Singh et al.[36] reported prevalence. Both studies found it to be 5.1%. Boyle et al. investigated trauma patients treated by road ambulance in Australia[34], whereas Singh et al. explored patients from all aetiologies in Canada where air-medical transport was utilised[36].

c. How do paramedics currently recognise clinical deterioration?

Four of the studies used pre-alerting to hospitals as a measure of current clinical judgment in identifying patients at risk of clinical deterioration. If paramedics notified the receiving hospital of their arrival, it was considered detection of clinical deterioration. Four studies developed or compared an EWS[3,31,32,33]. Fullerton et al. completed a detailed comparison of clinical judgement and EWS in all aetiologies[3]. Specificity in detecting critical illness was found to be higher for clinical judgement (94.1% vs 76.2%) however, sensitivity was lower (61.8% vs 71.1%)[3]. These findings were similar to another study completed that same year (2012)[31]. Lastly, a study investigating sepsis found clinical judgement recognition of deterioration to have a sensitivity of 59%[33].

Discussion

This review aimed to identify how paramedics define clinical deterioration, what is the prevalence of deteriorating patients, and how clinical deterioration is currently recognised. Although the majority of the studies (7/8) made mention of a definition, all of these were ad-hoc and developed specifically for each study. The prevalence of prehospital clinical deterioration is poorly explored, with only two studies discussing the frequency deterioration (5.1%). Furthermore, a small number of significant barriers to recognition were identified in the literature. Most research discussing prehospital deterioration and EWS validation is lacking a robust evidence base.

Jones et al. identified a similar issue during a study investigating in-hospital clinical deterioration, noting the major concern identified was lack of a consensus definition among clinicians[37]. Accordingly, the authors found that clinicians' recognition and response to clinical deterioration has shifted markedly over time. Initially, definitions were based on iatrogenesis and medical neglect, then the concept of clinical deterioration continued to

evolve alongside adverse events and was defined as "one or more discrete complications"[37, p.1030]. Finally, it was reported that adverse events were preceded by physiological abnormality, which led to the development of objective criteria. This study demonstrates the difficulty for clinicians in employing consistent practice without a thorough understanding of deterioration, and the importance of first establishing a clear, consensus-based concept of clinical deterioration to underpin future research and practice in this space.

With respect to recognition, two studies reported that paramedics were suboptimal at identifying clinical deterioration due to medical aetiology by comparison to trauma[3,5,31,33,35]. Fullerton et al. identified "failing in current practice is [the] pre-hospital practitioner's diminished ability to detect patients at high risk of death presenting with general medical pathology"[3, p.560]. For example, sepsis patients are at a heightened risk of clinical deterioration due to commonly exhibiting nonspecific symptoms[38]. Brown and Warwick corroborate this, finding "there is a lower threshold for making a prior alert in trauma than for medical conditions"[35, p.291]. Furthermore, Fullerton et al., Beaumont et al.[39] and Tait[40] all reported an association between clinician experience and recognition of clinical deterioration. Generally, less experienced clinicians have limited clinical exposure and thus may have difficulty evaluating the full clinical picture to identify the risk factors of deterioration. As suggested by Jones et al., this may be compounded by the subjectivity surrounding the concept of clinical deterioration, further clouding a clinician's judgement[37]. It is important to be aware of these issues relating to recognition as they have implications on prehospital practice. In an environment that has little oversight, and is diverse with regards to patient presentations, paramedics' exposure to critically ill patients can be limited.

As discussed, identifying critically ill patients can be complicated thus it is important for organisations to establish comprehensive systems to assist clinicians[41]. Consequently, there has been increasing interest in the research and clinical community around development and validation of EWS systems or tools to facilitate early recognition of the deteriorating patient[42,43,44]. EWS combine regular observation of vital signs with established response criteria to decide if more experienced or skilled staff are required[8]. These systems have been implemented in several countries, and even mandated as a standard of care in UK hospitals and ambulance services[42]. EWS are widely used in the health industry in Australia. Queensland Health (Aus) employs the Adult Deterioration Detection System (ADDS) for adult patients, Children Early Warning Tool (CEWT) for paediatrics[45], and recently signed an agreement with the United Nations to allow use of these systems worldwide[45].

With the exception of ambulance services in the UK that have adopted the National Early Warning Score (NEWS), EWS are limited to in-hospital use[46,47]. Following a system wide implementation of NEWS in the UK, the first study to investigate the distribution and use of this tool in the out-of-hospital setting was recently completed[48]. Only 63% of attendances had NEWS recorded and the percentage of patients with this score documented "changed very little over time"[48 p.289]. Nonetheless, out of this cohort, 18% were calculated to have a NEWS ≥5 ("the score chosen to trigger a referral or discussion with secondary care")[48 p.291]. Although preliminary research in this area has commenced, it remains unknown whether adaptations of in-hospital scoring systems can simply be extrapolated to prehospital care. The suitability of EWS for prehospital practice requires proper assessment, particularly given the shorter window of care in the prehospital setting. Other small-scale international studies have tested the functionality of various assessment tools in the prehospital setting[2,3,49], yet this has been done without the foundation of an agreed definition for prehospital deterioration.

Given the lack of definition, the reported prevalence of clinical deterioration in the prehospital setting is poorly discussed in the literature. Only two studies investigated the frequency of deteriorating patients[34,36]. This demonstrates another substantial gap in the literature. Interestingly, a study by Brown and Warwick identified a "clinically critical" group (n = 189) as part of their methodology. Within this cohort, 46% of patients had at least one abnormal vital sign recorded by paramedics[35]. This finding raises questions about whether an isolated finding is prognostic of prehospital clinical deterioration or if it is syndromic, and what proportion of patients with physiological parameters outside normal range subsequently deteriorate during prehospital care. In-hospital studies have found up to 40% of Australian patients in emergency departments (ED) meet the criteria to activate a Medical Emergency Team (MET) at one or more times during ED care[50,51]. Given that paramedics play a significant role in the initial care of patients prior to handing over to ED[52], it is vital to ascertain how often, and which patients, deteriorate prehospitally to aid awareness and clear communication of patient status during the handover process, and facilitate timely, streamlined patient care. Therefore, creating a standardised operational definition could not only increase our understanding of the deteriorating patient but potentially reduce morbidity and mortality, ultimately improving patient outcomes.

Directions for future research and practice

The development of a standardised operational definition of clinical deterioration for the prehospital environment is crucial to lead improved early recognition of risk factors; inform clinical decision making in the field; develop and evaluate an effective EWS for the prehospital space; and inform objective guidelines for pre-alerting practices. To ensure that future definitions of clinical deterioration are valid and relevant to the broader prehospital

setting, a consensus-based approach is required. Determination of prevalence across aetiologies may identify potential weaknesses within prehospital care and guide subsequent studies. For example, this knowledge can be used to develop training programs for novice paramedics, who may not have been exposed to a variety of deteriorating patients.

Limitations

The studies reviewed were confined to publications in English. Due to the scoping nature of this review, it is primarily descriptive in nature and only a level of evidence rating was completed.

Conclusion

Currently, there is no consistent definition of prehospital clinical deterioration in the literature and the reported prevalence is poorly explored. The development of a standardised definition is crucial to assessing clinical deterioration, determining its prevalence, and improving recognition.

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Appendix A: Search Strategy – Population, Concept, Context

Search Number	**PCC**	**Search Terms**
Search #1	Population	• Ambulance* • Paramedic* • Prehospital • Pre-hospital • Out-of-hospital
Search #2	Concept	• Recogni* • Respon* • Detect* • Identif* • Predict* • EWS or NEWS or MEWS • Early warning system* • Early warning score* • Early warning tool* • Rapid response system* • Rapid response • Track and trigger • Trigger tool* • Screening tool* • Risk score* • Risk assessment*
Search #3	Context	• Deteriorat* • Patient deterioration • Clinical deterioration • Failure to rescue • Adverse event* • Decompensat* • Critical care • Critical illness • Critically ill
Search #4	#1 AND #2 AND #3	

Appendix B: Data Extraction Table

Year	**Country**	**Author/s**	**Aetiology**	**Definition of Clinical Deterioration**	**Recognition Process**	**Study Design**	**Sample Size (n=)**	**Key Findings**	**Limitations**	**Recommendations** (e.g. Further Research)

2012	UK	Booth SM, Bloch M.	All	- No definition provided - Patients included were a selection of those treated in the resuscitation room at hospital	- Each case reviewed by a consultant physician, actively involved in the education and delivery of prehospital care, blinded to alert status and with access to both - Physician decided whether a pre-alert would've been appropriate - Physician decision then compared to ambulance crew alerting - Scotland has pre-alerting for specific conditions created by Joint	- Prospective cohort study over 7 weeks of patients treated in the resuscitation room at hospital when investigator was on duty - Excluded procedural monitoring (e.g. procedural sedation) - Data recorded: age, gender, presenting problem, alert status and whether an alert would have	104 Median age 65yrs (range of 0-92) 53% men, 47% women Case breakdown: 73% medical, 17% surgical, 8% arrests	- 90 patients judged to require pre-alert - 90% of ambulance alerts were appropriate - 10% over alert rate - 28% of critically ill patients that should have been alerted were not alerted (majority of these are	Only included 1/8 of patients treated in resuscitation area over study period Sample bias due to only sourcing from resus area (more likely to be unwell and thus receive alert) Potential under-triaging in pragmatic	Further work involving larger samples and patients from other areas of the ED is required to gain more insight

					Royal Colleges Ambulance Liason Committee (JRCALC) - Tested pre-alert guidance tool with under-triage rate of 1% and over-triage rate of 5%	been prompted by the guidance of JRCALC		medical of whom present with chest pain) - Clinician judgement sensitivity 72% and specificity 50%	alert requirement category due to not exact replication of prehospital situation	

2008	Australia	Boyle M, Smith E, Archer F.	Trauma	- Clear definition: "a person's condition is said to have suddenly deteriorated if there is a decrease in any of the physiological status components from the last recorded observations to the most recent. This deterioration is in light of on-going management of the patient's overall condition.	- As per author's "sudden deterioration criteria" - Predetermined set of physiological criteria: pulse rate, blood pressure (BP), respiratory rate, conscious state, new uncontrollable haemorrohage, cardio-respiratory arrest.	- Retrospective cohort study of patient's who deteriorated in care (either on scene or en route) of Victorian EMS during 2002 - Each patient care record (PCR) manually reviewed to establish eligibility (pre set inclusion/exclusion criteria) - Victoria, Australia	2,893 (from these 206 were excluded due to insufficient injury data to give final total of 2,687) - Mean age 39.6 - 72.2% adults, 23.1%	- 5.1% of trauma patients from 2002 were found to deteriorate - 85% (n = 2,463) had sudden decrease in BP (>20mm Hg or <90mmHg) - Out of deteriorated patients: 51.7% had prehospit	- Patient's medications not always included on PCR - Potential for missing PCRs - Missing identifying data on PCR thus cannot be certain hospital data was	- Impact of medications (e.g. pain relief from EMS or even patient own meds) on BP drop BP criteria "may have been too sensitive"

				This time frame between the observations would normally be about fifteen minutes"			elderly, 4.3% paediatrics	al potential major trauma, 7.6% had hospital defined major trauma, 2% died	linked successfully Hospital bypass and diversion not well documented	

2006	UK	Brown E, Bleetman A.	All	- Determined by authors to include patients who would receive immediate attention from ED staff - Two groups: ambulance alerted and authors own criteria - Critically ill patients according to authors 1. Triage category of "priority one" on arrival to ED (Manchester triage system)	- Based on assessing current pre-alerting to hospitals - Which patients are underalerted or overalerted - "Previous studies have identified that inappropriate alerts are infrequent and underalerting is a more common problem, particularly in medically ill patients"	- Patients prospectively identified from alert log kept by alert telephone at hospital Study conducted over period of 1 week in Feb 2005 ?unsure how this time period was chosen - Retrospectively conducted - searched ED records for patients that met criteria - Included both adults and paediatrics	454	Total of 30 patients were alerted (6.6%): - Level of appropriateness determined to be 85% - Inappropriate alerts 15% Total of 52 fit authors criteria (11.4%) - 23 of these had been alerted (44%) - 29 arrived at hospital	- 1-week snapshot - Paramedics alerted prospectively and data was analysed retrospectively from clinical notes and diagnoses - Some patients can become criticall	- Further studies to quantify accuracy of ambulance alerting - Alerting practice of medically ill patients needs to be improved - Consider providing ambulance crews a tool to determine alert trigger

				2. Complaint or diagnosis any of following: cardiac arrest, respiratory arrest, myocardial infarction, severe burns, status epilepticus, ruptured ectopic pregnancy, shock, coma, hypothermia, poisoning, meningitis, acute pulmonary		- No specific age/gender breakdown (only identify between adult vs paediatric but no cut offs specified)		announced (56%) <u>Largest group of underalerted patients was those presenting with medical problems</u> (particularly in cases of chest pain) Recommend validation of MEWS at which level to trigger alert would be set at 5 -	y ill AFTER arrival at hospital which was not accounted for	

				oedema, life threatening asthma - Immediate requirement of any following: theatre, intensive care unit, high-dependency unit, mortuary, transfer to tertiary centre for definitive care						

2001	UK	Brown R, Warwick J.	All	- Mention of "clinically critical (CC)" -Brought by non-blue light ambulance. Subsequently admitted directly to ICU, CCU, HDU, theatre, or who died in A&E - Authors independently considered each case to decide whether patients could be identified as CC in pre-hospital phase and whether prior alert	- Based on hospital alerting practices - Comparing those patients that received alerts compared to those that did not but should have	- Retrospective - Patients identified from manual log of "blue calls" generated in A&E - Blue call VS non-blue call (CC)	Out of 205 "blue calls", 189 had complete details available Blue Calls: - 63% men and mean age 46 (range 0-106)	- 42 (55%) of CC patients would have benefited from alert (of these 27 were chest pains suggestive of MI) - Blue call cases 69% medical, 26% trauma, 5% obstetric - CC cases were 83% medical, 5% trauma	Authors reviewing each CC case instead of applying objective criteria - Methodology a little confusing	Devise protocol for prior alert based on evidence in the literature Validate scores such as Revised Trauma Score - Have standarised message structure for phone alerts including vital signs, mechanism or type of illness

				would have been beneficial			Non-blue (CC): - 60% men and mean age 58 (range 10-93)	and 12% obstetric - Trauma cases had vital signs recorded most frequently - 25% of blue call patients did not have any vital signs recorded 46% of CC cases had at least one abnormal vital sign		

2012	UK	Fullerton J, Price CL, Silvey NE, Brace SJ, Perkins GD.	All	- Patient's considered to have deteriorated if they experienced an "adverse event" within 24 hours of admission to hospital - Adverse event = requirement of immediate operative management, admission to intensive care unit (ICU), high dependency unit (HDU) or coronary care unit (CCU), require attendance of	- Used hospital pre-alerting as a measure of clinical deterioration identification by paramedics - States that "no standarised protocol describing indications for pre-alert at hospital currently exists and decisions are based on subjective criteria" - Compared alerts with Modified Early Warning System (MEWS) to decide on which	- Retrospective observational cohort study of patient's charts - COMPARISON MEWS v clinician judgement - Primary outcome was whether or not a patient suffered an adverse event within 24 hours of admission - Correct or accurate pre-alerts regarded as those where an adverse event	3057 Mean age 54.9 (SD 23.8 years) Female 50.5% Male 49.5%	- Rates of critical illness detection and outcome prediction are low - Paramedic clinical judgement sensitivity of 61.8% and specificity of 94.1% - MEWS sensitivity 71.1% and specificity 76.2% - Combination	One ambulance service and one receiving hospital Limited time frame thus low event rate Some missing data Adverse event window of 24h may be too short Patients with pre-existing do not	External validation with larger population set, prospectively derived from multiple ambulance services and multiple receiving centres Testing and comparison of other existing early warning scores

				MET team, transfer to tertiary centre for definitive care, cardiac arrest or death	is superior in detecting deterioration	- subsequently occurred - MEWS scores calculated from first set of prehospital vitals		system: MEWS + clinical judgement overriding negative decision: sensitivity 72.4% and specificity 84.8% - Predominant pathology of patients with adverse event was medical	resuscitate orders or those made subsequent to admission could not be identified and thus were not excluded	

2010	USA	Seymour C, Kahn J, Cooke C, Watkins T, Heckbert S, Rea T.	Non-trauma	- Critical illness = severe sepsis, delivery of mechanical ventilation, or death at any point during hospitalization - Did not include admission to ICU because can be influenced by ED disposition, ICU bed availability and local practice variation	- Authors developed their own scoring model which will not be analysed in detail for this review	- Retrospective cohort study over 5 years - Excluded cardiac arrest, traumatic injuries - Included EMS presentations of patients >18yrs, documentation of vitals/examination, taken to receiving facility - Final sample randomly allocated into development (60%) and validation	144,913 (Development: n = 87,266 Validation: n = 57,647)	- Critical illness during hospitalization occurred in approx. 5% of both development (5.5%) and validation cohorts (5.4%) - Multivariable predictors of illness: -Older age -Low systolic BP	Definition may misclassify some patients who do not truly require critical care (e.g. low-risk sepsis patients) Missing data for GCS and pulse oximetry was common Did not evaluate predictors such as	More practical models needed before implementing to practice (perhaps incorporating biomarker measurement such as lactate) Information technology solutions may be required to integrate real time physiological data and decision making

2009	Canada	Singh J, MacDonald R, Bronskill S, Schull M.	All	- "Critical event" = death, major resuscitative procedures,	- Combination of interventions, physiological parameters, drug administration and change in condition - Detailed list of items	(40%) cohorts Retrospective cohort	19,228	-abnormal resp rate -low GCS -low Spo2 -nursing home resident - Patients with critical illness presented with greater alterations in initial prehospital vital signs	race/ethnicity, socioeconomic status Model overidentified critical illness identified as high risk and under identified critical illness among low risk	Better understanding of patient-level predictors of adverse events to improve staff

				haemodynamic deterioration (SBP <80mmHg, MAP <60mmHg or in-flight administration of a vasopressor), inadvertent extubation or respiratory arrest - Critical event during air-medical transport was primary outcome	considered to be "major resuscitative procedures" (e.g. needle thoracotomy) – refer to Box 1			- Prevalence found to be 5.1% (1 event per 12.6 hours of transport time) - Increased risk of deterioration: -females -had greater baseline instability -more likely to have received assisted ventilation before	- Retrospective data thus unable to obtain patient-level score of severity of illness - Excluded patients transported by primary care crews	preparation before transport

								transport -longer transport time - Hemodynamic deterioration most frequent		

2011	USA	Suffoletto B, Frisch A, Prabhu A, Kristan J, Guyette FX, Callaway CW.	Sepsis	- Defined serious infection with 1) mild infection (ED physician report of acute infection and patient discharged) and 2) severe infection (ED physician report of acute infection and patient admitted to the ICU) to determine the effect of illness severity on operating characteristics	- Presence of abnormal prehospital physiologic characteristics for the patient (heart rate >90 beats/min, systolic blood pressure <100 mmHg, respiratory rate >20 breaths/min, pulse oximetry <95%, history or suspicion of fever, altered mental status) - Report judgment of patient's infection status - Study also developed tool	- Prospective observational study, convenience sample of EMS providers and ED clinicians asked to complete a brief questionnaire about same patients - Data collection over 2 months during 5-10 hour blocks (balanced between week days and weekends) chosen at	199 Excluded: - <18 yrs - Transfers - Trauma and stroke patients with pre-hospital alerts No mention	- 16% diagnosed with serious infection -50% septic (2 or greater abnormal vitals) - 16% admitted to ICU - Primary outcome associated with prehospital hypotension (SBP <100), EMS suspicious of fever, prehospit	Single site study from convenience sample Did not collect in-hospital information and used ED diagnosis to assess outcome	Determine the effect of training or diagnostic aids for improving sensitivity of prehospital identification of patients with serious infection

						random as per researcher assistant availability - Primary outcome: serious infection	of gender/age breakdown	al judgement of infection (presence of any of those sensitivity 59% and specificity 81%) -		

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