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BMJ Open Optimising paediatric afferent component early warning systems: a hermeneutic systematic literature review and model development

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ABSTRACT

Objective To identify the core components of successful early warning systems for detecting and initiating action in response to clinical deterioration in paediatric inpatients.

Methods A hermeneutic systematic literature review informed by translational mobilisation theory and normalisation process theory was used to synthesise 82 studies of paediatric and adult early warning systems and interventions to support the detection of clinical deterioration and escalation of care. This method, which is designed to develop understanding, enabled the development of a propositional model of an optimal afferent component early warning system.

Results Detecting deterioration and initiating action in response to clinical deterioration in paediatric inpatients involves several challenges, and the potential failure points in early warning systems are well documented. Track and trigger tools (TTT) are commonly used and have value in supporting key mechanisms of action but depend on certain preconditions for successful integration into practice. Several supplementary interventions have been proposed to improve the effectiveness of early warning systems but there is limited evidence to recommend their wider use, due to the weight and quality of the evidence; the extent to which systems are conditioned by the local clinical context; and the need to attend to system component relationships, which do not work in isolation. While it was not possible to make empirical recommendations for practice, the review methodology generated theoretical inferences about the core components of an optimal system for early warning systems. These are presented as a propositional model conceptualised as three subsystems: detection, planning and action.

Conclusions There is a growing consensus of the need to think beyond TTTs in improving action to detect and respond to clinical deterioration. Clinical teams wishing to improve early warning systems can use the model to consider systematically the constellation of factors necessary to support detection, planning and action and consider how these arrangements can be implemented in their local context.

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Strengths and limitations of this study

- The literature in this field is heterogeneous and better at identifying system weakness than it is effective improvement interventions. By deploying social theories and a hermeneutic review methodology it was possible to develop a propositional model of the core components of an afferent component paediatric early warning system.
- The model is derived from logical inferences drawing on the overall evidence synthesis, social theories and clinical expertise, rather than strong empirical evidence of single intervention effectiveness.
- There is a growing consensus of the need to take a whole systems approach to improve the detection and response to deterioration in the inpatient paediatric population and this paper offers an evidence-based framework for this purpose.

INTRODUCTION

Failure to recognise and act on signs of clinical deterioration in the hospitalised child is an acknowledged safety concern.¹ Track and trigger tools (TTT) are a common response to this problem. A TTT consists of sequential recording and monitoring of physiological, clinical and observational data. When a certain score or trigger is reached then a clinical action should occur including, but not limited to, altered frequency of observation, senior review or more appropriate treatment or management. Tools may be paper based or electronic and monitoring can be automated or undertaken manually by staff.

Despite the growing use of TTTs there is limited evidence of their effectiveness as a single intervention in reducing mortality or arrest rates in hospitalised children.²⁻³ Results from the largest international cluster randomised controlled trial of a TTT (the Bedside Paediatric Early Warning System

(BedsidePEWS)) did not support TTT use to reduce mortality, and highlighted the multifactorial mechanisms involved in detecting and initiating action in response to deterioration.⁴ These findings lend further weight to a developing consensus about the need to look beyond TTTs to the impact of wider system factors on detecting and responding to deterioration in the inpatient paediatric population.^{2 5-9} This paper reports on a theoretically informed systematic hermeneutic literature review¹⁰ to identify the core components and mechanisms of action of successful afferent component early warning systems (EWS) in paediatric hospitals and is one of three linked reviews undertaken as part of a wider UK study commissioned to develop and evaluate an evidence-based paediatric warning system.^{3 11} It addressed the following question:

What sociomaterial and contextual factors are associated with successful or unsuccessful Paediatric Early Warning Systems (with or without TTTs)?

METHOD

Design

We performed a hermeneutic systematic review of the relevant literature. A hermeneutic systematic review is an iterative process, integrating analysis and interpretation of evidence with literature searching and is designed to develop a better understanding of the field.¹⁰ The popularity of the method is growing in health services research where it has value in generating insights from heterogeneous literatures that cannot be synthesised through standard review methodology¹² and would otherwise produce inconclusive findings (see ref 9). The purpose of the review was not exhaustive aggregation of evidence, but to develop an understanding of the social, material and contextual factors associated with successful or unsuccessful paediatric early warning systems (PEWS).

Theoretical framework

Data extraction and interpretation was informed by translational mobilisation theory (TMT)^{13 14} and normalisation process theory (NPT).^{15 16} TMT is a practice theory which explains how goal-oriented collaborative activity is mobilised in unpredictable environments (box 1) and how the relevant mechanisms of action are conditioned by the local context. It is well suited for understanding EWS which require the organisation of action in evolving conditions, in a variety of clinical environments, with different teams, skill mixes, resources, structures and technologies. NPT shares the same domain assumptions as TMT and is concerned with 'how and why things become, or do not become, routine and normal components of everyday work',^{15 16} directing attention to the preconditions necessary for successful implementation of interventions. The theoretical framework informed our data extraction strategy, interpretation of the evidence and the development of a propositional model of an optimal paediatric early warning system.

Box 1 Mechanisms of translational mobilisation and their application to rescue trajectories¹⁴

Object formation—how people draw on the interpretative resources available to them within a strategic action field to create the objects of their practice. Enrolment into an escalation trajectory requires multiple examples of object formation beginning with construction of an individual as at risk of deterioration and a regime of vital signs monitoring instigated, through recognition that the patient's physiological status is a cause for concern, to the identification of the patient as requiring a specific intervention. How this is achieved is highly dependent on the features of the local strategic action field.

Translation—the processes that enable practice objects to be shared and different understandings accommodated. It points to the actions necessary in order for a patient that is an object of concern for nursing staff to be translated into a clinical priority for the doctor and, if necessary, to be translated into the focus of intervention by the emergency response team.

Articulation refers to the secondary work processes that align the actions, knowledge and resources necessary for the mobilisation of projects of collective action. It is the work that makes the work, work. Responding to deterioration is time critical and articulation work is necessary to ensure the availability of resources and materials to support clinical management. This is not a mundane observation; catastrophic failures in patient safety are often attributed to the lack of functioning equipment¹⁰⁷ and the absence of monitoring equipment has been identified as a factor undermining the implementation of early warning track and trigger tools.⁴⁸ Attending to articulation in rescue trajectories also underlines the temporal ordering of action and the mechanisms required to achieve this, directing improvement efforts towards the organisation's escalation policy, for example.

Reflexive monitoring refers to the processes through which people collectively or individually appraise and review activity. In a distributed field of action, reflexive monitoring is the means through which members accomplish situational awareness¹⁰⁸ of an overall project. The importance of situation awareness in rescue trajectories is well recognised, but achieving this is challenging. Reflexive monitoring is conditioned by the wider institutional context which will include a multiplicity of informal and formal mechanisms designed for this purpose: nursing and medical handovers, the ward round, safety briefings. The form, frequency and effectiveness of these processes in supporting detecting and acting on deterioration would need to be taken into account in any improvement initiative.

Sensemaking refers to the processes through which agents create order in conditions of complexity. It draws attention to how the material and discursive processes by which members organise their work, account for their actions and construct the objects of their practice also give meaning and substance to the institutional components of strategic action fields that shape activity and condition future activity.

Focus of the review

The literature in this field identifies four integrated components which work together to provide a safety system for at-risk patients: (1) the afferent component which detects deterioration and triggers timely and appropriate action; (2) the efferent component which consists of the people and resources providing a response; (3) a process improvement component, which includes system auditing and monitoring; and (4) an administrative component focusing on organisational leadership

and education required to implement and sustain the system.¹⁷ Our focus was limited to the afferent components of the system.

Stages of the review

Stage 1: scoping the literature

Literature was identified through a recent scoping review,⁷ team members' knowledge of the field, hand searches and snowball sampling techniques. The purpose was to (1) inform our review question and eligibility criteria and (2) identify emerging themes and issues. While we drew on several reviews of the literature^{5 12–14} we always consulted original papers. Data were extracted using data extraction template 1 (online supplementary appendix 1) and analysed to produce a provisional conceptual model of the core components of paediatric early warning systems. Additional themes of relevance were identified: family involvement, situational awareness (SA), structured handover, observations and monitoring and the impact of electronic systems and new technologies.

Stage 2: searching for the evidence

We undertook systematic searches of the paediatric and adult EWS literature (the goals and mechanisms of collective action in detection and rescue trajectories are the same). For the adult literature we used the same search strategies but added a qualitative filter to limit the scope to studies most likely to yield the level of sociomaterial and contextual detail of value to the review. Literature informing additional areas of interest was located through a combination of systematic and hand searches. Systematic searches (searches 2 and 3) were undertaken in areas where we anticipated locating evidence of the effectiveness of specific interventions to strengthen EWS. Theory-driven searches reflected the conceptual requirements of the model development.

Systematic searches

A systematic search was initially conducted across a range of databases from 1995 to September 2016 to identify relevant studies on the PEWS literature. This search was updated to cover literature from September 2016 to May 2018. An additional three systematic searches were conducted from 1995 to September 2016 to identify supplementary papers to aid in developing understanding on the PEWS literature:

1. Adult EWS.
2. Interventions to improve SA.
3. Structured communication tools for handover and handoff.

Detailed information on the search methodology can be found in online supplementary appendix 2. Grey literature was excluded in order to keep the review manageable.

Theory-driven searches

Additional theory-driven searches were conducted in the following areas:

1. Family involvement.

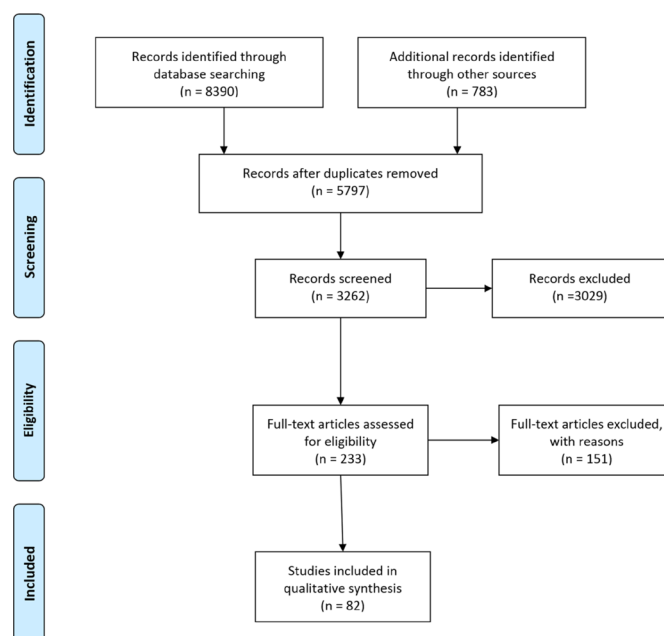


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (adapted from Moher *et al*¹⁰⁹).

2. Observations and monitoring.
3. The impact of electronic systems.

These were a combination of exploratory, computerised, snowball and hand searches. As the analysis progressed, we continued to review new literature on EWS as this was published.

Screening

After removing duplicates 5284 references were identified for screening. A modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram is provided (figure 1). Papers were screened by title to assess eligibility and then by full text to assess relevance for data extraction. The PEWS and adult EWS searches were screened by two researchers, searches 2 and 3 were screened by the lead reviewer.

Stage 3: data extraction and appraisal

Data extraction template 2 (online supplementary appendix 3) was applied to all papers included in the review. As is typical of reviews of this kind, evidential fragments and partial lines of inquiry formed the unit of analysis rather than whole papers.¹⁸ These fragments were quality assessed according to the contribution they made to the developing analysis rather than assessing the paper as whole through the use of formal appraisal tools. Data extraction and quality appraisal were undertaken concurrently and double checked by a second reviewer.

Stage 4: developing a propositional model

A propositional model was developed specifying the core ingredients of a paediatric early warning system (table 1). It comprises logical inferences derived from the theoretical framework and evidence synthesis, informed by

**Table 1** Propositional model

	Proposition	Conceptual requirements
Detection	Detection of deterioration depends on timely and appropriate <i>monitoring</i> of vital signs and relevant risk factors.	<p>At a minimum, this requires:</p> <ul style="list-style-type: none"> ▶ Staff are aware of which vital signs need to be monitored. ▶ Staff are aware of the minimum frequency of observations required for the children in their care. ▶ Staff are aware of the need to review the frequency of observations for children in their care. ▶ Staff are aware of additional clinical assessments required for children with prior risk factors. ▶ Monitoring tasks are allocated to staff members with appropriate skills to conduct them. ▶ Staff have access to appropriate equipment to accurately monitor vital signs, and conduct other clinical assessments. ▶ Staff are aware of roles and responsibilities for monitoring. ▶ Staff have time to conduct accurate, timely and appropriate monitoring of vital signs, alongside other work commitments. ▶ Staff concern is formally recognised as a valid indicator of deterioration. ▶ Staff are supported to develop and use their intuition in detecting signs of deterioration. ▶ Staff understand the value of family concerns in the detection of deterioration. ▶ Families are involved with defining normal physiological parameters for their child. ▶ Families receive guidance about what to do if they are concerned that their child's condition is deteriorating. ▶ Staff keep families informed about developments in their child's care and treatment.
Detection	Detection of deterioration depends on timely and appropriate <i>recording</i> of signs of deterioration.	<p>At a minimum this requires:</p> <ul style="list-style-type: none"> ▶ Staff are aware of the need to record vital signs, family concern and staff concern promptly and accurately. ▶ Staff are aware of roles and responsibilities for recording vital signs, family concern and staff concern. ▶ Staff have appropriate skills to accurately record vital signs, family concern and staff concern. ▶ Staff have access to appropriate equipment to accurately record vital signs, family concern and staff concern. ▶ There are an appropriate number of staff to carry out required tasks.
Detection	Detection of deterioration depends on timely and appropriate <i>interpretation</i> of signs of deterioration.	<p>At a minimum this requires:</p> <ul style="list-style-type: none"> ▶ Staff are aware of prior factors that increase children's risk of deterioration (eg, premature birth). ▶ Staff are aware of roles and responsibilities for interpreting signs of deterioration. ▶ Staff take into account vital signs, family concern and staff concern in assessing the condition of children in their care. ▶ Teams have appropriate skills to discern patterns and trends of signs and symptoms. ▶ Staff have the opportunity to learn how to interpret signs of deterioration from shadowing more senior staff. ▶ Care is organised to enable staff to recognise patterns and trends for children. ▶ Families are in a position to discern patterns of signs and symptoms in their child.
Planning	Planning depends on <i>reviewing</i> indicators of deterioration for each patient.	<p>At a minimum this requires:</p> <ul style="list-style-type: none"> ▶ For each child, all indicators of deterioration are brought together and kept up to date. ▶ There is a regular mechanism for reviewing the status of all children in the ward to identify those children who are a concern. ▶ There is a regular mechanism for reviewing staffing levels and skills mix, workload, acuity and admissions.

Continued

Table 1 Continued

	Proposition	Conceptual requirements
Planning	Planning depends on staff being aware at ward level of the status of individual patients and the availability of skills and resources, and <i>preparing</i> an appropriate response.	At a minimum this requires: <ul style="list-style-type: none"> ▶ There is a regular mechanism for communicating the review of all children, staffing levels and other resources to the rest of the team and senior managers. ▶ There is a regular mechanism for planning appropriate response to deterioration. ▶ Senior staff members are allocated responsibility for managing demand and resources. ▶ Senior staff members are allocated responsibility for communicating response plans. ▶ There is an action plan for children at risk of deterioration which is shared with families and staff caring for them.
Action	Action depends on clear escalation and response processes.	At a minimum this requires: <ul style="list-style-type: none"> ▶ A trigger or prompt to act from detection or planning phases. ▶ Clearly defined graded escalation and response procedures—agreed at organisational level. ▶ Staff receive guidance about how to escalate and respond. ▶ Staff understand their roles and responsibilities in the escalation procedure as activators and responders. ▶ Staff are encouraged and supported in raising concerns. ▶ Families are encouraged and supported in raising concerns. ▶ Staff are able to communicate information across professional hierarchies using a structured approach to sharing information. ▶ Clear structures to support action, including the use of a ‘no false alarms’ policy so staff are not deterred from escalating care.
Action	Action depends on evaluation.	At a minimum this requires: <ul style="list-style-type: none"> ▶ Escalation and response processes are reviewed to promote learning. ▶ There is opportunity for staff to discuss differences of opinion in the need for escalation. ▶ No blame is assigned to those who escalate.

clinical experts on the team. Iterations of the model were developed in collaboration with clinical colleagues. A series of face-to-face meetings were conducted to review structure, wording and applicability to clinical practice.

Patient and public involvement

This review was conducted as part of a larger mixed methods study (ISRCTN 94228292), which used a formal, facilitated parental advisory group. The group comprised parents of children who had experienced an unexpected adverse event in a paediatric unit and provided input which helped shape the broader research questions and wider contextual factors to consider, specifically within the family involvement element of the system. The results of the review will be disseminated to parents through this group.

RESULTS

Included studies

Eighty-two papers were included in the review. Forty-six papers focused on TTT implementation and use in paediatric and adult contexts (24 from the paediatric search and the remaining 22 from the adult-focused search); the remaining 36 papers contributed supplementary data on factors related to the wider warning system. See [table 2](#) for a detailed breakdown of this process. No studies

were located that adopted a whole systems approach to detecting and responding to deterioration.

Analysis

In TMT the primary unit of analysis is the ‘project’, which defines the social and material actors (people, materials, technologies) and their relationships involved in achieving a particular goal. The goals of the afferent paediatric warning system are: first, that the child is identified as at risk and a vital signs monitoring regime instigated; second, that evidence of deterioration is identified through monitoring and categorised as such; and third, that timely and appropriate action is initiated in response to deterioration. Our analysis of the literature suggests that three subsystems within the afferent component of EWS support these processes: the *detection* of signs deterioration; the *planning* needed to ensure teams are ready to act when deterioration is detected; and the initiation of timely *action*. While we have focused on the afferent component, it is important to remember that all elements of the overall safety system (efferent component, process improvement and administrative arm) need to be working in concert in order to maintain an optimal paediatric early warning system. In the next section, we report on the literature in relation to each subsystem.

**Table 2** Screening breakdown

	PEWS	EWS	Structured handover	Situational awareness	Electronic systems	Observations and monitoring	Family involvement	Snowball sample
Database searching	3564	1155	3369	302	–	–	–	–
Additional sources	83	7	150	46	–	–	–	–
Records after duplicates removed	2194	751	2156	199	–	–	–	–
Hand searches	431	–	–	–	26	20	15	5
Title screening	90	751	2156	199	26	20	15	5
Abstract screening	62	106	N/A	N/A	26	20	15	5
Full paper screening	39	65	37	26	26	20	15	5
Included in syntheses	24	22	4	6	10	2	9	5

EWS, early warning system; N/A, not applicable; PEWS, Paediatric Early Warning System.

Detection

The goal of the detection subsystem is to recognise early signs of deterioration, so the child becomes the focus of further clinical attention. This requires, first, that the child is identified as at risk and a vital signs monitoring regime instigated and, second, that the child is identified as showing signs of deterioration.

Despite widespread use, the evidence on TTT effectiveness in predicting adverse outcomes in hospitalised children is weak.³ Many TTTs have only been validated retrospectively and postpredictive values were generally low. Studies reporting significant decreases in cardiac arrest calls or mortality had methodological concerns. The literature does suggest that TTTs have value in supporting process mechanisms in the detection subsystem. Vital signs monitoring is undertaken on all hospital inpatients and, like other high-volume routine activity, is often delegated to junior staff^{19–38} who may not have sufficient skills to interpret results.^{21 22 37} TTTs have value in mitigating these risks: by specifying physiological thresholds that indicate deterioration they take knowledge to the bedside and act as prompts to action^{19 39} which can lead to a more systematic and frequent approach to monitoring and improved detection of deterioration.^{40 41}

TTT's effectiveness in fulfilling these functions depends on certain preconditions. The review highlighted that TTT use was impacted by the availability of appropriate and functioning equipment,^{22 27 29 34 39 42–46} (in)adequate staffing and night-time pressures^{22 26 29 30 37 40 42–44 47–52} and an appropriately skilled workforce.^{26 28 36 43 49 50 53–57} On this latter point, while several papers report on education packages to improve the detection of deterioration, the evidence is not robust enough to recommend specific

programmes.^{23–25 28 30 35 55 58–60} There were also times whereby nursing staff prioritised sleep over waking a patient to take vital signs.^{46 61}

TTTs are also used differently depending on the experience of the user. For juniors, they provide a methodology and structure for monitoring clinical instability and identifying deterioration, whereas more experienced staff reportedly use TTTs as confirmatory technologies.^{19–32} The importance of professional intuition in detecting deterioration is extensively reported across the literature^{19–22 26 27 29 31 32 36–40 42 43 45 46 48 50–53 60 62–68} and several authors recommend the inclusion of 'staff concern' in tool criteria.^{26 48 51 57} This is important; TTTs may be of less value in patients with chronic conditions because of altered normal physiology or where subtle changes are difficult to detect.⁶⁴ It is also the case that TTTs are implemented in contexts governed by competing organisational logics which impact on their value and use.^{43 54 58} For example, Mohammed Iddrisu *et al*⁵⁷ show TTTs have limited value immediately after surgery because acceptable vital sign parameters are different in the immediate postoperative period.

There is growing interest in the literature in strategies that facilitate patient and relative involvement in the early detection of deterioration.^{69 70} Healthcare professionals depend on families to explain their child's normal physiological baseline and identify subtle changes in their child's condition but this information is not always systematically obtained.^{71 72} Some authors propose family involvement in interdisciplinary rounds (This is an editorial paper),⁷³ but this requires parents to have detailed information about the signs and symptoms they should be attending to⁷² and as yet there is little evidence on

effective strategies for how they might be involved in the detection of deterioration.⁷³

While much of the literature reports on intermittent manual vital signs monitoring and paper-based recording systems, across the developed world there is a growing use of electronic technologies, which have important implications for the wider detection subsystem.⁷⁴ We considered a number of evaluations of new technologies which indicated that electronic vital signs recording is associated with a number of positive outcomes, particularly timeliness and accuracy, when compared with paper-based systems.^{75–76} They can provide prompts or alerts for monitoring,^{77–79} which facilitates better recognition of deterioration and is associated with a reduction in mortality.^{78–80} These studies tend to evaluate new technologies in isolation, however, and do not engage with the literature highlighting alarm fatigue which is known to mitigate effectiveness over time or concerns about overburdening staff with alerts.^{81–83} Moreover, the successful implementation of new technologies is conditioned by the local context. For instance, where manual input into an electronic device is required, access to computers is an essential precondition. When computers were not available, staff ‘batch’ the collection of vital signs before data entry, thereby delaying the timely detection of deterioration.^{27 45 84} In another study where the electronic system was found to be cumbersome and separated the collection and entry of data from the review of vital signs, verbal reports were favoured to ensure timely communication of information.⁸⁵ See [table 3](#) for a summary of the evidence reported.

Planning

Detecting and responding to deterioration involves the coordination of action in conditions of uncertainty and competing priorities. The goal of the ‘Planning’ subsystem is to ensure the clinical team are ready to act in the event of evidence of deterioration and is reflected in the growing interest in the literature on structures to facilitate team SA, group decisions and planning.⁶²

TTTs have been found to support SA. Their use enabled clinicians to have a ‘bird’s-eye’ view over all admitted patients on a ward as well as encouraging staff to consider projected acuity levels of the ward.⁸⁶ A number of studies also report on ‘huddles’ in facilitating SA.^{32 65 87 88} A huddle is a multidisciplinary event scheduled at predetermined times where members discuss specific risk factors around deterioration and develop mitigation plans. One study combined the introduction of huddles with a ‘watchstander’, a role fulfilled by a charge nurse or senior resident, whose primary function is to know patients at high risk for deterioration.⁸⁸ These initiatives were associated with a near 50% reduction in transfers from acute to intensive care determined to be unrecognised situation awareness events. A further strategy identified by Goldenhar *et al* describes the use of the ‘watcher’ category to designate a patient as at risk where staff have a ‘gut feeling’ deterioration is likely.⁸⁷ A recent study used the

category of ‘watcher’ to create a bundle of expectations to standardise communication and contingency planning. Once a patient was labelled ‘a watcher’ a series of five specific tasks, such as documentation of physician awareness of watcher status and that the family had been notified of the change in the patient’s status, needed to be completed within 2 hours.⁸⁹

Handovers are integral to clinical communication and contribute to SA. The extensive literature on handover indicates that information sharing can be of variable quality^{47 54 90} and there is growing evidence that structured approaches improve this.^{30 47 54 63 87 90–94} Ranging from a checklist system^{91 93} to a cognitive aid developed through consensus,^{23 94} most of the published interventions are variations of the Situation-Background-Assessment-Recommendation (SBAR) tool.^{54 90–92} While effective handover depends on communicative forms that extend beyond the information transfer that is typically the focus of structured handover tools,⁹⁰ in the context of EWS a lack of standardisation allows greater margin for individualistic practices and difficulties accessing complementary knowledge and establishing shared understandings.⁴⁷

There is also a literature on the use of common information spaces—such as whiteboards—in facilitating SA in the healthcare team.^{23 33 47 53 55 58 67} These should be in a visible location and colour coded to correspond with the TTT score, where relevant.^{47 55 58} Electronic systems automate this information and allow information to be reviewed remotely. However, they disconnect vital signs data from the patient and hence other indicators of clinical status and access to data is contingent upon the availability of computers.^{27 45 47 84 95}

The literature indicates that SA can be facilitated in different ways in different contexts and it is the relationship between system elements that is important.⁴⁷ In their study on SA in delivery suites, Mackintosh *et al* discuss the three main supports for SA—whiteboard, handover and coordinator role—and illustrate how these interacted in organisations with strong SA compared with those with reduced levels. Crucially, this ‘interplay’ between the different activities was highly context dependent; ‘the same supports used differently generate different outcomes’ (p 52).⁴⁷ See [table 4](#) for a summary of the planning evidence.

Action

The goal of the ‘Action’ subsystem is to initiate appropriate action in response to evidence of deterioration. The literature suggests that mobilising action across professional boundaries/hierarchies is challenging, with differences in language between doctors and nurses and power dynamics contributory factors.^{27 40 41 50 52 57 60 96} TTTs are in part a response to the challenges of communication in mobilising action in response to deterioration. By transforming a series of discrete observations into a summative indicator of deterioration—such as a score or a trigger—TTTs ‘translate’ and package the patient’s status into a form that can be readily communicated

Table 3 Summary of detection evidence

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Andrews and Waterman ¹⁹	UK	Interviews and observations	Grounded theory	EWS	Importance of 'gut feeling' in detecting deterioration. Vital signs monitoring delegated to junior staff.
Astroth <i>et al</i> ⁵⁰	USA	Semistructured interviews with nurses	Coding categories were generated from the data, and consensus on final themes was achieved through an iterative process.	EWS	Staff encouraged to use their intuition when activating the RRT
Azzopardi <i>et al</i> ²⁰	Australia	Survey	Statistical analysis	PEWS	Track and trigger tools used to confirm or identify deterioration depending on experience. Useful for junior staff. Vital signs monitoring delegated to junior staff.
Bellomo <i>et al</i> ⁷⁹	International: USA, Sweden, UK, Netherlands, Australia	Before-and-after multicentred international controlled trial	Automated vital signs monitoring and early warning score calculated, international study, blinded trial, hospitals retained own early warning score and escalation policy.	Electronic systems	The electronic health record (EHR) provides a prompt to action.
Bonafide <i>et al</i> ²¹	USA	Semistructured interviews	Grounded theory	PEWS	Vital signs monitoring delegated to junior workers who may not have the knowledge to interpret results. Track and trigger tools used to confirm or identify deterioration depending on experience and particularly useful for junior staff. Professional intuition important for senior staff to detect deterioration.
Bonafide <i>et al</i> ⁸¹	USA	Prospective feasibility study	Video recording and electronic patient data collected prospectively. Pragmatic observational study of VitalPAC deployment in two large hospitals.	Electronic systems	Alarm fatigue—a barrier to escalation
Bonafide <i>et al</i> ⁸³	USA	Video review and response time outcome	Statistical analysis	PEWS	Alarm fatigue—a barrier to escalation

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Braaten ²²	USA	Document review and interviews using the principles of cognitive work analysis	Inductive and deductive forms of analysis—cognitive work analysis, framework and directed content analysis	EWS	Vital signs monitoring delegated to junior workers who may not have the knowledge to interpret results. Track and trigger tools used to confirm or identify deterioration depending on experience. Professional intuition important for more senior staff/when clinical change is abrupt. Issues around availability of equipment and staffing.
Brady and Goldenhar ⁶³	USA	Focus groups x7—held in groups of participants with similar roles	Constant comparison	Situational awareness	Paediatric early warning score supplementing gut feeling but these were not standardised.
Burns <i>et al</i> ⁶⁸	USA	Semistructured interviews were used drawing on a descriptive phenomenological methodology.	Iterative thematic analysis	Snowball sample	Importance of professional intuition is reported.
Chua <i>et al</i> ³⁶	Singapore	A qualitative survey using critical incident technique	Inductive content analysis	EWS	Vital signs monitoring is the responsibility of nurses. The regularity of this activity can lead to it being viewed as a mundane activity. Importance of 'gut feeling' and intuition in detection of deterioration.
Cioffi ⁴⁸	Australia	Unstructured interviews with nurses who had activated the medical emergency team (MET)	Simple code and retrieve	EWS	Importance of gut feeling and 'knowing' your patient in the detection of deterioration. Importance of having staff concern in the MET criterion.
Cioffi ⁵¹	Australia	Unstructured interviews	Simple code and retrieve	EWS	Importance of gut feeling and intuition in recognising deterioration. Importance of having staff concern in a calling criteria.
Cioffi <i>et al</i> ⁴²	Australia	Focus groups with clinicians and nurses exploring their responses to abnormal vital signs	Constant comparison	EWS	Intuition important, particularly for more senior staff to detect AVS. Knowing your patient reported as key; knowledge and experience seen as essential.

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Claussen <i>et al</i> ⁶⁵	USA	Retrospective review of calls to the rapid response team (RRT) and cardiac arrest calls to evaluate impact of evidence-based guidelines (preintervention). Modified Early Warning Score and huddle implemented. EHR available throughout to compare pre and post.	Descriptive statistics	Electronic systems	Professional intuition used in conjunction with the Modified Early Warning Score
Davies <i>et al</i> ⁶³	USA	Survey looking at barriers to rapid response system (RRS) activation	Statistical analysis	EWS	Professional intuition used over RRS activation criteria — barrier to activation
de Groot <i>et al</i> ⁶²	Netherlands	Retrospective patient review and semistructured interviews with professionals	Descriptive statistics and grounded theory	PEWS	Importance of professional intuition is reported.
Donohue <i>et al</i> ⁶⁴	UK	Qualitative design with critical incident technique. Semistructured interviews with nurses and the outreach team.	Thematic analysis	EWS	Importance of gut feeling and intuition in detecting deterioration
Downey <i>et al</i> ⁷⁴	UK	Narrative review	'Patterns were identified and translated to themes, which were further refined using an iterative process.'	PEWS	Drive towards automated alerts
Endacott <i>et al</i> ⁴³	UK	Mixed methods case study — semistructured interviews and audit of charts	Qualitative content analysis and descriptive statistics	Observations and monitoring	Gut feeling important — interestingly particularly for nurses whereas doctors sought additional empirical evidence to back up intuition.
Endacott and Westley ³⁹	Australia	Questionnaire, in-depth interviews and observations	Content analysis and constant comparison	EWS	Intuition and anticipatory skills important in detecting deterioration
Entwistle ⁷³	USA	Editorial	N/A	Family involvement	Little evidence/no evaluations of policies or practices that encourage and support family involvement in clinical monitoring. Propose the innovative practice of interdisciplinary rounds where families are invited, and communication is directed to the patient and family.

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Fagan <i>et al</i> ⁶²	USA	Observational cohort comparison study	Descriptive statistics	Electronic systems	Concerns about overburdening staff with automated alerts. When considering the patient's baseline, nursing staff are expected to notify the patient's care provider immediately responsible for the patient when the vital signs meet or exceed the clinical trigger.
Graedon and Graedon ⁷²	USA focus	Opinion piece	N/A	Family involvement	Parents to explain child's baseline. Need to have detailed information about signs and symptoms that they should look for that would require alerting the medical team. Propose the need for structured inclusion of family concern during ward rounds (safety walkrounds).
Hands <i>et al</i> ⁴⁴	UK	The vital signs (VS) and early warning data for all inpatients for 1 year to investigate patterns of VS observations collected	Statistical	Observations and monitoring	Staffing levels and availability of equipment impede the collection of vital signs and early warning data. Night-time factors also play a role with a decrease in observations noted.
Hope <i>et al</i> ⁶¹	UK	Semistructured interviews with 17 registered nurses	Constant comparative method informed by grounded theory	Snowball sample	Wider context of night-time care considered; there is some indication that staff are making a choice and prioritising sleep over monitoring.
James <i>et al</i> ³⁷	UK	Postal survey with healthcare assistants (HCA) using closed and open questions	Descriptive statistics and content analysis of qualitative data	Observations and monitoring	Factors other than the score used to detect deterioration – intuition/patient's own descriptions. Vital signs monitoring delegated to junior staff who may not have the skills to interpret results; many HCAs did not 'fully understand this neurological assessment and it is implications for the acutely unwell patient thus resulting in the risk of an inaccurate Early warning score' (p 552).
Jensen <i>et al</i> ⁴⁶	Denmark	Focus group exploring nurses' experiences with paediatric early warning scores	Qualitative meaning condensation analysis	PEWS	Sleeping as a part of care identified. Professional intuition. Night-time pressures.

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Jones <i>et al</i> ⁶⁶	Australia	Questionnaire about understandings and barriers to activating a MET	Simple descriptive statistics	EWS	Intuition important when detecting deterioration
Jones <i>et al</i> ⁷⁷	UK	Electronic capture of physiological data to see if automated clinical alerts increase compliance with an early warning score and improve patient outcomes	Statistical	Electronic systems	Electronic systems can provide prompts or alerts for monitoring vital signs. This system demonstrated significant improvement in clinician attendance to patients who are acutely ill with an early warning score of 3 and above.
Kaul <i>et al</i> ²⁴	USA	Descriptive cross-sectional study; nurse and medical staff survey	Descriptive statistics	PEWS	Benefits of Bedside PEWS — nurses more likely to identify early signs of deterioration and a greater ability to escalate care. Delegation to junior staff justified.
Lobos <i>et al</i> ²⁵	Canada	Implementation report	Simple descriptive statistics	PEWS	Delegation to junior staff. Education package developed around the RRS with a variety of informal lectures and interactive sessions; ‘lunch and learns’, ‘education coffee carts’ and simulation programmes for instance.
Lydon <i>et al</i> ⁴⁰		30 semistructured interviews based on the theory of planned behaviour were conducted. Questionnaire with Likert scale developed from the interview data.	Deductive content analysis	PEWS	Professional intuition
Mackintosh <i>et al</i> ³⁸	UK	Ethnographic perspective; observations, semistructured interviews	Data were inductively and deductively coded using NVivo V.8 and organised thematically.	EWS	Delegation of routine observation and vital signs monitoring to junior staff. Professional intuition important; ‘knowing the patient’ important for detecting subtle changes in a patient’s condition.

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Mackintosh <i>et al</i> ²⁷	UK	Comparative case study—an FRS using ethnographic methods including observations, interviews and documentary review	Inductive and deductive coding facilitated by NVivo. Also used theme building and structuring methods from framework analysis while also informed by other theoretical frameworks such as 'technology-in-practice'.	EWS	Observations and monitoring delegated to junior staff/HCAs and nurses—early warning system (EWS) legitimised importance of these tasks. Importance of pattern recognition and intuition. The TTTs used to confirm or identify deterioration and are particularly useful for junior staff.
Mackintosh <i>et al</i> ⁸²	UK	Ethnographic study using observations (>120 hours), semistructured interviews (n=45) and documentary review	Thematic analysis with data analysed iteratively in addition to a more strategic and policy-focused coding framework	EWS	Professional intuition important when detecting deterioration
Massey <i>et al</i> ⁶⁷	Australia	In-depth semistructured interviews	Inductive approach—thematic analysis	EWS	Importance of intuition or 'sensing clinical deterioration'
McDonnell <i>et al</i> ²⁶	UK	Single-centre, mixed methods, before-and-after study including a survey to measure changes in nurses' knowledge after implementation of a track and trigger system (T&Ts). Also, qualitative interviews.	Statistical analysis and thematic framework analysis	EWS	T&Ts used to confirm or identify deterioration depending on the experience of the user. Specific objective information was seen as helping the response arm prioritise work Importance of professional intuition or 'gut feeling' in detecting deterioration. Need for staff concern in T&Ts.
McKay <i>et al</i> ⁵⁹	Australia	Prospective, controlled, before-and-after intervention trial	Statistical analysis	PEWS	Specific education package developed around the paediatric early warning score which assists in the recognition of deterioration
Mohammed <i>et al</i> ⁷⁵	UK	Three phases; the first two were based in a classroom and asked nurses to calculate an early warning score from vignettes using a handheld computer. The third phase followed the previous approach but was based on the ward after nurses had been using the device for 4 weeks.	Statistical	Electronic systems	Timeliness of electronic vital signs recording when compared with paper systems

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Mohammed Iddrisu <i>et al</i> ⁵⁷	Australia	To explore nurses' role in recognising and responding to deteriorating postoperative patients through focus groups	Thematic analysis	Snowball sample	Staff concern in tool criteria useful
Paciotti <i>et al</i> ⁷¹	USA	Semistructured interviews with clinicians	Grounded theory and constant comparison	Family involvement	Physicians depend on families to explain a child's baseline.
Pattison and Eastham ²⁹	UK	Mixed methods study looking at the impact of a critical care outreach team (CCOT)	Statistical analysis and grounded theory	EWS	Track and trigger tool is used to either confirm or identify deterioration depending on the experience of the user. 'Gut feeling'/intuition important—patient appearance often an important sign in detecting deterioration.
Radeschi <i>et al</i> ⁶⁰	Italy	Multicentre survey to identify the attitudes and barriers to MET utilisation	Statistical analysis	EWS	Intuition (physical appearance important) in detecting deterioration
Schmidt <i>et al</i> ⁷⁸	UK	Retrospective analysis of data collected routinely. Pragmatic observational study of VitalPAC deployment in two large hospitals.	Statistical analyses	Electronic systems	Electronic systems provide prompts for alerts, facilitate better recognition of deterioration and are associated with reduced mortality.
Sefton <i>et al</i> ⁷⁶	UK	Controlled study of vital signs documentation and paediatric early warning Score calculation and a survey of acceptability	Descriptive statistics	PEWS	Errors in paper-based documentation were found; incorrect age-specific chart used; inaccurate documentation of values and plotting of trends; incorrect score calculation. In comparison, the error rate using the electronic score was low.
Shearer <i>et al</i> ³¹	Australia	A mixed methods study	Iterative coding	EWS	Importance of professional intuition
Sønning <i>et al</i> ⁴¹	Norway	Questionnaire of a sample of staff who use a paediatric early warning score	Descriptive statistics	PEWS	Appreciate that a paediatric early warning score encourages a systematic approach to monitoring.
Stevenson and Nilsson ⁸⁵	Sweden	Qualitative; focus groups with 21 registered nurses	Content analysis of interviews	Electronic systems	Verbal reports were favoured over the electronic system.
Stewart <i>et al</i> ³²	Sweden	Mixed methods. Retrospective review of records and nurse-led focus groups.	Statistical analysis and content analysis	EWS	Intuition still plays a part—the 'score' was rarely the single determining factor in activation but rather prompted nurses to gather additional information.

Continued

Table 3 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Subbe <i>et al</i> ⁸⁰	UK	A before-and-after study of an electronic automated advisory VS monitoring and notification system. Elevated scores were relayed to an RRT.	Statistical analysis	Snowball sample	Automated versus monitoring associated with a decrease in mortality
Wager <i>et al</i> ⁸⁴	USA	Observational study	Descriptive statistics	Electronic systems	Batching of patient data whereby the care provider handwrites the patient's vital signs and uploads it to the computer at a later time is common, especially as the computers are often busy. Individual tablet PCs seem to eliminate this from occurring.
Watson <i>et al</i> ⁴⁵	USA	Mixed methods, retrospective medical record observations and observations of nurse interactions in 1 min blocks	Observation analysis, although this is not described, and statistical analysis	PEWS	Information relating to transfer to electronic systems—distance the 'eyes' of the nurses from the patient; batching. Intuition.
Wheatley ³⁴	UK	Ethnographic approach; participant observation and semistructured interviews	Thematic and content analysis	Observations and monitoring	The regularity of vital signs monitoring may also lead to it becoming viewed as mundane practice that can be delegated to healthcare assistants. Workplace pressure/equipment failures affect quality of observations.

AVS, abnormal vital signs; N/A, not applicable; TTT, track and trigger tool.

Table 4 Summary of planning evidence

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Abraham <i>et al</i> ⁶¹	USA	Pre/postprospective study	The quality and completeness of the handoff note—both tools—was assessed by a multiprofessional round.	Structured handover	Value of a checklist tool for handover
Brady and Goldenhar ⁶³	USA	Focus groups x7—held in groups of participants with similar roles	Constant comparison	Situational awareness	Huddle useful to proactively identify and plan for risk. Structure to support handover important.
Brady <i>et al</i> ⁶⁸	USA		Statistical process control charts	Situational awareness	Huddles led by a watchstander charge nurse. When risk is identified the team discussed this and developed a plan to mitigate risk.
Claussen <i>et al</i> ⁶⁵	USA	Retrospective review of calls to the rapid response team (RRT) and cardiac arrest calls to evaluate impact of evidence-based guidelines	Descriptive statistics	Electronic systems	The huddle was seen as useful and was called as a patient's status was changing to 'red' so that all team members were informed.
Davies <i>et al</i> ⁵³	USA	Survey looking at barriers to rapid response system (RRS) activation	Statistical analysis	EWS	Activation criteria displayed around the hospital
Demmel <i>et al</i> ⁶⁸	USA	Discussion of the set-up and implementation of a paediatric early warning scoring tool and an associated algorithm	Rapid Plan-Do-Study-Act (PDSA) cycles were implemented using small tests of change. The data from the PDSA cycles were continuously collected, analysed and reviewed with the multidisciplinary staff and planning team and used to give ongoing direction to the implementation plan.	PEWS	Importance of common information spaces and display of activation criteria throughout the hospital

Continued

Table 4 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Donahue <i>et al</i> ²²	USA	Focus group evaluation of a training programme which was developed to teach paraprofessionals Situation-Background-Assessment-Recommendation (SBAR) communication tool	Not clear	Structured handover	Value of a structured approach to handover. Adaptation of the SBAR tool for handover.
Ennis ²³	Ireland	Description of implementation of paediatric early warning score and subsequent audit (prospective cohort observational study)	Simple descriptive statistics of numbers of children triggering the paediatric early warning score and compliance with escalation protocol	PEWS	Common information spaces important and display of activation criteria throughout the hospital. Usefulness of ISBAR as a communication tool.
Goldenhar <i>et al</i> ²⁷	USA	Semistructured interviews and focus groups to develop a deeper understanding of a newly implemented huddle system	Constant comparison	Situational awareness	Importance of the huddle—empowerment and sense of community; facilitated greater and better information sharing. Each huddle participant was asked to systematically report on patients in their units who they thought would deteriorate in the near future and to label them as ‘watchers’, asking senior nurses and physician leads to coach charge nurses on how to integrate their perceptions into an informal severity of illness assessment (comprehension) and training the clinicians on how to use the information to facilitate prediction and planning for at-risk patients (projection).

Continued

Table 4 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Mackintosh <i>et al</i> ⁴⁷	UK	Ethnographic two-stage process of lightly structured observations followed by a more focused period of data generation to test and elaborate the outcomes from stage 1	Initial thematic analysis and search for negative cases	Situational awareness	For teams with a strong level of situation awareness (SA), key supports were all used in a balanced and supportive manner to gather and disseminate information which served to promote a culture of shared ownership and a proactive model of workload management, with temporary disruptions to the model easily accommodated. Whiteboard—when used effectively was a vital means for supporting SA. It provides teams with a snapshot of a constantly changing workload, the team's activity levels and resource availability. Workload at times compromised its effectiveness. And irrespective of workloads, location and local traditions had a bearing on its use and usefulness. Whiteboards need to be in a visible location. Importantly, the interplay between these key supports for SA will vary depending on the context; the same supports used differently will naturally produce different outcomes. Handover took many forms: structured and informal; profession specific and interprofessional; participatory or a one-way transmission of information. The effectiveness of SA was dependent on the form that handover took—who was present, contributions made, information relayed. SA was more likely to be compromised when key people were absent. Senior staff coordinator important for SA and became compromised if they were largely focused on providing patient care.
Mackintosh <i>et al</i> ²⁷	UK	Comparative case study—an RRS using ethnographic methods including observations, interviews and documentary review	Inductive and deductive coding facilitated by NVivo. Also used theme building and structuring methods from framework analysis while also informed by other theoretical frameworks such as 'technology-in-practice'.	EWS	Availability of equipment was an issue where the track and trigger tool (TTT) was electronic. Electronic systems helped HCAs and nursing staff to share understandings, planning and manage their workload.
Massey <i>et al</i> ⁶⁷	Australia	In-depth semistructured interviews	Inductive approach—thematic analysis	EWS	Common information spaces useful. Display of activation criteria throughout hospital.

Continued

Table 4 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
McCroory <i>et al</i> ⁵⁴	USA	Prospective, preinterventional and postinterventional study to evaluate the educational intervention of teaching ABC-SBAR (airway, breathing, circulation followed by situation, background, assessment, and recommendation)	Two blinded reviewers assessed 52 video-recorded handoffs for inclusion, order and elapsed time to essential handoff information using a scoring tool.	Structured handover	Information sharing for handovers is of variable quality. A more structured approach will improve information sharing and therefore situational awareness—‘without a structured hand-off tool, paediatric interns overemphasise background information and leave the reason for the call delayed’. Adaptation of the SBAR tool to include ABC—usefulness of this.
Mullan <i>et al</i> ⁹³	USA	Descriptive observational study	Checklists were evaluated for rates of use, completion and identification of potential safety events.	Situational awareness	The value of more structured approach to information sharing and situational awareness. Uses a checklist handover system for physicians. Checklist items focused on the status of the patient, ED providers and hospital resources. A ‘Read-Do’ format was designed.
Parker <i>et al</i> ⁸⁹	USA	Manual review of all eligible patient records	Descriptive statistics	PEWS	Example of a bundle around the ‘watcher’ category with five components that needed to be completed within 2 hours of a patient being designated as such.
Pearson and Duncan ³⁰	UK	Brief review of the evidence base surrounding paediatric early warning scores	N/A	PEWS	Value of a more structured approach to communication—advocate the use of a shared communication model, such as SBAR, to communicate findings to superiors.
Pezzolesi <i>et al</i> ⁸⁰	UK	Delphi study for tool development	Descriptive statistics. Handovers were analysed and rated according to a measure of essential skills.	Situational awareness	Information on handover—can be of variable quality. Most handover tools are adaptations of SBAR) communication tool. Important to remember that handover facilitates teamwork and this hinges on communicative forms that extend beyond the information transfer that is typically the focus of structured handover tools.
Randhawa <i>et al</i> ⁸⁵	USA	Description of the implementation process with cardiopulmonary arrest (CPA) statistics before and after implementation	Once a cycle from the implementation has been completed this is evaluated and then another cycle begins.	PEWS	Whiteboards placed in a central location displayed scores of all patients so that staff could quickly assess which patients were at high risk for deterioration. Activation criteria displayed throughout the hospital.

Continued

Table 4 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Stewart <i>et al</i> ³²	Sweden	Mixed methods. Retrospective review of records and nurse-led focus groups.	Statistical analysis and content analysis	EWS	Huddle—the score was used during the daily bed ‘huddle’ with the nursing administrators to evaluate current unit acuity, determine staffing need and prepare for any transfers.
Van Voorhis and Willis ³³	USA	Discussion paper highlighting the process of developing a paediatric RRS	N/A	PEWS	Display of activation criteria throughout the hospital on lanyards and use of whiteboards useful
de Vries <i>et al</i> ⁶⁶	Netherlands	Semistructured interview	Qualitative content analysis	PEWS	Paediatric early warning score/TTT is used to support situational awareness. Use of a score enables clinicians to have a ‘bird’s-eye’ view over admitted patients.
Wager <i>et al</i> ⁶⁴	USA	Observational study. Explored the timeliness and quality of vital signs data entered by three different recording methods.	Descriptive statistics	Electronic systems	Batching of patient data whereby the care provider handwrites the patient’s vital signs and uploads it to the computer at a later time is common, especially as the computers are often busy.
Watson <i>et al</i> ⁴⁵	USA	Mixed methods, retrospective medical record observations and observations of nurse interactions	Observation analysis, although this is not described, and statistical analysis	PEWS	Availability of equipment is a factor.
Weiss <i>et al</i> ⁶⁴	Canada	A randomised controlled trial in an academic paediatric intensive care unit (PICU) of 20 handover events	Differences between intervention and control groups were assessed using the Mann-Whitney test and multivariate linear regression.	Structured handover	Value of a more structured approach to support information sharing—a cognitive aid to facilitate handover that prompted residents to transmit this information. The handover aid was not linked to hospital information systems—so this had to be completed by hand before handover. Handover is an opportunity for learning and professional socialisation.
Wong <i>et al</i> ⁶⁵	UK	Description of user-focused design process for use of electronic monitoring and numbers of observations taken using the system. Acceptability questionnaire.	Descriptive statistics on the number of observations recorded using the SEND system and the number of active users	Electronic systems	Development of a flexible electronic system which enabled staff to have an overview of patients—reflections on disconnection

ED, emergency department; EWS, early warning system; HCA, healthcare assistant; N/A, not applicable.

enabling individual-level clinical data to be synthesised, made sense of and shared.^{19–29 33 39 41 42 46 48 50 51 56 62 66 74 86}

One study, however, found that TTTs were regarded as a nursing tool and were therefore not valued by clinicians. Consequently, nurses encountered difficulties in summoning a response.⁴⁶

Several studies also report on the use of SBAR in this context. Like TTTs, SBAR translates information into a form that provides structure, consistency and predictability when presenting patient information. SBAR has been shown to help establish common language and expectations, minimising differences in training, experience and hierarchy and facilitating nurse–clinician communication. While several papers advocate combining SBAR with TTTs,^{23 25 27 30 35 45 50} none specifically evaluated SBAR use. Mackintosh *et al* highlight that audit data suggest resistance to SBAR, with others cautioning that overextending SBAR use carries the risk of SBAR fatigue and attenuation of its effects.²⁷

Structured communication tools like TTTs and SBAR do not solve all the challenges of acting in response to evidence of deterioration. Barriers to action were widely reported in the literature where these tools were in place. These include: a general disinclination to seek help,^{19–22 25 27 29 31 36–39 42 48 50 51 56 64 67} concerns about appearing inadequate in front of colleagues^{20 22 36 38 50 67} and failure of staff to invest in the escalation or calling criteria.^{21 22 49} A number of papers also reported negative attitudes to rapid response team (RRT) or medical emergency team (MET) use in the efferent component of safety systems. METs and RRTs operate outside the immediate medical team and create different issues in paediatric warning systems than when the escalation response is managed by the treating team. These include a reluctance to activate because of the perceived busyness of paediatric intensive care unit or medical staff,^{20 29 39 48 50 51} because previous expectations about an appropriate response were not met, or a sense that the situation was under control (particularly when the physiological instability is in the area of expertise of the treating team).^{22 29 31 38 42 50 52 64}

No literature reported on successful interventions to facilitate RRT use, but several propose strategies to support escalation where there was no designated response team in place in the efferent component. These include informal peer support, where inexperienced staff team up with more experienced staff^{21 29 50 64 67}; clear structures to support action and a supportive culture that does not penalise individual decision-making, including the use of a ‘no false alarms’ policy so staff are not deterred from escalating care.^{21 29 36 73} Senior leadership is consistently identified as important^{8 20–23 25 27 30 32 33 35 47 52 58 66 67}; lack of support from superiors meant that staff are less likely to escalate and more likely to adhere to hierarchies within the current system.^{25 40 66} There is some evidence to suggest that any escalation policy should be linked to an administrative arm that reinforces the system, measures outcomes and works to ensure an effective system.^{27 30}

There is a small literature on family involvement in the Action subsystem. Several studies report on Condition-Help, a programme developed in the USA to support families to directly activate an RRT if they have concerns about their child’s condition. Families are also becoming increasingly recognised as playing a key role in the activation of RRTs in Australia.⁹⁷ Research has evaluated the appropriateness of calls that were made by patients or relatives^{33 97–101} but has not considered why calls were *not* made.⁷⁰ Involving family members in escalation demands vigilance, requiring them to take a proactive and interactive role with staff with potentially some degree of confrontation, particularly if challenging the appropriateness of decisions taken.^{73 97} Families need both cognitive and emotional resources to raise concerns that involve negotiating hierarchies and boundaries.^{35 70} The literature points to a degree of professional resistance to family involvement in activation, with reports of physician concern that their role would be undermined, that resources would be stretched with an increase in calls and that it might divert attention away from those in need.^{71 97 99 102 103} although these fears are not supported by the evidence.^{71 102 104} See [table 5](#) for a summary of the evidence relating to the action component of the model.

Synthesis and model development

The literature in this field is heterogeneous and stronger on the sociomaterial barriers to successful afferent component paediatric early warning systems than it is on solutions. While a number of different single interventions have been proposed and some have been evaluated, there is limited evidence to recommend their use beyond the specific clinical contexts described in the papers. This reflects both the weight and quality of the evidence, the extent to which paediatric systems are conditioned by the local clinical context and also the need to attend to the relationship between system components and interventions which work in concert not in isolation. There is also a growing realisation in the quality improvement field that an intervention that has been successful in one context does not necessarily produce the same results elsewhere which cautions against a ‘one size fits all’ approach.^{105 106}

While it is not possible to make empirical recommendations for practice, a hermeneutic review methodology enabled the generation of theoretical inferences about the core components of an optimal paediatric early warning system. These model components are logical inferences derived from an overall synthesis of the evidence, informed by our theoretical framework and clinical expertise. These are presented as a propositional model conceptualised as three subsystems: detection, planning and action (see [table 1](#)).

DISCUSSION

This paper reports on one of three linked reviews undertaken as part of a wider UK study commissioned to develop and evaluate an evidence-based national paediatric early

Table 5 Summary of action evidence

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Adelstein <i>et al</i> ⁴⁹	Australia	Prospective comparison of rapid response team (RRT) criteria breaches	Statistical	EWS	Day/night differences in activation identified. Nurses may not understand what is required for activation. Staff not investing in calling criteria.
Almblad <i>et al</i> ⁶	Sweden	Retrospective review of the electronic patient record and a context assessment of the work environment using the Alberta Context Tool	Statistical		Snowball sample Senior leadership consistently identified as important.
Andrews and Waterman ¹⁹	UK	Interviews and observations	Grounded theory	EWS	Track and trigger tools (TTT) act as prompts to action. TTT used to overcome challenges in communication and particularly valuable for junior staff. Negative attitude towards calling for help.
Astroth <i>et al</i> ⁵⁰	USA	Semistructured interviews with nurses	Coding categories were generated from the data, and consensus on final themes was achieved through an iterative process.	EWS	Situation under control—no need to escalate or perceived business of medical staff discouraged staff from RRT activation. Staff encouraged to use their intuition when activating the RRT. Concern about feeling inadequate in front of colleagues a barrier to RRT activation. Inexperienced staff teaming up—led to staff trusting their own judgement. Traditional hierarchies a barrier to RRT activation—nurses more likely to call the attending physician rather than activate the RRT.
Azzopardi <i>et al</i> ²⁰	Australia	Survey	Statistical analysis	PEWS	Score rarely the determining factor in escalation—would not escalate for a patient who looked well but would not trigger. Negative attitude towards calling for help—feeling inadequate/perceived business of paediatric intensive care unit had an impact on doctors escalating but not nurses. Senior leadership is important when implementing a MET.

Continued

Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Bavare <i>et al</i> ¹⁰⁴	USA	Retrospective observational study of rapid response events	Descriptive statistics	PEWS	All family-activated RRT had appropriate clinical triggers with the most common being uncontrolled pain. More than half of Family-Initiated pediatric rapid response (FIRR) had a vital signs change that should have qualified clinician-RRT activation. Seventy-six per cent FIRRs needed at least one or more interventions. Twenty-seven per cent of family-initiated RRTs needed transfer to intensive care unit compared with 60% transfer rate for clinician RRTs.
Bogert <i>et al</i> ⁹⁸	USA	Implementation of Condition Help (ConditionH)	Descriptive statistics	Family involvement	Implementation of ConditionH. ConditionH being addressed during daily rounds.
Bonafide <i>et al</i> ²¹	USA	Semistructured interviews	Grounded theory	PEWS	Disinclination to seek help and concerns about appearing inadequate in front of colleagues. Informal peer support. Senior leadership important.
Braaten ²²	USA	Document review and interviews using the principles of cognitive work analysis	Inductive and deductive forms of analysis—cognitive work analysis, framework and directed content analysis	EWS	Issues around availability of equipment and staffing. Negative attitude/delays around calling for help with staff needing to justify escalation. Other factors impact on this including the perception that the situation is under control/perceived business of physicians/not wanting to appear inadequate.
Brady <i>et al</i> ⁹⁸	USA.		Statistical process control charts	Situational awareness	Concerns about resources reported
Brady <i>et al</i> ¹⁰²	USA	A retrospective cohort study looking at the association between family and clinician activations and transfer to the intensive care unit following a MET call	Quality improvement methods and statistical process control charts were used to assess the rate of family activation of METs.	Family involvement	Direct mechanism for families to activate a MET. Concerns from clinicians about a family-activated MET overburdening the system are unfounded.
Chua <i>et al</i> ⁹⁶	Singapore	A qualitative survey using critical incident technique	Inductive content analysis	EWS	Staff felt that they had not been educated to an adequate level—training lacking. Negative attitude towards calling for help—fears of appearing inadequate.

Continued

Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Cioffi ⁴⁸	Australia	Unstructured interviews with nurses who had activated the medical emergency team (MET)	Simple code and retrieve	EWS	Reluctance to activate—doubting ability; fears of appearing inadequate; decisions made based on the perceived availability of resources/business of medical staff/time of day all had an impact on decisions to activate the MET. Importance of having staff concern in the MET criterion.
Cioffi ⁵¹	Australia	Unstructured interviews	Simple code and retrieve	EWS	Importance of having staff concern in a calling criteria. Reluctance to activate—business of ward a factor.
Cioffi <i>et al</i> ⁴²	Australia	Focus groups with clinicians and nurses exploring their responses to abnormal vital signs	Constant comparison	EWS	Availability of equipment an issue/staffing pressures; staff unable to carry out routine monitoring that would enable the detection of abnormal vital signs (AVS)/escalation hampered because of difficulty finding the appropriate senior person. MET criteria used to confirm or identify deterioration depending on experience. Negative attitude towards asking for help—lack of confidence questioning peers/fear of being reprimanded/feeling the situation was under control.
de Groot <i>et al</i> ⁶²	Netherlands	Retrospective patient review and semistructured interviews with professionals	Descriptive statistics and grounded theory	PEWS	Easily approachable nurses and physicians, as well as good communication, were considered to be vital for timely intervention in cases of clinical deterioration in paediatric patients. Facilitators for the implementation of registration of paediatric early warning score included the integration of scores into the electronic patient records.
Dean <i>et al</i> ⁹⁹	USA	Two-year reflection following implementation of ConditionH	Descriptive statistics	Family involvement	ConditionH criteria for activation. Concern that family-activated RRS could divert attention away from resources. Clinician involvement important. Daily 'patient rounds' involving patients and families is useful. Patients and families have access to relevant information and understand the medical information and care plans.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Demmel <i>et al</i> ⁶⁸	USA	Discussion of the set-up and implementation of a paediatric early warning scoring tool and an associated algorithm	Rapid Plan-Do-Study-Act (PDSA) cycles were implemented using small tests of change.	PEWS	Education package developed around the history and development of paediatric early warning scores along with the rationale for and the goals of the initiative. The scoring process was explained and how it would be integrated into routine nursing assessments; normal vital sign parameters were reviewed. Importance of common information spaces and display of activation criteria throughout the hospital. Senior lead commitment and importance of champions integral for implementation.
Donohue <i>et al</i> ⁶⁴	UK	Qualitative design with critical incident technique. Semistructured interviews with nurses and the outreach team.	Thematic analysis	EWS	Some resistance to escalation—clinicians preferring to deal with patient problems within their own team. Inexperienced staff teaming up with more experienced staff once patient deterioration was recognised.
Downey <i>et al</i> ⁷⁴	UK	Narrative review	'Patterns were identified and translated to themes, which were further refined using an iterative process.'	PEWS	Impact on communication—packaging information. Facilitates communication across hierarchies.
Endacott and Westley ³⁹	Australia	Questionnaire, in-depth interviews and observations	Content analysis and constant comparison	EWS	Art of referral important—using the right language and suggesting actions that would be acceptable to the doctor. Availability of equipment a factor. Negative attitude towards calling for help; escalation dependent on perceived capability of medical staff.
Ennis ²³	Ireland	Description of implementation of paediatric early warning score and subsequent audit (prospective cohort observational study)	Simple descriptive statistics of numbers of children triggering the paediatric early warning score and compliance with escalation protocol	PEWS	Structured education and training programme on the use of Identify-Situation-Background-Assessment-Recommendation (ISBAR) and paediatric early warning score was provided and nurse manager/staff nurse in charge should review any educational requirements in completing the paediatric early warning score particularly for relief staff. Common information spaces important and display of activation criteria throughout the hospital. Usefulness of ISBAR as a communication tool. Senior lead commitment—paediatric early warning score management policy developed/senior staff promote and reinforce use of the tool

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Entwistle ⁷³	USA	Editorial	N/A	Family involvement	Little evidence/no evaluations of policies or practices that encourage and support family involvement in clinical monitoring. Propose the innovative practice of interdisciplinary rounds where families are invited, and communication is directed to the patient and family.
Gerdik <i>et al</i> ¹⁰³	USA	Routine data collection for number of RRT calls and the result of these activations and patient/family survey relating to RRT activation	Statistical analysis	Family involvement	Direct mechanism for families to activate the RRT. Barriers to family activation highlighted, specifically professional resistance. Physician and leadership support important to overcome barriers.
Gill <i>et al</i> ⁹⁷	Australia	Commentary drawing together family-centred care concepts, the National Safety and Quality Healthcare Service (NSQHS) Standards and the development of family-initiated care in Australia	N/A	PEWS	Family-activated RRTs now increasingly common in Australia. In the first instance, families need to be aware of the policy. Stress the importance of understanding the number and nature of the call. Reports on health professional's resistance to it. Families need vigilance to escalate care. Need resources in order to negotiate hierarchies and boundaries.
Greenhouse <i>et al</i> ¹⁰⁰	USA focus	Discussion about the implementation of ConditionH	Descriptive statistics	Family involvement	Appropriateness of calls is reported rather than why they are made. Note some scepticism and wariness among nurses and physicians.
Hueckel <i>et al</i> ¹⁰¹	USA	Scripted family teaching about RRT activation at the time of patient admission from ConditionH	Descriptive statistics about delivery of educational programme and RRT call-out; survey testing family understanding	Family involvement	Description of Condition Help. Appropriateness of calls is reported rather than why they are made.
James <i>et al</i> ³⁷	UK	Postal survey with healthcare assistants (HCA) using closed and open questions	Descriptive statistics and content analysis of qualitative data	Observations and monitoring	Workload and ward distractions a barrier to activation, such as time spent locating equipment. Disinclination to seek help from senior staff/clinicians.

Continued

Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Jensen <i>et al</i> ⁴⁶	Denmark	Focus group exploring nurses' experiences with a paediatric early warning score	Qualitative meaning condensation analysis	PEWS	Paediatric early warning score as a nursing tool and therefore not valued by medic—no universal language because of this; 'when you call and say that they have a score of 5, then they don't know what 5 means' (FG2 P1).
Kaul <i>et al</i> ²⁴	USA	Descriptive cross-sectional study; nurse and medical staff survey	Descriptive statistics	PEWS	Noted that the score provides a 'universal language' and interdisciplinary communication
Lobos <i>et al</i> ²⁵	Canada	Implementation discussion	Simple descriptive statistics	PEWS	Situation-Background-Assessment-Recommendation (SBAR) helps establish a common language and guide escalated events. Negative attitude towards calling for help—traditional hierarchies a barrier to activation/concerns about communication between primary and responding team. No false alarms and debriefing useful. Importance of champions (using a social marketing approach) to encourage, inter-professional collaboration & advisory group to help establish a sense of ownership'. Lack of support from superiors means less likely to escalate.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Mackintosh <i>et al</i> ⁶⁷	UK	Comparative case study—a rapid response system (RRS) using ethnographic methods including observations, interviews and documentary review	Inductive and deductive coding facilitated by NVivo. Also used theme building and structuring methods from framework analysis while also informed by other theoretical frameworks such as ‘technology-in-practice’.	EWS	Availability of equipment an issue where the TTT was electronic. Gave junior staff licence to escalate care. Additionally, ‘while standardisation of practice clearly has its benefits, it also comes at a cost that these tools attenuate lower level staff’s authority and ability to persuade staff higher up in the organisation of the credibility of their knowledge’ (p 143). Efforts to develop junior staff’s communication and clinical understanding need to acknowledge power dynamics at play. Usefulness of SBAR communication tool as part of the escalation policy as reported by staff (not seen in action). Negative attitude towards escalation—difficulty in summoning a response. Senior lead commitment to patient safety was important. Zero tolerance for cardiac arrest was championed by senior staff. Night-time/out-of-hours pressures identified.
Mackintosh <i>et al</i> ⁶⁸	UK	Ethnographic perspective; observations, semistructured interviews	Data were inductively and deductively coded and organised thematically.	EWS	Negative attitude towards seeking help. Escalating care outside the parameters marked by a track and trigger tool proved difficult; power struggles identified—junior staff have difficulty persuading more senior staff of the credibility of their knowledge. Difficulties in activation across professional boundaries.
Massey <i>et al</i> ⁶⁷	Australia	In-depth semistructured interviews	Inductive approach—thematic analysis	EWS	Common information spaces useful. Display of activation criteria throughout hospital. General negative attitude towards calling for help—appearing inadequate in front of others. Importance of leadership support. Peer support—would often consult their colleagues.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
McCabe <i>et al</i> ³⁵	UK	Opinion piece about lessons to be learnt from the adult experience of implementing early warning systems	N/A	PEWS	Specific education package needed on how to use an early warning system (EWS) and on basic clinical assessment, guidance and standardisation of observation and monitoring. Advocate situational simulated scenario education and e-learning. Highlight the usefulness of communication tools such as SBAR for establishing roles and responsibilities, engaging them in making an appropriate management plan that can, if necessary, be escalated. Senior lead commitment key – reflected in resources and education – to improve the safety and quality of care of hospitalised patients. Families need to be empowered to request a patient review.
McDonnell <i>et al</i> ²⁶	UK	Single-centre, mixed methods before-and-after study including a survey to measure changes in nurses' knowledge after implementation of a track and trigger system (T&Ts). Also, qualitative interviews.	Statistical analysis and thematic framework analysis	EWS	Rolling education programme for all nurses on the recognition and response to deteriorating patients and an overview of the T&Ts. Workplace pressures; nurses concerned that they could not always summon a timely response from doctors/night-time pressures also identified. Need for staff concern in T&Ts.
Monaghan ²⁸	UK focus	Commentary on the development of the Brighton paediatric early warning score and setting up a paediatric critical care outreach team	Simple descriptive statistics of all activations, actions and outcomes during the first 3 months of implementation	PEWS	Education-based model was developed to assist in recognising deterioration. Temporary staff/workplace pressures impact on staff's ability to detect deterioration.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Paciotti <i>et al</i> ⁷¹	USA	Semistructured interviews with clinicians to explore physicians' viewpoints on families facilitating the identification of children with a deteriorating condition	Grounded theory and constant comparison	Family involvement	Concerns that resources would be diverted away with an increase in calls — not supported
Pattison and Eastham ²⁹	UK	Mixed methods study looking at the impact of a critical care outreach team (CCOT)	Statistical analysis and grounded theory	EWS	Availability of equipment an issue/workload. Negative attitude towards calling for help — situation under control/ward business. Inexperienced staff teaming up/checking with peers before calling the CCOT.
Pearson and Duncan ³⁰	UK	Brief review of the evidence base surrounding the paediatric early warning score together with reflections from their own experiences from the Birmingham Children's Hospital	N/A	PEWS	Team training and education is important increasing confidence in the use of medical language and empowering bedside carers. 'Although doing observations is fundamental to nursing practice many ... have not been taught a structured approach to assessment.' Advocate a simulated environment. Value of a more structured approach to communication — advocate the use of a shared communication model such as SBAR to communicate findings to superiors. Need for senior commitment — cultural change may be required to ensure management support (reflected in resources and education)/importance of champions.
Salamonson <i>et al</i> ⁵⁶	Australia	Survey with closed and open questions to examine perceptions of and satisfaction with the MET	Descriptive statistics and content analysis	EWS	Need for more education on deterioration identified. Negative attitude towards asking for help; attitude of MET team a barrier to activation.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Shearer <i>et al</i> ³¹	Australia	A multimethod study; a point prevalence survey; a prospective audit of all patients experiencing a cardiac arrest, unplanned intensive care unit (ICU) admission or death over an 8-week period. Structured interviews with staff to explore cognitive and sociocultural barriers to activation.	Iterative coding	EWS	Adequate staffing and a lack of beds on critical care leads to a failure to activate the RRS. Score rarely the single determining factor in activation despite the fact that staff recognised patients met activation criteria. Data from the point prevalence study confirm this as only one patient had a serious adverse event. Negative attitude towards calling for help – situation under control; treating team had expertise to treat (particularly when the physiological instability was in the area of expertise of the treating team). Traditional (intraprofessional clinical) hierarchies a barrier to activation.
Sønning <i>et al</i> ⁴¹	Norway	Questionnaire of a sample of staff who use a paediatric early warning score	Descriptive statistics	PEWS	Nurses gain self-confidence. More effective communication.
Stewart <i>et al</i> ³²	Sweden	Mixed methods. Retrospective review of records and nurse-led focus groups.	Statistical analysis and content analysis	EWS	The RRS was valuable for junior staff escalating care across hierarchical and professional boundaries. Senior lead commitment – culture of support promoted by nursing administrators.

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Table 5 Continued

Author	Country	Methodology	Analysis	Search area	Evidence contribution
Van Voorhis and Willis ³³	USA	Discussion paper highlighting the process of developing a paediatric RRS. The system was evaluated by prospectively collected data recorded on RRS activation forms and existing performance improvement database information.	N/A	PEWS	Display of activation criteria throughout the hospital on lanyards and use of whiteboards useful. Debriefing following activation and a commitment to no false alarms is encouraged. Senior lead commitment—administrative arm of the RRS vital. Uses Condition Help. The appropriateness of calls was facilitated by the 'no false alarms' culture.
de Vries <i>et al</i> ⁸⁶	Netherlands	Semistructured interview	Qualitative content analysis	PEWS	Paediatric early warning score facilitated communication across hierarchies.
Watson <i>et al</i> ⁴⁵	USA	Mixed methods, retrospective medical record observations and observations of nurse interactions in 1 min blocks	Observation analysis, although this is not described, and statistical analysis	PEWS	Availability of equipment a factor. Score rarely the determining factor in escalation. SBAR.

N/A, not applicable.

warning system.³ Drawing on TMT and NPT, we have synthesised and analysed the findings from the review to develop a propositional model to specify the core components of optimal afferent component paediatric early warning systems. While there is a growing consensus of the need to think beyond TTTs to consider the whole system, no frameworks exist to support such an approach. Clinical teams wishing to improve rescue trajectories should take a whole systems perspective focused on the constellation of factors necessary to support detection, planning and action and consider how these relationships can be managed in their local setting. TTTs have value in paediatric early warning systems but they are not the sole solution and depend on certain preconditions for their use. An emerging literature highlights the importance of planning and indicates that combinations of interventions may facilitate situation awareness. Professional judgement is also important in detecting and acting on deterioration and the evidence points to the importance of a wider organisational culture that is supportive of this. Innovative approaches are needed to support family involvement in all aspects of paediatric early warning systems, which are sensitive to the cognitive and emotional resources this requires. System effectiveness requires attention to the sociomaterial relationships in the local context, senior support and leadership and continuous monitoring and evaluation. New technologies, such as moving from paper-based to electronic TTTs, have important implications for all three subsystems and critical consideration should be given to their wider impacts and the preconditions for their integration into practice.

Limitations of the review

The literature in this field is heterogeneous and better at identifying system weakness than it is effective improvement interventions. It was only by deploying social theories and a hermeneutic review methodology did it prove possible to develop a propositional model of the core components of an afferent component paediatric early warning system. This model is derived from logical inferences drawing on the overall evidence synthesis, social theories and clinical expertise, rather than strong empirical evidence of single intervention effectiveness. Consequently, there is a growing consensus of the need to take a whole systems approach to improve the detection and response to deterioration in the inpatient paediatric population.

CONCLUSION

Failure to recognise and act on signs of deterioration is an acknowledged safety concern¹ and TTTs are a common response to this problem. There is, however, a growing recognition of the importance of wider system factors on the effectiveness of responses to deterioration.^{5,7} We have reviewed a wide literature and analysed this using social theories to develop a propositional model of an optimal

afferent component paediatric early warning system that can be used as a framework for paediatric units to evaluate their current practices and identify areas for improvement. TTT use should be driven by the extent to which teams think that they will help improve the effectiveness of their system as a whole.

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REFERENCES

- 1 Subbe CP, Welch JR. Failure to rescue: using rapid response systems to improve care of the deteriorating patient in hospital. *Clin Risk* 2013;19:6–11.
- 2 Chapman SM, Wray J, Oulton K, *et al*. Systematic review of paediatric track and trigger systems for hospitalised children. *Resuscitation* 2016;109:87–109.
- 3 Trubey R, Huang C, Lugg-Widger FV, *et al*. Validity and effectiveness of paediatric early warning systems and track and trigger tools for identifying and reducing clinical deterioration in hospitalised children: a systematic review. *BMJ Open* 2019;9:e022105.
- 4 Parshuram CS, Dryden-Palmer K, Farrell C, *et al*. Effect of a paediatric early warning system on all-cause mortality in hospitalised paediatric patients: the epoch randomized clinical trial. *JAMA* 2018;319:1002–12.
- 5 The Irish Paediatric Early Warning System (PEWS). *NCEC national clinical guideline No. 12*. Department of Health Ireland, 2015.
- 6 Rihari-Thomas J, Newton PJ, Sibbritt D, *et al*. Rapid response systems: where we have come from and where we need to go? *J Nurs Manag* 2018;26:1–2.
- 7 Lambert V, O'Shea M, Walshe C, *et al*. A systematic literature review to support the development of a national clinical guideline – paediatric early warning system (PEWS), 2014. Available: <http://health.gov.ie/wp-content/uploads/2014/03/PEWS-Sytematic-Literature-Review-Oct-2014.pdf> [Accessed Aug 2019].
- 8 Almblad A-C, Siltberg P, Engvall G, *et al*. Implementation of pediatric early warning score; adherence to guidelines and influence of context. *J Pediatr Nurs* 2018;38:33–9.
- 9 Lambert V, Matthews A, MacDonnell R, *et al*. Paediatric early warning systems for detecting and responding to clinical deterioration in children: a systematic review. *BMJ Open* 2017;7:e014497.
- 10 Boell SK, Cecez-Kecmanovic D. A hermeneutic approach for conducting literature reviews and literature searches. *CAIS* 2014;34:257–86.
- 11 Thomas-Jones E, Lloyd A, Roland D, *et al*. A prospective, mixed-methods, before and after study to identify the evidence base for the core components of an effective Paediatric Early Warning System and the development of an implementation package containing those core recommendations for use in the UK: Paediatric early warning system - utilisation and mortality avoidance- the PUMA study protocol. *BMC Pediatr* 2018;18:244.
- 12 Greenhalgh T, A'Court C, Shaw S. Understanding heart failure; explaining telehealth – a hermeneutic systematic review. *BMC Cardiovasc Disord* 2017;17:1–16.
- 13 Allen D, May C, Practice O. Organizing practice and practicing organization: an outline of translational mobilization theory. *Sage Open* 2017;7:215824401770799–43.
- 14 Allen D. Translational mobilisation theory: a new paradigm for understanding the organisational elements of nursing work. *Int J Nurs Stud* 2018;79:36–42.
- 15 May C, Finch T. Implementing, embedding, and integrating practices: an outline of normalization process theory. *Sociology* 2009;43:535–54.
- 16 May CR, Johnson M, Finch T. Implementation, context and complexity. *Implement Sci* 2016;11:1–12.
- 17 Jagt EWvander. Improving pediatric survival from resuscitation events: the role and organization of hospital-based rapid response systems and code teams. *Curr Pediatr Rev* 2013;9:158–74.
- 18 Pawson R. *Evidence-based policy: a realist perspective*. London: Sage, 2006.
- 19 Andrews T, Waterman H. Packaging: a grounded theory of how to report physiological deterioration effectively. *J Adv Nurs* 2005;52:473–81.
- 20 Azzopardi P, Kinney S, Moulden A, *et al*. Attitudes and barriers to a medical emergency team system at a tertiary paediatric Hospital. *Resuscitation* 2011;82:167–74.
- 21 Bonafide CP, Roberts KE, Weirich CM, *et al*. Beyond statistical prediction: qualitative evaluation of the mechanisms by which paediatric early warning scores impact patient safety. *J Hosp Med* 2013;8:248–53.
- 22 Braaten JS. Ce: original research: hospital system barriers to rapid response team activation: a cognitive work analysis. *Am J Nurs* 2015;115:22–32.
- 23 Ennis L. Paediatric early warning scores on a children's ward: a quality improvement initiative. *Nurs Child Young People* 2014;26:25–31.
- 24 Kaul M, Snethen J, Kelber ST, *et al*. Implementation of the bedside paediatric early warning system (BedsidePEWS) for nurse identification of deteriorating patients. *J Spec Pediatr Nurs* 2014;19:339–49.
- 25 Lobos A-T, Fernandes R, Ramsay T, *et al*. Patient characteristics and disposition after pediatric medical emergency team (Met) activation: disposition depends on who activates the team. *Hosp Pediatr* 2014;4:99–105.
- 26 McDonnell A, Tod A, Bray K, *et al*. A before and after study assessing the impact of a new model for recognizing and responding to early signs of deterioration in an acute Hospital. *J Adv Nurs* 2013;69:41–52.
- 27 Mackintosh N, Rainey H, Sandall J. Understanding how rapid response systems may improve safety for the acutely ill patient: learning from the frontline. *BMJ Qual Saf* 2012;21:135–44.
- 28 Monaghan A. Detecting and managing deterioration in children. *Paediatr Nurs* 2005;17:32–5.
- 29 Pattison N, Eastham E. Critical care outreach referrals: a mixed-method investigative study of outcomes and experiences. *Nurs Crit Care* 2012;17:71–82.
- 30 Pearson G, Duncan H. Early warning systems for identifying sick children. *Paediatr Child Health* 2011;21:230–3.
- 31 Shearer B, Marshall S, Buist MD, *et al*. What stops Hospital clinical staff from following protocols? An analysis of the incidence and factors behind the failure of bedside clinical staff to activate the rapid response system in a multi-campus Australian metropolitan healthcare service. *BMJ Qual Saf* 2012;21:569–75.
- 32 Stewart J, Carman M, Spegman A, *et al*. Evaluation of the effect of the modified early warning system on the nurse-led activation of the rapid response system. *J Nurs Care Qual* 2014;29:223–9.
- 33 Van Voorhis KT, Willis TS. Implementing a pediatric rapid response system to improve quality and patient safety. *Pediatr Clin North Am* 2009;56:919–33.
- 34 Wheatley I. The nursing practice of taking level 1 patient observations. *Intensive Crit Care Nurs* 2006;22:115–21.
- 35 McCabe A, Duncan H, Heward Y. Paediatric early warning systems: where do we go from here? *Paediatr Nurs* 2009;21:14–17.
- 36 Chua WL, Mackey S, Ng EKC, *et al*. Front line nurses' experiences with deteriorating ward patients: a qualitative study. *Int Nurs Rev* 2013;60:501–9.
- 37 James J, Butler-Williams C, Hunt J, *et al*. Vital signs for vital people: an exploratory study into the role of the healthcare assistant in recognising, recording and responding to the acutely ill patient in the general ward setting. *J Nurs Manag* 2010;18:548–55.
- 38 Mackintosh N, Humphrey C, Sandall J. The habitus of 'rescue' and its significance for implementation of rapid response systems in acute health care. *Soc Sci Med* 2014;120:233–42.
- 39 Endacott R, Westley M. Managing patients at risk of deterioration in rural hospitals: a qualitative study. *Aust J Rural Health* 2006;14:275–9.
- 40 Lydon S, Byrne D, Offiah G, *et al*. A mixed-methods investigation of health professionals' perceptions of a physiological track and trigger system. *BMJ Qual Saf* 2016;25:688–95.
- 41 Sonning K, Nyrud C, Ravn IH. A survey of healthcare professionals' experiences with the paediatric early warning score (PEWS). *Nor J Clin Nurs* 2018;12:e64605.
- 42 Cioffi J, Salter C, Wilkes L, *et al*. Clinicians' responses to abnormal vital signs in an emergency department. *Aust Crit Care* 2006;19:66–72.
- 43 Endacott R, Kidd T, Chaboyer W, *et al*. Recognition and communication of patient deterioration in a regional Hospital: a multi-methods study. *Aust Crit Care* 2007;20:100–5.
- 44 Hands C, Reid E, Meredith P, *et al*. Patterns in the recording of vital signs and early warning scores: compliance with a clinical escalation protocol. *BMJ Qual Saf* 2013;22:719–26.
- 45 Watson A, Skipper C, Steury R, *et al*. Inpatient nursing care and early warning scores: a workflow mismatch. *J Nurs Care Qual* 2014;29:215–22.
- 46 Jensen CS, Nielsen PB, Olesen HV, *et al*. Pediatric early warning score systems, nurses perspective – a focus group study. *J Pediatr Nurs* 2018;41:e16–22.
- 47 Mackintosh N, Berridge E-J, Freeth D. Supporting structures for team situation awareness and decision making: insights from four delivery suites. *J Eval Clin Pract* 2009;15:46–54.
- 48 Cioffi J. Nurses' experiences of making decisions to call emergency assistance to their patients. *J Adv Nurs* 2000;32:108–14.
- 49 Adelstein B-A, Piza MA, Nayyar V, *et al*. Rapid response systems: a prospective study of response times. *J Crit Care* 2011;26:635.e11–e18.
- 50 Astroth KS, Woith WM, Stapleton SJ, *et al*. Qualitative exploration of nurses' decisions to activate rapid response teams. *J Clin Nurs* 2013;22:2876–82.
- 51 Cioffi J. Recognition of patients who require emergency assistance: a descriptive study. *Heart Lung* 2000;29:262–8.

- 52 Mackintosh N, Watson K, Rance S, *et al.* Value of a modified early obstetric warning system (MEOWS) in managing maternal complications in the peripartum period: an ethnographic study. *BMJ Qual Saf* 2014;23:26–34.
- 53 Davies O, DeVita MA, Ayinla R, *et al.* Barriers to activation of the rapid response system. *Resuscitation* 2014;85:1557–61.
- 54 McCrory MC, Aboumatar H, Custer JW, *et al.* "ABC-SBAR" training improves simulated critical patient hand-off by pediatric interns. *Pediatr Emerg Care* 2012;28:538–43.
- 55 Randhawa S, Roberts-Turner Renee', Woronick K, *et al.* Implementing and sustaining evidence-based nursing practice to reduce pediatric cardiopulmonary arrest. *West J Nurs Res* 2011;33:443–56.
- 56 Salamonson Y, van Heere B, Everett B, *et al.* Voices from the floor: nurses' perceptions of the medical emergency team. *Intensive Crit Care Nurs* 2006;22:138–43.
- 57 Mohammed Iddrisu S, Hutchinson AF, Sungkar Y, *et al.* Nurses' role in recognising and responding to clinical deterioration in surgical patients. *J Clin Nurs* 2018;27:1920–30.
- 58 Demmel KM, Williams L, Flesch L. Implementation of the pediatric early warning scoring system on a pediatric hematology/oncology unit. *J Pediatr Oncol Nurs* 2010;27:229–40.
- 59 McKay H, Mitchell IA, Sinn K, *et al.* Effect of a multifaceted intervention on documentation of vital signs and staff communication regarding deteriorating paediatric patients. *J Paediatr Child Health* 2013;49:48–56.
- 60 Radeschi G, Urso F, Campagna S, *et al.* Factors affecting attitudes and barriers to a medical emergency team among nurses and medical doctors: a multi-centre survey. *Resuscitation* 2015;88:92–8.
- 61 Hope J, Recio-Saucedo A, Fogg C, *et al.* A fundamental conflict of care: Nurses' accounts of balancing patients' sleep with taking vital sign observations at night. *J Clin Nurs* 2018;27:1860–71.
- 62 de Groot JF, Damen N, de Loos E, *et al.* Implementing paediatric early warning scores systems in the Netherlands: future implications. *BMC Pediatr* 2018;18:128.
- 63 Brady PW, Goldenhar LM. A qualitative study examining the influences on situation awareness and the identification, mitigation and escalation of recognised patient risk. *BMJ Qual Saf* 2014;23:153–61.
- 64 Donohue LA, Endacott R, Track ER. Track, trigger and teamwork: communication of deterioration in acute medical and surgical wards. *Intensive Crit Care Nurs* 2010;26:10–17.
- 65 Claussen D, Garner D, Crow B. Early warning signs and the EHR: at the intersection of technology and care. *Nurs Manage* 2013;44:14–16.
- 66 Jones D, Baldwin I, McIntyre T, *et al.* Nurses' attitudes to a medical emergency team service in a teaching hospital. *Qual Saf Health Care* 2006;15:427–32.
- 67 Massey D, Chaboyer W, Aitken L. Nurses' perceptions of accessing a medical emergency team: a qualitative study. *Aust Crit Care* 2014;27:133–8.
- 68 Burns KA, Reber T, Theodore K, *et al.* Enhanced early warning system impact on nursing practice: a phenomenological study. *J Adv Nurs* 2018;74:1150–6.
- 69 Rainey H, Ehrich K, Mackintosh N, *et al.* The role of patients and their relatives in 'speaking up' about their own safety - a qualitative study of acute illness. *Health Expect* 2015;18:392–405.
- 70 Mackintosh NJ, Davis RE, Easter A, *et al.* Interventions to increase patient and family involvement in escalation of care for acute life-threatening illness in community health and hospital settings. *Cochrane Database Syst Rev* 2017;50.
- 71 Paciotti B, Roberts KE, Tibbetts KM, *et al.* Physician attitudes toward family-activated medical emergency teams for hospitalized children. *Jt Comm J Qual Patient Saf* 2014;40:187–92.
- 72 Graedon J, Graedon T. Enlisting families as patient safety allies. *Clin Pediatr Emerg Med* 2006;7:265–7.
- 73 Entwistle V. Nursing shortages and patient safety problems in hospital care: is clinical monitoring by families part of the solution? *Health Expect* 2004;7:1–5.
- 74 Downey CL, Tahir W, Randell R, *et al.* Strengths and limitations of early warning scores: a systematic review and narrative synthesis. *Int J Nurs Stud* 2017;76:106–19.
- 75 Mohammed M, Hayton R, Clements G, *et al.* Improving accuracy and efficiency of early warning scores in acute care. *Br J Nurs* 2009;18:18–24.
- 76 Sefton G, Lane S, Killen R, *et al.* Accuracy and efficiency of recording pediatric early warning scores using an electronic physiological surveillance system compared with traditional Paper-Based documentation. *Comput Inform Nurs* 2017;35:228–36.
- 77 Jones S, Mullally M, Ingleby S, *et al.* Bedside electronic capture of clinical observations and automated clinical alerts to improve compliance with an early warning score protocol. *Crit Care Resusc* 2011;13:83–8.
- 78 Schmidt PE, Meredith P, Prytherch DR, *et al.* Impact of introducing an electronic physiological surveillance system on hospital mortality. *BMJ Qual Saf* 2015;24:10–20.
- 79 Bellomo R, Ackerman M, Bailey M, *et al.* A controlled trial of electronic automated Advisory vital signs monitoring in general Hospital wards. *Crit Care Med* 2012;40:2349–61.
- 80 Subbe CP, Duller B, Bellomo R. Effect of an automated notification system for deteriorating ward patients on clinical outcomes. *Crit Care* 2017;21:1–9.
- 81 Bonafide CP, Zander M, Graham CS, *et al.* Video methods for evaluating physiologic monitor alarms and alarm responses. *Biomed Instrum Technol* 2014;48:220–30.
- 82 Fagan K, Sabel A, Mehler PS, *et al.* Vital sign abnormalities, rapid response, and adverse outcomes in hospitalized patients. *Am J Med Qual* 2012;27:480–6.
- 83 Bonafide CP, Localio AR, Holmes JH, *et al.* Video analysis of factors associated with response time to physiologic monitor alarms in a children's Hospital. *JAMA Pediatr* 2017;171:524–31.
- 84 Wager KA, Schaffner MJ, Foulis B, *et al.* Comparison of the quality and timeliness of vital signs data using three different data-entry devices. *Comput Inform Nurs* 2010;28:205–12.
- 85 Stevenson JE, Nilsson G. Nurses' perceptions of an electronic patient record from a patient safety perspective: a qualitative study. *J Adv Nurs* 2012;68:667–76.
- 86 de Vries A, Draaisma JMT, Fuijkschot J. Clinician perceptions of an early warning system on patient safety. *Hosp Pediatr* 2017;7:579–86.
- 87 Goldenhar LM, Brady PW, Sutcliffe KM, *et al.* Huddling for high reliability and situation awareness. *BMJ Qual Saf* 2013;22:899–906.
- 88 Brady PW, Muething S, Kotagal U, *et al.* Improving situation awareness to reduce unrecognized clinical deterioration and serious safety events. *Pediatrics* 2013;131:e298–308.
- 89 Parker MW, Carroll M, Bolser B, *et al.* Implementation of a communication bundle for high-risk patients. *Hosp Pediatr* 2017;7:523–9.
- 90 Pezzolesi C, Manser T, Schifano F, *et al.* Human factors in clinical handover: development and testing of a 'handover performance tool' for doctors' shift handovers. *Int J Qual Health Care* 2013;25:58–65.
- 91 Abraham J, Kannampallil T, Patel B, *et al.* Ensuring patient safety in care transitions: an empirical evaluation of a handoff intervention tool. *AMIA Annu Symp Proc* 2012;2012:17–26.
- 92 Donahue M, Smith L, Dykes P, *et al.* Phase 2 of the empower project: enhancing communication for paraprofessionals. *J Contin Educ Nurs* 2010;41:197–8.
- 93 Mullan PC, Macias CG, Hsu D, *et al.* A novel briefing checklist at shift handoff in an emergency department improves situational awareness and safety event identification. *Pediatr Emerg Care* 2015;31:231–8.
- 94 Weiss MJ, Bhanji F, Fontela PS, *et al.* A preliminary study of the impact of a handover cognitive aid on clinical reasoning and information transfer. *Med Educ* 2013;47:832–41.
- 95 Wong D, Bonnici T, Knight J, *et al.* Send: a system for electronic notification and documentation of vital sign observations. *BMC Med Inform Decis Mak* 2015;15:68.
- 96 Preece MHW, Hill A, Horswill MS, *et al.* Designing observation charts to optimize the detection of patient deterioration: reliance on the subjective preferences of healthcare professionals is not enough. *Aust Crit Care* 2012;25:238–52.
- 97 Gill FJ, Leslie GD, Marshall AP. Family initiated escalation of care for the deteriorating patient in hospital: Family centred care or just "box ticking". *Aust Crit Care* 2016;29:195–200.
- 98 Bogert S, Ferrell C, Rutledge DN. Experience with family activation of rapid response teams. *Medsurg Nurs* 2010;19:215–22.
- 99 Dean BS, Decker MJ, Hupp D, *et al.* Condition help: a pediatric rapid response team triggered by patients and parents. *J Healthc Qual* 2008;30:28–31.
- 100 Greenhouse PK, Kuzminsky B, Martin SC, *et al.* Calling a condition H(elp). *Am J Nurs* 2006;106:63–6.
- 101 Hueckel RM, Mericle JM, Frush K, *et al.* Implementation of condition help: family teaching and evaluation of family understanding. *J Nurs Care Qual* 2012;27:176–81.
- 102 Brady PW, Zix J, Brill R, *et al.* Developing and evaluating the success of a family activated medical emergency team: a quality improvement report. *BMJ Qual Saf* 2015;24:203–11.



- 103 Gerdik C, Vallish RO, Miles K, *et al.* Successful implementation of a family and patient activated rapid response team in an adult level 1 trauma center. *Resuscitation* 2010;81:1676–81.
- 104 Bavare AC, Thomas JK, Elliott EP, *et al.* Family-Initiated pediatric rapid response: characteristics, Impetus, and outcomes. *J Healthc Qual* 2018;40:103–9.
- 105 Bion J, Richardson A, Hibbert P, *et al.* 'Matching Michigan': a 2-year stepped interventional programme to minimise central venous catheter-blood stream infections in intensive care units in England. *BMJ Qual Saf* 2013;22:110–23.
- 106 Dixon-Woods M, Leslie M, Tarrant C, *et al.* Explaining matching Michigan: an ethnographic study of a patient safety program. *Implement Sci* 2013;8.
- 107 National Patient Safety Agency. *Recognising and responding appropriately to early signs of deterioration in hospitalised patients*. London: NPSA, 2008.
- 108 Gilson RD. Special issue preface. *Hum Factors* 1995;37:3–4.
109. Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.