



EUROPE

# **Paediatric Early Warning Systems: a scoping study**

Lessons from a rapid review: Annexes

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## Annex A. Methodology

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As part of a scoping process to inform THIS Institute's plans for a potential future study examining the processes of de-implementing incumbent practices and services in healthcare, RAND Europe was asked to examine a sample of the published literature on PEW scores and PEW systems to draw out learning about the nature of scores and systems currently used and their strengths and limitations, as well as to examine insights on the influences on successful PEW implementation and effectiveness. To the extent possible, RAND Europe was asked to note any insights related to issues of standardisation and to the associated de-implementation of old practices that often accompanies standardisation processes in healthcare. The findings presented in this briefing document are based primarily on a literature review and are complemented with expert insights based on scoping interviews. These methods are detailed below.

### 1.1. Literature review

The literature review conducted is not a comprehensive review of the evidence but based on a sample of articles specifically selected in collaboration with THIS Institute due to their relevance to the proposed focus of future work. The sources reviewed are limited to academic publications and those shared confidentially by NHS England and NHS Improvement and do not extend to the wider grey literature. However, we have taken a systematic approach to searching the literature and screening potentially relevant records as set out below.

#### 1.1.1. Search strategy

A search of the literature was conducted by a librarian (IK) using a systematic approach. This followed the piloting of search terms, which were refined to ensure relevant articles were captured without superfluous material. The refined search terms were applied to the Medline database on 1 July 2019, covering the period from 2010 to the present. The search terms used are presented in Table 1. The search was limited to literature relating to the UK. Due to the scoping nature of the review, no limits were applied to article type.

**Table 1. Search terms used for literature review**

	<p><b>Medline</b>  <b>2010 – present</b>  <b>Search conducted 1 July 2019</b></p>
1	(p?ediatric* or child* or infant* or neonat*).mp. or exp adolescent/ or exp child/ or exp infant/
2	("early warning" or ews or (track* adj trigger*) or "warning score" or "escalation policy" or "escalation policies" or "escalation protocol" or "escalation protocols" or warning system* or alert* or ((detect* or diagnos* or identif*) adj5 (deteriorat* or declin* or (adverse adj event*) or (risk adj3 (death or dying)))) or (health status indicator* or (severity of illness adj3 (scale* or scor* or index* or indices*)) or trigger criter* or calling criter* or patient at risk or PAR)).mp
3	1 and 2
4	(pews or ptts) mp
5	3 or 4
6	exp united kingdom/ or (national health service* or nhs).ti,ab,in. or (gb or "g.b." or Britain* or (british* not "british Columbia") or uk or "u.k." or united kingdom* or (england not "new england") or northern Ireland* or northern irish* or scotland* or Scottish* or ((wales or "south wales") not "new south wales") or welsh).ti,ab,jw,in.
7	5 and 6

"mp" is the default search field used by Medline. [title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

"exp" is the exploded search term

In addition to articles identified through a database search, we also sought input from an expert advisor to the study: a clinician with significant expertise in the development, use and standardisation of PEW scores and systems. This identified a number of additional articles from the academic literature. Documents relating to the development of a standardised PEW system in England were also included.

### 1.1.2. Paper selection

Records identified by the searches were assessed for inclusion by screening titles and abstracts against a set of inclusion and exclusion criteria, as set out in Table 2. These were developed in consultation with THIS Institute. All records were double-screened (by SP and GA); cases of disagreement were reviewed by a third reviewer (SM).

**Table 2. Inclusion and exclusion criteria**

Inclusion criteria	Exclusion criteria
<p>Articles which focus on:</p> <ul style="list-style-type: none"> <li>The paediatric use of early warning scores and systems, track-and-trigger tools or similar rapid alert tools.</li> </ul>	<p>Articles which focus on:</p> <ul style="list-style-type: none"> <li>EWS not used in a hospital setting (e.g. used by parents at home)</li> <li>Measures of symptoms that may be included in a PEWS but where the measures are not being used as an early warning for deterioration in the study context (e.g. pressure ulcers, fatigue, etc.)</li> <li>Risk-of-mortality scores (lots of these are not necessarily EWS)</li> <li>Disease-specific scores for recognising and measuring disease symptoms rather than as an early warning of deterioration</li> <li>Scoring systems for severity of disease rather than EWS</li> <li>Maternity EWS unless focusing on a newborn infant.</li> </ul>

Due to the number of potentially relevant articles identified at this stage, a further round of screening was undertaken in consultation with THIS Institute. Titles and abstracts were screened by two reviewers (SM and GM), based on direct relevance to the scoping exercise’s focus. Articles identified as relevant by both reviewers were included in the review. Full-text articles were retrieved, and data extracted as set out in section 1.1.3.

### 1.1.3. Extraction and synthesis

During this stage, data were extracted from full-text articles identified as eligible for inclusion (including those identified through our search and those identified by our expert advisor) using an Excel template (see Annex B). Data extraction was undertaken by three researchers (SP, SB, and GA). In line with this exercise’s scoping nature, we did not follow a full narrative synthesis approach. However, we extracted and analysed information and learning points specifically related to the aims of the scoping exercise along with information capturing geographical context and clinical setting. References were managed using Endnote (version 8).

### 1.1.4. Overview of the included literature

The academic literature search conducted in Medline identified 3,754 articles. Of these, 42 articles were identified as potentially relevant following a screening of titles against inclusion and exclusion criteria. In collaboration with RAND, THIS Institute selected 11 of the 42 articles for full-text review, based on their particular relevance to the scoping exercise. Our expert advisor identified eight further articles.

Overall, we analysed 19 journal articles and five confidential documents relating to the development of a national PEW system in England. Among the journal articles, 11 were review articles, including 4 systematic reviews, 1 hermeneutic systematic review involving an iterative process that integrates analysis and

interpretation of evidence with literature searching) and 6 informal literature reviews/commentary pieces with no reported methods. Articles reviewed also included one abstract relating to a prospective mixed-methods before-and-after study and one editorial.

Six of the reviewed articles reported on the findings of primary studies with a range of designs. This included one qualitative focus group study, one survey-based study, one cluster randomised controlled trial, one retrospective observational study of administrative data, one descriptive account of implementing a PEW system, and one pilot study.

## 1.2. Interviews

In addition to the literature review, we conducted three semi-structured interviews with experts involved in developing standardised national PEW systems or with relevant expertise in this regard. The five individuals interviewed were identified through our clinical advisor:

- Chris Hancock, Programme Lead, Acute Deterioration, 1000 Lives Improvement/Improvement, Public Health Wales
- Fiona Astill – Welsh Clinical Leadership Fellow, Health Education and Improvement Wales
- Clare Dieppe - Consultant Paediatrician Emergency Medicine, Swansea Bay University Health Board
- Neil Spencely - Head of Paediatric Intensive Care, Royal Children’s Hospital, Glasgow; Scottish National Patient Safety Lead for Paediatrics; Lead Paediatric Intensivist, Yorkhill Children’s Hospital
- Raymond Nethercott – Consultant Paediatrician, Western Health and Social Care Trust; Officer for Ireland, the Royal College of Paediatrics and Child Health.

Throughout the report, we reference information from interviewees by referring to them as Int1, Int2, etc. To preserve confidentiality, however, the numbering does not correspond to the order in which they are listed here. The interviews lasted approximately 60 minutes and were audio-recorded with the consent of the interviewee. Notes were taken during the interviews, and the audio-recordings were used to verify information in the notes and support analysis. The interviews covered the following:

- Current practice for PEW scores and systems used within the region, the parameters included and how there are administered
- Strengths, weaknesses and effectiveness of the PEW scores or systems in use
- Enablers and challenges to the effective use of PEW scores and systems
- Experiences relating to the introduction of PEW scores systems into a healthcare setting
- Views and experiences relating to the standardisation of PEW systems (and, if relevant, to de-implementation).

## Annex B. Extraction template

Table 3: Extraction template for review of literature

Category of information	Field	Notes for researcher
Information on article / study	Article reference	Full reference
	Article type	Indicate whether a review, primary study
	Study aim	What is the stated aim of the study?
	Study design	What is the study design, e.g. RCT, systematic review, quality improvement project, etc.?
	Setting	Type of setting(s) on which article is focused e.g. acute hospital, ambulance, community /primary care
	Clinical context	Clinical context(s) covered e.g. Paediatric inpatients, emergency department. If focused on a particular clinical condition, please specify
	Country focus	Country (or countries) on which paper is focused
Information on factors influencing implementation and effectiveness	Enablers to <u>implementation</u>	Record here any factors <u>explicitly noted by study authors as enablers or facilitators</u> to implementation [NOTE: Consider here wider socio-technical system. If no enablers discussed, please record 'none discussed']
	Challenges to <u>implementation</u>	Record here any factors <u>explicitly noted by study authors as challenges</u> to implementation [NOTE: Consider here wider socio-technical system. If no challenges discussed, please record 'none discussed']
	Requirements for <u>implementation</u>	Record here any requirements for implementation noted by study authors but not described as enablers or challenges [NOTE: Consider here wider socio-technical system]
	Factors influencing the effectiveness of the score or system in identifying patient conditions	Any evidence relating to factors influencing the effectiveness of scores/systems in identifying patient conditions
	Factors influencing the effectiveness of the score or system in triggering a response	Any evidence relating to factors influencing the effectiveness of scores/systems in triggering a response
	Insights relating to de-commissioning or de-implementation	Any insights set out by <u>study authors</u> relating to de-commissioning or de-implementation of previous systems or practices
Information relating to the specific score or system	PEWS score or system(s) covered	List the name(s) of any PEW scores, systems or 'track-and-trigger system' covered (if more than one, use a separate line for each one)
	PEWS type	State whether a PEW Score, PEW System or 'track-and-trigger' system
	Definition of score or system	How is the PEW score, system or 'track-and-trigger' system defined?

	Features	<i>What are the key features of the PEW score, system or 'track-and-trigger' system?</i>
	Format	<i>What is the format of the score or system? E.g. composite score or a process for reaching a score</i>
	Geographical details	<i>Where has the PEW score or system been implemented? As much information as is available, e.g. region, city, specific hospital(s)</i>
	Prevalence	<i>Record here any information that indicates the prevalence of use of a particular PEWS Score or system, e.g. the number of trusts using it</i>
	Strengths of scores or systems	<i>Any identified strengths of specific scores or systems [NOTE: just of the score/system itself - not the wider socio-technical system]</i>
	Weaknesses of scores or systems	<i>Any identified weaknesses of specific scores or systems [NOTE: just of the score/system itself - not the wider socio-technical system]</i>
	<u>Researcher</u> insights and inferences (PEWS-specific)	<i>Observations or Inferences made by <u>researchers</u> about specific PEWS -features, strengths, weaknesses</i>
	Comment on quantity and/or quality of evidence	

## Annex C. Table of PEWS in use in UK

Table 4: A selection of PEWS in use in the UK

Name of specific PEWS	Score-based or trigger-based	# parameters	Parameters	# age bands	Format
Bedside PEW System*	Score-based	7	Oxygen saturation Heart rate Respiratory rate Systolic blood pressure Capillary refill time Respiratory distress Oxygen therapy	5	N/A
Bristol PEW tool*	Trigger-based	14	Oxygen saturation Heart rate Respiratory rate Staff concern Seizure Glasgow Coma Score Apnoea +/- bradycardia Diabetic ketoacidosis Clinical tiring or complete airway obstruction Hyperkalaemia Nebulised adrenaline Signs of shock (prolonged capillary refill time, poor perfusion, low blood pressure) Suspected meningococcus Unresponsive or only responding to pain	5	Single parameter trigger score (If any one indication is fulfilled, action is taken)***
Cardiff and Vale PEW System*	Score-based	8	Oxygen saturation/oxygen therapy (combined under one parameter) Heart rate Respiratory rate Systolic blood pressure Staff concern Respiratory Consciousness Airway threat	5	N/A
MET activation criteria I (Medical emergency)	Trigger-based	9	Oxygen saturation Heart rate Respiratory rate Systolic blood pressure Staff concern	5	N/A

team activation criteria)*			Consciousness/seizure (combined under one parameter) Respiratory distress/apnoea or cyanosis (combined under one parameter) Airway threat Cardiac or respiratory arrest		
NHSI PEWS (NHS Institute PEWS)*	Score-based	7	Oxygen saturation Heart rate Respiratory rate Staff concern/parent concern (combined under one parameter) Consciousness Respiratory distress Stridor, apnoea	4	N/A
PEW Score I*	Score-based	4	Respiratory Behaviour Cardiovascular Vomiting post-surgery/15m nebulisers (combined under one parameter)	1	N/A
PEW System Score I*	Score-based	19	Oxygen saturation Heart rate Respiratory rate Systolic blood pressure Capillary refill time Temperature Glasgow coma score Oxygen therapy More than 3 medical specialties involved in care Abnormal airway (not tracheostomy) Bolus fluid Central venous line in situ Gastrostomy Home Oxygen Medication score Previous admission to ICU Pulses Severe cerebral palsy Transplant recipient	5	N/A
Brighton PEWS**	Score-based	5	Respiratory rate Heart rate Respiratory effort/distress Loss of consciousness/behaviour Capillary refill time Oxygen therapy Skin colour Quarter hourly nebulisers Persistent vomiting post-surgery (Some of these are combined under 1 parameter – for example, heart rate, skin colour and	1	Aggregate score Score range 0-13 (Behaviour, Cardiovascular and Respiratory all scored 0-3, and 2 points added for ¼ hourly nebulisers or persistent

Melbourne activation criteria (MAC)**	Trigger-based	9	capillary refill time are scored under one cardiovascular parameter)  Respiratory rate Heart rate Respiratory effort/distress Level of consciousness/behaviour Oxygen saturation Systolic blood pressure Staff concern Airway problems Cardiac or respiratory arrest	>1	vomiting after surgery)***  Single parameter trigger score (If any one indication is fulfilled, action is taken)***
Paediatric Observation Priority Score (POPS)***	Score-based	8	Pulse Respiratory rate Temperature Oxygen saturation Breathing effort Level of consciousness (AVPU) Gut feeling Other (oncology patient, significant PMH, congenital heart disease)	5	Aggregate score  Each parameter scored 0-2; Any child with an aggregate score above 8 should be considered for escalation
Paediatric Advanced Warning Score (PAWS)*** (modified from Brighton PEWS)	Score-based	3	Respiratory rate Heart rate Respiratory effort/distress Loss of consciousness/behaviour Capillary refill time Oxygen therapy Skin colour Quarter hourly nebulisers Persistent vomiting post-surgery (Some of these are combined under 1 parameter – for example, heart rate, skin colour and capillary refill time are scored under one cardiovascular parameter)	1	Aggregate score  Score range 0-13 (Behaviour, Cardiovascular and Respiratory all scored 0-3, and 2 points added for hourly nebulisers or persistent vomiting after surgery)

\*Information extracted from [1]

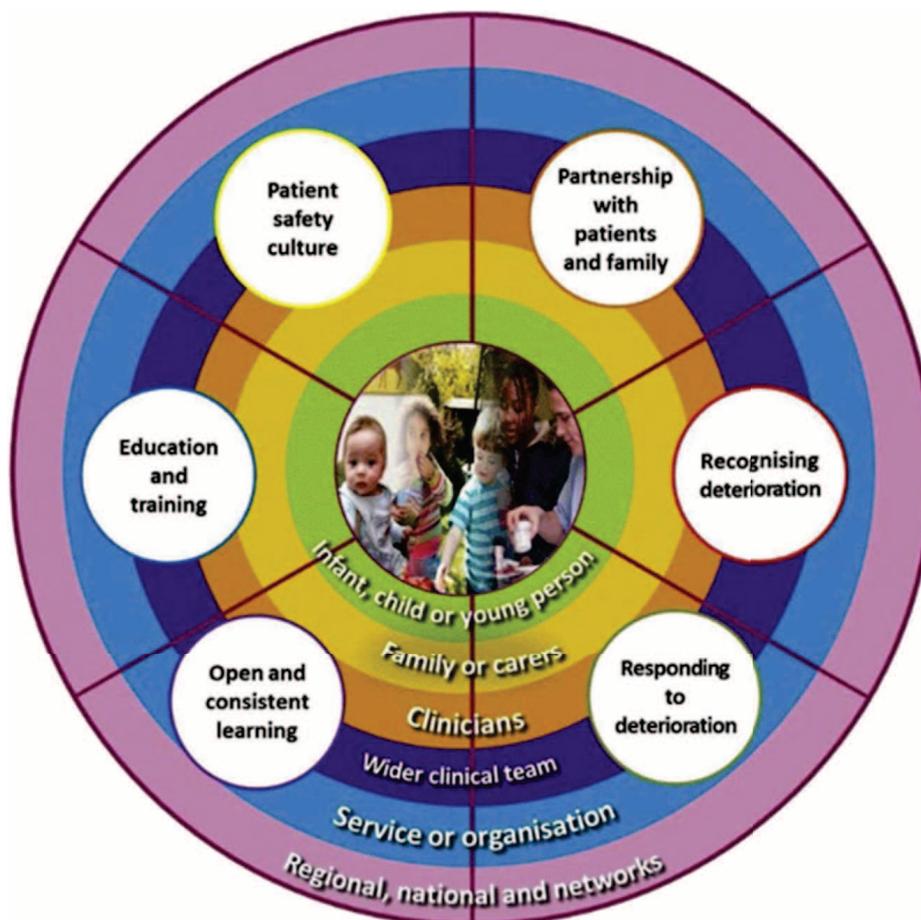
\*\*Information extracted from [2]

\*\*\*Information extracted from [3]

## Annex D. Safe Systems Framework Conceptualisation

The Safe System Framework for children at risk of deterioration, developed by NHS Improvement and the Royal College of Paediatrics and Child Health (referenced in the commentary by Roland (2017) [11]) conceptualises the PEW system in terms of nested levels of support for the identification of and response to the deteriorating child. This model places the infant, child or young person at the centre, supported by family or carers, clinicians providing direct care, the wider clinical team, service providers and regional and national networks. The framework specifies six core elements of a safety system, requiring engagement across these groups: (i) developing a patient safety culture; (ii) creating partnerships with patients and families; (iii) recognising deterioration; (iv) responding to deterioration; (v) open and consistent learning through evaluation; and (vi) education and training.

Figure 1: Safe Systems Framework Conceptualisation [4]



## Annex E. References in Annexes

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1. Chapman, S.M., et al. *Systematic review of paediatric track and trigger systems for hospitalised children*. Resuscitation. 2016. **109**: pp. 87-109.
2. Trubey, R., 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** (5): p. e022105.
3. Lambert, V.e.a. *A systematic literature review to support the development of a National Clinical Guideline – Paediatric Early Warning System (PEWS)*. 2014. School of Nursing and Human Sciences (SNHS).
4. Roland, D. *Paediatric Early Warning Systems: myths and muses*. Paediatrics and Child Health. 2017. **27** (5): pp. 242-46.