

**Use of Paediatric Early Warning Systems in Great Britain – Has there been a change of practice in the last 7 years?**

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## **Abstract**

**Objective:** To determine the use of Paediatric Early Warning Systems (PEWS) and Rapid Response Teams (RRTs) in paediatric units in Great Britain.

**Design:** Cross sectional survey.

**Setting:** All hospitals with inpatient paediatric services in Great Britain.

**Outcome measures:** Proportion of units using a PEWS, origin of PEWS used, criterion included in PEWS, proportion of units with a RRT and membership of RRT.

**Results:** The response rate was 95% (149/157). 85% of units were using a PEWS and 18% had an RRT in place. Tertiary units were more likely than District General Hospital to have implemented a PEWS, 90% versus 83%, and a RRT, 52% versus 10%. A large number of PEWS were in use, the majority of which were unpublished and unvalidated systems.

**Conclusion:** Despite the inconclusive evidence of effectiveness, the use of PEWS has increased since 2005. The implementation has been inconsistent with large variation in the PEWS used, the activation criteria used, availability of an RRT and the membership of the RRT. There must be a co-ordinated national evaluation of the implementation, impact and effectiveness of a standardised PEWS programme in the various environments where acutely sick children are managed.

## BACKGROUND

Paediatric Early Warning Systems (PEWS) have been established for use in acutely unwell children in order to identify the physiological and behavioural signs of deterioration prior to collapse[1]. These include ward-based systems in both district general and tertiary hospitals and also those used in emergency and urgent care departments[2, 3, 4]. The umbrella term “Early Warning Systems” is used to describe the implementation of pre-defined alert criteria within observations charts which trigger additional nursing or medical involvement either from the assigned clinical team or from a critical care outreach service[5]. A variety of systems exist with a general trend for an observation chart layout with at least heart rate, respiratory rate, temperature and saturations being part of a key data set [2,3,4,5]. The evidence supporting the use of such systems is not entirely clear and, although intuitively beneficial, systematic reviews have not demonstrated this[6,7]. A variety of reasons may contribute to this finding which includes poor sensitivity and specificity of the tool, poor completion of observations charts and inadequate educational implementation[8].

In 2005, 21.5% of NHS trusts in the UK that care for children used a PEWS [11]. Eight of the 31 PEWS in use were a variation of two previously published tools, the Bristol[12] and Brighton[13] models. The PEWS in use were extremely variable, 36 different parameters were used in various combinations. No parameters were used in all of the PEWS, the most common used parameter (respiratory rate) was utilised in just over half of the PEWS.

Recently in the UK a number of major case reviews of childhood deaths have cited either the absence of proper assessment or a failure to act on warning signs from an assessment as contributing factors. In response to these deficiencies Confidential Enquiry into Maternal and Child Health (CEMACH) [9] recommend that PEWS are utilised in environments which care for children. The Children and Young People’s Health Outcomes Forum [10] recommended the same, and highlighted further research is required to establish PEWS’ role in keeping children safe.

In order to determine whether the use of PEWS has altered, potentially in response to these reports, a survey of hospitals with paediatric in-patients was undertaken. For the purpose of the survey, PEWS were defined as a system where patients are given a value based on objective or subjective criteria and Rapid Response Teams [RRT] were defined as individuals with enhanced critical care skills (nursing, medical or physiotherapy background) who are available in addition to the usual nursing and medical team.

## **METHODS**

An electronic survey was created in Survey Monkey™ which included questions in the 2005 PEWS survey as well as additional questions on number of beds, composition of an RRT if utilised and derivation, auditing and validation of a PEWS tool if present. A question on the parameters used in PEWS was taken directly from the results of the 2005 survey with an additional field of 'other' with a free text response. This survey was piloted on a small number of consultants known to use PEWS in their departments.

A list of NHS trusts in England was obtained[14]. The trusts were contacted by telephone to determine if they provided paediatric in patient care and those without were excluded from the survey. Between July 2011 and July 2012 the electronic survey link was sent to the clinical directors of all remaining NHS trusts in England. In Scotland and Wales the electronic survey link was sent to all college tutors by the office manager of the Royal College of Paediatrics and Child Health. Non-responders were sent a reminder e-mail and then contacted by phone. Another member of the clinical team was contacted if it was not possible to reach the clinical director or college tutor directly. A shorter telephone survey was completed in early 2013 with hospitals that had not completed the electronic survey. The results were transferred to Microsoft excel™ and analysed descriptively.

## RESULTS

157 hospitals were identified that provided paediatric in patient care. 126 hospitals were classified as a District General Hospital (DGH) and 31 as a tertiary hospital. The response rate to the electronic survey was 61.7% (97/157), to the telephone survey of non responders 86.7 % (52/60), giving an overall response rate of 94.9% (149/157). The overall response rate was 94.4% (119/126) in DGHs and 96.8% (30/31) in tertiary hospitals. DGHs made up 78.4% (76/97) of respondents to the electronic survey and 82.7% (43/52) of the telephone survey respondents.

84.6% (126/149) of units reported using a PEWS and 18.2% (26/144<sup>\*</sup>) had an RRT in place (<sup>\*</sup>5 hospitals, 4 DGHs and 1 tertiary, did not provide any information on a RRT in the telephone survey). PEWS were used in 83.2% (99/119) of DGHs and 90.0% (27/30) tertiary hospitals. RRTs had been introduced in 9.6% (11/115) of DGHs and 51.8% (15/29) of tertiary hospitals and in all cases included a doctor. Responders to the electronic survey were less likely to have implemented a PEWS (79.4% vs 94.2%) but more likely to have an RRT (24.7% vs 4.3%) than responders to the shorter telephone survey. Data presented in tables 1 - 4 were obtained from the electronic survey. 26 units who had introduced PEWS stated that their PEWS was based on a previously published system (Table 2). The identified systems were Brighton (9), Institute Of Innovation and Improvement (6), Bristol/Plymouth (4), Yorkshire (4), Toronto (1), Melbourne (1) and Cardiff (1).

Respiratory rate and Heart rate were the two most common criterion used in the PEWS systems with over 50% of respondents using these and oxygen saturations, abnormal consciousness and effort of breathing. 47 criterion were mentioned, 36 of these from the original 2005 survey and a further 11 additional ones. Capillary refill time, not utilised by hospitals in the 2005 survey, was used in six locations but no other additional criteria was used in more than two.

Table 1 – Implementation of PEWS and/or RRT by type of hospital from electronic survey

Type of System	Type of hospital		
	District General Hospital	Tertiary Centre	All
PEWS present and requires action by medical or nursing staff (No RRT)	48 (63.2%)	6 (28.6%)	54 (55.7%)
PEWS present and requires action by medical, nursing staff or RRT	10 (13.2%)	13 (61.9%)	23 (23.7%)
No PEWS present but RRT triggered by medical or nursing concern	1 (1.3%)	0 (0%)	1 (1.0%)
No PEWS or RRT present	17 (22.4%)	2 (9.5%)	19 (19.6%)
Total	76 (100%)	21 (100%)	97 (100%)

Table 2 – Origin of PEWS currently in use from electronic survey

PEWS Based on:	Number of Responses (percentages)
Previously published system	26 (33.8%)
Unpublished system in use at another hospital	19 (24.7%)
Purposely designed for own unit	15 (19.5%)

Unsure	8 (10.4%)
No response	9 (11.7%)
Total	77 (100%)

Table 3 -Membership of RRT by type of hospital from electronic survey

Member of RRT	Type of hospital	
	DGH n=11	Tertiary n=13
Paediatric Intensive Care Consultant	0 (0%)	4 (30.8%)
Paediatric Intensive Care Registrar	0 (0%)	8 (61.5%)
Paediatric Intensive Care Nurse	1 (9.1%)	8 (61.5%)
Advanced Nurse Practitioner	3 (27.3%)	5 (38.5%)
Paediatric Consultant	8 (72.7%)	4 (30.8%)
Paediatric Registrar	9 (81.8%)	10 (76.9%)
Paediatric SHO	10 (90.9%)	9 (69.2%)
Paediatric Nurse	10 (90.9%)	4 (30.8%)
Anaesthetist	8 (72.7%)	5 (38.5%)
Paediatric Intensive Care Consultant and/or Paediatric Consultant	8 (72.7%)	6 (46.2%)

Table 4 – Criteria used in PEWS from electronic survey

Criterion	DGH n=58		Tertiary n=19		Total n=77	
	number	%	number	%	number	%
Respiratory rate	52	89.7	16	84.2	68	88.3
Heart rate	52	89.7	16	84.2	68	88.3
Oxygen saturation	45	77.6	14	73.7	59	76.6
Abnormal consciousness	41	70.7	13	68.4	54	70.3
Respiratory effort	39	67.2	9	47.4	48	62.3
Nurse concern	33	56.9	9	47.4	42	54.5
Systolic blood pressure	28	48.3	13	68.4	41	53.2
Oxygen therapy	34	58.6	7	36.8	41	53.2
Temperature	28	48.3	7	36.8	35	45.5
Shock	29	50.0	5	26.3	34	44.2
Doctor concern	23	39.7	8	42.1	31	40.3
Respiratory arrest	21	36.2	7	36.8	28	36.4
Stridor/wheeze	19	32.8	6	31.6	25	32.5
Apnoea	20	34.5	4	21.1	24	31.2
Prolonged seizure	16	27.6	4	21.1	20	26.0

Remaining Criteria (criterion from original survey in bold)      Range of number of sites using criteria

Exhaustion	15-20
Burns>10%, Mean Blood pressure, Artificial airway, Nebulised medication, Meningococcaemia, Diabetic Ketoacidosis, Major Trauma, Need for ventilation,	10-14
Central line (temporary), Abnormal Coagulation, Inotrope Infusion, <b>Capillary Refill Time</b> , Abnormal serum sodium, Fluid Bolus > 10mls/kg, Arrhythmia, Abnormal serum potassium, Urine output, Acidosis.	5-9
<b>Airways threat</b> , Cardiac Pacing (temporary), Neutropenia.	2-4
<b>Abdominal pus drainage, Abdominal pain&gt;12 years of age, Bilious vomiting, Bleeding or blood loss, Anaphylaxis, Burns&gt;5%, Persistent vomiting post surgery, Predisposing risk (premature or special needs), Parental concern, Post ICU discharge.</b>	1

## DISCUSSION

Although the response rates differed and the denominators are likely to have changed over the time frame there has been an increase in the use of PEWS, 83% of District General Hospitals (DGHs) and 90% of tertiary centres now have PEWS in place. The higher uptake in tertiary centres could be explained by the greater presence of intensive care staff to provide an RRT who can respond to the PEWS or the perception of greater need arising from the more complex cases managed in these settings.

No randomised control trials of the effectiveness of PEWS and RRT, used either alone or in combination, have been published and results from before and after studies are inconsistent[6]. All of the before and after studies investigated the use of PEWS and RRT in combination[15, 16, 17, 18].. In our survey only a quarter of the units surveyed had an RRT in place, with a large difference between DGHs where only 10% of units had an RRT compared to 52% of tertiary centres. A potential explanation for the difference is that DGHs do not have additional or highly specialist staff available to make up an RRT. Where an RRT was in place in a DGH the majority of team members appeared to be staff that would have already been providing the care for the children. Although fewer DGHs had an RRT they tended to have more senior paediatricians in the team, 46% of RRTs in tertiary hospitals included a general or paediatric intensive care consultant compared to 73% in DGHs. The response to PEWS in DGHs is therefore normally provided by the staff whose concerns led to the introduction of PEWS and RRT in the first place.

The range of systems and criteria (Table 4) used in these systems is now even greater than in the 2005 survey. Respiratory and heart rate have increased from around 50% of use in the original survey to nearly 90% in our current review, with oxygen saturations, abnormal consciousness and respiratory effort also all increasing in use. Data supporting the use of these exists in systematic reviews [19] but not specifically for early warning score use. The increase may reflect increasing research in serious illness recognition or anecdotal believes corroborated by increasing PEWS use.

However the 47 criteria are an eclectic mix of physiological measurements, clinical examination findings, laboratory investigations, diagnoses and outcomes. Given ongoing concerns with the ability of health care professionals to recognise seriously ill children and media reports regarding the concerns of parents being unheeded it is perhaps surprising that only one system used parental concern. However this may reflect the lack of specific evidence on this particular parameter.

The survey has a number of potential limitations. We were unable to identify a definitive list of all hospitals which provide in patient paediatric care in Great Britain. It is possible that we failed to identify some units, however any omissions are likely to be small and are unlikely to affect our overall conclusions. The low response rate to the initial electronic survey necessitated the telephone survey of non responders. Concerns that response bias might lead us to overestimate the proportions of hospitals that had implemented a PEWS were unfounded. The slightly higher rate of PEWS utilisation in the initial non responders might be explained by the fact this part of the survey was undertaken at a later point in time.

## Recommendations

A National Early Warning Score (NEWS) for adult patients has been developed by a multi-disciplinary working party led by the Royal College of Physicians[20]. A similar approach could be led by the Royal College of Paediatrics and Child Health. Regardless if implementation of PEWS is to become universal whatever system is suggested must be simple to use and acceptable to the end user. The variety of parameters used by units creates difficulty in standardising a common chart but reflects the desire for units to have locally derived systems. It would seem sensible therefore that a common 'core' data set is obtained for all PEWS with the ability to add additional observations where required. A proposed system may include respiratory rate, heart rate and oxygen saturations as a minimum as this is the core data included in multiple PEWS systems and was the top three items in the survey results. Conscious level, respiratory effort, nursing concern, blood pressure and oxygen therapy may be suggested items as these are additional features highlighted in systematic reviews of

detecting serious illness[19] and used by at least 50% of units currently. Additional items may include temperature, presence of stridor/wheeze and additional treatments (infusions etc).

Despite the lack of definitive evidence of effectiveness and the potential for harm PEWS are being introduced in the UK. The potential for harm arise from "false negatives" where treatment of children who do not trigger a PEWS may be delayed and from "false positives" by the over treatment of children who would not have gone on to develop critical illness. Neither of these aspects has been thoroughly delineated for PEWS and although reformulating an approved medicine in a hospital pharmacy would be inconceivable it appears to be acceptable for hospitals to develop their own PEWS despite the absence of an evidence base about their performance characteristics.

A cluster randomised controlled trial of a PEWS in tertiary hospitals has been registered in North America[21] which does have arms in the UK. To complement this study, and address the difficulty of generalising results from different types of hospital, an exploration of the utilisation of PEWS in DGHs and Tertiary hospitals in the UK is urgently required. This would aim to determine the reasons for variability in implementation and use of different criterion.

## **CONCLUSION**

Improving seriously ill childrens' outcomes requires the right person at the right time with the knowledge and skills to intervene in a timely manner. Despite the inconclusive evidence of effectiveness, the use of PEWS has increased since 2005. The implementation has been inconsistent with large variation in the PEWS used, the activation criteria used, availability of an RRT and the membership of the RRT. It is difficult for units to resist the implementation of a PEWS system because of the perception that they must be a good thing, reinforced by feedback from critical case reviews and the recommendation of CEMACH. There must be a co-ordinated national evaluation of the implementation, impact and effectiveness of a standardised PEWS programme in the various environments where acutely sick children are managed.

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## **CONTRIBUTOR STATEMENT**

The original idea was conceived by Dr. Damian Roland and Dr. Colin Powell. Alison Oliver and Dr. Dawn Edwards collected and followed up data and Dr. Brendan Mason provided support in statistical analysis. Dr Roland prepared an initial draft and all authors contributed to subsequent revisions.

## **COMPETING INTERESTS**

No competing interests are declared.

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## **ETHICAL APPROVAL**

The authors reviewed the National Research Ethics Committee advice on defining research (Available from: <http://www.nres.nhs.uk/EasySiteWeb/GatewayLink.aspx?allId=355>) published in December 2009 and determined that this project was not classified as research.

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### **What is known about this topic**

Paediatric Early Warning scores (PEWS) are recommended by a number of national organisations and regulators

In 2005 less than 25% of UK hospitals had an early warning score system in use

### **What this study adds**

There has been a significant increase in the use of PEWS. Tertiary centres are more likely to use PEWS and have a RRT than district general hospitals. The specific make up of PEWS remains variable between hospitals and may include the use of un-validated systems.

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