Systematic review of paediatric alert criteria for identifying hospitalised children at risk of
critical deterioration

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CRD summary
This review found that evidence regarding the validity, reliability and utility of paediatric alert criteria was weak. Studies were needed to determine which physiological parameters or combinations of parameters best predicted serious adverse events. The included studies were limited both in the definition of parameters and their evaluation. Further research was needed. The authors' conclusions reflect the limited evidence.

Authors' objectives
To assess the number and nature of published paediatric alert criteria (that may be able to predict clinical deterioration) and evaluate their validity, reliability, clinical effectiveness and clinical utility.

Searching
CINAHL, The Cochrane Library, DARE, EMBASE and MEDLINE were searched for relevant studies published between January 1990 and February 2009. Search terms were indicated and the search strategy was provided in an online appendix. Reference lists of included articles were searched. Citation searching was performed using Web of Science. Corresponding authors of included studies and other relevant experts were contacted to review the list of studies for inclusion for completeness. Only papers published in full and in English were included.

Study selection
Studies were eligible if they described the development, testing or use of paediatric alert criteria (either an early warning score/system or activation/trigger criteria to mobilise a rapid response team) in hospitalised children cared for on wards outside the critical care setting. No inclusion criteria were specified regarding study design, but review articles and papers primarily dealing with adults were excluded unless data on paediatric patients could be adequately separated.

Studies were conducted in USA, Canada, Australia and UK. Most studies were conducted in children's hospitals; one was conducted in a tertiary centre for paediatrics in a university hospital. The purpose of the paediatric alert criteria in the different studies included activation of a rapid response team, screening of the acutely ill child and identification of children at risk of a blue code (imminent or actual cardiopulmonary arrest; also referred to as code rate). Criteria varied in complexity: the most complex paediatric alert criteria had 19 parameters; other studies had between five and 14 parameters. All paediatric alert criteria included a measure of consciousness; most included a measure of respiratory rate, heart rate and oxygen saturation. All of the age-dependent tools included heart rate, systolic blood pressure and respiratory rate as the age-related parameters. There was considerable diversity in cut-off points for activation of the paediatric alert criteria for the commonly monitored vital signs and there was a lack of consistency in the type and definition of parameters in the paediatric alert criteria and in use of age ranges (some studies used overlapping age ranges).

Abstracts of the studies identified in the search were checked against the inclusion criteria. Potentially eligible studies were examined in full. The authors did not state how many reviewers performed the selection, but they stated that they followed CRD guidance.

Assessment of study quality
Quality assessment was based on recommendations for developing clinical decision rules and guidance for systematic reviews of tests of diagnostic and prognostic accuracy. Studies were rated as adequate, unclear or inadequate based on study design by two authors according to the CRD criteria and McGinn et al. 2000 (the authors did not provide details on this analysis).

Data extraction
The data extraction form was based on that of a previous review of a related subject and included various parameters relevant to study design and evaluation: time to event; time period where data collection was censored; estimates of diagnostic accuracy (positive predictive value, sensitivity, specificity); study design; sample and follow-up of patients; outcome measures; prognostic variable; and statistical analysis.

The authors did not state how many reviewers performed the data extraction, but they stated that CRD guidance was followed.

Methods of synthesis
Paediatric alert criteria were classified as: single parameter systems (periodic observation of selected clinical signs compared to a simple set of criteria with predefined thresholds with a response algorithm activated when any criterion was met); multi-parameter systems (response algorithm involves more than one criterion being met or differs according to the number of criteria met); aggregate weighted scoring systems (weighted scores are assigned to physiological values and clinical signs and compared to predefined trigger thresholds); and combination systems (involved single- or multiple-parameter systems in combination with aggregate weighted scoring systems).

Paediatric alert criteria were also classified as age-dependent or age-independent. Parameters within each paediatric alert criterion were classified based on the categories: related to specific diagnosis; related to specific event; related to specific intervention; intuitive; based on objective clinical measure; based on subjective clinical measure; and mixed (combination of types listed).

Data were presented narratively using text and tables.

Results of the review
Eleven papers that described 10 paediatric alert criteria fulfilled inclusion criteria. Five of these reported method of development and diagnostic accuracy of the paediatric alert criteria in 4,470 cases and 308 controls (two studies included controls).

Three of the studies that reported methods of development and testing of accuracy of the paediatric alert criteria used a retrospective design and two used a prospective design (three had a quality rating of adequate and two of inadequate). Three paediatric alert criteria reported positive predictive values (between 2.2% and 5.8%), four reported sensitivity (between 78% and 90%) and specificity (between 64% and 95%), but not all reported data completely and correctly.

None of the studies reported the impact on patient outcomes of introducing paediatric alert criteria; five reported the effect of a rapid response team activated as a result of the paediatric alert criteria on rates of cardiac and respiratory arrest and hospital-wide mortality rates. Two studies showed significant reductions in hospital-wide mortality and code rates after introduction of a rapid response team. One of these studies also showed a reduction in preventable ward cardiopulmonary arrest. There were no improvements in overall ward cardiopulmonary arrest.

Only one study assessed inter rater reliability of the paediatric alert criteria, which was found to be high (intraclass coefficient 0.92, p<0.001). None of the studies examined ease and efficiency of use of paediatric alert criteria and user acceptability.

Authors’ conclusions
Evidence regarding the validity, reliability and utility of paediatric alert criteria was weak and further well-conducted studies were needed.

CRD commentary
This systematic review addressed a clearly stated research question. Appropriate broad inclusion criteria were defined. Measures were taken to avoid the introduction of error and bias during the review process. The literature search included a variety of relevant databases. Search terms were indicated. Only studies in English were included and relevant non-English studies may have been omitted. Methodological quality was assessed. Studies were presented in tables and text according to whether they had reported methods of development and diagnostic accuracy of paediatric.
alert criteria or not. Given the heterogeneity of the data available, a narrative synthesis was appropriate. No information was provided on the patient population and it seemed that there were also limits in reporting in the included studies. There was a lack of consistency in the parameters presented in the different studies, with a range of cut-off points (such as for vital signs) and criteria for overlapping age groups. Methodological quality was presented only for five studies (those that reported method of development and diagnostic accuracy) and only two of those were of adequate quality. On the whole, study designs were low quality.

The authors’ conclusions reflect the limited evidence and their recommendations for further research seem appropriate.

**Implications of the review for practice and research**

**Practice:** The authors cautioned against widespread adoption of paediatric alert criteria without more robust research. Hospitals that already used paediatric alert criteria should have ongoing performance monitoring that may highlight modifications to improve the performance of the tool. Hospitals that were considering the introduction of paediatric alert criteria should consider the criteria that best meet their local needs and patient population as evidence on validity and reliability was limited.

**Research:** The authors stated that studies were needed to determine which physiological parameters or combinations of parameters best predicted serious adverse events. These then needed to be evaluated prospectively for validity, reliability and utility before widespread adoption into clinical practice. For existing paediatric alert criteria, further studies were needed to determine levels of sensitivity and specificity in a variety of settings, taking into account the impact of age and type and severity of illness on performance of the paediatric alert criteria. In particular, valid cut-off points and age-related thresholds for vital signs should be investigated further.

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.