**PEWS CoSTR : GRADE Summary of Evidence :**

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**Question:** Pediatric early warning systems/scores (PEWS) with or without rapid response teams/medical emergency teams (RRTs/METs) compared to no PEWS or standard care (without a scoring system)

**Setting:** Infants, children, and adolescents in any inpatient setting

**Bibliography:**

| **Certainty assessment** | | | | | | | **№ of patientsd** | | **Effect** | **Certainty** | **Importance** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **№ of studies** | **Study design** | **Risk of bias** | **Inconsistency** | **Indirectness** | **Imprecision** | **Other considerations** | **PEWS** | **no PEWS / Standard care** | **IRR/RR** |
| **Mortality** | | | | | | | | | | | |
| 1 | RCT | not serious | not serious | not serious | seriousb | none | 97/251859 | 147/307584 | RR 1.24; 95 CI 0.95 to 1.62 (p=0.110) | ⨁⨁◯◯ Low | CRITICAL |
| 9 | Cohort Studies | seriousa | not serious | seriousa | very seriousb,c | none | 1231/473549 | 1762/532607 | pooled RR 1.17; 95% CI 0.98 to 1.40 (p=0.087) |
| **Cardiopulmonary Arrest** | | | | | | | | | | | |
| 6 | Cohort studies | seriousa | not serious | not serious | very seriousb,c | none | 104/480091 | 131/503759 | pooled IRR/RR 1.22; 95% CI 0.93 to 1.59 (p=0.153). | ⨁◯◯◯ Very low | CRITICAL |
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| **Significant clinical deterioration event**   |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 1 | RCT | not serious | not serious | not serious | seriousb | none | 127/251859 | 259/307584 | RR 1.67; 95% CI 1.34 to 2.08 (p<0.001) | ⨁⨁◯◯ Low | CRITICAL | | 5 | Cohort studies | seriousa | not serious | seriousa | very seriousb,c | none | 602/202357 | 616/212177 | Pooled RR 1.09; 95% CI 0.84 to 1.42 (p=0.517) |   **Unplanned code events** | | | | | | | | | | | |
| 4 | Cohort studies | seriousa | not serious | seriousa | very serious,b | none | 166/143766 | 292/251253 | pooled IRR/RR 1.73; 95% CI 1.01 to 2.96 (p=0.046) | ⨁◯◯◯ Very low | IMPORTANT |

**CI:** confidence interval; **IRR:** incidence rate ratio; **RR:** risk ratio

#### Explanations

a. Observational studies with “before and after” methodology,

b. Very few patients with outcome of interest

c. Very wide confidence intervals

**PEWS CoSTR : Evidence-to-Decision Table**

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| Question: | |
| **Do Pediatric Early Warning Systems reduce mortality and significant clinical deterioration? (A systematic Review)** | |
| **Population:** | Children born term (gestation ≥37 weeks) to ≤18 years old in the inpatient setting, including emergency departments |
| **Intervention:** | Pediatric early warning systems (PEWS) with or without rapid response teams (RRTs) |
| **Comparison:** | No pediatric early warning systems (PEWS) and no rapid response teams (RRTs) |
| **Main outcomes:** | A significant clinical deterioration event, including but not limited to: (1) Unplanned/crash tracheal intubation, (2) Unanticipated fluid resuscitation and inotropic/vasopressor use (3) Cardiopulmonary resuscitation (CPR) or Extracorporeal Membrane Oxygenation (ECMO) (4) Death in patients (all-cause mortality) without a Do Not Resuscitate (DNR) order. |
| **Setting:** | In-patient setting, including emergency departments |
| **Perspective:** |  |
| **Background:** | While there is limited evidence that pediatric early warning system interventions result in a reduction in in-hospital clinical deterioration, some effectiveness studies, with significant methodological limitations, appear to show clinical benefits. The use of pediatric early warning systems (PEWS) should decrease clinically important deteriorations on the wards in non-tertiary care / community hospitals. There was sufficient evidence to warrant a systematic review based on the scoping review performed in 2020. |
| **Conflict of interests:** | None |

# Assessment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | Recognizing early clinical deterioration and responding clinically in a timely manner in pediatrics is important in improving clinical care and outcome for potentially ill and seriously ill children.  There is good evidence that pediatric early warning systems (PEWS) help identify early deterioration with many studies conducted validating the various pediatric early warning scores developed as well as pediatric rapid response teams (RRTs). |  |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ○ Moderate ● Large ○ Varies ○ Don't know | The patient-centric outcomes of reduction in mortality, reduction in cardiopulmonary arrest events in hospital paediatric patients are highly desirable.  If proven to be effective through early recognition triggering early intervention, pediatric early warning systems can be instrumental in saving lives and improving functional outcomes for children at risk of clinical deterioration. |  |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large ○ Moderate ○ Small ● Trivial ○ Varies ○ Don't know | No substantial undesirable anticipated effects were seen in studies published. |  |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ● Low ○ Moderate ○ High ○ No included studies | The systematic review and meta-analysis demonstrated trends of pediatric early warning systems decreasing in-hospital mortality, cardiopulmonary arrest events, and significant clinical deterioration events, although not to statistically significant levels. Based on observational studies, it did show a significant decrease in code events.  However, there were significant limitations in the studies. Parshuram 2018 (which is the only RCT) was limited by the variation in the effector arm. The pediatric early warning system observational studies all used before-and-after study-designs, with the inherent limitations of unaccounted or confounding variables and contemporaneous trends and the inability to develop a comparable control group with the potential for risk of bias. The studies that used mortality as an outcome had a very low event rate and studies that used clinical deterioration had varying definitions including cardiopulmonary arrest. | Many studies focus on the derivation and validation of various pediatric early warning systems. These studies demonstrated that pediatric early warning systems were able identify a sick child early, with robust performance.  Demonstrating a statistically significant effect after a new implementation is difficult given the limitations. Quality improvement methodology could be used to regulate the impact of pediatric early warning systems that requires a series of changes that include educational processes, documentation review with feedback systems, and modification of other factors thought to improve the delivery of care.  While this systematic review and meta-analysis as a whole did not demonstrate a statistically significant decrease in critical outcomes of mortality, cardiopulmonary arrest events and significant clinical deterioration events, it does not necessarily show a lack of clinical benefit or value of pediatric early warning systems.  This systematic review and meta-analysis suggest that more randomized controlled trials with an efferent arm should be undertaken to validate current findings. |
| Values Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ●No important uncertainty or variability | There is no uncertainty or variability in using mortality as a key outcome.  In the pediatric early warning system studies, mortality is a common outcome marker. A major limitation to evaluation of these systems is the low rate of pediatric cardiopulmonary arrest and mortality (especially outside the intensive care unit setting), including within the hospitals from which the data in this analysis originate. As such, demonstrating a statistically significant effect after a new implementation is difficult.  There is paucity of studies looking at uncertainty about or variability in how people value using clinical outcomes other than mortality and cardiopulmonary arrest and instead use other clinical deterioration events as clinical outcomes in pediatric early warning system studies. | In measuring effectiveness of pediatric early warning systems, other critical and important outcomes like critical deterioration events and code blue events should be used in future studies. |
| Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison  ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know | In this systematic review and meta-analysis, mortality, cardiopulmonary arrest outside of intensive care, significant clinical deterioration, and code events were used as clinical outcome markers. Most studies demonstrated that these clinical events were generally low frequency (especially outside the critical care setting). However, in any systems that have inpatient monitoring systems (whether specifically pediatric early warning systems or otherwise) with ongoing process-improving initiatives, these would likely result in decrease frequency in these events.  There was a demonstrated significant decrease in codes events and trend towards decreased in-hospital mortality, cardiopulmonary arrest events and significant clinical deterioration. While it is not certain that pediatric early warning systems are superior to no pediatric early warning systems in decreasing these, the critical outcomes of interest, the absence of clinical benefit does not necessarily show its lack of benefit or value.  Future specific research will need to focus on prospective evaluation of different pediatric early warning systems with efferent arms for predicting, identifying, and providing early intervention for patients at risk for different forms of decompensation, including primary respiratory, circulatory, and neurologic etiologies. Additional outcome measures apart from cardiopulmonary arrest rate or hospital mortality are required. Future studies using the incidence of significant clinical deterioration as key clinical outcomes should be undertaken. | Our taskforce reaffirms that the implementation of pediatric early warning systems should be part of an overall clinical response system, with the task force placing a higher value on improving healthcare provider ability to recognize and intervene for patients with deteriorating illness over the expense incurred by a healthcare system committing significant resources to implement pediatric early warning systems. The task force also noted that the complex process of optimizing patient care is likely to include both the implementation of pediatric early warning systems and ongoing healthcare provider education. |
| Resources required How large are the resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ● Varies ○ Don't know | There is paucity of studies looking at resources required using pediatric early warning scores and pediatric early warning systems with or without rapid response teams.  Furthermore, these further studies should look not only at the health economic impact and benefits of pediatric early warning systems in resource-rich healthcare institutions but also in healthcare institutions in resource-limited countries. | Our taskforce agreed that the decision to use pediatric early warning systems or other validated inpatient monitoring systems should be balanced between use of existing resources and capabilities of the healthcare setting to adapt to its use and the consequences of its use. |
| Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ● Low ○ Moderate ○ High ○ No included studies | There is paucity of studies looking at required resources required to develop and sustain pediatric early warning scores and pediatric early warning systems with or without rapid response teams in healthcare institutions.  These further studies should look not only at pediatric early warning systems in resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries.  Many studies, while not describing cost per se, did provide details into the training, staffing and implementation resources required for pediatric early warning systems. These are variable across sites depending on: 1) Existing infrastructure, including level of care (e.g., tertiary pediatric center, intensive care unit); 2) Resource-availability (24/7 specialist availability, respiratory technicians, etc.); 3) Need and duration of training. | Our taskforce placed a higher value on the potential to recognize and intervene for patients with deteriorating illness over the expense incurred by a healthcare system committing significant resources to implement pediatric early warning systems or validated inpatient monitoring systems.  We recognize that the decision to use these inpatient monitoring systems should include staff education, workflows, and audits. This should be balanced by the existing resources and capabilities of the institution. |
| Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ No included studies | There is paucity of studies looking at cost effectiveness of pediatric early warning scores and pediatric early warning systems with or without rapid response teams in healthcare institutions.  However, if implementation of a pediatric early warning systems does decrease mortality and morbidity, it would prevent downstream patient morbidity and mortality. As such it would likely be cost-effective.  Future studies should be undertaken to evaluate cost-effectiveness of pediatric early warning systems in resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries. |  |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know | There is paucity of studies looking at equity of pediatric early warning scores and pediatric early warning systems with or without rapid response teams in healthcare institutions.  These further studies should look not only at PEWS in resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries. When powered with more analyzable data, these should be stratified by resource-availability e.g., Gross National Income or Sociodemographic Index status of the country. |  |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know | There is paucity of studies looking at acceptability of pediatric early warning scores and pediatric early warning systems with or without rapid response teams in healthcare institutions.  These further studies should look not only at pediatric early warning systems in resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries. |  |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know | There is paucity of studies looking at feasibility of pediatric early warning scores and pediatric early warning systems with or without rapid response teams in healthcare institutions.  These further studies should look not only at pediatric early warning systems in resource-rich healthcare institutions but also in healthcare institutions from resource-limited countries. |  |

# **Summary of judgements**

|  | **Judgement** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Problem** | No | Probably no | Probably yes | **Yes** |  | Varies | Don't know |
| **Desirable Effects** | Trivial | Small | Moderate | **Large** |  | **Varies** | Don't know |
| **Undesirable Effects** | Large | Moderate | **Small** | **Trivial** |  | Varies | Don't know |
| **Certainty of evidence** | Very low | **Low** | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | **Probably favors the comparison** | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **Certainty of evidence of required resources** | **Very low** | **Low** | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **Equity** | Reduced | **Probably reduced** | **Probably no impact** | **Probably increased** | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Feasibility** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |

# **Type of recommendation**

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| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
| ○ | ○ | ○ | ● | ○ |

# **Conclusions**

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| Recommendation |
| **Treatment Recommendations**  We suggest using pediatric early warning systems to monitor hospitalized pediatric patients with the aim of identifying those who may be deteriorating (weak recommendation, low quality evidence). |
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| Justification |
| The PLS Task Force concluded that the implementation of pediatric early warning systems should be part of an overall clinical response system, with the task force placing a higher value on improving healthcare provider ability to recognize and intervene for patients with deteriorating illness over the expense incurred by a healthcare system committing significant resources to implement pediatric early warning systems. The task force also noted that the complex process of optimizing patient care is likely to include both the implementation of pediatric early warning systems and ongoing healthcare provider education. The PLS Task Force agreed that the decision to use pediatric early warning systems should be balanced between use of existing resources and capabilities of the healthcare setting to adapt to its use and the consequences of its use.  In making these recommendations, the PLS Task Force considered the following:  Values, Preferences, and Task Force Insights  The evidence is equipoised to justify the use of pediatric early warning systems to significantly decrease in-hospital pediatric mortality, significant clinical deterioration, and cardiopulmonary arrest events. However, in systems with available resources that prioritize and value the potential to decrease the incidence of code events for inpatient pediatric patients, there was very weak evidence to support the use of pediatric early warning systems in this context.  The taskforce recognized the significant limitations of available evidence in its treatment recommendations, but also the importance and the potential value of improving healthcare providers’ ability to recognize and intervene for patients with deteriorating illness. The use of pediatric early warning systems should be balanced with the expense incurred by a healthcare system committing significant resources to implement pediatric early warning systems. This complex process of optimizing patient care is likely to include both the implementation of pediatric early warning systems as part of a system and ongoing healthcare provider education. The PLS Task Force agreed that the decision to use pediatric early warning systems should be balanced between use of existing resources and capabilities of the healthcare setting to adapt to its use, and the consequences of its use.  For existing systems using pediatric early warning systems, local validation, site-specific adaptation of its use, and longitudinal evaluation of its effectiveness are important.  Knowledge Gaps & Recommendations  • The amount and quality of evidence in children compared with adults for the role of Early Warning Systems or Scores in the inpatient setting is very low. In the pediatric early warning system studies, mortality is a common outcome marker. A major limitation to evaluation of these systems is the low rate of pediatric cardiopulmonary arrest and mortality (especially outside the intensive care unit setting), including within the hospitals from which the data in this analysis originate. As such, demonstrating a statistically significant effect after a new implementation is difficult. We recommend that a workgroup should be set up to recommend & standardize important clinical outcomes that should be tracked and measured following implementation of pediatric early warning systems in hospitals and healthcare systems.  • The other major limitation in our analysis is the use of before-and-after studies, with the inherent limitations of unaccounted or confounding variables and inability to develop a comparable control group associated with the problems of confounding variables and contemporaneous trends. Future studies should not be limited to RCTs but include comparative study approaches as well as Quality Improvement (QI) and longitudinal studies. Quality improvement methodology could be used to regulate the impact of a series of changes that include educational processes, documentation review with feedback systems, and modification of other factors thought to improve the delivery of care.  • Further studies for pediatric early warning systems should focus on controlled trials evaluating RRT compared to no RRT and various compositions of efferent arms and look into specific pediatric subgroups including pediatric patients in the emergency department setting and specific subgroups of pediatric disease populations – e.g. pediatric oncology and prospectively evaluate different pediatric early warning systems for predicting, identifying, and provide early intervention for patients at risk for different forms of decompensation, including primary respiratory, circulatory, and neurologic etiologies.  • Other future studies should look at pediatric patients in the out-of-hospital setting as well as pediatric patients in resource-rich countries and patients from resource-limited countries and these studies should be powered with more analyzable data and be stratified by resource-availability e.g., Gross National Income or Sociodemographic Index status of the country.  • With regards to pediatric early warning systems implementation considerations, studies should look into staff training/education methodology for pediatric early warning systems implementation, resourcing; feasibility; cost-effectiveness; equity and acceptability of pediatric early warning systems into the existing healthcare systems. |

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| Subgroup considerations |
| * Pediatric patients in the emergency department setting * Pediatric inpatients * Specific subgroups of pediatric disease populations – e.g., pediatric oncology etc. * Pediatric patients in the out-of-hospital setting * Pediatric patients in resource-rich countries and patients from resource-limited countries |
| Implementation considerations |
| * Resourcing * Feasibility * Cost-effectiveness * Equity and * Acceptability |

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| Monitoring and evaluation |
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| Research priorities |
| * Future studies should not be limited to RCTs but include comparative study approaches as well as Quality Improvement (QI) and longitudinal studies. Quality improvement methodology could be used to regulate the impact of a series of changes that include educational processes, documentation review with feedback systems, and modification of other factors thought to improve the delivery of care. * Further studies for pediatric early warning systems should focus on controlled trials evaluating RRT compared to no RRT and various compositions of efferent arms and look into specific pediatric subgroups including pediatric patients in the emergency department setting and specific subgroups of pediatric disease populations – e.g. pediatric oncology and prospectively evaluate different pediatric early warning systems for predicting, identifying, and provide early intervention for patients at risk for different forms of decompensation, including primary respiratory, circulatory, and neurologic etiologies. * Other future studies should look at pediatric patients in the out-of-hospital setting as well as pediatric patients in resource-rich countries and patients from resource-limited countries and these studies should be powered with more analyzable data and be stratified by resource-availability e.g., Gross National Income or Sociodemographic Index status of the country. * With regards to pediatric early warning systems implementation considerations, studies should look into staff training/education methodology for pediatric early warning systems implementation, resourcing; feasibility; cost-effectiveness; equity and acceptability of pediatric early warning systems into the existing healthcare systems. |