

BRIEF REPORT

Reliability and Usability of a 7-Minute Chart Review Tool to Identify Pediatric Prehospital Adverse Safety Events

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BACKGROUND AND OBJECTIVES: Although medical errors in the hospital are a recognized source of morbidity and mortality, less is known about safety events in the prehospital care of children. As part of a multiphase study, we developed and evaluated the reliability and usability of the pediatric prehospital safety event detection system (PEDS), a tool used to identify safety events in prehospital care.

METHODS: The tool was based on hospital chart review tools, literature review, and results from focus groups and a national Delphi survey. After reviewer training, preliminary testing, and initial use, we refined the tool on the basis of data analysis and reviewer feedback. Thirty charts were randomly selected from our study population of pediatric transports with lights and sirens in Multnomah County, Oregon, and independently reviewed by 2 pediatric emergency physicians with experience in prehospital care to evaluate interrater reliability and time to completion of the final tool.

RESULTS: The PEDS tool contains 36 items, takes reviewers a median of 7 minutes to complete (interquartile range: 4–12), and exists in both paper and electronic formats. When comparing the presence or absence of severe safety events between 2 expert arbiters, we found 87% agreement ($\kappa = 0.68$), indicating good agreement.

CONCLUSIONS: The PEDS tool is the first chart review tool designed to identify safety events for children receiving prehospital care, and it displayed good usability and reliability in this study. With this tool, we provide a novel mechanism for researchers, clinicians, and prehospital care leaders to identify opportunities to improve care for children.

ABSTRACT

www.hospitalpediatrics.org

DOI:https://doi.org/10.1542/hpeds.2017-0155

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HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: Dr Eriksson received funding from the Agency for Healthcare Research and Quality (K12 HS022981); the other authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: Funded by the National Institute for Child Health and Human Development of the National Institutes of Health under award number 1 R01 HD062478. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Funded by the National Institutes of Health (NIH).

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Dr Eriksson contributed to the conception and design of the study and the design of the data collection instrument (chart review tool), interpreted data, drafted parts of the initial manuscript, and reviewed and revised the manuscript; Ms Ovregaard contributed to the design of the data collection instrument (chart review tool), analyzed and interpreted data, drafted parts of the initial manuscript, and critically reviewed the manuscript; Drs Hansen and Meckler contributed to the conception and design of the study, contributed to the design of the data collection instrument (chart review tool), acquired and interpreted data, and critically reviewed the manuscript; Ms Skarica coordinated and supervised data collection and critically reviewed the manuscript; Dr Guise conceptualized and designed the study, contributed to the design of the data collection instrument (chart review tool), interpreted data, and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.



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Prehospital care provided by emergency medical services (EMS) personnel, including first responders, emergency medical technicians, and paramedics, is an essential component of the emergency care system for children. Medical errors and other safety events represent a significant source of morbidity and mortality in hospitalized patients, including children.¹⁻³ Much less is known about medical errors in EMS, but authors of emerging literature have identified many areas in which pediatric prehospital care could be improved.⁴⁻⁹

Medical chart review has been used to systematically characterize errors and adverse events for hospitalized patients, playing an essential role in understanding and improving care quality.¹⁰⁻¹⁴ There are no existing tools in use to guide an organized and efficient review of pediatric prehospital charts, which represents a key barrier to studying and improving the quality and safety of prehospital care for children. Our objective was to create and validate the first retrospective chart review tool for the pediatric prehospital environment to facilitate the systematic detection of adverse safety events for children receiving EMS care. We have reported elsewhere the results of chart reviews using a preliminary version of this tool^{15,16}; with this report, we describe the creation and validation of a streamlined tool.

METHODS

The Children's Safety Initiative—Emergency is a large multiphase study funded by the National Institutes of Health to characterize the epidemiology of patient safety events in the prehospital emergency care of children.^{4,17-20} We developed the pediatric prehospital safety event detection system (PEDS) chart review tool on the basis of hospital chart review tools.^{10,21,22} Building on our previously reported findings of focus groups of EMS providers¹⁸ and a national Delphi survey of prehospital care experts,¹⁷ which was used to identify and categorize factors contributing to safety events, we developed and refined tool content and established content validity. In Fig 1, we describe the steps taken during the development and validation of the tool.

We obtained electronic patient care reports for EMS transports with lights and sirens

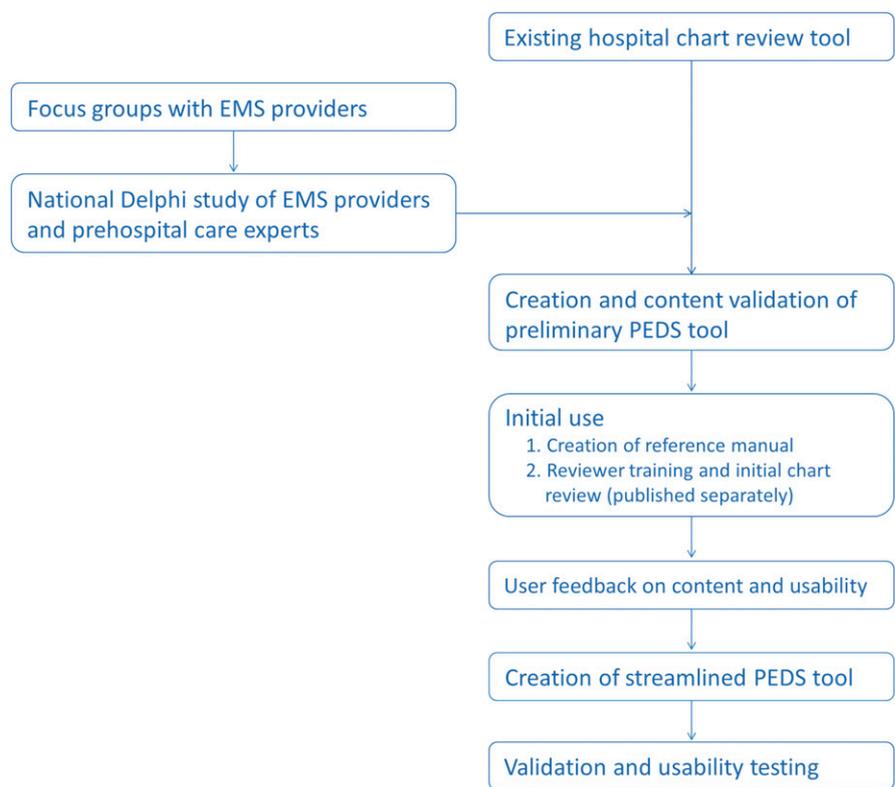


FIGURE 1 Development and validation of the PEDS chart review tool.

(indicating a time-sensitive emergency condition such as cardiac arrest) from 2009 to 2011 for patients <18 years of age in Multnomah County, Oregon. These patient care reports (which represent the electronic “chart” for prehospital care) adhere to the National EMS Information System standard and include highly structured data elements containing demographic and medical information,²³ as well as a free-text narrative. We trained paramedic and emergency medicine physicians in the use of a preliminary version of this tool for a separately reported chart review project.¹⁶ We created a reference manual to help reviewers understand the intent of the tool items and answer common questions. Reviewers were encouraged to ask questions and provide feedback on the content and usability of the tool and reference manual; on the basis of reviewer input, these were iteratively updated during the initial phases of the chart review. On the basis of our experiences using the preliminary tool, items that were redundant, unused, or generated ambiguous data were

eliminated using study team consensus. The tool was also streamlined to enhance usability and clarity, although key content remained unchanged (see Table 1 and Fig 2 for a description of tool elements and format, which are described in more detail in the results section). An electronic version was created by using REDCap secure tools hosted at Oregon Health and Science University.²⁴

Validation methods were based on recommendations for retrospective chart reviews.²⁵ We randomly selected 30 charts for review from charts used to describe pediatric transports from 2009 to 2011 in Multnomah County with lights and sirens; 2 pediatric emergency medicine physicians familiar with previous versions of the tool (M.H. and G.M.) served as reviewers for interrater reliability testing. We calculated the percent agreement in the detection of a severe adverse safety event (SAS version 9.4; SAS Institute, Inc, Cary, NC). We focused on severe adverse safety events; although the identification of less severe events may be subjective, we

TABLE 1 Organization of the PEDS Chart Review Tool

Section Number	Section Name	Description	Total, No. Items	Free Text, No. Items	Multiple Choice, No. Items	Ordinal Scale, No. Items
1	Case identification and clinical background	Reviewer name, case background, patient characteristics, primary diagnosis	12	11	1	0
2	Assessment, diagnosis, and clinical decision-making	Details of safety events related to assessment, diagnosis, and decision-making, as well as resuscitation protocols	5	0	3	2
3	Procedures and interventions	Details of safety events related to procedures and airway interventions	6	0	4	2
4	Medications and fluids	Details of safety events related to medications and intravenous fluids	11	0	7	4
5	Overall assessment	Primary factor associated with safety events and ranking of each domain's contribution to safety events	2	1	0	1

expected to find best agreement in the detection of events that had the potential for permanent harm or death. Interrater reliability was assessed with Cohen's κ coefficient (Stata Statistical software, release 14; StataCorp, College Station, TX). The results were compared with known thresholds for evaluating κ ($\kappa > 0.75$ indicates

excellent reproducibility, $0.4 \leq \kappa \leq 0.75$ denotes good reproducibility, and $\kappa < 0.4$ indicates marginal reproducibility).^{26,27} To assess usability, we measured the combined time required by research assistants and reviewers to complete a chart review using the electronic version of the tool.

After interrater reliability testing, we reviewed discrepancies between expert arbiters to refine guidance for reviewers in the reference manual.

RESULTS

The final PEDS tool contains 36 items in 5 sections (Table 1). Some items include discrete data elements that can be completed by a research assistant; remaining items are completed by a clinical reviewer (Fig 2). Adverse safety events are identified in each of the following clinical domains: (1) assessment, impression and/or diagnosis, and clinical decision-making; (2) procedures and airway interventions; and (3) medications and fluids. Events are also categorized by type (unintended injury or consequences, near misses, suboptimal actions, errors, or management complications), potential severity (mild, moderate, or severe), and preventability (10-point scale). The tool is available in paper or electronic form, together with a reference manual (available as Supplemental Figs 3 and 4 and at <https://www.storc.org>), and will be periodically updated.

When comparing the presence or absence of severe safety events between our 2 expert arbiters, we found 87% agreement ($\kappa = 0.68$), indicating good reproducibility. We found 70% agreement when comparing the presence or absence of any safety event; because of expected agreement of 70%, κ was 0, indicating poor reproducibility. The median time to complete this retrospective chart review tool was 7 minutes (interquartile range: 4–12 minutes).

4.4 **Details of medication adverse safety event:** If you checked "Yes" to the question above, indicating that there was an UNSEM, was there an issue related to: *(Please check all that apply and describe details below)*

- Medication indicated and not given
- Delay in giving medication
- Wrong medication selected
- Wrong dose administered *(please select overdose or underdose below)*
 - Overdose
 - Underdose
- Wrong route of administration
- Wrong concentration of medication used
- Inadequate monitoring
- Other: _____

Please describe details: _____

4.5 **Potential harm from medication adverse safety event:** *Using your best clinical judgment, to what degree could the medication UNSEM have harmed the patient?*

- No harm likely
- Mild temporary harm, including additional treatment or mild adverse effect from unnecessary treatment
- Permanent or severe harm, including death

4.6 **Preventability of medication adverse safety event:** Given the information the EMS professional had at the time, was the medication UNSEM preventable?

1	2	3	4	5	6	7	8	9	10
<input type="checkbox"/>									
Not at all preventable								Completely preventable	

FIGURE 2 Appearance of part of section 4 of the PEDS chart review tool. These response items are focused on describing details, harm, and preventability of a medication adverse safety event.

DISCUSSION

We have developed and refined the first tool used to systematically identify adverse safety events in the prehospital care of children. The PEDS tool allows assessors to review prehospital charts in 7 minutes, with 87% ($\kappa = 0.68$) interrater agreement regarding the occurrence of a severe safety event. This reliability is similar to that of previously published hospital chart review tools,^{13,27,28} and the time to completion is less than half the time required to review longer and more complex hospital charts.^{14,29} The PEDS tool can be used to further identify the specific domains of patient care and severity of safety events within these domains.

Pediatric prehospital care has historically been overlooked as a source of adverse safety events, but authors of recent studies suggest that improvements in the prehospital care of children are needed.^{4–9} Disturbingly, whereas survival among adults with out-of-hospital cardiac arrest has improved since 2006, there has been no similar improvement in survival among children.^{30–32} The PEDS tool provides a feasible and user-friendly template for the assessment of quality of prehospital care in children. Using this tool, we have identified that at least 1 adverse safety event occurs in the prehospital care of two-thirds of critically ill or injured children and that many of these events are preventable.¹⁶

Data collection is a key barrier in EMS research,³³ and we found no existing tools being used to measure the quality of pediatric prehospital care. We have made the PEDS tool and accompanying user's guide publicly available and will continue to refine them in hopes that these resources will enable EMS leaders and researchers to collect data to measure and track changes in the quality and safety of prehospital care for children.

This study has several limitations. There is no gold standard against which to validate the PEDS tool beyond expert opinion, and generating validity evidence in this setting is challenging. Early hospital chart review studies faced the same limitation but were nonetheless essential in advancing the

science and practice of quality assessment and improvement.^{10,21,22} We have tried to mitigate this limitation by using a robust, transparent process to develop and refine the tool and accompanying manual. Although we found good interrater reliability in the detection of severe safety events, the high prevalence of nonsevere events led to high expected agreement and a low Cohen's κ . With this finding, we highlight a known limitation of κ .³⁴ Given the lack of gold standard and our findings of best reliability in the detection of severe safety events, the tool may perform best in situations where its use is restricted to specific populations, to detect specific safety events, or when significant effort has been made to calibrate reviewers. A second limitation of any chart review tool is incomplete or inaccurate documentation in the medical record, and this tool is susceptible to the same limitation. The most likely impact of incomplete documentation is that, with the tool, users underestimate the true rate of adverse safety events in pediatric prehospital care compared with direct observation.³⁵ A third limitation is that we calculated interrater reliability on the basis of the reviews of 2 physician experts who were familiar with the tool. The reliability of the tool when used by nonphysicians or by untrained reviewers has not been determined. In its current form, the PEDS tool may therefore best be used by EMS medical directors, and further study of the reliability of the tool when used by reviewers with other training backgrounds is needed. Lastly, it is important to note that the purpose of this tool is not to blame individuals for mistakes, but to improve care in a just culture that balances individual and organizational responsibility to promote patient safety.

CONCLUSIONS

The PEDS chart review tool represents a novel systematic approach to identifying severe adverse safety events in pediatric prehospital care. The PEDS tool may be a useful method for researchers and prehospital medical directors to identify opportunities to improve care and safety for children in the out-of-hospital setting.

Acknowledgments

Thank you to Tabria Harrod for creating and editing the electronic version of the chart review tool via research electronic data capture.

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Hospital Pediatrics 2018;8;494

DOI: 10.1542/hpeds.2017-0155 originally published online July 30, 2018;

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