Emergency Transfers: An Important Predictor of Adverse Outcomes in Hospitalized Children

Farah S Hussain, BS[1]*; Tina Sosa, MD[2]; Lilliam Ambroggio, PhD, MPH[2,3]; Regan Gallagher, MSN, CPN[4]; Patrick W Brady, MD, MSc[2,3,5]

[1]University of Cincinnati College of Medicine, Cincinnati, Ohio; [2]Division of Hospital Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; [3]Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio; [4]Department of Patient Services, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; [5]James M. Anderson Center for Health Systems Excellence, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio.

In-hospital arrests are uncommon in pediatrics, making it difficult to identify the risk factors for unrecognized deterioration and to determine the effectiveness of rapid response systems. An emergency transfer (ET) is a transfer from an acute care floor to an intensive care unit (ICU) where the patient received intubation, inotropes, or ≥3 fluid boluses in the first hour after arrival or before transfer. Improvement science work has reduced ETs, but ETs have not been validated against important health outcomes. This case–control study aimed to determine the predictive validity of an ET for outcomes in a free-standing children's hospital. Controls were matched in terms of age, hospital unit, and time of year. Patients who experienced an ET had a significantly higher likelihood of in-hospital mortality (22% vs 9%), longer ICU length of stay (4.9 vs 2.2 days), and longer posttransfer length of stay (26.4 vs 14.7 days) compared with controls (P < .03 for each). *Journal of Hospital Medicine* 2019;14:482-485. Published online first June 7, 2019. © 2019 Society of Hospital Medicine

Unrecognized in-hospital deterioration can result in tragic consequences for pediatric patients. The majority of deterioration events have antecedents such as increasingly abnormal vital signs and new concerns from nurses.[1] Recent meta-analyses have shown that rapid response systems (RRSs), which include trigger mechanisms such as a pediatric early warning score (PEWS), are associated with a reduced rate of arrests and in-hospital mortality.[2,3] Cardiopulmonary arrest rates are useful metrics to judge the effectiveness of the system to identify and respond to deteriorating adult patients; however, there are important challenges to their use as an outcome measure in pediatrics. Arrests, which have been relatively uncommon in pediatric patients, are now even less frequent since the adoption of a RRS in the majority of children's hospitals.[4,5] Several innovations in these systems will be context-dependent and hence best first evaluated in a single center, where arrests outside of the intensive care unit (ICU) may occur rarely. Identification of valid, more frequent proximal measures to arrests may better identify the risk factors for deterioration. This could potentially inform quality improvement efforts to mitigate clinical deterioration.

Bonafide et al. at the Children's Hospital of Philadelphia developed and validated the critical deterioration event (CDE) metric, demonstrating that children who were transferred to the ICU and who received noninvasive ventilation, intubation, or vasopressor initiation within 12 hours of transfer had a >13-fold increased risk of in-hospital mortality.[6] At Cincinnati Children's Hospital Medical Center, an additional proximal outcome measure was developed for unrecognized clinical deterioration, now termed emergency transfers (ETs).[7-9] An ET is defined as any patient transferred to the ICU where the patient received intubation, inotropes, or three or more fluid boluses in the first hour after arrival or before transfer.[9] Improvement science work that aimed at increasing clinician situation awareness was associated with a reduction in ETs,[8] but the association of ETs with mortality or other healthcare utilization outcomes is unknown. The objective of this study was to determine the predictive validity of an ET on in-hospital mortality, ICU length of stay (LOS), and overall hospital LOS.

METHODS

We conducted a case–control study at Cincinnati Children's Hospital, a free-standing tertiary care children's hospital. Our center has had an ICU-based RRS in place since 2005. In 2009, we eliminated the ICU consult such that each floor-to-ICU transfer is evaluated by the RRS. Nurses calculate a Monaghan PEWS every four hours on the majority of nursing units.

Patients of all ages cared for outside of the ICU at any point in their hospitalization from January 1, 2013, to July 31, 2017, were eligible for inclusion. There were no other exclusion criteria. The ICU included both the pediatric ICU and the cardiac ICU.

***Corresponding Author:** Farah S Hussain, BS; E-mail: hussaifs@mail.uc.edu; Telephone: 513-205-0429.

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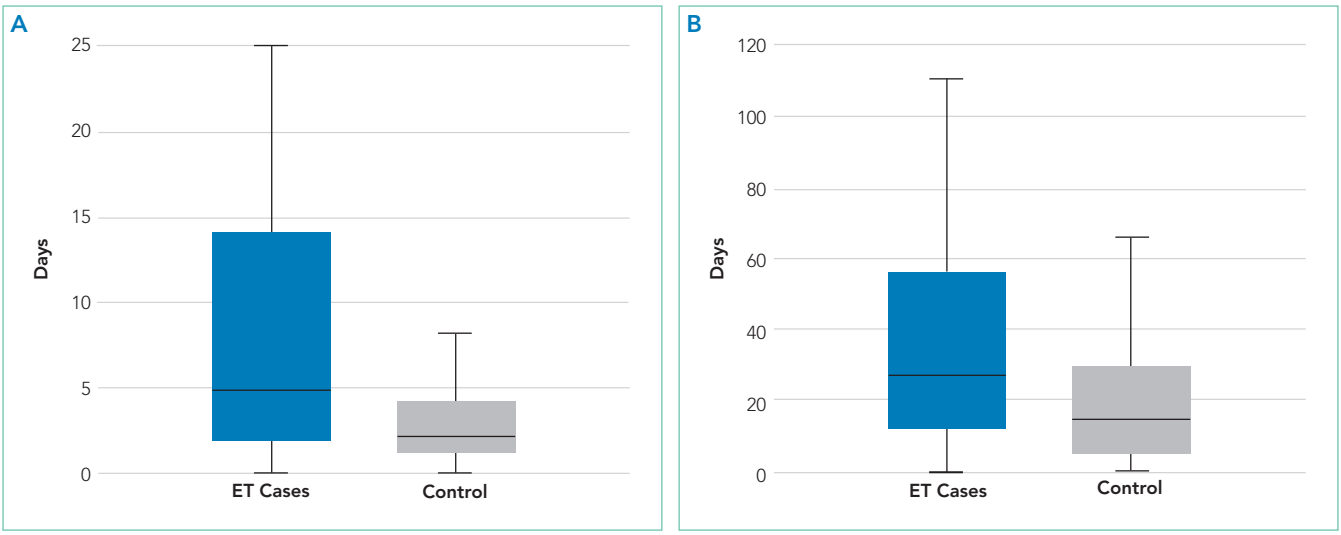

FIG. (A) **ICU length of stay**. ET cases had a median posttransfer ICU length of stay of 4.9 days. Controls had a median posttransfer ICU length of stay of 2.2 days (P = .001). (B) **Hospital length of stay**. ET cases had a median posttransfer hospital length of stay of 26.4 days versus controls with 14.7 days (P = .001).

Abbreviations: ET, emergency transfer; ICU, intensive care unit.

Cases

We identified all ET cases from an existing situation awareness database in which each RRS call is entered by the hospital nursing supervisor, whose role includes responding to each RRS activation. If the patient transfer meets the ET criteria, the nurse indicates this in the database. Each ET entry is later confirmed for assurance purposes by the nurse leader of the RRS committee (RG). For the purposes of this study, all records were again reviewed and validated using manual chart review in the electronic health record (Epic Systems, Verona, Wisconsin).

Controls

We identified nonemergent ICU transfers to serve as controls and matched those to ET in cases to limit the impact of confounders that may increase the likelihood of both an ET and a negative outcome such as ICU mortality. We identified up to three controls for each case from our database and matched in terms of age group (within five years of age), hospital unit before transfer, and time of year (within three months of ET). These variables were chosen to adjust for the impact of age, diversity of disease (as hospital units are generally organized by organ system of illness), and seasonality on outcomes.

Outcome Measures

Posttransfer LOS in the ICU, posttransfer hospital LOS, and in-hospital mortality were the primary outcome measures. Patient demographics, specific diagnoses, and number of medical conditions were a priori defined as covariates of interest. Data for each case and control were entered into a secure, web-based Research Electronic Data Capture (REDCap) database.

Analysis

Descriptive data were summarized using counts and percentages for categorical variables and medians and ranges for continuous variables due to nonnormal distributions. Chi-square test was used to compare in-hospital mortality between the ETs and the controls. The Wilcoxon rank-sum test was used to compare LOS between ETs and controls. All data analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

RESULTS

A total of 45 ETs were identified, and 110 controls were matched. Patient demographics were similar among all cases and controls (P > .05). Patients with ETs had a median age of seven years (interquartile range: 3-18 years), and 51% of them were males. The majority of patients among our examined cases were white (68%) and non-Hispanic (93%). There was no statistical difference in insurance between the ETs and the controls. When evaluating the hospital unit before the transfer, ETs occurred most commonly in the Cardiology (22%), Hematology/Oncology (22%), and Neuroscience (16%) units.

ETs stayed longer in the ICU than non-ETs [median of 4.9 days vs 2.2 days, P = .001; Figure (A)]. Similarly, ET cases had a significantly longer posttransfer hospital LOS [median of 35 days vs 21 days, P = .001; Figure (B)]. ETs had a 22% in-hospital mortality rate, compared with 9% in-hospital mortality in the matched controls (P = .02; Table).

DISCUSSION

Children who experienced an ET had a significantly longer ICU LOS, a longer posttransfer LOS, and a higher in-hospital mortality than the matched controls who were also transferred to the ICU. Researchers and improvement science teams at multiple hospitals have demonstrated that interventions targeting improved situation awareness can reduce ETs; we have demonstrated that reducing ETs may reduce subsequent adverse outcomes.[8,10]

These findings provide additional support for the use of the ET metric in children's hospitals as a proximal measure for

TABLE. **In-Hospital Mortality**

	Died n (%)	Survived n (%)	Total
Emergency transfer	10 (22%)	35 (78%)	45
Control	10 (9%)	100 (91%)	110
Total	20	135	155

P = .02

significant clinical deterioration. We found mortality rates that were overall high for a children's hospital (22% in ET cases and 9% among controls) compared with a national average mortality rate of 2.3% in pediatric ICUs.[11] This is likely due to the study sample containing a significant proportion of children with medical complexity.

Aoki et al. recently demonstrated that ETs, compared with non-ETs, were associated with longer LOS and higher mortality in a bivariate analysis.[12] In our study, we found similar results with the important addition that these findings were robust when ETs were compared with matched controls who were likely at a higher risk of poor outcomes than ICU transfers in general. In addition, we demonstrated that ETs were associated with adverse outcomes in a United States children's hospital with a mature, long-standing RRS process. As ETs are considerably more common than cardiac and respiratory arrests, use of the ET metric in children's hospitals may enable more rapid learning and systems improvement implementations. We also found that most of the children with ETs present from units that care for children with substantial medical complexity, including Cardiology, Hematology/Oncology, and Neurosciences. Future work should continue to examine the relationship between medical complexity and ET risk.

The ET metric is complementary to the CDE measure developed by Bonafide et al. Both metrics capture potential events of unrecognized clinical deterioration, and both offer researchers the opportunity to better understand and improve their RRSs. Both ETs and CDEs are more common than arrests, and CDEs are more common than ETs. ETs, which by definition occur in the first hour of ICU care, are likely a more specific measure of unrecognized clinical deterioration. CDEs will capture therapies that may have been started up to 12 hours after transfer and thus are possibly more sensitive to identify unrecognized clinical deterioration. However, CDEs also may encompass some patients who arrived at the ICU after prompt recognition and then had a subacute deterioration in the ICU.

The maturity of the RRS and the bandwidth of teams to collect data may inform which metric(s) are best for individual centers. As ETs are less common and likely more specific to unrecognized clinical deterioration, they might be the first tracked as a center improves its RRS through QI methods. Alternatively, CDEs may be a useful metric for centers where unrecognized clinical deterioration is less common or in research studies where this more common outcome would lead to more power to detect the effect of interventions to improve care.

Our study had several limitations. Data collection was confined to one tertiary care children's hospital with a high burden of complex cardiac and oncology care. The results may not generalize well to children hospitalized in smaller or community hospitals or in hospitals without a mature RRS. There is also the possibility of misclassification of covariates and outcomes, but any misclassification would likely be nondifferential and bias toward the null. Matching was not possible based on exact diagnosis, and the unit is a good but imperfect proxy for diagnosis grouping. At our center, overflow of patients into the Cardiology and Hematology/Oncology units is uncommon, mitigating this partially, although residual confounding may remain. The finding that ETs are associated with adverse outcomes does not necessarily mean that these events were preventable; however, it is important and encouraging that the rate of ETs has been reduced at two centers using improvement science interventions.[8,10]

CONCLUSION

Patients who experienced an ET had a significantly higher likelihood of in-hospital mortality, spent more time in the ICU, and had a longer hospital LOS posttransfer than matched controls. The use of the ET metric in children's hospitals would allow for further analysis of such patients in hopes of identifying clinical characteristics that serve as predictors of deterioration. This may facilitate better risk stratification in the clinical system as well as enable more rapid learning and systems improvements targeted toward preventing unrecognized clinical deterioration.

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References

1. Schein RM, Hazday N, Pena M, Ruben BH, Sprung CL. Clinical antecedents to in-hospital cardiopulmonary arrest. *Chest*. 1990;98(6):1388-1392. https://doi.org/10.1378/chest.98.6.1388.

2. Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. *Crit Care*. 2015;19:254. https://doi.org/10.1186/s13054-015-0973-y.
3. Bonafide CP, Roland D, Brady PW. Rapid response systems 20 years later: new approaches, old challenges. *JAMA Pediatrics*. 2016;170(8):729-730. https://doi.org/10.1001/jamapediatrics.2016.0398.
4. Hayes LW, Dobyns EL, DiGiovine B, et al. A multicenter collaborative approach to reducing pediatric codes outside the ICU. *Pediatrics*. 2012;129(3):e785-e791. https://doi.org/10.1542/peds.2011-0227.
5. Raymond TT, Bonafide CP, Praestgaard A, et al. Pediatric medical emergency team events and outcomes: a report of 3647 events from the American Heart Association's get with the guidelines-resuscitation registry. *Hosp Pediatr*. 2016;6(2):57-64. https://doi.org/10.1542/hpeds.2015-0132.
6. Bonafide CP, Roberts KE, Priestley MA, et al. Development of a pragmatic measure for evaluating and optimizing rapid response systems. *Pediatrics*. 2012;129(4):e874-e881. https://doi.org/10.1542/peds.2011-2784.
7. Brady PW, Goldenhar LM. A qualitative study examining the influences on situation awareness and the identification, mitigation and escalation of recognised patient risk. *BMJ Qual Saf*. 2014;23(2):153-161. https://doi.org/10.1136/bmjqs-2012-001747.
8. Brady PW, Muething S, Kotagal U, et al. Improving situation awareness to reduce unrecognized clinical deterioration and serious safety events. *Pediatrics*. 2013;131(1):e298-e308. https://doi.org/10.1542/peds.2012-1364.
9. Brady PW, Wheeler DS, Muething SE, Kotagal UR. Situation awareness: a new model for predicting and preventing patient deterioration. *Hosp Pediatr*. 2014;4(3):143-146. https://doi.org/10.1542/hpeds.2013-0119.
10. McClain Smith M, Chumpia M, Wargo L, Nicol J, Bugnitz M. Watcher initiative associated with decrease in failure to rescue events in pediatric population. *Hosp Pediatr*. 2017;7(12):710-715. https://doi.org/10.1542/hpeds.2017-0042.
11. McCrory MC, Spaeder MC, Gower EW, et al. Time of admission to the PICU and mortality. *Pediatr Crit Care Med*. 2017;18(10):915-923. https://doi.org/10.1097/PCC.0000000000001268.
12. Aoki Y, Inata Y, Hatachi T, Shimizu Y, Takeuchi M. Outcomes of 'unrecognised situation awareness failures events' in intensive care unit transfer of children in a Japanese children's hospital. *J Paediatr Child Health*. 2018;55(2):213-215. https://doi.org/10.1111/jpc.14185.