

Comment on Cardiac Arrest Survival in Pediatric and General Emergency Departments

Pediatric readiness in emergency departments (EDs) has been a major focus over the last decade, but outcome data are lacking to justify the need for dedicated pediatric EDs. Michelson and colleagues¹ have made an important contribution to exploring the relationship between patient outcome and emergency care setting. However, we are concerned that there are significant unmeasured confounders in these data that affect the validity of the association between mortality and ED type, thus bringing the study's results into question.

Pediatric out-of-hospital cardiac arrest (OHCA) survival is known to be significantly affected by prehospital interventions, including bystander cardiopulmonary resuscitation (CPR),² automated external defibrillation,³ and timely transportation to definitive care.⁴ The National Emergency Department Sample was used for this study, and this database does not have variables representing prehospital interventions or transport time. In addition, the authors note that all of the pediatric EDs were in urban regions as compared with general EDs, which included both rural and urban hospitals. Rural status may be a surrogate for a longer transport time, thus decreasing the likelihood of survival. The authors should have considered a sensitivity analysis of pediatric and general EDs in urban regions to validate the finding that it was ED type and not transport time that related differences in survival.

A second concern is the assumption that all cardiac arrests in the ED were OHCA because the National Emergency Department Sample does not differentiate in-hospital cardiac arrest (IHCA) from OHCA. The authors cite the pediatric IHCA study from the National Registry of Cardiopulmonary

Resuscitation by Nadkarni et al,⁵ which revealed that 14% of IHCA occurred in an ED. This investigation excluded patients with OHCA, thus no comparison between the frequency of ED versus OHCA can be inferred from this study. Conversely, Nadkarni et al⁵ indicate that >10% of ED IHCA may have been misclassified as OHCA by Michelson and colleagues.¹

Finally, the authors note that there was a significantly higher rate of CPR documented in general EDs as compared with pediatric EDs. The difference in CPR rates between EDs indicates that there may have been a difference in baseline characteristics of children seen at each ED type. Children may have been in a peri-arrest versus arrest state in pediatric EDs; children who do not have CPR coded may not in fact meet the definition of OHCA or were a healthier population overall that did not require CPR. In addition, children may have been transported from general EDs to pediatric EDs after receiving CPR and stabilization.

Some of these points have been noted by Michelson and colleagues,¹ and despite our criticisms we applaud the authors for shedding light on an area of controversy. The findings of this study require further investigation and can be validated by using OHCA registries such as the Cardiac Arrest Registry to Enhance Survival or the Resuscitation Outcomes Consortium Epistry, with an emphasis not only in outcomes between pediatric and general EDs but also EDs in urban and rural regions.

Jessica J. Wall
Pediatric Emergency Medicine, Children's Hospital of Philadelphia
E-mail: jessica.j.wall@gmail.com

Maryam Y. Naim
Cardiac Critical Care, Children's Hospital of Philadelphia

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

REFERENCES

1. Michelson KA, Hudgins JD, Monuteaux MC, Bachur RG, Finkelstein JA. Cardiac arrest survival in pediatric and general emergency departments. *Pediatrics*. 2018; 141(2):e20172741
2. Naim MY, Burke RV, McNally BF, et al. Association of bystander cardiopulmonary resuscitation with overall and neurologically favorable survival after pediatric out-of-hospital cardiac arrest in the United States: a report from the Cardiac Arrest Registry to Enhance Survival surveillance registry. *JAMA Pediatr*. 2017; 171(2):133–141
3. Fukuda T, Ohashi-Fukuda N, Kobayashi H, et al. Public access defibrillation and outcomes after pediatric out-of-hospital cardiac arrest. *Resuscitation*. 2017;111:1–7
4. Tijssen JA, Prince DK, Morrison LJ, et al; Resuscitation Outcomes Consortium. Time on the scene and interventions are associated with improved survival in pediatric out-of-hospital cardiac arrest. *Resuscitation*. 2015;94:1–7
5. Nadkarni VM, Larkin GL, Peberdy MA, et al; National Registry of Cardiopulmonary Resuscitation Investigators. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. *JAMA*. 2006;295(1): 50–57

doi:10.1542/peds.2018-1567A

Authors' Response

We appreciate the opportunity to respond to Drs Wall and Naim's comments and criticisms. We agree that understanding of current OHCA outcomes is both important and incomplete.

Like Drs Wall and Naim, we also worried about residual confounding of the relationship between ED type and survival. To confound this association, a risk factor for survival in cardiac arrest would also have to be associated with ED type. We are not aware of evidence suggesting that prehospital interventions such as bystander CPR are associated with ED type, although this is theoretically possible. However, transport time is likely associated with ED type and would likely be a

confounder on the basis of the urban location of the pediatric EDs in our study. To address this legitimate concern, we reanalyzed our data, restricting the sample to EDs located in all metropolitan areas and EDs located only in large, central metropolitan areas. When restricting to metropolitan areas, survival among noninjured children with OHCA was 19.2% and 33.8% among nonpediatric and pediatric EDs, respectively ($P < .001$). When restricting to large, central metropolitan areas, survival was 20.2% and 29.3% among nonpediatric and pediatric EDs ($P = .002$). Although we did not directly measure transport times, the long transport times sometimes seen in rural areas are eliminated in this analysis.

It is possible that some visits for cardiac arrest in our study were misclassified as OHCA when they were truly IHCA. However, we believe the influence of IHCA on our analysis would be minimal for several reasons. First, in the Nadkarni study,¹ there were 121 pediatric in-ED cardiac arrests across 253 large hospitals (median 260 beds), or only 0.5 IHCA per large ED. Second, reports of nontraumatic OHCA incidence (8.0 per 100 000 person-years) from a large registry study² are similar to the

incidence of nontraumatic OHCA in our study (7.9 per 100 000 person-years), suggesting that nearly all of the analyzed patients in our study experienced OHCA. Third, although IHCA versus OHCA may be associated with the likelihood of survival, we do not have evidence that it is associated with ED type. Thus, we believe that contamination of our sample with IHCA episodes is likely to be small, and its effect on the primary analysis would also likely be small.

We believe our study's limitations are outweighed by its representativeness and inclusion of EDs that do not typically participate in cardiac arrest outcomes research. For instance, Nadkarni et al's¹ important study of IHCA outcomes was focused primarily on large facilities that paid a fee to participate in a cardiac arrest outcomes registry, which may differ in important ways from nonparticipating centers.

With that said, we strongly agree with Drs Wall and Naim that further study in which OHCA registries with clinical information are used will help confirm or refute our finding that ED type may influence survival. We further encourage researchers to include care settings in which outcomes are not

routinely measured, such as small rural or community EDs.

Kenneth A. Michelson, MD, MPH
Pediatric Emergency Medicine Physician, Boston Children's Hospital
E-mail: kenneth.michelson@childrens.harvard.edu

Richard G. Bachur, MD
Division Chief, Emergency Medicine, Boston Children's Hospital

Jonathan A. Finkelstein, MD, MPH
Chief, Patient Safety and Quality, Boston Children's Hospital

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

REFERENCES

1. Nadkarni VM, Larkin GL, Peberdy MA, et al; National Registry of Cardiopulmonary Resuscitation Investigators. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. *JAMA*. 2006;295(1): 50–57
2. Atkins DL, Everson-Stewart S, Sears GK, et al; Resuscitation Outcomes Consortium Investigators. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. *Circulation*. 2009;119(11): 1484–1491

doi:10.1542/peds.2018-1567B

Authors' Response

Kenneth A. Michelson, Richard G. Bachur and Jonathan A. Finkelstein
Pediatrics 2018;142;

DOI: 10.1542/peds.2018-1567B originally published online July 31, 2018;

Updated Information & Services	including high resolution figures, can be found at: http://pediatrics.aappublications.org/content/142/2/e20181567B
References	This article cites 2 articles, 1 of which you can access for free at: http://pediatrics.aappublications.org/content/142/2/e20181567B#BIBL
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Emergency Medicine http://www.aappublications.org/cgi/collection/emergency_medicine_sub Trauma http://www.aappublications.org/cgi/collection/trauma_sub
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.aappublications.org/site/misc/Permissions.xhtml
Reprints	Information about ordering reprints can be found online: http://www.aappublications.org/site/misc/reprints.xhtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®



PEDIATRICS[®]

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Authors' Response

Kenneth A. Michelson, Richard G. Bachur and Jonathan A. Finkelstein

Pediatrics 2018;142;

DOI: 10.1542/peds.2018-1567B originally published online July 31, 2018;

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/142/2/e20181567B>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2018 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN[®]

