ARTICLE

Access to Pediatric Trauma Care in the United States

Michael L. Nance, MD; Brendan G. Carr, MD, MA, MS; Charles C. Branas, PhD

Objectives: To catalog trauma center resources and estimate access to age-specific trauma care for children younger than 15 years in the United States.

Design: Cross-sectional study collating information from national, state, and local trauma systems authorities to create a catalog of verified pediatric trauma centers (PTCs) and self-designated "candidate" trauma centers. Access-to-care calculations were estimated using all US block groups and prior validated methods.

Setting: United States.

Patients: Children in the US younger than 15 years.

Main Outcome Measures: The PTC statuses of hospitals in the United States. Percentages of pediatric populations (by state and population density) having access (by ground or air) within 60 minutes to a PTC.

Results: A total of 170 verified PTCs were identified in 41 states (including the District of Columbia). An estimated 71.5% of pediatric patients were within 60 minutes of a verified PTC by air or ground transport, 43% if ground transportation only was considered. An estimated 17.4 million children did not have access to a PTC within 60 minutes. Access ranged from 22.9% of the population in the most rural areas of the United States to 93.5% in the most urban. The addition of 24 candidate centers increased coverage to 77.4% of the pediatric population being within 60 minutes of a PTC.

Conclusions: Current pediatric trauma resources vary greatly by state and population density, with many children, particularly in rural areas, underserved. A thorough standardized catalog of verified PTCs is necessary to accurately assess pediatric trauma needs now and to optimize future trauma system planning for children.

Arch Pediatr Adolesc Med. 2009;163(6):512-518

Author Affiliations:
Department of Surgery, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania (Dr Nance); Departments of Emergency Medicine (Dr Carr) and Biostatistics and Epidemiology (Drs Carr and Branas), University of Pennsylvania School of Medicine, Philadelphia.

INJURY IS THE MOST SIGNIFICANT public health threat to children in the United States. More children aged 1 to 14 years die of injury-related causes than all other causes combined.[1] As one important approach to addressing this mortality burden, trauma centers have been shown to provide a survival benefit to severely injured patients, both adult and pediatric.[2-4]

Trauma care systems in the United States have progressed to the point that a comprehensive inventory of adult trauma centers now exists and is regularly updated.[5,6] Using this inventory, population access to adult trauma centers was recently calculated, showing sizable gaps in coverage for many parts of the United States.[7] At the time of this previous analysis, a similar inventory of pediatric trauma centers (PTCs) did not exist. Similar population access estimates for children have thus not been calculated, and potentially important information regarding gaps in coverage and locations of underserved populations are not available to US trauma systems planners interested in reducing pediatric mortality due to injury. We therefore sought to create an inventory of PTCs to calculate and analyze the population's access to pediatric-specific trauma care for children younger than 15 years in the United States.

METHODS

DATA SOURCES

Pediatric Trauma Centers

To date, no national inventory of PTCs has been compiled. To create such an inventory, information was collated from national, regional, and local sources regarding the PTC status of health care institutions across the United States. The American College of Surgeons Committee on Trauma (ACS-COT) is responsible for the accreditation of trauma centers (including pediatric) in many states and, as such, pediatric-capable trauma centers identified by the ACS-COT were included (n=87).[8] The American Trauma Society also maintains a list of adult

trauma centers, including centers designated as pediatric-capable; these were also included in our inventory (n=35). Many states (eg, Pennsylvania, Ohio) have created state-level verification and accrediting bodies to oversee trauma center designation independent of the ACS. To clarify pediatric capabilities at individual centers in states not using the ACS for verification or not identified through the American Trauma Society, additional data and information were obtained from Web-based resources and personal phone calls made to state and local trauma system authorities (eg, State Departments of Health) including trauma directors and program managers, when necessary. A total of 87 institutions were identified through state and other resources. Some centers were identified through multiple sources (ie, both ACS and state-verified). Recognition by any of the above credentialing mechanisms defined the pool of verified PTCs used for access calculations.

Finally, the National Association of Children's Hospitals and Related Institutions (NACHRI) allows member institutions to classify themselves (ie, self-reported) as trauma centers (n=86).[9] In all but 1 of the institutions identified exclusively by NACHRI self-reporting (n=24), both a pediatric intensive care unit and separate pediatric emergency department were available. The addition of self-designated trauma centers to the larger PTC group yielded a list of 194 unique institutions with declared capability for care of pediatric trauma patients. Access calculations focused on verified PTCs (ACS and/or state, other). For comparative purposes, access analyses for the population of all PTCs (verified and NACHRI self-designated centers) were also performed. However, those access calculations based on all PTCs were used to demonstrate the incremental benefit of the addition of candidate (and likely capable) centers to the overall access calculations for the United States.

Population Data

Population information was obtained using data from the US Census Bureau local and state estimates and trends in deliverable addresses from the US Postal Service (Claritus Inc, Ithaca, New York).[10] Our main geographic units of analysis were block groups. A block group is a geographic unit containing 600 to 3000 people that does not cross state or county boundaries. Each block group's population was assigned a point in space (a centroid) that was nearest to most of its residents. Population estimates and population-weighted centroids for 208 667 block groups were calculated for 2007.

Air Ambulance Data

Air ambulance data were obtained from the January 2005 version of the Atlas and Database of Air Medical Services.[11] These data included the locations of all helipad depots operated by air medical service providers that respond to emergency scenes in the 50 states and the District of Columbia (DC). We did not include fixed wing air medical services in our model.

ACCESS CALCULATIONS

Access was calculated by summing the population younger than 15 years that could reach a PTC by ground or air ambulance within the specified prehospital time period (60 minutes). To estimate distance for these populations to trauma centers, we used block group boundaries and centroids available from the US Census Bureau. The distance between the population-weighted block group centroid and the nearest trauma center was calculated using straight-line and rectilinear distance formulas.[12,13] Depending on the mode of transport (ground or air), each block group was linked its nearest trauma center. Redundant access to other trauma centers was not considered. The pediatric population within a block group that could reach a trauma center was never counted more than once in the summation formula for access. All programming code was written and tested using Compaq Visual Fortran Version 6.6 (Compaq Computer Corporation, Houston, Texas), translated into C++ (Microsoft Corporation, Seattle, Washington), and validated by comparing output from the Fortran code with output from the C++ code.

Once distance from population to trauma center was estimated, we converted the distance into driving and flying times adjusted for population density. Drives were classified as urban, suburban, or rural by averaging the population densities of the block group surrounding each trauma center and the block group of origin and creating tertiles of average population density (urban, suburban, rural). We used empirically derived ambulance drive speeds of 20.1 mph for urban driving, 47.5 mph for suburban driving, and 56.4 mph for rural driving.[14]

To complete the time estimate for the prehospital interval, we imputed empirically derived times for other essential prehospital intervals. The activation interval, or the time from the emergency (911) call until ambulance dispatch, was imputed as 1.4, 1.4, and 2.9 minutes for urban, suburban, and rural areas, respectively. The response interval, or the time from ambulance dispatch until scene arrival, was imputed by multiplying the drive time from scene to the emergency department, derived above by the constants 1.6, 1.5, and 1.4 minutes for urban, suburban, and rural drives, respectively. Finally, 13.5, 13.5, and 15.1 minutes were added to the model to account for time spent on scene with the patient.

To calculate helicopter flying times, we multiplied helicopter depot–specific cruise speeds by straight-line flying distances from helicopter depot to the block group centroid and from the block group centroid to the closest trauma center. We then added an empirically derived constant for helicopter activation time of 3.5 minutes and for helicopter on-scene time of 21.6 minutes.[14]

Block group population access calculations were aggregated to compute estimates of access for the entire country as well as all 50 states and DC. To allow comparisons of rural and urban access differences, each of the 208 667 block groups in the United States were stratified into deciles based on population density. Access calculations (the percentage of the pediatric population with access by air or ground to a verified PTC within 60 minutes) were performed for each of the population density deciles.

RESULTS

TRAUMA CENTER ESTIMATES FOR VERIFIED PTCs

A total of 170 unique PTCs were identified using the described methodology. Centers were reported in 41 states (including DC). In the United States there was, on average, 1 PTC per 358 000 children (a census-estimated 60 919 105 children aged <15 years were used for calculations).

ACCESS ESTIMATES FOR VERIFIED PTCs

Access estimates varied by state, mode of transportation, and time to care (**Table**). Overall, the percentage of children with access to a PTC increased as the time allowed increased (**Figure 1**). The percentage of chil-

Table. Percentages of Children With Access to Pediatric Trauma Centers by State[a]

State	Percentage		
	Verified Trauma Centers Only		Verified and Self-designated Trauma Centers
	Driving Only for 60 min	Driving or Flying for 60 min	Driving or Flying for 60 min
AK	40.8	52.5	52.5
AL	16.9	39	42.9
AR	0.7	6.3	32.4
AZ	0	0.5	67.6
CA	55.1	89.4	89.4
CO	26.5	78.9	83.3
CT	40.7	99.8	99.8
DC	100	100	100
DE	62	85.7	85.7
FL	61.6	87.5	87.5
GA	26.5	62.7	71.8
HI	0	0	0
IA	22.9	49.2	52.6
ID	2.2	10.8	10.8
IL	42.4	83.9	86.1
IN	38.7	85.6	89.5
KS	44.2	60.6	60.6
KY	11	60.3	71.3
LA	8.3	10.1	44
MA	62.2	97.9	97.9
MD	63.3	97.1	97.1
ME	0	0	0
MI	53.7	80.2	84.3
MN	56.7	79.9	80.5
MO	43.9	64.8	64.8
MS	14.6	27	28.3
MT	0	0	0
NC	33.9	69.9	73.9
ND	0	0	0
NE	0	0	0.5
NH	4.2	48.3	48.3
NJ	71.7	100	100
NM	0	0	0
NV	87.8	93.9	93.9
NY	78.3	95.2	95.2
OH	58.8	94.3	94.3
OK	28	35.7	64.5
OR	42.3	57.4	57.4
PA	48.9	93.8	93.8
RI	89.6	99.9	99.9
SC	37.7	69.6	73.3
SD	0	0	31.9
TN	16.1	37.1	78.3
TX	19.6	54.8	69.4
UT	43.2	81.4	81.4
VA	38.2	56.2	56.2
VT	34.7	66.1	66.1
WA	58	91.9	91.9
WI	34.6	58.6	58.6
WV	26.3	63.4	63.4
WY	0	0	0
US	42.6	71.5	77.4

[a] Access times are for flying or driving, permitting crossing of state line.

dren with access to a PTC also increased if air transportation was considered in the analysis (Figure 1). Overall, it was estimated that 71.5% of the US pediatric

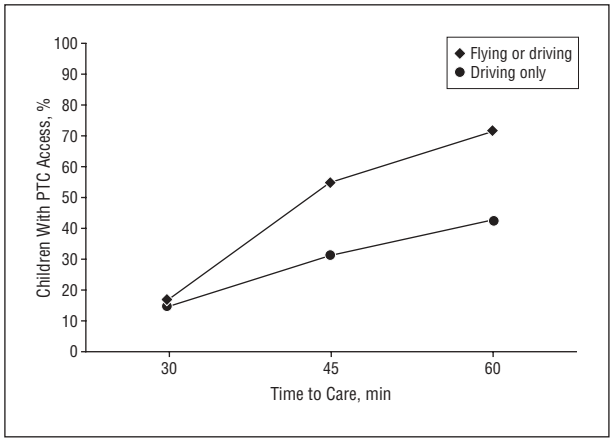

Figure 1. Response times based on mode of transportation for children with pediatric trauma center (PTC) access in the United States.

population younger than 15 years was within 60 minutes of a PTC by ground or air transportation, 42.6% if only ground transportation was considered.

More than 90% of the pediatric population had 60-minute access to a PTC by air or ground transportation in 11 states (including DC), with more than 75% with access in 20 states, more than 50% with access in 33 states, and more than 25% with access in 39 states (**Figure 2**). Less than 25% of the population was within 60 minutes of a PTC in 12 states. Overall, an estimated 17.4 million children did not have access to a PTC within 60 minutes (a census-estimated 60 919 105 children aged <15 years were used for calculations). Geographically, this care varied widely, with large land areas uncovered by pediatric trauma services (**Figure 3**). Overall, only 15.1% of the land area in the United States was within 60 minutes of a PTC by air or ground transportation (although this did include 71.5% of the target population).

POPULATION DENSITY AND ACCESS

Access to a PTC within 60 minutes varied directly with population density (decile range, 22.9 to 93.5) (**Figure 4**). Only 22.9% of children in the least population dense (lowest decile) block groups had access to a PTC within 60 minutes. By comparison, 93.5% of children living in the most population-dense (highest decile) areas had access to a PTC within 60 minutes.

ACCESS ESTIMATES INCLUDING CANDIDATE PTCs

If the self-designated candidate PTCs identified through NACHRI were included in the access calculations, there would be 194 unique centers in 45 states (including DC). An average of 1 pediatric trauma resource per 314 000 children (a census-estimated 60 919 105 children aged <15 years were used for calculations) would be realized. Overall, 77.4% of the US pediatric population (aged <15 years) would be within 60 minutes of a PTC by ground or air transportation, 48% if ground transportation only was considered (**Figure 5**). The incremental benefit of adding these candidate centers was access to a PTC for an estimated 3.6 million more children. Geo-

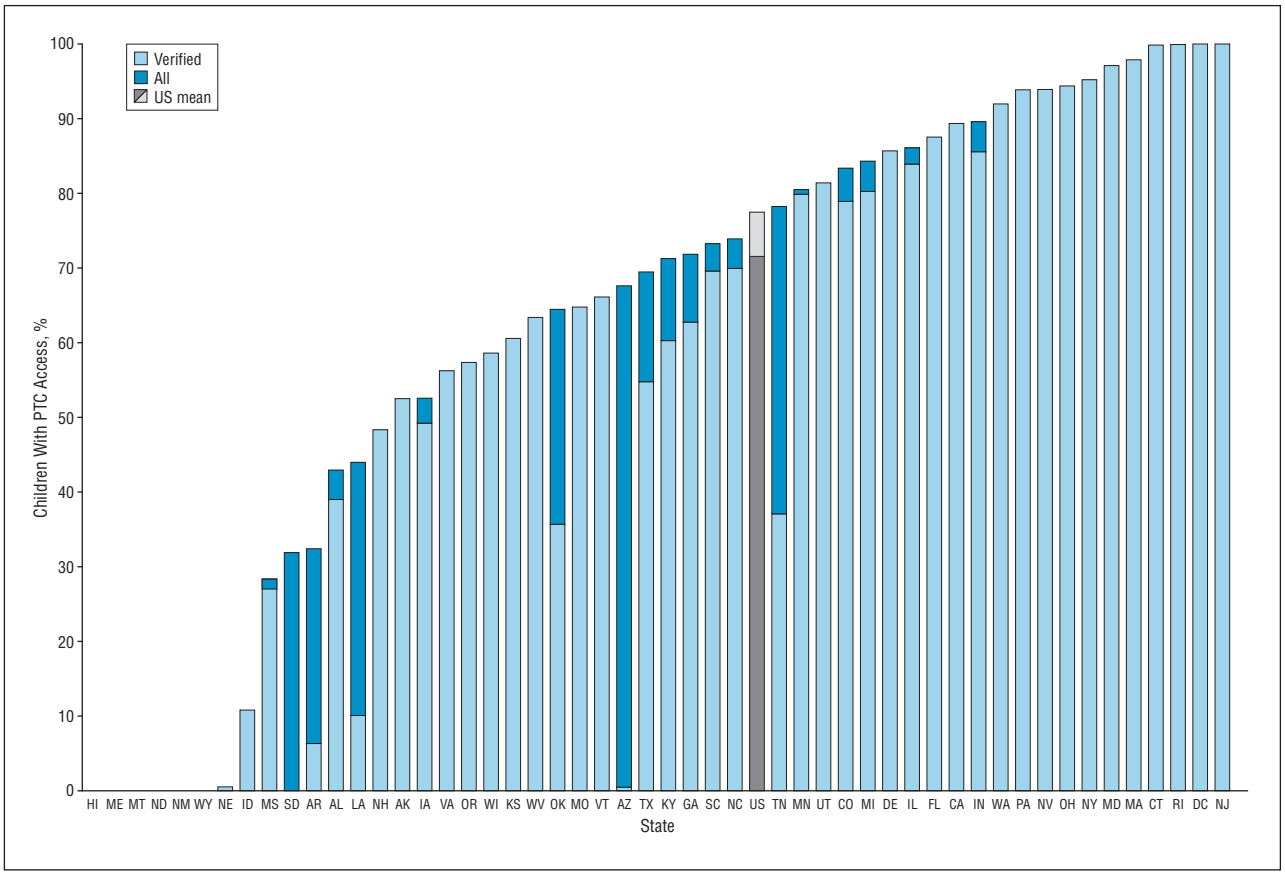

Figure 2. Percentage of children with 60-minute access to a verified pediatric trauma center (PTC) by state. Incremental improvement with inclusion of pediatric-capable self-designated centers.

graphically, care still varied widely, with large land areas uncovered by pediatric trauma services. However, the incremental benefit of adding these candidate centers (an estimated 3.6 million more children with coverage) to the access for children is evident (Figure 5).

COMMENT

Timely access to an appropriate level of care is necessary to reverse the untoward anatomic and physiologic cascade of events associated with severe trauma. In this study, we demonstrated that timely access to verified PTCs is inadequate for children in the United States. It was estimated that more than 17 million children did not have access to a verified PTC within 60 minutes (by ground or air transportation). There was great variation in access estimates at the state level (range, 0% to 100% of children) and based on block group population density (22.9% in the least population dense areas and 93.5% in the most population dense areas).

Both the Institute of Medicine and US Department of Health and Human Services reports recognized fragmentation and variation in pediatric emergency care.[15,16] The Institute of Medicine strongly recommended coordination, regionalization, and accountability in its vision of pediatric emergency and trauma care.[15] The Department of Health and Human Services recommended categorization to identify the "readiness and capability of a hospital and its staff to provide optimal emergency care" for children.[16] The observations in this study support the findings and recommendations of these national assessments.

Creating a reliable sustainable inventory of PTCs is essential to achieve this categorization goal. While designating a single national accrediting body for PTC designation would be optimal, establishing guidelines that indicate the basic resources necessary for PTC designation are certainly in order (eg, having at least a pediatric emergency department and pediatric intensive care unit). In addition, guidelines that inform the best locations and minimum patient volumes of such pediatric facilities relative to similar pediatric facilities nearby also deserve consideration in terms of optimal trauma system design. Such guidelines would provide a benchmark for institutions offering care for injured children.

While this study does not directly address outcome from injury as it relates to PTC access, it stands to reason that limited access may equate to suboptimal trauma care and a lower likelihood of survival. Several authors have demonstrated superior outcomes for children treated in designated PTCs.[17-20] For the youngest pediatric trauma patients (0-10 years) with more severe injuries (Injury Severity Score >15), it was noted that in-hospital mortality, length of stay, and charges were all significantly higher in adult hospitals than in pediatric hospitals.[17] Studies focusing on specific organ system injuries (eg, spleen,

Figure 3. Geographic representation of access within 60 minutes to a verified pediatric trauma center (PTC).

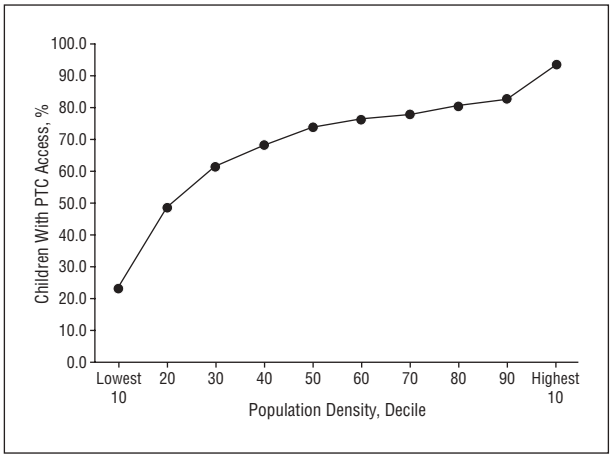

Figure 4. Percentage of children with access to care in a verified pediatric trauma center (PTC) within 60 minutes based on population density (by decile).

brain) have also demonstrated superior outcomes in pediatric-focused centers.[18-20] These differences in outcomes may be related to the availability of 2 key PTC elements: pediatric intensive care unit beds and dedicated pediatric emergency department resources.[21] In this study, we included centers that were self-reported as trauma resources by NACHRI, as they possessed (with a single exception) the minimal elements of a pediatric intensive care unit and a dedicated pediatric emergency department. However, while these centers likely were able to provide the necessary care, self-designation is not a replacement for a verification process ensuring adherence to a variety of minimum standards over time.

The availability of pediatric intensive care unit beds has been correlated with a significant reduction in trauma-related mortality.[22] The lack of pediatric-specific personnel and equipment at adult institutions caring for pediatric emergency patients has been documented.[23] Despite these published findings, most pediatric trauma care (including children with severe injuries) is rendered at non-PTCs.[18,24] Although the care currently delivered to children outside of designated PTCs may indeed be adequate, without reliable guidelines to characterize and geographically locate PTCs, one cannot accurately determine if optimal care is being provided to severely injured children in the United States.

One of the barriers to optimizing trauma care delivery to children has been the absence of an inventory of the resources available and their corresponding loca-

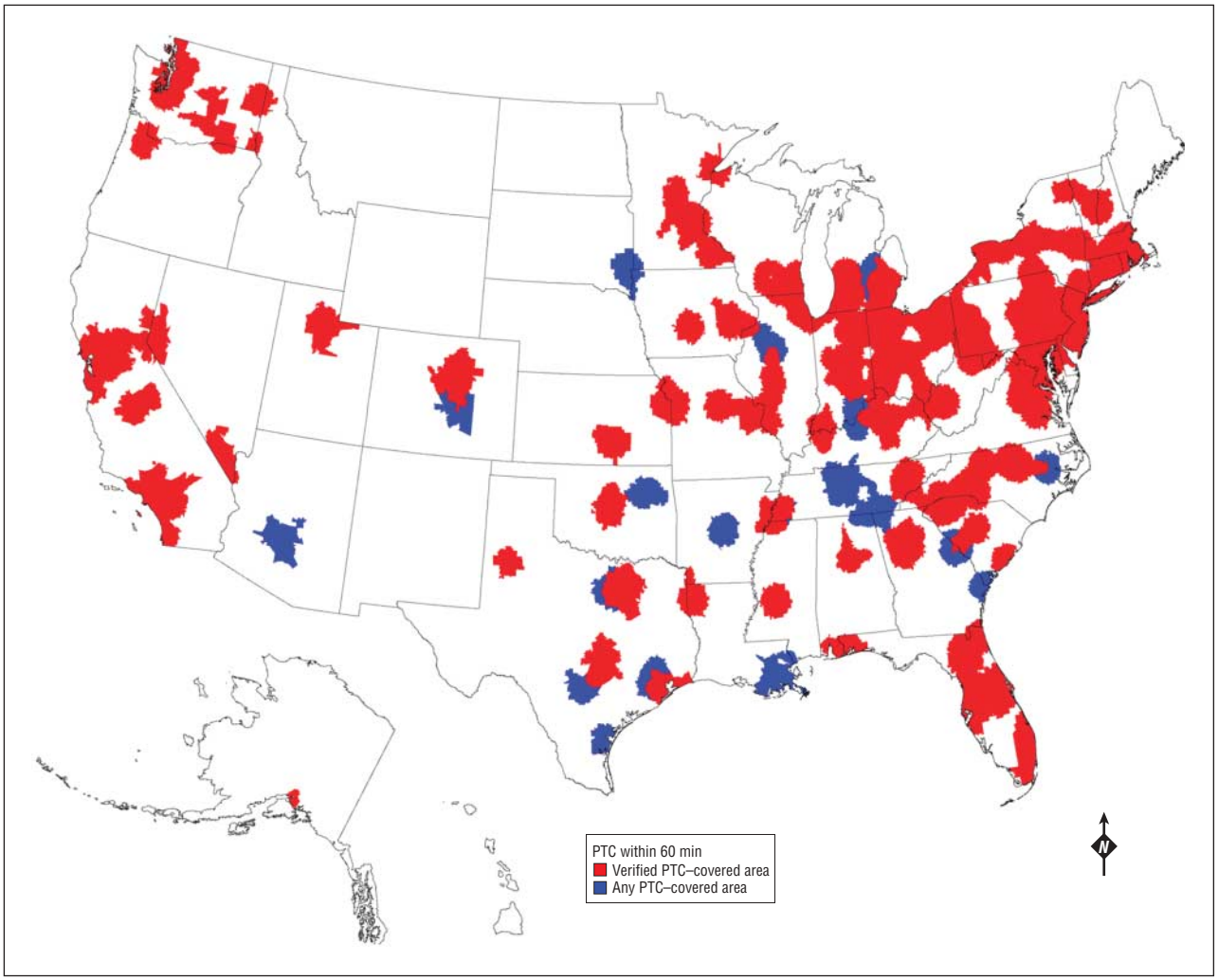

Figure 5. Incremental benefit in 60-minute access with the addition of pediatric-capable self-designated pediatric trauma centers (PTCs) to the coverage provided by verified PTCs.

tions. Prior analyses in the adult population used an inventory of adult trauma centers and demonstrated substantial geographic variability in available resources.[5,7] It was our hypothesis that such variability also existed in the pediatric population. However, the lack of a similar inventory of pediatric trauma resources prohibited the same analysis in children. To address this shortcoming, we created an inventory of verified PTCs using the above-described methodology. In addition, to demonstrate the incremental improvement in access that occurs with the inclusion of self-designated PTCs, we analyzed the population of all trauma centers (verified and NACHRI). Not surprisingly, there was an improvement in access overall and in selected states. It is likely that many of these self-designated centers already function capably as PTCs, but do so without formal verification. Centers likely do not seek formal verification because there is no organized state trauma system mandating it or because the verification process is costly (both from a financial perspective and man power perspective) and those resources may be better spent elsewhere (eg, direct patient care).

In an effort to gauge the effect of rural or urban location on access to pediatric trauma care, we stratified the access calculations by deciles of population density. Children in the more population-dense (urban) areas had a more than 4-fold greater rate of access to PTCs than children in the less population-dense (rural) settings (93.5% vs 22.9%, respectively). A similar variation in access to trauma care was observed in the adult population.[25] Only 24% of adults in rural settings had access to trauma care within 60 minutes. By comparison, 95% of adults living in urban settings were within 60 minutes of trauma care.[25] Such disparity is related in large part to the geographic location of trauma centers, which have historically been located in large urban settings. With a better inventory of available resources, optimal trauma systems planning could be provided based on trauma resource allocation modeling.[26]

Understanding the distribution of existing PTCs and gaps in access will allow for more thoughtful trauma systems planning. The ongoing work of the National Highway Traffic Safety Administration, Health Resources and Services Administration, Centers for Disease Control and Prevention, Agency for Healthcare Research and Quality, and their academic partners to develop a National Emergency Medical Services Information System could

provide useful information in future calculations of PTC access.[27] Creation of a national accrediting body and/or trauma system, funded externally, would help to more accurately inventory PTCs and ensure that the standards of minimum resources of care for injured children are met. This information maintained by a national body may prove vital in policy planning and trauma system organization and should be a public health priority in the future.

Some study limitations deserve mention. Despite the redundancy in our inclusion criteria, it is recognized that some small number of pediatric-capable centers may have been omitted. We would expect that number to be acceptably low, thus having a minimal effect on our estimates. Even with these few centers omitted, the work here is a reasonable first step in developing a sustainable inventory of pediatric trauma resources. Without a reliable and sustainable national mechanism to identify all institutions with pediatric trauma capabilities, any estimates of access or system performance will be inaccurate to some degree. Additional limitations to our access calculations have been described in detail elsewhere.[7]

We have demonstrated that pediatric trauma access varies across the United States. While more than 70% of the pediatric population is within 60 minutes of some level of PTC, an estimated 17.4 million are not. The creation of an inventory of PTCs allowed us to perform these access calculations. A hospital's capacity to provide optimal care for injured children, however, is dynamic, and our inventory captures only a fixed moment in time. To optimize pediatric trauma care planning, the development of a thorough, standardized, and continuously updated catalog of pediatric trauma resources is necessary.

Accepted for Publication: November 13, 2008.
Correspondence: Michael L. Nance, MD, Department of Surgery, The Children's Hospital of Philadelphia, 34th and Civic Center Boulevard, Philadelphia, PA 19104 (nance@email.chop.edu).
Author Contributions: Dr Nance had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Nance, Carr, and Branas. *Acquisition of data:* Carr and Branas. *Analysis and interpretation of data:* Nance, Carr, and Branas. *Drafting of the manuscript:* Nance. *Critical revision of the manuscript for important intellectual content:* Nance, Carr, and Branas. *Statistical analysis:* Branas. *Administrative, technical, and material support:* Nance and Carr.
Financial Disclosure: None reported.
Funding/Support: This study was supported in part by funds available through the Josephine J. and John M. Templeton Jr Endowed Chair in Pediatric Trauma.
Additional Contributions: We are grateful to Marlen Kokaz, MS, Karl Dailey, BS, and Vicky Tam, MA, at the Cartographic Modeling Lab at the University of Pennsylvania, Philadelphia, for programming and mapping support.

REFERENCES

1. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS). Department of Health and Human Services Web site. http://www.cdc.gov/ncipc/wisqars. Accessed November 15, 2007.
2. Pracht EE, Tepas JJ III, Langland-Orban B, Simpson L, Pieper P, Flint LM. Do pediatric patients with trauma in Florida have reduced mortality rates when treated in designated trauma centers? *J Pediatr Surg*. 2008;43(1):212-221.
3. Potoka DA, Schall LC, Gardner MJ, Stafford PW, Peitzman AB, Ford HR. Impact of pediatric trauma centers on mortality in a statewide system. *J Trauma*. 2000; 49(2):237-245.
4. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med*. 2006;354(4):366-378.
5. MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA*. 2003;289(12):1515-1522.
6. The trauma information exchange program. American Trauma Society Web site. http://www.amtrauma.org/tiep/index.html. Accessed July 17, 2008.
7. Branas CC, MacKenzie EJ, Williams JC, et al. Access to trauma centers in the United States. *JAMA*. 2005;293(21):2626-2633.
8. Trauma programs: verified trauma centers. American College of Surgeons Web site. http://www.facs.org/trauma/verified.html. Accessed July 19, 2008.
9. National Association of Children's Hospitals and Related Institutions Web site. http://www.childrenshospitals.net/AM/Template.cfm?Section=Homepage&Template=/customSource/homepage/homepage.cfm. Accessed July 17, 2008.
10. US Census Bureau Web site. http://www.census.gov. Accessed November 9, 2008.
11. Atlas and Database of Air Medical Services (ADAMS) Web site. http://www.ADAMSairmed.org. Accessed January 2005.
12. Love RF, Morris JG; Wisconsin University Madison Mathematics Research Center. Mathematical models of road travel distances. *Manage Sci*. 1979;252:130-139.
13. Love RF, Morris JG, Wesolosky GO. *Facilities Location: Models and Methods*. New York, NY: North-Holland Publishers; 1988.
14. Carr BG, Caplan JM, Pryor JP, Branas CC. A meta-analysis of prehospital care times for trauma. *Prehosp Emerg Care*. 2006;10(2):198-206.
15. Committee on the Future of Emergency Care in the United States Health System. *Future of Emergency Care: Emergency Care for Children: Growing Pains*. Washington, DC: National Academy Press; 2006.
16. US Department of Health and Human Services. *Healthy People 2010: With Understanding and Improving Health and Objectives for Improving Health*. 2nd ed. Washington, DC: US Government Printing Office; 2000.
17. Densmore JC, Lim HJ, Oldham KT, Guice KS. Outcomes and delivery of care in pediatric injury. *J Pediatr Surg*. 2006;41(1):92-98.
18. Mooney DP, Rothstein DH, Forbes PW. Variation in the management of pediatric splenic injuries in the United States. *J Trauma*. 2006;61(2):330-333.
19. Davis DH, Localio AR, Stafford PW, Helfaer MA, Durbin DR. Trends in operative management of pediatric splenic injury in a regional trauma system. *Pediatrics*. 2005;115(1):89-94.
20. Potoka DA, Schall LC, Ford HR. Improved functional outcome for severely injured children treated at pediatric trauma centers. *J Trauma*. 2001;51(5):824-834.
21. American College of Surgeons Committee on Trauma. *Resources for Optimal Care of the Injured Patient*. Chicago, IL: American College of Surgeons; 2006.
22. Odetola FO, Miller WC, Davis MM, Bratton SL. The relationship between the location of pediatric intensive care unit facilities and child death from trauma: a county-level ecologic study. *J Pediatr*. 2005;147(1):74-77.
23. Gausche-Hill M, Schmitz C, Lewis RJ. Pediatric preparedness of US emergency departments: a 2003 survey. *Pediatrics*. 2007;120(6):1229-1237.
24. Segui-Gomez M, Chang DC, Paidas CN, Jurkovich GJ, Mackenzie EJ, Rivara FP. Pediatric trauma care: an overview of pediatric trauma systems and their practices in 18 US states. *J Pediatr Surg*. 2003;38(8):1162-1169.
25. Branas CC. No time to spare: improving access to trauma care. Leonard Davis Institute Issue Brief. 2005;11:1-4. http://www.upenn.edu/ldi/healthpol.html#issuebriefs. Accessed November 9, 2008.
26. Branas CC, MacKenzie EJ, ReVelle CS. A trauma resource allocation model for ambulances and hospitals. *Health Serv Res*. 2000;35(2):489-507.
27. NEMESIS technical assistance center. National EMS Information System Web site. http://www.nemsis.org/index.html. Accessed November 9, 2008.