United States Government Accountability Office

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March 2017

PEDIATRIC TRAUMA CENTERS

Availability, Outcomes, and Federal Support Related to Pediatric Trauma Care

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GAO-17-334

March 2017

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GAO Highlights

Highlights of GAO-17-334, a report to congressional requesters

Why GAO Did This Study

Pediatric trauma—a severe and potentially disabling or life threatening injury to a child resulting from an event such as a motor vehicle crash or a fall—is the leading cause of disability for children in the United States. More children die of injury each year than from all other causes combined. GAO was asked to examine issues related to pediatric trauma care.

This report examines (1) what is known about the availability of trauma centers for children and the outcomes for children treated at different types of facilities, and (2) how, if at all, federal agencies are involved in supporting pediatric trauma care and how these activities are coordinated. GAO analyzed data on the number of pediatric and adult trauma centers in the United States relative to the pediatric population under 18 years of age. GAO used 2015 data on trauma centers from the American Trauma Society's Trauma Information Exchange Program and 5-year population estimates for 2011-2015 from the U.S. Census Bureau's American Community Survey, which were the latest available data at the time of GAO's analysis. GAO also reviewed the existing peer-reviewed, academic literature on outcomes for pediatric trauma patients, interviewed stakeholder group representatives and federal agency officials involved in activities related to hospital-based pediatric trauma care, and reviewed available agency documentation.

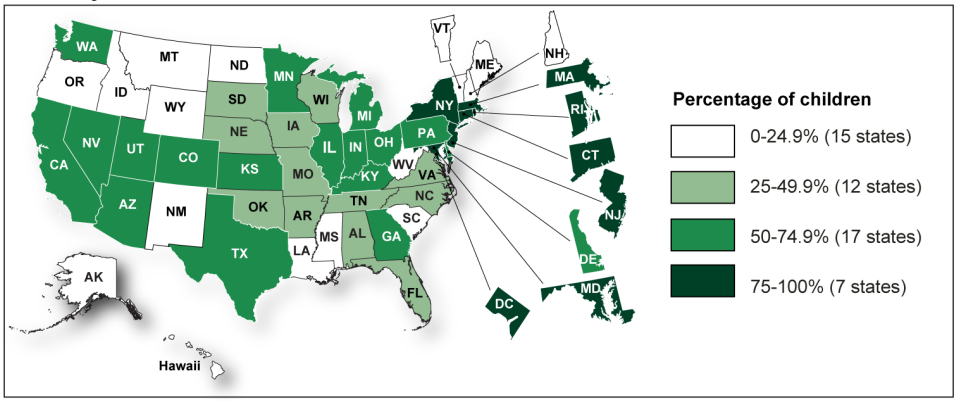
HHS provided technical comments on a draft of this report, which GAO incorporated as appropriate.

View GAO-17-334. For more information, contact Marcia Crosse at (202) 512-7114 or crossem@gao.gov.

What GAO Found

GAO estimates that 57 percent of the 73.7 million children in the United States during the period 2011-2015 lived within 30 miles of a pediatric trauma center that can treat all injuries regardless of severity. Among states, the proportion of children who lived within 30 miles of these pediatric trauma centers varied widely. In areas without pediatric trauma centers, injured children may have to rely on adult trauma centers or less specialized hospital emergency departments for initial trauma care. Some studies GAO reviewed, including nationwide studies, found that children treated at pediatric trauma centers have a lower mortality risk compared to children treated at adult trauma centers and other facilities, while other state-level studies GAO reviewed found no difference in mortality. Further, some studies GAO reviewed and stakeholders GAO interviewed suggest that more information is needed on outcomes other than mortality for children treated at pediatric trauma centers because mortality can be a limited outcome measure, as overall mortality is low among severely injured children.

Estimated Percentage of Children Who Lived within 30 Miles of a High-Level Pediatric Trauma Center, by State, 2011-2015



Sources: GAO analysis of American Trauma Society and U.S. Census Bureau data (data); Map Resources (map). | GAO-17-334

Note: High-level pediatric trauma centers have the resources to treat all injured children, regardless of injury severity.

Two agencies within the Department of Health and Human Services (HHS)—the Health Resources and Services Administration (HRSA) and the National Institutes of Health (NIH)—have grant programs and other activities that support hospital-based pediatric trauma care. For example, HRSA's Emergency Medical Services for Children Program provides grants to integrate pediatric emergency care—which encompasses care for both traumatic injury and illness—into states' larger emergency medical services systems. GAO also found that federal activities related to hospital-based pediatric trauma care and other emergency care are coordinated through an interagency group and arrangements among agencies. For example, HRSA and NIH staff participate in the Council on Emergency Medical Care, an interagency group established to coordinate emergency care activities across the federal government by promoting information sharing and policy development.

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Abbreviations

ACS-COT	American College of Surgeons Committee on Trauma
ASPR	Office of the Assistant Secretary for Preparedness and Response
CDC	Centers for Disease Control and Prevention
EMSC	Emergency Medical Services for Children
HHS	Department of Health and Human Services
HRSA	Health Resources and Services Administration
NIH	National Institutes of Health

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

March 27, 2017

The Honorable Greg Walden
Chairman
Committee on Energy and Commerce
House of Representatives

The Honorable Michael C. Burgess
Chairman
Subcommittee on Health
Committee on Energy and Commerce
House of Representatives

The Honorable Richard Hudson
House of Representatives

The Honorable Fred Upton
House of Representatives

Pediatric trauma—a severe and potentially disabling or life threatening physical injury to a child resulting from an event such as a motor vehicle crash or a fall—is the leading cause of disability for children in the United States. More children die of injury each year than from all other causes combined. According to the Centers for Disease Control and Prevention (CDC), more than 8,000 children under 18 years of age suffered fatal injuries in 2015. Further, according to the latest available CDC estimates, unintentional injuries to children under 18 that resulted in hospitalization combined for an estimated $22.9 billion in medical and other costs in 2010.

Most traumatic injuries—including those to children—are treated in a hospital emergency department. However, for severe physical injuries, emergency departments may not have the equipment or personnel resources necessary to effectively provide treatment, so severely injured patients may be transported directly to a trauma center or transferred to a trauma center by an emergency department. Trauma centers are facilities with the specialized resources needed to care for patients with severe physical injuries. Not all trauma centers have pediatric-specific capabilities. Pediatric trauma centers have the specialized resources—

providers, equipment, and expertise—needed to care for children with severe physical injuries.[1]

Concerns have been raised that many children may not have ready access to pediatric trauma centers. For example, a 2009 study estimated that at least 17.4 million children across the United States could not reach a pediatric trauma center within an hour by air or ground transportation.[2] Similarly, a 2005 study estimated that 46.7 million people (both adults and children) did not have access to a trauma center within an hour's travel time.[3] Timely access to appropriate hospital-based pediatric trauma care can be significant in limiting death or disability for injured children. Further, in 2006 the Institute of Medicine reported that emergency care services—including trauma care—for children have traditionally been fragmented, with emergency medical services, trauma centers, and public health agencies focused on their separate missions.[4] Responsibility for trauma and emergency care is primarily at the state and local level with some involvement at the federal level.

You asked us to review issues related to pediatric trauma. This report describes

[1]Pediatric trauma care refers to the care received in any setting by a child who has suffered a traumatic injury, while a trauma center is a hospital-based setting specifically designated to provide trauma care. In addition to trauma centers, trauma care can be provided in other settings such as a non-trauma center emergency department. In this report, we use the term "hospital-based pediatric trauma care" to refer to emergency medical care provided to children at a pediatric trauma center, adult trauma center, or non-trauma center emergency department.

[2]See M. L. Nance, B. G. Carr, and C. C. Branas, "Access to Pediatric Trauma Care in the United States." *Archives of Pediatric & Adolescent Medicine*, vol. 163, no. 6 (2009). This study specifically examined "verified pediatric trauma centers" which were defined in the study as any pediatric-capable trauma centers that the American College of Surgeons Committee on Trauma (ACS-COT) or the American Trauma Society had identified or that a state or local authority had designated as a pediatric trauma center.

[3]See C. C. Branas et al., "Access to Trauma Centers in the United States." *JAMA*, vol. 293, no. 21 (2005).

[4]Institute of Medicine of the National Academies, Committee of the Future of Emergency Care in the United States Health System, *Emergency Care for Children: Growing Pains* (Washington, D.C.: 2006). This was one report in a series of three on the emergency care system in the United States that the Institute of Medicine published.

(1) what is known about the availability of trauma centers for children and the outcomes for children treated at different types of facilities, and

(2) how, if at all, federal agencies are involved in supporting pediatric trauma care and how these activities are coordinated.

In appendix I we also provide information on the training and resources available to physicians and nurses for delivering pediatric trauma care.

To describe what is known about the availability of trauma centers for children, we analyzed 2015 data from the American Trauma Society Trauma Information Exchange Program on the number and location of trauma centers in the United States.[5] We also analyzed data from the U.S. Census Bureau's American Community Survey 5-year population estimates for 2011 through 2015 of children under 18.[6] These data were the most current data available at the time of our analysis. We analyzed these data to estimate the number and percentage of children who live within 30 miles of a pediatric or adult trauma center, focusing our analysis on level I, II, and III pediatric or adult trauma centers.[7] In this report, we

[5]The American Trauma Society Trauma Information Exchange Program collects data on adult and pediatric trauma centers annually through a survey of states. The program verifies the data it collects by comparing it to data from prior years and other publicly available data and by verifying the data with trauma centers and state trauma program managers.

[6]The American Community Survey 5-year estimates are updated annually and are based on data collected continuously from a sample of households during the entire 60 month period. We used the 5-year estimates rather than 1-year estimates because they are based on larger sample sizes and thus are more reliable.

[7]We determined whether children in each zip code lived within 30 miles of a trauma center by calculating the distance between the central point of each zip code and the nearest trauma center. As such, part of the population in each distance calculation will be located beyond this central point. We used a 30 mile radius that was not limited by state boundaries and chose this distance because other studies have used 30 miles as a benchmark for assessing trauma center availability. For example, one study that measured distance in miles to trauma centers rather than time alone used this distance, as well as another study that measured distance to the nearest trauma center based on zip codes, which is the same unit of analysis we used. See R.Y. Hsia and Y. Shen, "Possible Geographical Barriers to Trauma Center Access for Vulnerable Patients in the United States: An Analysis of Urban and Rural Communities," *Archives of Surgery*, vol. 146, no. 1 (2011) and R.Y. Hsia and Y. Shen, "Rising Closures of Hospital Trauma Centers Disproportionately Burden Vulnerable Populations," *Health Affairs*, vol. 30, no. 10 (2011). Pediatric and adult trauma centers across the United States are categorized into levels that refer to the kinds of resources available in the trauma center and the number of patients admitted each year.

refer to level I and level II centers as "high-level" trauma centers because they have the resources to provide definitive care for all injured patients.[8] We refer to level III trauma centers as "mid-level" trauma centers because these facilities have the resources to provide some definitive care, have transfer agreements in place with high-level centers, and serve areas without high-level trauma centers. To assess the reliability of the data from the American Trauma Society Trauma Information Exchange Program on the number and location of trauma centers in the United States, we interviewed a knowledgeable official about the process for collecting the data and verified the location and level of trauma centers in selected states by comparing the data to publicly available lists of trauma centers from the American College of Surgeons, state emergency medical services websites, and other official state and hospital websites. To assess the reliability of the U.S. Census Bureau's American Community Survey 5-year population estimates of children under 18, we reviewed relevant documentation and performed data checks to check for outliers, errors, and consistency. Based on our review of the data and relevant documentation, we determined that all the data we used were sufficiently reliable for estimating the availability of trauma centers for children.

To determine what is known about outcomes for children treated at different facility types, we performed a structured search of research databases, such as MEDLINE, Embase, and Scopus to identify any peer-reviewed, scholarly literature published from January 1, 2007, through September 30, 2016, on outcomes for hospital-based care provided to children who have suffered physical trauma. In our searches, we used a combination of search terms such as "trauma center," "pediatric," and "outcome." We identified 18 peer-reviewed studies that were relevant for our purposes. We considered a study relevant if it presented findings that compared outcomes for injured children between different types of facilities, such as outcomes for injured children treated at a pediatric trauma center compared to an adult trauma center or an emergency department that was not a trauma center. We also interviewed stakeholder groups involved in pediatric trauma care and incorporated

[8]Definitive care is care provided to completely manage a patient's condition. This includes a full range of medical care, such as having the surgical capabilities to treat a life-threatening injury and rehabilitative medical care.

into our report relevant information on pediatric trauma outcomes that representatives identified.[9]

To describe how, if at all, federal agencies are involved in supporting pediatric trauma care, we interviewed federal agency officials about their ongoing activities related to hospital-based pediatric trauma care, including funding and any coordination with other agencies or departments. To corroborate statements from agency officials and to obtain additional information, we also reviewed available documentation from agencies about their activities, such as strategic plans, funding announcements, and other relevant documentation. We limited our review to agencies involved in supporting hospital-based pediatric trauma care.[10]

We conducted this performance audit from May 2016 to March 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Children who have suffered a severe and potentially life threatening physical injury as a result of an event such as a motor vehicle crash or a fall need specialized care because of their unique anatomical, physiological, and psychological characteristics. Trauma centers—a key part of a region's trauma system—have specialized resources to care for traumatically injured patients, with pediatric trauma centers having dedicated resources specific to the treatment of traumatically injured children. Responsibility for developing and operating emergency care systems, including trauma systems, primarily rests at the state and local level, with some involvement at the federal level.

[9]The nine stakeholder groups we interviewed included those representing the perspectives of trauma care physicians and nurses, pediatric specialists, and research and advocacy organizations involved in hospital-based pediatric trauma care.

[10]Agencies or departments primarily involved in continuum of trauma care activities other than hospital-based trauma care were outside the scope of our review. This includes agencies like the U.S. Department of Transportation's National Highway Traffic Safety Administration and its efforts related to pre-hospital care—the initial assessment, treatment, and transport of a patient to the nearest facility capable of treating a patient's injuries—and the efforts of the CDC related to injury prevention.

Resources to Address Injured Children's Unique Needs

Children typically require specialized resources—both equipment and personnel—wherever they receive care due to unique anatomical, physiological, and psychological needs. For example, the use of specially sized equipment or the adjustment of medication dosages based on a child's weight are required when treating children with traumatic injuries. In its 2006 report on emergency care for children, the Institute of Medicine recommended that all emergency departments appoint certain personnel who would address the resources that children need. Specifically, it recommended that all emergency departments have two part-time pediatric emergency coordinators—one a physician—who would have a number of responsibilities, including ensuring that fellow emergency department and other providers have adequate skills and knowledge to treat children, overseeing pediatric care quality improvement initiatives, and ensuring the availability of pediatric medications, equipment, and supplies. Additionally, the National Pediatric Readiness Project found that emergency departments with a pediatric emergency coordinator were more than twice as likely to have important policies in place related to treating children.[11]

Trauma Centers

Trauma centers have specialized resources to care for traumatically injured patients. Most emergency departments across the United States do not qualify as trauma centers because they do not have the optimal resources to treat severely-injured patients.

Trauma center levels. Trauma centers across the United States are designated as one of five levels, which refer to the kinds of resources available in the trauma center and the number of patients admitted yearly. Making this designation is the responsibility of state or sometimes local entities, such as a state's office of emergency medical services. While the criteria used to designate a trauma center's level can vary from state to state, most states have adopted guidelines that are either the same as or similar to the guidelines developed by the American College of Surgeons

[11]M. Gausche-Hill et al., "A National Assessment of Pediatric Readiness of Emergency Departments," *JAMA Pediatrics*, vol.169, no. 6 (2015). The National Pediatric Readiness Project is a partnership between the American Academy of Pediatrics, the American College of Emergency Physicians, the Emergency Nurses Association, and the federal Emergency Medical Services for Children (EMSC) program within the Health Resources and Services Administration (HRSA).

Committee on Trauma (ACS-COT).[12] Table 1 summarizes the general criteria for trauma centers based on the ACS-COT guidelines.

Table 1: General Criteria for Trauma Centers

Level I	Capable of providing total care for every aspect of injury—from prevention to rehabilitation. Elements include 24 hour in-house coverage by general surgeons and prompt availability of care in specialties (e.g., neurosurgery and plastic surgery). Provides leadership in prevention and operates an organized teaching and research effort to help direct new innovations in trauma care. Admits a certain volume of patients each year (e.g., at least 1,200 trauma patients).
Level II	Meets the same clinical care requirements as a level I center, including 24-hour immediate coverage by general surgeons. Can initiate care for all injured patients. Does not have the leadership, teaching, or research requirements of a level I trauma center.
Level III	Can provide prompt assessment, resuscitation, surgery, intensive care, and stabilization of injured patients and emergency operations. Has transfer agreements in place for patients who need more comprehensive care at a level I or II trauma center. Can provide complete clinical care for most minor to moderately injured patients. Elements include 24-hour immediate coverage by emergency medicine physicians and the prompt availability of general surgeons.
Level IV	Can provide advanced trauma life support prior to transferring patients to a higher level trauma center. Provides evaluation, stabilization, and diagnostic capabilities for injured patients. Elements include basic emergency department facilities and 24-hour laboratory coverage.
Level V	Can provide initial evaluation, stabilization, and diagnostic capabilities and can prepare patients for transfer to centers with higher levels of care. Elements include basic emergency department facilities, available trauma nurse and physician available upon patient arrival, and after-hour protocols if the facility is not open 24 hours a day.

Sources: American College of Surgeons Committee on Trauma (ACS-COT) and American Trauma Society. | GAO-17-334

Note: These general criteria for levels I through IV are adapted from the resources identified in the 2014 edition of the ACS-COT publication *Resources for the Optimal Care of the Injured Patient*. The criteria for level V trauma centers are as described by the American Trauma Society. For the purposes of this report, we classified level I and II trauma centers as "high-level" trauma centers and level III trauma centers as "mid-level" trauma centers. We did not classify or analyze data related to level IV and V trauma centers.

Types of trauma centers. There are two types of trauma centers—pediatric and adult. Some trauma centers are only an adult trauma center, some are only a pediatric trauma center, and some are both.[13] Pediatric

[12]These guidelines are outlined in the publication *Resources for the Optimal Care of Injured Patients*. In addition to publishing these guidelines, ACS-COT also has a program to verify the presence of those resources for both adult and pediatric trauma centers. The ACS-COT verification program verifies level I and II centers for pediatrics and levels I, II, and III centers for adults. Trauma centers are "designated" by the appropriate authority in their state or local area. A trauma center can be both a "designated" center and a "verified" trauma center. If the trauma center is verified it means that the center has gone through the voluntary ACS-COT verification process.

[13]A single facility that is both an adult trauma center and a pediatric trauma center is called a mixed trauma center. A mixed trauma center can have separate adult and pediatric designations or ACS-COT verification at different levels. For example, a trauma center could be designated as a level center I for adults and as a level II center for pediatrics.

trauma centers have dedicated resources to treat injured children and can be either stand-alone children's hospitals or distinct units within larger hospitals.

A pediatric trauma center must meet all the same requirements that an adult trauma center must meet, as well as additional requirements.[14] For example, according to ACS-COT guidelines,

- a level I pediatric trauma center must have at least two surgeons who are board certified in pediatric surgery and must admit 200 or more injured children younger than 15 annually; and
- a level II pediatric trauma center must have at least one board-certified pediatric surgeon and must admit 100 or more injured children younger than 15 annually.[15]

Pediatric trauma centers are expected to provide trauma care for the most severely injured children and have a leadership role in education, research, and planning with other trauma centers and non-trauma center hospitals in their geographic area with regards to care for injured children.

ACS-COT recommends that pediatric trauma centers be used to the fullest extent feasible to treat traumatically injured children; however, due to the limited number and geographic distribution of these centers, ACS-COT recognizes that adult trauma centers or non-trauma centers must provide initial care for injured children in areas where specialized pediatric resources are not available. Research shows that even in states that designate trauma centers, nearly half of injured children—45 percent—are treated at non-trauma centers.[16] Many of these non-trauma centers where injured children receive treatment do not treat a high volume of

[14]Most states only designate level I and level II pediatric trauma centers, but there are some states that designate level III pediatric trauma centers. The ACS-COT voluntary verification program verifies level I and II pediatric trauma centers.

[15]Adult trauma centers may have some of the dedicated resources to treat injured children, although not at the same level as a pediatric trauma center. For ACS-COT verification, ACS-COT requires any adult trauma center that admits 100 or more injured children younger than 15 years old annually to meet additional criteria demonstrating their capability to care for injured children. For example, at these centers trauma surgeons must be credentialed for pediatric trauma care by the hospital's credentialing body and there must be appropriate resuscitation equipment available.

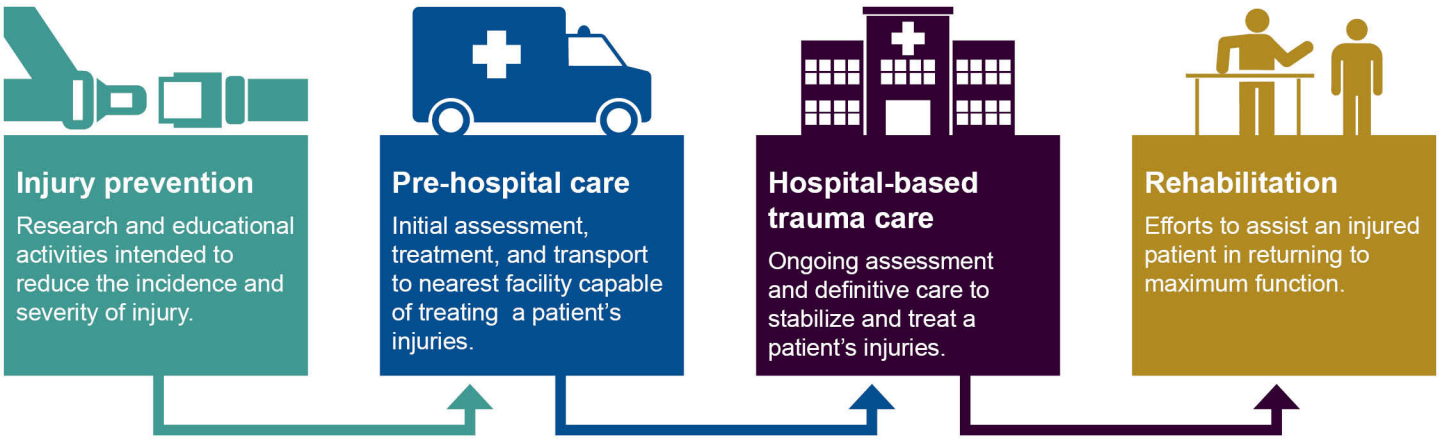
[16]M. Segui-Gomez et al., "Pediatric trauma care: an overview of pediatric trauma systems and their practices in 18 US states," *Journal of Pediatric Surg*ery, Vol. 38, No. 8. (2003).

pediatric patients and may not have the equipment recommended for treating children. The National Pediatric Readiness Project's 2013 assessment of over 4,100 hospitals across the United States found that about 69 percent of hospitals see fewer than 14 children per day and that at least 15 percent of hospitals lacked one or more specific pieces of equipment recommended for treating children.[17]

Trauma Systems: Continuum of Trauma Care Activities and the Federal Role

Within trauma systems, coordinated trauma care activities occur across a broad continuum, ranging from injury prevention activities and pre-hospital care to hospital-based trauma care and rehabilitation (see fig. 1). Trauma care is an essential component of emergency care, which encompasses all services involved in emergency medical care—both injury and illness. A comprehensive trauma system may involve public health officials and departments, emergency medical services personnel, emergency departments and trauma centers, stakeholder and advocacy groups, and families, among others. Such a system typically organizes the delivery of trauma care across the continuum at the local, regional, state, or national level.

Figure 1: Continuum of Trauma Care Activities



Source: GAO. | GAO-17-334

[17]The 4,100 hospitals that responded to the assessment represented 83 percent of all hospital emergency departments across the United States. See M. Gausche-Hill, et al., "National Assessment," 527; 531.

Responsibility for developing and operating trauma systems and the broader emergency care efforts of which they are a part primarily rests at the state and local level, with some support from federal programs. Generally, federal involvement in trauma care has addressed trauma care system development or research. For example, the Department of Health and Human Services (HHS) Secretary can make grants and enter into cooperative agreements and contracts to conduct and support research, training, evaluations, and demonstration projects related to trauma care and to foster the development of trauma care systems.[18] Additionally, in 2006, HHS' Health Resources and Services Administration (HRSA) released the Model Trauma System Planning and Evaluation document, a guide for trauma system development across the United States. The guide has helped provide a foundation to create and maintain systems of trauma care for communities, regions, and states.

Over Half of the Nation's Children Live within 30 Miles of a High-Level Pediatric Trauma Center, and Studies Differ on How Well Such Centers Work to Lower Mortality

We found that 57 percent of children in the United States lived within 30 miles of a high-level pediatric trauma center during the period 2011-2015. Some of the studies we reviewed suggest that children treated at pediatric trauma centers have a lower risk of mortality compared to children treated at other types of facilities, while other studies found no difference in mortality.

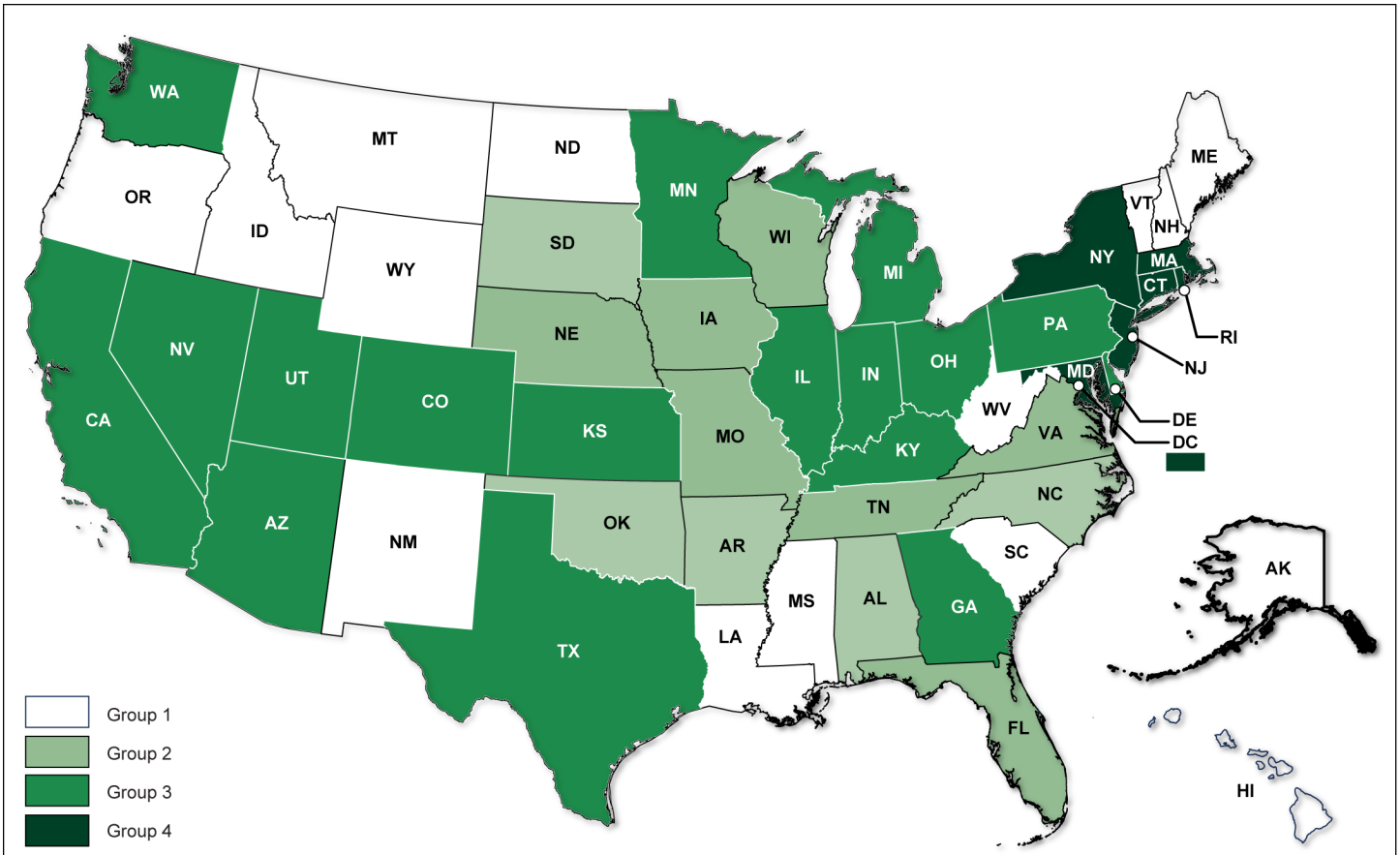
[18]Trauma Care Systems Planning and Development Act of 1990, Pub L. No. 101-590, § 3, 104 Stat. 2915, 2915-2928 (1990) (codified, as amended, at 42 U.S.C. § 300d).

An Estimated 57 Percent of Children Lived within 30 Miles of a High-Level Pediatric Trauma Center during the Period 2011-2015, Although the Percentage Varied by State

Our analysis of data from the American Trauma Society and the Census Bureau's American Community Survey shows that 57 percent, or 41.9 million, of the estimated 73.7 million children in the United States lived within 30 miles of a high-level pediatric trauma center during the period 2011-2015. These centers have the dedicated resources necessary to treat all injuries, regardless of severity. Among states, the proportion of children who lived within 30 miles of a high-level pediatric trauma center varied widely, ranging from no children in eight states to more than 90 percent of children in four states (see fig. 2).[19]

[19]See appendix II for the location of the 136 high-level pediatric trauma centers across the United States in 2015. These centers include stand-alone children's hospitals and centers co-located with adult trauma centers.

Figure 2: Estimated Percentage of Children Who Lived within 30 Miles of a High-Level Pediatric Trauma Center, by State, 2011-2015



Group 1 0-24.9% of state's children lived within 30 miles of a high-level pediatric trauma center	Group 2 25-49.9% of state's children lived within 30 miles of a high-level pediatric trauma center	Group 3 50-74.9% of state's children lived within 30 miles of a high-level pediatric trauma center	Group 4 75-100% of state's children lived within 30 miles of a high-level pediatric trauma center
● 15 states	● 12 states	● 17 states	● 7 states
● 393,628 children within 30 miles	● 6.7 million children within 30 miles	● 26.1 million children within 30 miles	● 8.8 million children within 30 miles
● 8 states with no children within 30 miles			● 4 states with 90% or more children within 30 miles

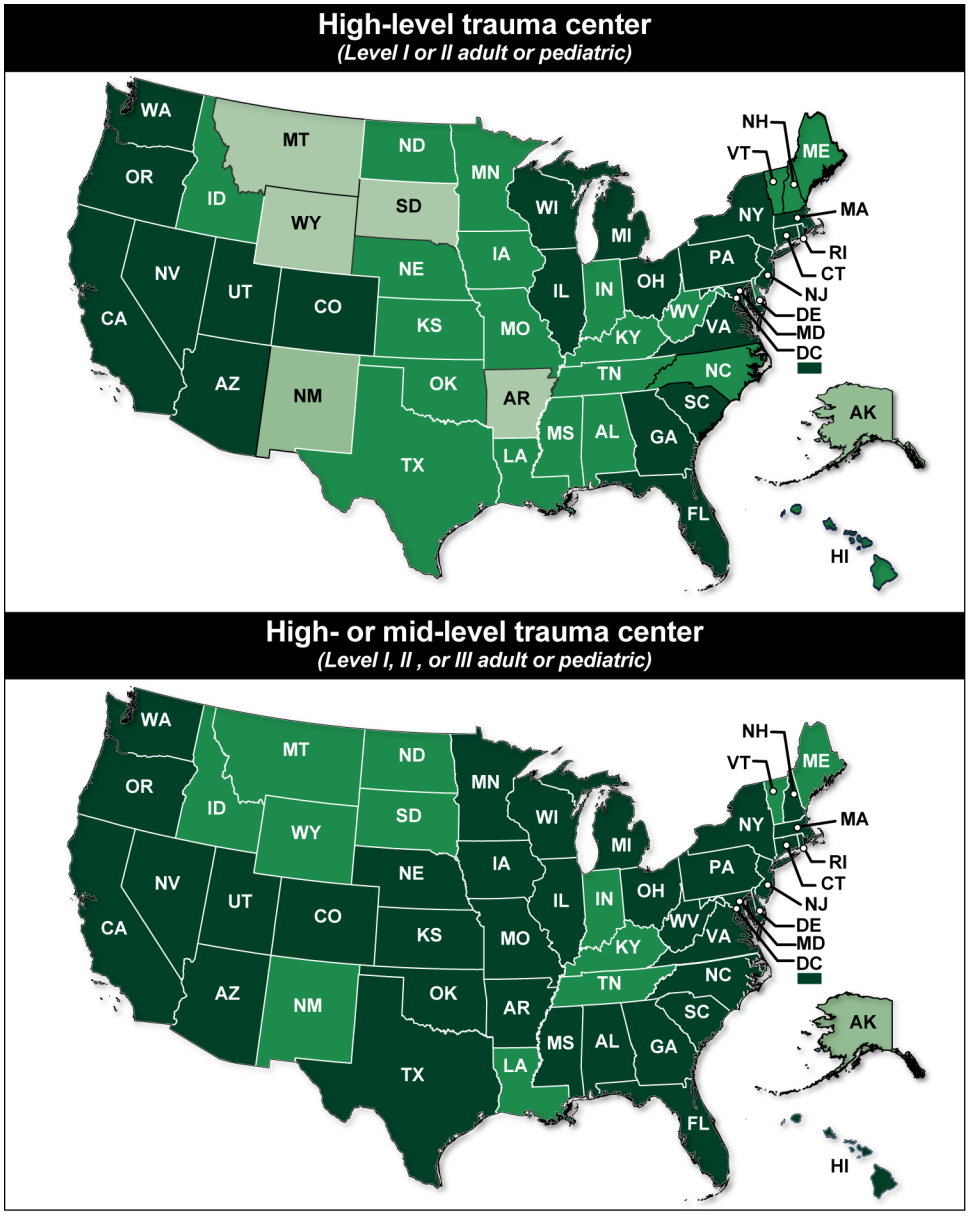
Sources: GAO analysis of American Trauma Society and U.S. Census Bureau data (data); Map Resources (map). | GAO-17-334

Note: Child population estimates are based on the U.S. Census Bureau's American Community Survey data 5-year estimates during the period 2011-2015. To identify trauma center locations, we used 2015 data from the Trauma Information Exchange Program of the American Trauma Society. High-level pediatric trauma center refers to level I and level II pediatric trauma centers. In 2015, there were 136 high-level pediatric trauma centers in the United States.

While an estimated 41.9 million children lived within 30 miles of a high-level pediatric trauma center, an estimated 31.8 million children did not. In areas without high-level pediatric trauma centers, children may have to rely on adult trauma centers with the resources to treat injured patients, even though these facilities are not specialized to treat children. When we consider both adult and pediatric trauma centers, the percentage of children living within 30 miles of the nearest high-level trauma center increases to 80 percent. When we consider all high- and mid-level trauma centers, the percentage of children living within 30 miles of one of these facilities increases to 88 percent, or 65.1 million. The proportion of children who lived within 30 miles of high- or mid-level trauma centers during the period 2011-2015 varied by state (see fig. 3).[20]

[20]See appendix III for a detailed state by state table of the estimated percentage of children who lived within 30 miles of a high- or mid-level trauma center.

Figure 3: Estimated Percentage of Children Who Lived within 30 Miles of a High- or Mid-Level Trauma Center, by State, 2011-2015



Sources: GAO analysis of American Trauma Society and U.S. Census Bureau data (data); Map Resources (map). | GAO-17-334

Note: Child population estimates are based on the U.S. Census Bureau's American Community Survey data during the period 2011-2015. To identify trauma center locations, we used 2015 data from the Trauma Information Exchange Program of the American Trauma Society. In 2015, there were 136 high-level pediatric trauma centers and 524 high-level adult trauma centers–283 of these high level adult trauma centers were verified by the American College of Surgeons Committee on Trauma (ACS-COT). There were a total of 465 mid-level adult trauma centers and 10 mid-level pediatric trauma centers. Sixty-seven of those mid-level adult trauma centers were verified by ACS-COT.

The findings from our analysis of children's proximity to trauma centers are similar to the findings from other assessments of access to trauma care for all U.S. residents (adults and children). For example, one study found that in 2005, about 84 percent of residents could reach a high-level trauma center within an hour, and about 89 percent could reach a high- or mid-level trauma center in this time.[21]

Some Studies Suggest that Children Treated at Pediatric Trauma Centers Have a Lower Risk of Mortality, While Information on Other Outcomes Is Limited

Five of the studies we reviewed, including studies based on national data, suggest that children treated at pediatric trauma centers have a lower risk of mortality compared to children treated at other types of facilities. Three studies, which each analyzed data from a different state, found no significant differences in mortality.[22] In addition, seven studies examined other outcome measures, such as imaging use or the rates of certain surgical procedures for severely injured children. However, some of the studies we reviewed and stakeholders we interviewed suggested that data on pediatric outcomes is limited and that more information is needed on outcomes other than mortality for children treated at pediatric trauma centers. More information is needed, in part, because mortality can be a limited measure since overall mortality is low among severely injured children.

Mortality at pediatric trauma centers compared to other types of facilities. Five of the studies that we reviewed show that children treated at pediatric trauma centers had a lower risk of mortality compared with

[21]C. C. Branas et al., "Access to Trauma Centers in the United States." *JAMA*, vol. 293, no. 21 (2005).

[22]In total, we reviewed 18 studies that used various study designs and study populations. Eight of the 18 studies analyzed data that compared the mortality risk for children treated at pediatric trauma centers to the mortality risk for children treated at other types of facilities. However, there were also 6 studies that analyzed mortality data but made other comparisons (e.g., outcomes between pediatric trauma centers at different levels). Three studies were literature reviews of pediatric trauma outcomes, and 1 study examined an outcome other than mortality. Some studies examined both mortality and other outcomes. This includes 6 of the 7 studies that examined outcomes other than mortality.

children treated at adult trauma centers or children transferred to a pediatric trauma center for treatment after initial treatment at another facility.[23] For example, a 2015 study that examined hospitalizations nationwide among children ages 18 and under found that children treated at pediatric trauma centers had a lower risk of mortality compared with children treated at adult trauma centers or mixed trauma centers.[24] Another study from 2016 that examined hospitalizations nationwide for injured adolescents aged 15 to 19 had a similar finding.[25] A third study, from 2008, found that treatment in a pediatric trauma center compared to an adult trauma center was associated with an almost 8 percent reduction in the likelihood of mortality among pediatric trauma patients in Florida.[26]

[23]In addition, two other studies compared mortality for children treated at adult trauma centers to adult trauma centers with added qualifications in pediatrics. One study found lower mortality at the adult trauma centers with added qualifications in pediatrics, while the other study, which only focused on children with brain injuries, found no significant difference in mortality. At the time these studies were performed, any adult trauma center that admitted 100 or more injured children younger than 15 each year that met additional criteria demonstrating some capability to treat injured children were referred to as "adult trauma centers, with added qualifications in pediatrics". T. A. Oyetunji et al., "Treatment Outcomes of Injured Children at Adult Level 1 Trauma Centers: Are there Benefits from Added Specialized Care?" *American Journal of Surgery*, vol. 201, no. 4 (2011) and F. Ovalle Jr. et al., "Outcomes of Pediatric Severe Traumatic Brain Injury Patients Treated in Adult Trauma Centers with and without Added Qualifications in Pediatrics — United States, 2009." *Injury Epidemiology*, vol. 1, no. 1 (2014).

[24]A mixed trauma center is a hospital that has both pediatric and adult trauma units. C. Sathya et al., "Mortality among Injured Children Treated at Different Trauma Center Types," *JAMA Surgery*, vol. 150, no. 9 (2015). To examine the association between trauma center type and in-hospital mortality, this study reported odds ratios rather than a percentage difference in mortality. The crude mortality rates were 2.3 percent for children treated at adult trauma centers, 1.8 percent for children treated at mixed trauma centers, and 0.6 percent for children treated at pediatric trauma centers.

[25]R. B. Webman et al., "Association between Trauma Center Type and Mortality among Injured Adolescent Patients," *JAMA Pediatrics*, vol. 170, no. 8 (2016).

[26]E. E. Pracht et al., "Do Pediatric Patients with Trauma in Florida have Reduced Mortality Rates when Treated in Designated Trauma Centers?" *Journal of Pediatric Surgery*, vol. 43, no. 1 (2008). In addition to the studies in our review that compared mortality between facility types, there were three studies that examined what was in the literature about mortality. One study found that severely injured children treated at pediatric trauma centers had improved outcomes compared to those treated at adult trauma centers, while the other two studies found that the literature did not provide a definitive answer about which type of facility had the best outcomes. C. Ochoa et al., "Prior Studies Comparing Outcomes from Trauma Care at Children's Hospitals Versus Adult Hospitals," *The Journal of Trauma*, vol. 63, no. 6 Suppl. (2007); M. Petrosyan et al., "Disparities in the Delivery of Pediatric Trauma Care," *The Journal of Trauma*, vol. 67, no. 2 Suppl. (2009); and A. McCarthy et al., "Paediatric Trauma Systems and their Impact on the Health Outcomes of Severely Injured Children: An Integrative Review," *Injury-International Journal of the Care of the Injured*, vol. 47, no. 3 (2016).

Finally, two studies examined whether there were differences in outcomes based on whether children were transported directly to a pediatric trauma center following injury.[27] Both studies found that after adjusting for injury severity, mortality was lower for children who were taken directly to a pediatric trauma center compared with children who were initially taken to a local hospital.[28]

In contrast, three of the studies we reviewed did not find a significant difference in the risk of mortality for children treated at pediatric trauma centers compared to children treated at adult trauma centers.[29] All three of these studies were state-level analyses rather than analyses based on a national sample. For example, two studies, which each examined data for adolescents from a single state, did not identify significant differences in mortality among adolescents treated at pediatric and adult trauma

[27]J. F. Anders et al., "Comparison of Outcomes for Children with Cervical Spine Injury Based on Destination Hospital from Scene of Injury," *Academic Emergency Medicine*, vol. 21, no. 1 (2014) and F. O. Odetola et al., "Source of Admission and Outcomes for Critically Injured Children in the Mountain States," *Archives of Pediatrics & Adolescent Medicine*, vol. 164, no. 3 (2010). Anders et al. reported an odds ratio that indicated that after adjusting for injury severity patients taken directly to a pediatric trauma center were more likely to have a normal outcome than to die or have a persistent neurologic deficit. The study did not report a percentage difference in mortality. Odetola et al. found that after adjusting for injury severity and for the time elapsed since injury before admission to the trauma center among other factors, transferred patients had a 3-fold higher incident rate of death compared to children who were directly admitted.

[28]In addition, another study found a 37 percent lower pediatric injury-related mortality rate in states with an ACS-COT verified level I pediatric trauma center compared to states without a pediatric trauma center or states with only adult trauma centers. We did not count this study as one of the five studies that found lower mortality risk because it was a population-based study that did not use patient data on outcomes from different facility types. Instead, it compared injury-related mortality rates from each state to the types of trauma centers available in each state. See D. M. Notrica et al., "Pediatric Trauma Centers: Correlation of ACS-Verified Trauma Centers with CDC Statewide Pediatric Mortality Rates," *Journal of Trauma and Acute Care Surgery*, vol. 73, no. 3 (2012).

[29]We also identified one study that compared outcomes among pediatric trauma centers of different levels rather than between pediatric trauma centers and adult trauma centers. This study found no statistically significant difference in mortality between children treated at level I and level II pediatric trauma centers. See S. Miyata et al., "Should all Severely Injured Pediatric Patients be Treated at Pediatric Level I Trauma Centers? A National Trauma Data Bank Study," *American Surgeon*, vol. 81, no. 10 (2015). According to the authors, no difference may have been found because despite certain differences between level I and II pediatric trauma centers (e.g., in the number of pediatric surgeons or other pediatric specialists), the standards of care at level I and II pediatric trauma centers are identical.

centers.[30] While the third study found no difference in mortality among children treated at pediatric and adult trauma centers, it also found that children treated at trauma centers had a 0.79 percentage point decrease in mortality compared to children treated at non-trauma hospitals.[31]

Data on other outcomes. Seven studies examined outcomes other than mortality, but according to some of the studies we reviewed and stakeholders we interviewed, more information is needed on outcomes other than mortality for children treated at pediatric trauma centers. Further, as some studies note, mortality can be a limited measure for determining quality of care or a trauma center's contribution to survival, because overall mortality is low among severely injured children.[32] One 2015 study found that adding a pediatric trauma center in Delaware decreased the frequency of pediatric splenectomies—a procedure that removes a child's spleen.[33] Another study found that pediatric trauma centers performed less imaging than adult trauma centers when treating severely injured adolescents.[34]

Information on other outcomes was limited. One study from 2016 that we reviewed noted that in the pediatric trauma literature there are no

[30]A. E. Walther et al., "Teen Trauma without the Drama: Outcomes of Adolescents Treated at Ohio Adult Versus Pediatric Trauma Centers," *Journal of Trauma and Acute Care Surgery*, vol. 77, no. 1 (2014) and K. Matsushima et al., "Injured Adolescents, Not just Large Children: Difference in Care and Outcome between Adult and Pediatric Trauma Centers," *American Surgeon*, vol. 79, no. 3 (2013).

[31]N. E. Wang et al., "The Effect of Trauma Center Care on Pediatric Injury Mortality in California, 1999 to 2011," *Journal of Trauma and Acute Care Surgery*, vol. 75, no. 4 (2013). The authors noted that pediatric subspecialty care may have benefits, including possible mortality benefits that the authors were not able to identify with the analytic methods they used. They further noted that their findings demonstrate that trauma-specific care of any kind (adult or pediatric) can improve patient outcomes

[32]For example, in one nationwide study of 175,585 children with blunt or penetrating trauma who were hospitalized at a trauma center, the crude mortality rate was 1.6 percent.

[33]To preserve splenic function and prevent sepsis, non-operative management of splenic injuries is considered the standard of care for pediatric trauma patients as it is associated with shorter hospital stays and lower mortality. See E. Murphy, et al. "The Pediatric Trauma Center and the Inclusive Trauma System: Impact on Splenectomy Rates." *Journal of Trauma and Acute Care Surgery*, vol. 78, no. 5 (2015).

[34]The authors of this study noted that experts recommend careful use of imaging for children to minimize children's exposure to radiation and reduce their risk of cancer. A. E. Walther et al., "Teen Trauma," 113-114.

longitudinal studies on the long-term effects—both physical and psychological—of trauma on children.[35] In addition, another study we reviewed indicated that the selection of outcome measures for analysis was constrained by what was available in the dataset used for the study.[36] One stakeholder we interviewed told us that mortality is one of the few outcomes related to pediatric trauma that is captured in databases, because most trauma registries and other databases were initially developed to capture data for adult patients.[37] Moreover, a few stakeholders told us that the pediatric trauma system is not as well developed as the adult trauma system and that both pediatric trauma care and research have tended to occur in isolation. One of these stakeholders said that because of this fragmentation, it has been difficult for researchers to use or build on the outcome measures that other researchers have developed in their work.[38]

Two Agencies Support Hospital-Based Pediatric Trauma Care Activities and Coordinate Some Efforts through an Interagency Group

Hospital-based pediatric trauma care activities are supported primarily through grants from two agencies within HHS—HRSA and the National Institutes of Health (NIH). Officials from these agencies reported that activities related to pediatric trauma care are coordinated through an interagency group focused broadly on emergency care, as well as through arrangements between individual agencies.

[35]A. McCarthy et al., "Integrative Review," 583.

[36]F. Ovalle Jr. et al., "Outcomes of Pediatric Severe Traumatic Brain Injury," 9.

[37]According to the ACS-COT, a trauma registry is a file of uniform data elements that trauma centers should collect and analyze. The data collected includes descriptions of the injury event, demographics, prehospital information, diagnosis, care, outcomes, and costs of treatment of injured patients.

[38]According to one stakeholder, there is a new effort underway through the Emergency Medical Services for Children Innovation and Improvement Center to identify and develop key pediatric measures, although the effort is in its very early stages. For more information about the Center see the next section of our report.

Two Federal Agencies Support Hospital-Based Pediatric Trauma Activities Primarily through Grants, While Other Efforts Broadly Address Emergency Care

Two agencies within HHS—HRSA and NIH—have grant programs and other activities that support hospital-based pediatric trauma care (see table 2).

Table 2: Key Federal Activities Related to Hospital-Based Pediatric Trauma Care

Name	Type of Activity	Activity Summary
Health Resources and Services Administration (HRSA): Emergency Medical Services for Children (EMSC) Program		
State Partnership	Grant Program	This program aims to ensure pediatric emergency care is integrated into the larger emergency medical services system. Program performance measures include improving pediatric trauma care. HRSA had a total of 58 grantees under this program in fiscal year 2016.
Targeted Issues	Grant Program	This program supports innovation and increasing quality in pediatric emergency care. The grants focus on implementing research or cross-cutting projects on a larger scale. HRSA had a total of 5 grantees under this program in fiscal year 2016.
State Partnership Regionalization of Care	Grant Program	This program aims to develop systems of care models to improve pediatric emergency care capacity in rural and tribal areas. HRSA had a total of 3 grantees under this program in fiscal year 2016.
Pediatric Emergency Care Applied Research Network	Multi-Institutional Research Network	EMSC funds the infrastructure for this multi-institutional clinical research effort which aims to conduct meaningful and rigorous multi-institutional research into the prevention and management of illness and injuries in children. The effort includes 18 emergency departments and 9 pre-hospital emergency medical services affiliates.
National Pediatric Readiness Project	Quality Improvement Initiative	This collaborative quality improvement initiative aims to ensure that all U.S. emergency departments have the essential guidelines and resources in place to provide effective emergency care to children. In 2013, the project assessed over 4,100 emergency departments on how prepared they were to treat children. The next phase aims to develop tools and resources to address gaps identified in the data.
EMSC Innovation and Improvement Center	Program Support/Quality Improvement Initiative	The EMSC Innovation and Improvement Center, established in 2016, supports the grantees and initiatives listed above by providing expertise and fostering collaboration and innovation. For example, in its main initiative, a collaborative that aims to help states that are developing a program to identify and categorize emergency departments that have the resources to care for children, officials from 6 states serve as mentors to help 12 additional states develop programs.
National Institutes of Health (NIH): Pediatric Trauma and Critical Illness Branch		
Pediatric Trauma Research and Training Program	Scientific Program Area	This program supports investigator-initiated research and training aimed at advancing the science of trauma, injury prevention, and care for pediatric populations. The program supports research that addresses the full continuum of care and has a goal of reducing morbidity and mortality in children.

Name	Type of Activity	Activity Summary
Eunice Kennedy Shriver National Institute of Child Health and Human Development Consortium for Research on Pediatric Trauma and Injury Prevention	Grant Program	This grant program operates under the support of the Pediatric Trauma Research and Training Program. The goal of this grant program is to create a consortium of collaborative and multidisciplinary research teams that will identify and address gaps in research on pediatric trauma and injury prevention. While applications could be submitted beginning in December 2014, no projects have been funded as of January 2017.
Pediatric Critical Care Research and Training Program	Scientific Program Area	This program supports research and training opportunities to inform the practice of health care providers who stabilize, diagnose, and manage the care of critically ill children. The research focuses on investigating the safety and effectiveness of treatment and management for all sorts of pediatric critical illnesses and injuries (e.g., sepsis and traumatic brain injury).
Collaborative Pediatric Critical Care Research Network	Multi-Institutional Research Network	This network operates under the support of the Pediatric Critical Care Research and Training Program. The goal of this network is to develop an infrastructure for collaborative clinical trials and meaningful descriptive studies in pediatric critical care medicine.

Source: GAO Analysis of HRSA and NIH information. | GAO-17-334

Within HRSA, the Emergency Medical Services for Children (EMSC) program, established in 1984, provides funding to states and academic medical institutions. It does so primarily through six grant programs and cooperative agreements that aim to enhance the capacity of emergency care—including hospital-based trauma care—to address the needs of children. The program's annual appropriation is authorized at $20.2 million per fiscal year from fiscal years 2015 through 2019.[39] According to HRSA officials, EMSC is the only federal program that focuses specifically on improving emergency care for children.

Within NIH, the Pediatric Trauma and Critical Illness Branch supports research and training focused on preventing, treating, and reducing all forms of childhood trauma, injury, and critical illnesses. According to NIH officials, the Branch—which is part of the Eunice Kennedy Shriver National Institute of Child Health and Human Development—was established in 2012 to help unify research in pediatric trauma. Our analysis of data on all NIH-funded research in fiscal year 2015 shows that the Branch provided nearly $9 million in funding for 32 grants related to injuries.

Beyond these two agencies, a few other federal efforts more broadly address emergency care, including trauma care. While they are not focused on pediatric trauma care, these efforts may indirectly address the needs of pediatric populations. For example, the Emergency Care

[39]42 U.S.C. § 300w-9.

Coordination Center within the HHS Office of the Assistant Secretary for Preparedness and Response (ASPR) aims to strengthen the day-to-day emergency care system to better prepare the nation for times of crisis and to support the federal coordination of in-hospital emergency medical care activities.[40] Agency officials reported that the Center was funded at $820,000 per fiscal year in fiscal years 2015 and 2016. According to officials, the Center recently worked on two initiatives related to trauma—preparing a report requested by Congress on the nation's capacity to respond to mass casualty events and issuing a request for proposals to award a contract for the development of an inventory of emergency departments, trauma centers, and burn centers and their capabilities across the United States.

Recent federal funding to specifically support hospital-based trauma care activities or to develop trauma care systems has been limited as well. The Patient Protection and Affordable Care Act both continued existing and established new discretionary trauma care grant programs to help develop trauma care systems.[41] However, according to HHS officials, no appropriations were made for these new programs and no grants have been made under these new authorities.

[40]According to its charter, the Emergency Care Coordination Center was established to fulfill Homeland Security Presidential Directive #21 and in response to a series of three emergency care reports that the Institute of Medicine issued in 2006.

[41]For example, the Patient Protection and Affordable Care Act amended and reauthorized the EMSC program and created a new emergency and trauma care program to improve regional coordination of emergency services.. Pub. L. No. 111-148, §§ 3504, 5603, 124 Stat. 119, 518-521, 679 (2010). For additional information see C. Stephen Redhead and Elayne J. Heisler, *Public Health, Workforce, Quality, and Related Provisions in the ACA: Summary and Timeline,* R41278 (Washington, D.C.: Congressional Research Service, May 17, 2013).

Federal Activities Related to Hospital-Based Pediatric Trauma Care and Other Emergency Care Are Coordinated through an Interagency Group and Arrangements between Agencies

HRSA and NIH officials reported that activities related to hospital-based trauma care and other emergency care, including pediatrics, are coordinated through an interagency group and through arrangements between individual agencies (see table 3).[42] Both HRSA and NIH representatives are executive committee members of the Council on Emergency Medical Care, a federal interagency group led by ASPR's Emergency Care Coordination Center, a center specially created as the policy lead for emergency care activities across the federal government. ASPR officials told us that the Council on Emergency Medical Care is the central meeting place for agencies across the federal government on issues related to emergency care, including pediatric care.[43] HRSA and NIH officials reported using a variety of arrangements to collaborate with other federal agencies on hospital based pediatric trauma, such as supporting a program liaison position within another agency, establishing interagency agreements, and presenting at conferences and meetings.

[42]In prior work, we found that agencies used collaborative mechanisms, such as interagency groups, for multiple purposes, including information sharing and communication and policy development. See GAO, *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*, GAO-12-1022 (Washington, D.C.: Sept. 27, 2012).

[43]Both ASPR and HRSA officials also serve on the Federal Interagency Committee for Emergency Medical Services, which was established to ensure coordination among federal agencies on pre-hospital emergency and trauma care.

Table 3: Examples of Hospital-Based Pediatric Trauma Care-Related Coordination Efforts through Interagency Group and Arrangements between Agencies

Coordination Effort	Description
Agency for Healthcare Research and Quality	According to Health Resources and Services Administration (HRSA) officials, the Emergency Medical Services for Children (EMSC) program coordinates with the Agency for Health Care Research and Quality for data on hospital and emergency room utilization that can be used to examine trends in pediatric mortality. The officials told us that these data, obtained annually through an interagency agreement, are used for program planning.
Council on Emergency Medical Care	This interagency group aims to coordinate emergency care activities across the federal government through information sharing and policy development. It meets on a quarterly basis. Membership includes representatives from several agencies in the Department of Health and Human Services (HHS), Department of Defense, Department of Homeland Security, Department of Transportation, Executive Office of the President, and the Department of Veterans Affairs. The group is tasked with (1) identifying national issues in emergency and trauma care; (2) working to find synergy across participating agencies; and (3) advising the Emergency Care Coordination Center within HHS's Office of the Assistant Secretary for Preparedness and Response (ASPR) on the next steps and priorities for the federal government in emergency and trauma care.
Department of Defense Uniformed Services University of the Health Sciences	Officials from the EMSC program and subject matter experts from the Uniformed Services University of the Health Sciences are working together to develop a virtual pediatric trauma center framework, an online training resource for nurses and doctors. HRSA officials stated that the framework would help address challenges faced by providers in rural areas who do not regularly treat pediatric trauma patients.
Indian Health Service	HRSA officials reported that the EMSC program works in partnership with the Indian Health Service to engage tribal health facilities in the National Pediatric Readiness Project. HRSA and the Indian Health Service have an interagency agreement, which includes support to disseminate and promote the use of needed guidelines identified by the Pediatric Readiness assessment and to facilitate collaboration between Indian Health Service facilities and state EMSC program staff.
National Institutes of Health (NIH) Office of Emergency Care Research	An official from this office, the NIH center responsible for coordinating all NIH emergency care research and research training, told us that recent efforts to support research that integrates civilian and military trauma have not focused on pediatric populations to avoid duplicating the work of the Pediatric Emergency Care Applied Research Network.
NIH Pediatric Trauma and Critical Illness Branch	HRSA and NIH officials told us that while the EMSC program funds the infrastructure for the Pediatric Emergency Care Applied Research Network, the Pediatric Trauma and Critical Illness Branch is a large source of the funding for the clinical research that the Network undertakes. HRSA officials also reported that they participated in the strategic planning process and in efforts to identify research priorities for the NIH Pediatric Trauma and Critical Illness Branch.

Source: GAO Analysis of ASPR, HRSA, and NIH Information. | GAO-17-334

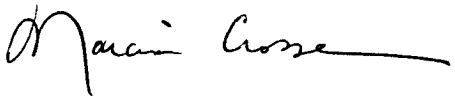
Agency Comments

We provided a draft of this report to HHS for comment. The department provided technical comments, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the Secretary of HHS and

other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-7114 or crossem@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.



Marcia Crosse
Director, Health Care

Appendix I: Training and Resources Available to Physicians and Nurses for Pediatric Trauma Care

Various types of training and resources are available for physicians and nurses on the delivery of pediatric trauma care. The training and resources are provided by stakeholder groups, such as professional, research and advocacy organizations. The training and resources from these groups supplement any training that physicians and nurses may receive during medical or nursing school or during any residencies or fellowships that may include or be completely focused on pediatric care.[1] The available training includes standardized courses that stakeholder groups have developed as well as more ad-hoc training on pediatric trauma care topics of interest. Stakeholder groups also have developed resources on pediatric trauma care that physicians and nurses can access and consult when needed. The resources available include both policy statements that detail the infrastructure or resources needed to provide pediatric trauma care at the facility-level and other more individualized and clinical practice resources for physicians and nurses about the delivery of pediatric trauma care.

To identify examples of the training and resources available to physicians and nurses on the delivery of pediatric trauma care, we interviewed stakeholder group representatives or received written responses from the following stakeholder groups: the American Academy of Pediatrics, the American Association of Neurological Surgeons/Congress of Neurological Surgeons, the American College of Emergency Physicians, the American College of Surgeons, the Childress Institute for Pediatric Trauma, the Emergency Nurses Association, the Pediatric Orthopaedic Society of North America, the Pediatric Trauma Society, and the Society of Trauma Nurses. We selected the groups to represent the perspectives of trauma care physicians and nurses, pediatric specialists, and research and advocacy organizations involved in or focusing on hospital-based pediatric trauma care. We asked all stakeholder groups a series of open-ended questions and, to the extent possible, corroborated statements with information available on stakeholder group websites.

Training

Many of the stakeholder groups we interviewed have developed standardized training courses on the evaluation, management, and

[1]For example, surgeons that specialize in neurosurgery go through 7 years of residency training. All neurosurgery residents must be involved with ten pediatric neurosurgical cases that result in surgery and those who want to specialize in trauma care or pediatric neurosurgery must also complete a sub-specialization fellowship, which furthers exposes them to pediatric trauma care cases.

treatment of trauma patients. In addition to standardized courses, stakeholder groups also offer other training opportunities related to pediatric trauma care on an ad-hoc basis (see table 4).

Table 4: Description of Courses and Examples of Other Training Opportunities Available to Physicians and Nurses on the Delivery of Trauma Care

Courses				
Course Name	**Sponsor**	**Course Description**	**Primary Audience**	**Pediatric Specific (Y/N)**
Advanced Pediatric Life Support	American Academy of Pediatrics and American College of Emergency Physicians	Course on the assessment and management of critically ill and injured children in the emergency department.	Physicians, nurses and other health care personnel	Y
Advanced Trauma Care for Nurses[a]	Society of Trauma Nurses	Two-day course that teaches established standards on trauma care and practical lifesaving skills through lectures and corresponding skill stations and simulations.	Nurses	N
Advanced Trauma Life Support[a]	American College of Surgeons Committee on Trauma (ACS-COT)	Two to two-and-a-half day course that provides training in the immediate management of trauma patients, including the assessment of a patient's condition, resuscitation and stabilization, and determining whether a patient's needs exceed a facility's capacity.	Physicians	N
Emergency Nursing Pediatric Course	Emergency Nurses Association	Two-day interactive course, focused on pediatric emergency care (both medical emergencies and trauma care).	Nurses and other health care personnel	Y
Pediatric Advanced Life Support	American Heart Association and American Academy of Pediatrics	Classroom-based course that uses videos and simulated pediatric emergencies to teach how to assess, care for, and resuscitate pediatric patients with respiratory, shock, and cardiac emergencies.	Physicians, nurses, and other health care personnel	Y
Rural Trauma Team Development Course	ACS-COT	One-day course that emphasizes a team approach on the initial evaluation and resuscitation of a trauma patient at a rural facility that includes interactive lectures and team performance scenarios.	Any individual involved in the care of the injured patient, including physicians, nurse practitioners, nurses, and other health personnel	N
Trauma Nursing Core Course	Emergency Nurses Association	Two-day interactive course with lectures, scenario-based skill stations (including a pediatric-specific station), and an exam that emphasizes the rapid identification of injuries and comprehensive assessment.	Nurses and other health care personnel	N

Other Training Opportunities	
Training Type	**Examples**
Conferences	Stakeholder groups reported offering pediatric trauma-specific content at annual meetings. For example: • The Society of Trauma Nurses offers a pediatric track at its annual conference and collaborated with the Pediatric Trauma Society to offer pre-conference training at the Pediatric Trauma Society's annual conference in 2016. • The Pediatric Orthopaedic Society of North America annually holds the International Pediatric Orthopaedic Symposium in conjunction with the American Academy of Orthopaedic Surgeons. This symposium includes several sessions on pediatric trauma including a pre-conference webinar for the 2016 symposium on acute pediatric skeletal trauma.
Webinars	The Childress Institute for Pediatric Trauma has sponsored webinars on pediatric trauma care covering topics such as disaster management, burn care, and extremity injury.
Other continuing education	The American Academy of Pediatrics and the American College of Emergency Physicians offer the Pediatrics Review and Education Program: Emergency Medicine continuing medical education course biennially. The course provides information on recent developments in the field of pediatric emergency medicine, including key developments in the area of pediatric trauma.

Source: GAO analysis of information from stakeholder group representatives and websites. | GAO-17-334

[a]The Advanced Trauma Care for Nurses course and the Advanced Trauma Life Support course for physicians are often taught concurrently.

These courses are generally available to all providers, but whether a provider must take any of these courses depends on the facility or system in which the provider works and its specific education or credentialing requirements. However, stakeholder representatives stated that these are all courses that any provider who treats trauma patients, including pediatric patients, generally should, and most likely will, take. For example, the American College of Surgeons Committee on Trauma (ACS-COT) publication, *Resources for Optimal Care of the Injured Patient* states that courses like the Advanced Trauma Life Support course, the Trauma Nursing Core Course, and the Advanced Trauma Care for Nursing course, among others, have become basic trauma education for providers.[2] These courses have both classroom-based lectures and interactive components. Most of the courses are general trauma courses with pediatric elements rather than courses that are specific to pediatric trauma. One stakeholder representative noted that all providers should learn the baseline principles of trauma care from these courses and then build on that baseline to learn principles that are specific to pediatric trauma. Representatives from stakeholder groups said that these courses usually include a lecture and a trauma simulation exercise for a pediatric

[2]One of the criteria used by the ACS-COT to verify a facility as a trauma center at any level is to verify that all general surgeons, emergency medicine physicians, and midlevel providers on the trauma team at the facility have successfully completed the Advanced Trauma Life Support course at least once.

patient, even if the overall focus of the course is on emergency or trauma care for the general adult patient population. For example, representatives from the Emergency Nurses Association told us that the Trauma Nursing Core Course includes a participant skill station that is specific to pediatric trauma. In addition, the manual for this course includes a chapter on pediatric trauma.

Resources

In addition to training, stakeholder groups have also developed resources for physicians and nurses related to pediatric trauma. The resources that these groups have developed, often in collaboration with each other, include 1) policy statements detailing the system-level infrastructure that must be in place to ensure that providers and facilities are prepared to care for injured children; and 2) other more individualized clinical resources, such as checklists, forums, and journal articles, that physicians and nurses can access to improve their individual knowledge and readiness to treat pediatric patients (see table 5).

Table 5: Examples of Resources Available to Physicians and Nurses on Pediatric Trauma

Examples of Policy Statements: **Statement Name (Year) and Authors**	**Description**
Management of Pediatric Trauma (2016) American Academy of Pediatrics, Pediatric Trauma Society, and Society of Trauma Nurses	Joint policy statement with several recommendations on pediatric trauma including, among other things, that • Children's needs should be integrated into trauma systems and disaster planning, • States should identify which facilities have the resources needed to care for injured children, • Evidence-based protocols should be developed for key aspects of care for injured children, and • Physicians and nurses must have continuing trauma education citing the Advanced Trauma Life Support course from the American College of Surgeons and the trauma nursing courses that the Society of Trauma Nurses and Emergency Nurses Association offer.
Guidelines for Care of Children in the Emergency Department (2009) American Academy of Pediatrics, American College of Emergency Physicians, and Emergency Nurses Association[a]	Joint policy statement outlining the resources and infrastructure that hospital emergency departments need to be prepared to serve critically injured or ill pediatric patients. One area highlighted is provider skills, knowledge, and training and the expectation that all emergency departments should have the infrastructure in place to ensure that physicians, nurses, and other health care providers have the necessary training and skills to treat all pediatric patients.
Definitions and Assessment Approaches for Emergency Medical Services for Children (2016) Fuchs. S, Terry M, Adelgais K, et al.[b]	Statement outlining the consensus of several organizations on the common terminology and components of the assessment and treatment approach for pediatric patients who are critically ill and injured.

Other Resource Types	Examples of Resource Type Use
Clinical Resources - Documents	The Pediatric Trauma Society posts member-submitted examples of clinical resources on its website. The posted resources provide examples of clinical practice guidelines that members have used as a framework for the evaluation and treatment of certain diagnoses or conditions. Resources are posted for head and facial trauma and cervical spine injuries, among other things.
Clinical Resources - Videos	The Pediatric Orthopaedic Society of North America offers POSNAcademy on its website. It is peer reviewed video learning specific to pediatric orthopedic issues, which are issues related to bones, joints, and muscles. Trauma is one of the key areas with videos available on the treatment of specific types of pediatric trauma involving musculoskeletal injuries.
Checklists	The American Academy of Pediatrics, American College of Emergency Physicians, Emergency Nurses Association, and others developed a checklist for providers in emergency departments to use to determine whether their emergency department is prepared to care for children. The checklist is based on the joint policy statement "Guidelines for Care of Children in the Emergency Department."
Online Forums	The Emergency Nurses Association has ENAConnect, an online forum where members can share best practices, discuss various topics, or ask questions pertaining to pediatric trauma care and other issues.
Articles Published In Stakeholder Group Journals	The Society of Trauma Nurses periodically devotes a special edition of the Journal of Trauma Nursing to pediatrics and also publishes articles in the journal throughout the year that are specific to trauma in the pediatric population.

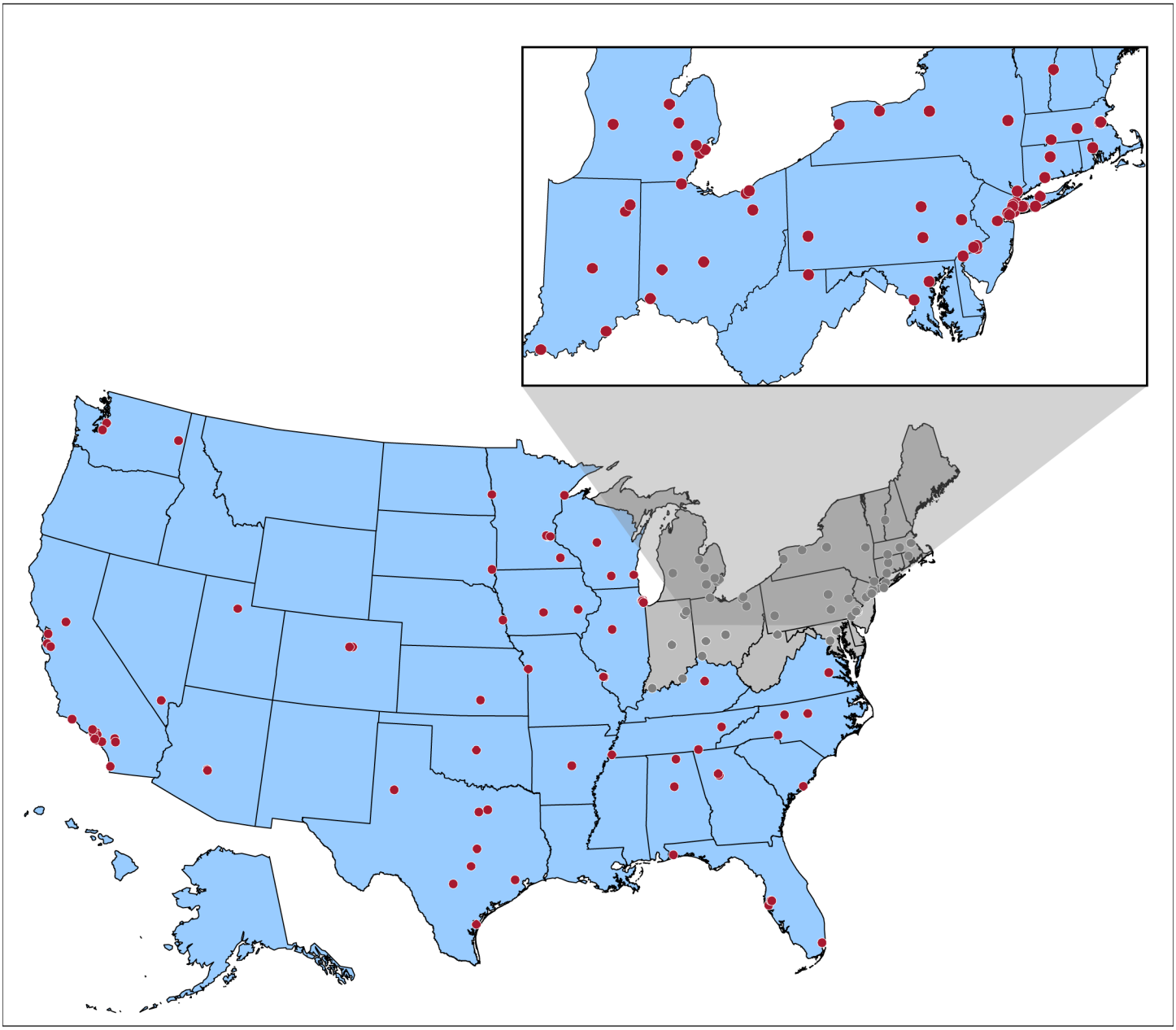
Source: GAO analysis of information from stakeholder group representatives and websites. | GAO-17-334

[a]The Guidelines for Care of Children in the Emergency Department has also been endorsed by many other organizations, including the Society of Trauma Nurses and the American College of Surgeons.

[b]This article is a consensus statement authored by a task force on pediatric life support. Groups with representatives on the task force include the American Academy of Pediatrics, the Emergency Nurses Association, the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, and many other groups such as those representing pre-hospital providers. See S. Fuchs et al., "Definitions and Assessment Approaches for Emergency Medical Services for Children," Pediatrics, vol. 138, no. 6 (2016).

Appendix II: Location of High-Level Pediatric Trauma Centers, United States, 2015

Figure 4: Location of High-Level Pediatric Trauma Centers, United States, 2015



Sources: GAO analysis of American Trauma Society data (data); Map Resources (map). | GAO-17-334

Note: To identify trauma center locations, we used 2015 data from the Trauma Information Exchange Program of the American Trauma Society. "High-level pediatric trauma center" refers to level I and level II pediatric trauma centers. In 2015, there were 136 high-level pediatric trauma centers in the United States.

Appendix III: Estimated Percentage of Children Who Lived within 30 Miles of a High- or Mid-Level Trauma Center, Detailed Tables by State, 2011-2015

Table 6: Estimated Child Population and Percentage of Children Who Lived within 30 Miles of a High- or Mid-Level Trauma Center, Detailed Tables by State, 2011-2015

		High Level Pediatric Trauma Center			High Level Adult or Pediatric Trauma Center			High- or Mid-Level Adult or Pediatric Trauma Center		
State	Est. Child Population	<10 miles	10-30 miles	>30 miles	<10 miles	10-30 miles	>30 miles	<10 miles	10-30 miles	>30 miles
All States	73,682,658	26.7	30.2	43.1	48.9	31.2	19.9	59.8	28.6	11.6
AK	187,960	-	-	100.0	33.9	6.9	59.1	33.9	6.9	59.1
AL	1,111,974	13.0	20.6	66.5	28.7	39.6	31.8	67.3	30.1	2.7
AR	707,831	10.7	14.6	74.7	19.4	23.4	57.2	56.3	28.8	14.9
AZ	1,617,889	22.1	40.9	37.1	57.5	23.3	19.2	62.5	20.4	17.1
CA	9,173,992	40.9	31.8	27.3	62.7	27.9	9.4	67.1	27.1	5.8
CO	1,241,825	31.8	25.7	42.5	69.6	18.4	12.0	82.7	11.7	5.6
CT	784,736	31.8	59.7	8.5	69.6	23.8	6.6	72.5	27.3	0.2
DC	111,305	100.0	-	-	100.0	-	-	100.0	-	-
DE	204,154	34.8	25.1	40.1	52.7	11.1	36.3	83.0	17.0	-
FL	4,041,002	13.8	24.3	61.9	51.8	39.9	8.3	51.8	39.9	8.3
GA	2,491,080	11.3	39.2	49.5	41.9	38.4	19.8	43.2	38.9	18.0
HI	308,197	-	-	100.0	36.2	33.2	30.6	51.8	47.3	1.0
IA	726,810	19.5	18.8	61.7	32.3	23.8	43.9	52.9	30.4	16.8
ID	429,438	-	2.5	97.5	19.7	37.3	43.0	33.1	41.3	25.7
IL	3,023,734	28.0	31.4	40.6	74.5	15.5	10.0	74.7	15.7	9.6
IN	1,586,651	25.0	30.0	45.1	31.1	34.4	34.4	34.2	40.3	25.5
KS	723,546	26.6	25.3	48.1	46.3	19.4	34.3	51.8	24.2	24.0
KY	1,018,630	22.1	28.0	49.8	22.8	29.9	47.3	25.1	35.6	39.3
LA	1,114,559	-	-	100.0	31.7	19.9	48.4	31.7	20.9	47.4
MA	1,397,629	38.1	54.0	7.9	43.7	49.3	7.0	58.2	37.4	4.4
MD	1,348,280	35.2	46.6	18.2	48.0	37.4	14.6	52.4	44.4	3.3
ME	262,217	-	-	100.0	26.1	40.6	33.3	28.3	43.9	27.8
MI	2,249,652	33.2	36.1	30.6	58.3	26.8	14.9	59.7	26.0	14.3
MN	1,280,609	36.0	30.1	34.0	44.6	29.5	25.9	65.7	24.4	9.9
MO	1,400,595	18.5	28.8	52.8	48.5	23.4	28.2	57.2	26.3	16.5
MS	736,138	-	6.7	93.3	22.5	28.2	49.3	44.2	35.7	20.1
MT	224,558	-	-	100.0	29.9	6.3	63.8	44.2	15.9	40.0
NC	2,283,835	13.8	33.9	52.3	28.8	40.3	30.9	37.3	41.6	21.2
ND	162,770	19.3	2.5	78.2	51.5	5.4	43.1	51.5	6.4	42.1
NE	465,021	35.9	8.8	55.3	55.7	13.8	30.5	65.5	19.5	15.0
NH	271,688	2.2	6.6	91.1	23.4	48.6	28.0	62.9	33.7	3.4

State	Est. Child Population	High Level Pediatric Trauma Center <10 miles	High Level Pediatric Trauma Center 10-30 miles	High Level Pediatric Trauma Center >30 miles	High Level Adult or Pediatric Trauma Center <10 miles	High Level Adult or Pediatric Trauma Center 10-30 miles	High Level Adult or Pediatric Trauma Center >30 miles	High- or Mid-Level Adult or Pediatric Trauma Center <10 miles	High- or Mid-Level Adult or Pediatric Trauma Center 10-30 miles	High- or Mid-Level Adult or Pediatric Trauma Center >30 miles
NJ	2,023,313	36.8	48.7	14.4	69.9	28.3	1.8	69.9	29.3	0.7
NM	506,207	-	-	100.0	26.4	17.5	56.1	46.5	22.9	30.6
NV	661,681	54.7	18.1	27.2	71.0	20.2	8.9	72.5	18.6	8.9
NY	4,251,773	68.4	16.1	15.5	76.0	16.7	7.3	77.2	16.2	6.6
OH	2,656,019	34.3	37.3	28.4	48.5	37.4	14.1	60.8	33.0	6.3
OK	947,895	17.1	15.6	67.3	32.1	25.3	42.6	61.2	26.8	12.0
OR	860,348	-	-	100.0	48.5	28.1	23.4	62.7	30.7	6.7
PA	2,722,234	29.8	42.6	27.6	55.0	35.5	9.5	55.9	37.1	7.1
RI	215,019	61.9	35.1	3.0	61.9	35.1	3.0	61.9	38.1	0.1
SC	1,081,833	5.2	14.8	80.0	29.6	51.4	19.0	54.1	39.0	6.8
SD	207,718	24.3	5.4	70.4	38.1	8.2	53.7	45.4	13.2	41.5
TN	1,490,321	16.4	21.0	62.7	29.5	37.3	33.2	33.1	38.1	28.7
TX	7,058,802	20.3	43.4	36.3	34.3	39.9	25.8	68.8	22.3	8.9
UT	897,106	13.8	47.4	38.8	56.7	24.5	18.8	67.8	23.3	8.9
VA	1,864,755	11.7	29.6	58.6	43.3	43.8	12.9	50.4	38.0	11.6
VT	123,271	2.8	9.7	87.6	21.0	31.2	47.8	21.0	40.3	38.7
WA	1,596,652	24.7	36.8	38.6	39.6	38.9	21.5	78.2	16.1	5.7
WI	1,309,323	25.4	22.8	51.8	41.5	40.5	18.0	65.0	29.7	5.3
WV	382,286	4.1	7.0	88.9	19.0	35.4	45.6	35.0	40.5	24.5
WY	137,797	-	-	100.0	29.2	1.2	69.6	53.9	7.3	38.8

Sources: GAO analysis of American Trauma Society and U.S. Census Bureau data. | GAO-17-334

Note: Child population estimates are based on the U.S. Census Bureau's American Community Survey data 5-year estimates during the period 2011-2015. To identify trauma center locations, we used 2015 data from the Trauma Information Exchange Program of the American Trauma Society. We refer to level I and level II pediatric and adult trauma centers as "high-level" trauma centers and level III pediatric and adult trauma centers as "mid-level" trauma centers.

"-" indicates that no children are in this category.

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, Karin Wallestad, Assistant Director, Alison Goetsch, Analyst-in-Charge, and Summar Corley made key contributions to this report. Also contributing were Leia Dickerson, Krister Friday, Giselle Hicks, Vikki Porter, and Jennifer Whitworth.

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