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State-level geographic variation in prompt access to care for children after motor vehicle crashes

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Abstract

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Background—Motor vehicle crashes (MVCs) are a principal cause of death in children; fatal MVCs and pediatric trauma resources vary by state. We sought to examine state-level variability in and predictors of prompt access to care for children in MVCs.

Materials and Methods—Using the 2010–2014 Fatality Analysis Reporting System, we identified passengers <15y involved in fatal MVCs (crashes on U.S. public roads with 1 death, adult or pediatric, within 30d). We included children requiring transport for medical care from the crash scene with documented time of hospital arrival. Our primary outcome was transport time to first hospital, defined as >1h or 1h. We used multivariable logistic regression to establish state-level variability in the percentage of children with transport time >1h, adjusting for injury severity (no injury, possible injury, suspected minor injury, suspected severe injury, fatal injury, unknown severity), mode of transport (Emergency Medical Services (EMS) air, EMS ground, non-EMS), and rural roads.

Results—We identified 18,116 children involved in fatal MVCs from 2010–2014; 10,407 (57%) required transport for medical care. Median transport time was 1h (IQR: [1,1]; range: [0,23]). The percent of children with transport time >1h varied significantly by state, from 0% in several states to 69% in New Mexico. Children with no injuries identified at the scene and crashes on rural roads were more likely to have transport times >1h.

Conclusions—Transport times for children after fatal MVCs varied substantially across states. These results may inform state-level pediatric trauma response planning.

Keywords

motor vehicle crashes; access to care; transport time; Fatality Analysis Reporting System; pediatric trauma

Introduction

Unintentional injury and, specifically, motor vehicle crashes (MVCs), are a substantial source of pediatric mortality in the U.S.¹ Prompt access to medical care following an MVC has been shown to be associated with improved outcomes, with prior studies demonstrating that arrival at definitive care within an hour of injury is associated with decreased mortality as well as decreased length of hospital stay.^{2,3} MVC-related mortality in children has been shown to vary by state, with age-adjusted mortality rates per 100,000 children varying from 0.25 in Massachusetts to 3.23 in Mississippi.⁴ Trauma response services are coordinated at the state level and there is known variability in available resources by state, with some states having funded trauma systems, others having non-funded trauma systems, and some having no state-supported trauma system.⁵

In addition, the availability of pediatric-specific trauma resources varies by state, with many states having multiple verified pediatric trauma centers and many having none.⁶ While there is debate over the value of dedicated pediatric trauma centers,^{7–9} there is evidence that treatment at these centers is associated with lower mortality rates.^{10–12} Further, there is often geographic separation between pediatric trauma resources, as these facilities tend to be located in metropolitan areas.⁶ Given the state-based variability in pediatric mortality after MVCs and the state-based variability in trauma resources, we hypothesized that differences

in timely access to care may drive differences in pediatric mortality following MVCs. We sought to understand first, the consistency of documentation of emergency medical services (EMS) hospital arrival times in a large national dataset; second, the variability in transport time greater than 1h from the scene of a crash to arrival at the first hospital by state in which the crash occurred; and third, state-level predictors of each of these outcomes.

Methods

Data source

We used the 2010–2014 Fatality Analysis Reporting System (FARS), a nationwide census maintained by the National Highway Traffic Safety Administration that provides publicly-available data on fatalities associated with MVCs. The FARS included all fatal crashes in the U.S., defined as crashes that occur on a public road and result in ≥1 death (adult or pediatric) within 30 days. The dataset contained information on the time of each crash, the time of EMS arrival, and the time of arrival at the first medical facility, in addition to information on injury severity as assessed by EMS, mode of transport, and location of the crash.¹³ State-level variables were compiled from additional sources, including the American College of Surgeons,¹⁴ the U.S. Census,¹⁵ and the medical literature.⁵

Study sample

We included children <15y riding in a passenger vehicle involved in a fatal crash who required transport to a hospital for medical evaluation (Figure 1). Passenger vehicles were defined by the National Highway Traffic Safety Administration as cars, sport utility vehicles (SUVs), vans, and pickup trucks with a gross weight ≤10,000 pounds.^{13,16} We excluded children classified as drivers, passengers on a motorcycle/bicycle, or pedestrians, as well as children in an unenclosed passenger or cargo area, the vehicle exterior, or a trailing unit, due to differential risk of injury severity among this group. We used a complete case analysis approach, dropping observations with missing data for key variables. Data were missing for fewer than 5% of observations for all variables except for hospital arrival time, which was missing for 55% of observations in which the child required transport.

Endpoints and predictors

Our primary outcomes were 1) documentation of hospital arrival time and 2) transport time. We assessed documentation of arrival time as a binary variable based upon the presence of hospital arrival time in the dataset for each child that was known to be transported to a hospital. We defined transport time as the difference between the hospital arrival time and the documented time of the crash. Transport time was also categorized as a binary variable (>1h or ≤1h), based upon the demonstrated value of reaching care within an hour of major trauma.³ Each main outcome was converted to a continuous variable at the state level, as the proportion of children in each state with the outcome. We identified additional state-level variables that might be related to our main outcomes, including the presence of state trauma systems,⁵ presence of American College of Surgeons (ACS)-verified pediatric trauma centers,¹⁰ and total state area,¹⁵ measured in square miles.

Statistical analysis

We compared characteristics in two different cohorts. One cohort consisted of all eligible patients, and made comparisons between children with a documented hospital arrival time and those without. The second cohort included only eligible patients with a recorded hospital arrival time and compared those with a time to hospital ≤ 1 h to those with a time to hospital >1 h. We used chi-squared tests to assess for univariate differences in cohort characteristics of interest. We performed multivariable logistic regression on the data for children with available transport time to assess the mean percentage of children whose transport time was >1 h in each state, adjusted for injury severity (no injury, possible injury, suspected minor injury, suspected severe injury, fatal injury, injury of unknown severity), mode of transport (EMS air, EMS ground, non-EMS), and crash occurring on a rural road. We described variability by state, dividing states into quartiles according to the percentage of children transported to the first hospital >1 h after the fatal MVC. To compare states with similar rural and geographic constraints, we stratified states based upon degree of urbanization. We defined an urbanization index as the number of U.S. Census Bureau urbanized areas in each state divided by the total state area in square miles (Appendix).^{15,17} We then compared the states ranked in the lowest quartile of urbanization to those in the highest quartile of urbanization.

To examine state-level predictors of our main outcomes, we compiled a state-level dataset by creating summary variables for important covariates, including mean child age, percentage female, percentage of each category of injury severity and mode of transport, and percentage of crashes on rural roads. We additionally included the other identified state-level variables of interest, including state trauma systems (funded vs. unfunded vs. none), the presence of a verified pediatric trauma center (≥ 1 vs. none), and state area. We examined univariate relationships between each factor and the outcomes of interest. We included all variables with a univariate relationship resulting in $p < 0.10$ in a multivariable linear regression model for each outcome of interest. We then applied a process of step-wise selection to remove non-significant variables ($p > 0.10$) until we obtained the final, most parsimonious, model for each outcome.

Analyses were performed using SAS 9.4 (Cary, NC). A two-sided p-value of 0.05 was used to determine significance in the final models. The Partners Human Research Committee approved this research.

Results

Cohort characteristics

Figure 1 illustrates selection of the study sample. Of 18,116 children involved in a fatal MVC from 2010–2014, 1,424 died at the scene. 10,407 required transport to a hospital for medical attention. Of these, hospital arrival time was documented for 4,650 children (Figure 1). Transport time >1 h was present for 14% of children, with an overall median transport time of 1h (IQR: [1,1]; range: [0,23]). Table 1 shows demographic, injury, and crash characteristics for the children included, stratified by transport time. Compared to children with time to first hospital ≤ 1 h, those with longer transport times more frequently had a non-

fatal injury, a non-EMS form of transport, and were involved in a crash occurring on a rural road (Table 1). Figure 2 illustrates the geographic distribution of the percentage of children transported by EMS air and the percentage of crashes occurring on a rural road (Figure 2a/b). When we compared observations for which arrival time was and was not available, there were no statistically significant differences between the age groups ($p=0.30$), sex ($p=0.47$), or crash occurrence on a rural road ($p=0.06$). However, there were significant differences in injury severity ($p<0.001$) and mode of transport ($p=0.01$) between the two groups, with a greater proportion of children missing hospital arrival time when classified with a suspected severe injury and when transported by EMS air (Table 1).

When we examined state-level characteristics, mean age and percentage of female children were similar across states. The percentage of crashes that occurred on a rural road varied from 17% in Illinois to 100% in Maine and Vermont. The percentage of children with no injury, possible injury, and suspected minor injury varied across states from 0–50%, 0–75%, and 0–80%, respectively. The percentages of children with suspected severe injury and fatal injury varied from 0–100% across states. The percentage of children transported by EMS air varied from 0% in many states to 33% in Illinois. The number of ACS-verified pediatric level 1 trauma centers varied from none in many states to 5 in California, while the number of any ACS-verified pediatric trauma centers varied from none in many states to 8 in California and Texas. Total state area ranged from 1,545 square miles in Rhode Island to 665,384 square miles in Alaska.

Documentation of transport times

The percentage of reported cases with documented hospital arrival times by state is shown graphically in Figure 3. While Florida, Idaho, Indiana, Michigan, and Nebraska had no recorded arrival times in the FARS dataset, Maine, New Hampshire, and Vermont had 100% of arrival times documented. We observed a regional pattern of recorded arrival times, with the lowest prevalence observed in the West (27%), compared to 47% in the Midwest, 49% in the South, and 53% in the Northeast (Table 2a).

In the state-level linear regression with percentage available arrival time as the outcome, we found that classification with an injury severity of possible injury or suspected minor injury were each associated with a small increased likelihood of available arrival time; states with greater proportions of children with possible or suspected minor injuries (as compared to greater proportions of severe or fatal injuries) were more likely to have a greater percentage of arrival times documented. For each percentage increase in children classified with possible injury, there was a small increase in available arrival time (0.59%; 95% CI: 0.14, 1.03), while for each percentage increase in children classified with a suspected minor injury, there was a slightly larger increase in available arrival time (1.03%; 95% CI: 0.61, 1.45).

Transport time variability

The proportion of children with transport times >1h also varied substantially by state, from 0% in Alaska, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, New Hampshire, Rhode Island, and Tennessee, to 69% in New Mexico. Again, we appreciated regional

differences, with the highest prevalence observed in the West (23%), compared to 14% in the Midwest, and 13% in the South and the Northeast (Table 2a). When stratified by the urbanization index, the most rural states were more likely to have transport times >1h compared to the most urban states (Table 2b). Figure 4 illustrates the mean predicted percentage of cases with transport time >1h, adjusted for injury severity, mode of transport, and rural roads.

In the state-level linear regression with mean predicted percentage of cases with transport time >1h as the outcome, we found that classification with an injury severity of no injury and crashes occurring on rural roads were each associated with increased likelihood of transport time >1h. For each percentage increase in children classified with no injury, there was a small increase in percentage of children with transport time >1h (0.78%; 95% CI: 0.23, 1.34). For each percentage increase in children transported from a crash on a rural road, there was also a small increase in percentage of children with transport time >1h (0.24%; 95% CI: 0.04, 0.44). Notably, we did not find statistically significant associations between either outcome and the presence of state trauma systems, presence of American College of Surgeons-verified pediatric trauma centers, or total state geographic area.

Discussion

We used the national FARS dataset to examine state-level variability in and predictors of prompt access to care for children involved in fatal MVCs. We found extreme variability in hospital arrival time documentation by state, with 5 states having no documentation of arrival time for children transported from the scene of an MVC, and only 3 states having 100% documentation. Children identified to have possible and suspected minor injuries were more likely to have available hospital arrival times. While most children reached care in <1h, 14% of children experienced a transport time >1h. The distribution of delayed time to trauma care varied substantially by state, with children identified to have no injuries and those transported from a crash on a rural road found to be more likely to have delayed time to trauma care.

These results are supported by prior reports from the adult trauma literature. While there is little published information on data documentation in national databases such as the FARS dataset, there are many previous studies on pre-hospital care times for trauma. These studies have been conducted at the state and county level, using population-based data. A meta-analysis including published studies with data from 20 states over a 30-year period summarized this work, finding mean total pre-hospital times of 31 minutes for urban ground ambulances and 43 minutes for rural ground ambulances.¹⁸ These estimates are consistent with most patients reaching care within 1h, as we demonstrated in the present study. One study comparing on-scene care provided by paramedics to adults and children found comparable levels of care and similar outcomes between the groups.¹⁹ However, the data in the present study do represent the first estimates of pre-hospital time after MVCs in the pediatric population and the only truly national sample.

There is also support in the literature for the relationship between crashes on rural roads and increased time to trauma care, with some evidence that MVCs occurring in rural areas are

associated with longer transport times and worse outcomes. A population-based cohort study in rural Washington state reported a median interval time between EMS dispatch and Emergency Department arrival of 48 minutes, with a 95th percentile of 95 minutes.²⁰ A second study analyzing state pre-hospital time and outcomes in Alabama found overall mean pre-hospital time was 42 minutes in rural settings compared to 25 minutes in urban settings in cases in which mortality occurred.²¹ This is consistent with our findings, which showed a small but statistically significant association between crashes on rural roads and delayed transport time to the first medical facility.

Our results must be interpreted in the context of the available data. One main finding of the study is that hospital arrival times are inconsistently documented in the NHTSA's nationwide dataset. Due to this inconsistency in reporting, the subgroup of patients with documented hospital arrival times may not be representative of the overall population of children involved in fatal MVCs. In particular, we found that children with no injuries and those transported from crashes on rural roads were more likely to experience delay in arrival at a medical facility. While we attempted to adjust for all possible confounding variables, we were unable to adjust for clinical status at the time of transport, due to the absence of clinical variables (i.e., heart rate, blood pressure, intubation requirement) in the dataset. In addition, the FARS dataset did not provide information on distance from the crash to the first hospital and subsequent transfers to different medical facilities, both of which would be of interest to further understand the patterns of accessing trauma care in this population.

The implications of this work are two-fold. First, the results showing variability in availability of hospital arrival times reveal an opportunity to improve data documentation in the acute post-trauma setting. We found that children with possible and suspected minor injuries were the most likely to have complete data; it may be that data documentation is not prioritized as consistently in children with more severe injuries due to urgent needs for clinical care. However, recording data comparably across different settings allows researchers to make comparisons on process and quality outcomes, which may lead to public health interventions. Second, the variability in transport times for children after MVCs represents an opportunity to improve pre-hospital care by targeting states with a greater percentage of cases with delayed time to trauma care. The finding that crashes on rural roads are associated with delays may be further addressed with consideration of interventions such as improved EMS air capability to reach individuals in rural areas quickly.

Conclusions

In conclusion, we performed an analysis of a national dataset of fatal MVCs, demonstrating substantial state-level variation in both documentation of hospital arrival times and transport times for children requiring transport to a hospital after an MVC. Description of this national variability may be useful to identify states with room for improvement in complete documentation and prompt hospital transport times. Future directions for this research may include using geospatial data to identify localities within these states that have longer transport times and may benefit from focused interventions. These types of studies may assist states with prioritizing trauma systems resources in order to improve prompt access to trauma care for children involved in fatal MVCs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Vital signs: Unintentional injury deaths among persons aged 0–19 years - United States, 2000–2009. *MMWR Morb Mortal Wkly Rep.* 2012; 61:270–276. [PubMed: 22513530]
2. Clark DE, Winchell RJ, Betensky RA. Estimating the effect of emergency care on early survival after traffic crashes. *Accid Anal Prev.* 2013; 60:141–147. DOI: 10.1016/j.aap.2013.08.019 [PubMed: 24056285]
3. Amram O, Schuurman N, Pike I, Friger M, Yanchar NL. Assessing access to paediatric trauma centres in Canada, and the impact of the golden hour on length of stay at the hospital: an observational study. *BMJ Open.* 2016; 6(1):e010274.doi: 10.1136/bmjopen-2015-010274
4. Wolf, LL., Chowdhury, R., Tweed, J., et al. Pediatric Deaths from Motor Vehicle Crashes: State-level Variation and Predictors of Mortality. In. American Academy of Pediatrics National Conference & Exhibition; San Francisco. 2016;
5. Kelly E, Kiemele ER, Reznor G, Havens JM, Cooper Z, Salim A. Trauma systems are associated with increased level 3 trauma centers. *J Surg Res.* 2015; 198(2):489–493. [PubMed: 25986210]
6. American College of Surgeons Committee on Trauma. [Accessed January 16, 2017] Resources for Optimal Care of the Injured Patient. https://www.facs.org/~media/files/qualityprograms/trauma/vrcresources/resources_for_optimal_care.ashx. Published 2014
7. Miyata S, Cho J, Lebedevskiy O, Matsushima K, Bae E, Bliss DW. Trauma experts versus pediatric experts: comparison of outcomes in pediatric penetrating injuries. *J Surg Res.* 2017; 208:173–179. DOI: 10.1016/j.jss.2016.09.040 [PubMed: 27993205]
8. Wang NE, Saynina O, Vogel LD, Newgard CD, Bhattacharya J, Phibbs CS. The effect of trauma center care on pediatric injury mortality in California, 1999 to 2011. *J Trauma Acute Care Surg.* 2013; 75(4):704–716. DOI: 10.1097/TA.0b013e31829a0a65 [PubMed: 24064887]
9. Osler TM, Vane DW, Tepas JJ, Rogers FB, Shackford SR, Badger GJ. Do pediatric trauma centers have better survival rates than adult trauma centers? An examination of the National Pediatric Trauma Registry. *J Trauma.* 2001; 50(1):96–101. [PubMed: 11231677]
10. Notrica DM, Weiss J, Garcia-Filion P, et al. Pediatric trauma centers: correlation of ACS-verified trauma centers with CDC statewide pediatric mortality rates. *J Trauma Acute Care Surg.* 2012; 73(3):566–70-2. [PubMed: 22929485]
11. Webman RB, Carter EA, Mittal S, et al. Association Between Trauma Center Type and Mortality Among Injured Adolescent Patients. *JAMA Pediatr.* 2016; 170(8):780.doi: 10.1001/jamapediatrics.2016.0805 [PubMed: 27368110]
12. Sathya C, Alali AS, Wales PW, et al. Mortality Among Injured Children Treated at Different Trauma Center Types. *JAMA Surg.* 2015; 150(9):874.doi: 10.1001/jamasurg.2015.1121 [PubMed: 26106848]
13. United States Department of Transportation. [Accessed June 8, 2016] Fatality Analysis Reporting System (FARS). Analytical User's Manual, 1975–2014. [ftp://ftp.nhtsa.dot.gov/fars/FARS-DOC/Analytical User Guide/USERGUIDE-2014.pdf](ftp://ftp.nhtsa.dot.gov/fars/FARS-DOC/Analytical%20User%20Guide/USERGUIDE-2014.pdf)
14. American College of Surgeons. Verified Trauma Centers -- American College of Surgeons.

15. United States Census Bureau. [Accessed January 20, 2017] State Area Measurements and Internal Point Coordinates. <https://www.census.gov/geo/reference/state-area.html>. Published 2010
16. Rivara FP, Cummings P, Mock C. Injuries and death of children in rollover motor vehicle crashes in the United States. *Inj Prev*. 2003; 9(1):76–80. [PubMed: 12642565]
17. United States Census Bureau. [Accessed March 17, 2017] 2010 Census Urban and Rural Classification and Urban Area Criteria. <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>. Published 2010
18. Carr BG, Caplan JM, Pryor JP, Branas CC. A Meta-Analysis of Prehospital Care Times for Trauma. *Prehospital Emerg Care*. 2006; 10(2):198–206. DOI: 10.1080/10903120500541324
19. Paul TR, Marias M, Pons PT, Pons KA, Moore EE. Adult versus pediatric prehospital trauma care: is there a difference? *J Trauma*. 1999; 47(3):455–459. [PubMed: 10498297]
20. Grossman DC, Hart LG, Rivara FP, Maier RV, Rosenblatt R. From roadside to bedside: the regionalization of trauma care in a remote rural county. *J Trauma*. 1995; 38(1):14–21. [PubMed: 7745644]
21. Gonzalez RP, Cummings GR, Phelan HA, Mulekar MS, Rodning CB. Does increased emergency medical services prehospital time affect patient mortality in rural motor vehicle crashes? A statewide analysis. *Am J Surg*. 2009; 197(1):30–34. DOI: 10.1016/j.amjsurg.2007.11.018 [PubMed: 18558397]

Figure 1.
Study population.

Figure 2a.

Figure 2b.

Figure 2.

Figure 2a. Percentage of children transported by EMS air by state, presented by quartile (0–50th percentile: 0%; 51st–75th percentile: 2%; 76th–100th percentile: >2%).

Figure 2b. Percentage of crashes occurring on a rural road by state, presented by quartile (0–25th percentile: 50%; 26th–50th percentile: 51–63%; 51st–75th percentile: 64–76%; 76th–100th percentile: >76%).

Figure 3. Documentation of hospital arrival times after motor vehicle crash, percentage of reported cases by state, presented by quartile.

Figure 4.

Transport time >1h, mean predicted percentage of cases by state, adjusted for injury severity, mode of transport, and crash occurring on a rural road. States with no available data on hospital arrival time are represented with hash marks. Data for states with available hospital arrival times are presented by quartiles of the outcome.

Table 1

Cohort characteristics

Variable	n (%)		n (%)	
	1 hour	>1 hour	Arrival time available	Arrival time not available
Overall	3,976 (86)	674 (14)	4,650 (45)	5,757 (55)
Age group (years)				
0–2	858 (22)	133 (20)	991 (21)	1,159 (20)
3–5	897 (23)	150 (22)	1,047 (23)	1,255 (22)
6–8	757 (19)	131 (19)	888 (19)	1,097 (19)
9–11	680 (17)	116 (17)	796 (17)	1,032 (18)
12–14	784 (20)	144 (21)	928 (20)	1,214 (21)
Sex				
Female	1,967 (49)	331 (49)	2,298 (49)	2,871 (50)
Male	2,009 (51)	343 (51)	2,352 (51)	2,886 (50)
Injury severity				
No injury	31 (0.8)	4 (0.6)	35 (0.8)	51 (0.9)
Possible injury	898 (23)	160 (24)	1,058 (23)	1,208 (21)
Suspected minor injury	1,475 (37)	242 (36)	1,717 (37)	1,973 (34)
Suspected severe injury	935 (24)	188 (28)	1,123 (24)	1,719 (30)
Fatal injury	613 (15)	80 (12)	693 (15)	774 (13)
Injury of unknown severity	24 (0.6)	0 (0)	24 (0.5)	32 (0.6)
Mode of transport to hospital				
EMS air	99 (2.5)	10 (1.5)	109 (2.3)	161 (2.8)
EMS ground	3,433 (86)	530 (79)	3,963 (85)	4,777 (83)
Other	444 (11)	134 (20)	578 (12)	819 (14)
Location of crash				
Rural road	2,446 (62)	586 (87)	3,032 (65)	3,653 (63)
Urban road	1,530 (38)	88 (13)	1,618 (35)	2,104 (37)

EMS, Emergency Medical Services

Table 2a

Outcomes by state and region

State	Required Transport n	Arrival Time Available n (%) [*]	Transport Time >1h n (%) [†]
Midwest	2,149	1,019 (47)	146 (14)
Illinois	275	3 (1)	0 (0)
Indiana	263	0 (0)	--
Iowa	96	71 (74)	8 (11)
Kansas	139	128 (92)	21 (16)
Michigan	213	0 (0)	--
Minnesota	107	57 (53)	4 (7)
Missouri	314	224 (71)	49 (22)
Nebraska	71	0 (0)	--
North Dakota	34	29 (85)	1 (3)
Ohio	461	398 (86)	53 (13)
South Dakota	25	20 (80)	1 (5)
Wisconsin	151	89 (59)	9 (10)
Northeast	745	396 (53)	50 (13)
Connecticut	40	20 (50)	0 (0)
Maine	17	17 (100)	0 (0)
Massachusetts	46	21 (46)	2 (10)
New Hampshire	34	34 (100)	0 (0)
New Jersey	119	91 (77)	5 (5)
New York	167	93 (56)	36 (39)
Pennsylvania	302	106 (35)	5 (5)
Rhode Island	12	6 (50)	0 (0)
Vermont	8	8 (100)	2 (25)
South	5,600	2,716 (49)	359 (13)
Alabama	364	53 (15)	7 (13)
Arkansas	225	36 (16)	18 (50)
Delaware	28	22 (79)	0 (0)
Florida	591	0 (0)	--
Georgia	486	361 (74)	44 (12)
Kentucky	298	234 (79)	24 (10)
Louisiana	266	243 (91)	23 (9)
Maryland	132	4 (3)	0 (0)
Mississippi	286	192 (67)	51 (27)
North Carolina	441	295 (67)	32 (11)
Oklahoma	270	246 (91)	41 (17)
South Carolina	298	96 (32)	11 (11)
Tennessee	458	1 (0)	0 (0)
Texas	1,140	865 (76)	98 (11)

State	Required Transport n	Arrival Time Available n (%) [*]	Transport Time >1h n (%) [†]
Virginia	216	20 (9)	5 (25)
West Virginia	101	48 (48)	5 (10)
West	1,913	519 (27)	119 (23)
Alaska	18	5 (28)	0 (0)
Arizona	267	109 (41)	23 (21)
California	721	2 (0)	1 (50)
Colorado	171	53 (31)	4 (8)
Hawaii	13	9 (69)	0 (0)
Idaho	96	0 (0)	--
Montana	84	75 (89)	16 (21)
Nevada	88	69 (78)	23 (33)
New Mexico	153	16 (11)	11 (69)
Oregon	80	51 (64)	13 (25)
Utah	109	57 (52)	9 (16)
Washington	64	30 (47)	6 (20)
Wyoming	49	43 (88)	13 (30)
U.S. Overall	10,407	4,650 (45)	674 (14)

^{*} Percent represents percent of those that required transport for whom arrival time was available.

[†] Percent represents percent of those with arrival time available for whom time to trauma care was >1h.

Table 2b

Outcomes by state, stratified by urbanization index *

State	Required Transport n	Arrival Time Available n (%) [†]	Transport Time >1h n (%) [‡]
Top quartile (most urban)			
Rhode Island	12	6 (50)	0 (0)
Connecticut	40	20 (50)	0 (0)
Delaware	28	22 (79)	0 (0)
New Jersey	119	91 (77)	5 (5)
Maryland	132	4 (3)	0 (0)
Massachusetts	46	21 (46)	2 (10)
Pennsylvania	302	106 (35)	5 (5)
New Hampshire	34	34 (100)	0 (0)
Florida	591	0 (0)	--
Indiana	263	0 (0)	--
South Carolina	298	96 (32)	11 (11)
Ohio	461	398 (86)	53 (13)
Bottom quartile (most rural)			
Alaska	18	5 (28)	0 (0)
Montana	84	75 (89)	16 (21)
Wyoming	49	43 (88)	13 (30)
Nevada	88	69 (78)	23 (33)
South Dakota	25	20 (80)	1 (5)
North Dakota	34	29 (85)	1 (3)
New Mexico	153	16 (11)	11 (69)
Nebraska	71	0 (0)	--
Utah	109	57 (52)	9 (16)
Oklahoma	270	246 (91)	41 (17)
Idaho	96	0 (0)	--
Kansas	139	128 (92)	21 (16)

* Urbanization index represents the number of urbanized areas in each state divided by the total state area in square miles.

[†]Percent represents percent of those that required transport for whom arrival time was available.

[‡]Percent represents percent of those with arrival time available for whom time to trauma care was >1h.