

## **Geographic Distribution of Trauma Burden, Mortality and Services in the United States: Does Availability Correspond to Patient Need?**

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## Abstract

**Background:** The association between the need of trauma care and trauma services has not previously been characterized. We compared the distribution of trauma admissions to state-level availability of trauma centers (TCs), Surgical Critical Care (SCC) providers, and SCC fellowships; and assessed the association between trauma-care provision and state-level trauma mortality.

**Study Design:** We obtained 2013 state-level data on trauma admissions, TCs, SCC providers, SCC fellowship positions, per-capita income, population size, and age-adjusted mortality-rates. Normalized densities (per-million-population, PMP) were calculated and generalized linear models used to test associations between provision of trauma services (higher-level TCs, SCC providers, and SCC fellowship positions) and trauma burden, per capita income, and age-adjusted mortality-rates.

**Results:** There were 1,345,024 trauma admissions (4,250 PMP), 2,496 SCC providers (7.89 PMP) and 1,987 TCs across the country, of which 521 were Level 1 or 2 (1.65 PMP). There was substantial variation between the top-five vs. bottom-five states in terms of L1/L2TCs and SCC surgeon availability ( $\sim 8.0:1.0$ ), despite showing less variation in trauma admissions density ( $1.5:1.0$ ). The distribution of trauma admissions was positively associated with SCC provider density and age-adjusted trauma mortality ( $p \leq 0.001$ ), and inversely associated with per-capita income ( $p < 0.001$ ). Age-adjusted mortality was inversely associated with the number of SCC providers PMP. For every additional SCC providers PMP, there was a decrease of 618 deaths/year.

**Conclusions:** There is an inequitable distribution of trauma services across the US. Increases in the density of SCC providers are associated with decreases in mortality. There was no

association between density of trauma admissions and the location of L1/L2TCs. In the wake of efforts to regionalize TCs, further efforts are needed to address disparities in the provision of quality care to trauma patients.

**Introduction:**

Trauma continues to be the leading cause of death among Americans aged 1-44<sup>1</sup>. Despite advances in medical care, there was a 23% increase in traumatic deaths over the last decade<sup>2</sup>. Initiation of organized trauma systems have been associated with decreases in mortality reportedly between 8% and 50%.<sup>3,4</sup> The mechanisms by which trauma systems reduce trauma mortality are not clear but may include pre-hospital emergency medical services, timely triage and transport, definitive medical care, and rehabilitation.<sup>5</sup> Designated trauma centers (TCs) are fundamental components of organized trauma systems. These facilities provide a number of specialized resources, including a surgical critical care (SCC) workforce, that is likely to be involved in managing the most severely injured patients.

Trauma systems across the United States (US) are more heterogeneous than in some other developed countries<sup>6,7</sup>. For example, systems vary in terms of funding, designation of TC levels, allocation of resources, and quality assurance.<sup>8</sup> Unlike some European countries in which healthcare is organized centrally,<sup>6</sup> hospitals in many US trauma systems are free to pursue TC accreditation<sup>5</sup> regardless of local need.<sup>9</sup> This variation in organized trauma care could lead to unequal distribution of resources and geographic disparities in trauma outcomes.

Although there has been a substantial increase in the number of TCs over the last 20 years,<sup>5</sup> up to 46.7 million Americans (approximately 15.8% of total population) do not have a TC within one hour of their home.<sup>10</sup> It has also been suggested that many hospitals struggle to recruit specialists in SCC to cover emergency calls because the work can be ‘intensive, unpredictable, and poorly compensated’.<sup>11,12</sup> Furthermore, among those who do decide to pursue the career, the majority

are expected to continue practicing close to their training hospitals, potentially exacerbating the difficulty of attracting SCC providers to lower-level TCs and to more remote areas.<sup>13</sup> However, with the emergence of acute care surgery as a practice paradigm, as much as 46% of general surgery residents are considering this as a career.<sup>14</sup> This could alleviate the shortage in SCC providers in the future given that the American Association for the Surgery of Trauma (AAST)-sponsored fellowships include SCC training besides trauma and emergency general surgery.

One fundamental goal of trauma system design is to ensure TC access to all Americans and guaranteeing a sustainable SCC workforce. However, it is unclear whether existing TC provision is truly consistent with clinical need. In this study, we sought to (1) examine the relationship between trauma burden and state availability of TCs, SCC providers, and SCC training opportunities; (2) explore associations between trauma burden, trauma provision, per-capita income, and state-level trauma mortality; and (3) provide an updated inventory of TCs, SCC providers, and SCC training positions across the US.

## Methods:

We undertook a state-level ecological study using data from multiple administrative sources. The variables included were: the number of trauma admissions per million population (PMP; trauma admissions density), the number of TCs PMP (density of TCs), the number of Level 1 and 2 TCs (L1/L2TCs) PMP (density of L1/L2TCs), the number of SCC providers PMP (density of providers), the number of SCC fellowship positions PMP (density of fellowship positions), state-level median per-capita income, and age-adjusted mortality rate. The study was approved by the Partners Human Research Committee, the Institutional Review Board of Brigham and Women's Hospital (MA, USA).

### *Incidence of trauma*

The Healthcare Cost and Utilization Project Nationwide Inpatient Sample (HCUP-NIS) and State Inpatient Databases (HCUP-SIDs) were used to determine nationally representative characteristics of trauma cases severe enough to require hospitalization, regardless of the type of hospital (TC or non-TC) to which patients were admitted. The HCUP-NIS is the largest publicly available all-payer inpatient health care database in the US and provides national weighted estimates of hospital inpatient stays based on discharges.<sup>15</sup> The HCUP-SIDs include inpatient all-payer discharge records from nearly all acute care hospitals in each individual state.<sup>16</sup> To obtain national and state-specific estimates, queries were performed through the HCUP online portal, HCUPnet,<sup>17</sup> on the HCUP-NIS and on all 37 available HCUP-SIDs. Traumatic injuries were defined using primary International Classification of Diseases, 9<sup>th</sup> Revision, Clinical Modification (ICD-9-CM) diagnosis codes, including those within the “injury and poisoning” index range (800-999) except for “late effects of injuries, poisonings, toxin effects, and other

external causes” (905-909), “superficial injuries” (900-919), “contusion with intact skin surface” (920-924), “effects of foreign body” (930-939), “burns” (940-949), “poisoning by drugs” (960-979), “toxic effects of substances” (980-989), “other and unspecified effects of external causes” (990-995), and “complications of surgical and medical care, not elsewhere classified” (996-999). Data were extracted for the most recent year available, which was 2013 in all cases except for Maine (2012), New Hampshire (2009) and Rhode Island (2012). HCUPnet also provided the percentage of patients with primary injury diagnoses codes that were discharged routinely, transferred to another hospital, discharged to a nursing home or other inpatient facility, to home health care, against medical advice, or who died while in-hospital, which helped to determine referral patterns and care pathways at the national level.

### *Trauma centers*

Data from the American Trauma Society (ATS) were used to identify hospitals with a TC designation (2015) and this was the only data source used for to identify the geographical location of hospitals. This dataset was provided directly by the ATS and included hospital name, American Hospital Association (AHA) ID, TC level designation (according to state/region or to ACS verification), pediatric TC level designation, burn center designation (assigned or self-reported), and postal address. TC level was coded as per state/region designation. ACS-verification level was used to impute data for four hospitals that had a missing state-level designation. ATS data were linked to data contained within the AHA Annual Survey to enrich the dataset with hospital characteristics, including US census region and rurality, as defined by the United States Department of Agriculture Economic Research Service’s county codes. Thirteen hospitals could not be linked by the unique identifier variable, name, or postal address

and were excluded from subsequent hospital characteristic analyses. They were, however, included in the geographical analyses.

#### *Surgical critical care providers and fellowships*

Providers that were certified in SCC by the American Board of Surgery (ABS) were identified using data published by the American Board of Medical Specialties (ABMS).<sup>18</sup> The ABS is one of the 24 member boards of the ABMS, which previously compiled this resource from state-level data on more than 800,000 specialty physicians across the US.<sup>18</sup> SCC providers serving in the military or practicing outside the US were excluded due to the inability to locate them within the US territories. According to the ABS, providers who completed a one-year training in surgical critical care or anesthesiology critical care or a two-year training in adult critical care medicine are eligible for SCC board certification. Data on SCC fellowship positions available per state (2013) were extracted from a National Residency Matching Program (NRMP) report,<sup>19</sup> which contains all available positions for SCC for the study period.

#### *State-level demographic details, trauma mortality rates, and income estimates*

US Census projections were used to obtain 2013 population estimates.<sup>20</sup> Age-adjusted mortality rates (per 100,000 population) at the state-level were obtained directly from the Centers for Disease Control and Prevention (CDC) Injury Prevention and Control (WISQARS™).<sup>21</sup> State-level per-capita income estimates were obtained from the 2009-2013 American Community Survey 5-Year Estimates.<sup>22</sup>



### *Statistical analyses*

The number of trauma admissions (clinical need), SCC providers, fellowship positions, and TCs were summarized nationally and at the state level. Standardized densities PMP were calculated for each factor. The magnitude of geographical variation at the state-level was assessed for each factor by obtaining a ratio of the mean density of the top and bottom five states. Geographic variation of hospitals and workforce were also illustrated with an intensity map of the densities of SCC providers per state, with superimposed locations (by zip code) of higher-level TCs (L1 and L2). In these analysis, higher-level TCs were grouped together as there are many similarities between L1 and L2 TCs.<sup>23</sup>

The associations between density of trauma admissions (primary variable) and SCC provider density, SCC fellowship positions density, TCs density, per-capita income, and age-adjusted mortality-rate (co-variates) at the state-level were tested using generalized linear regression models followed by post-estimation calculation of average marginal effects to yield predicted mean differences and 95% confidence intervals (95%CI). The associations of age-adjusted mortality rate at the state-level (secondary variable) and SCC provider density, SCC fellowship positions density, TCs density, per-capita income, and trauma admissions density (covariates) were examined in a similar manner.

Continuous density distributions were skewed. In order to account for the non-normal nature of the data, modified Park tests were used to determine the appropriate modeling strategy, which corresponded to a gamma distribution. Maps were created using ArcGIS (Esri, Redlands, CA)

and statistical analyses performed in Stata Statistical Software: Version 12.0 (College Station, TX). Two-sided p-values  $<0.05$  were considered significant.

## Results

### *Trauma burden*

The annual national burden of injured patients admitted to hospitals was 1,345,024, of which 2.4% died in-hospital, 43.8% were discharged to live independently in their own home, 41.4% to a nursing home or other inpatient facility, 9.6% to home health care, and 0.7% against medical advice. Nationally, the density of trauma admissions was 4,250 PMP. In descending order, the top five states were West Virginia, Missouri, Florida, North Dakota, and Maine, and the bottom five were North Carolina, Texas, Illinois, Utah, and Washington (eTable 1). The ratio of trauma admission density between the top and bottom five states was 1.5. The age distribution of patients admitted for traumatic injuries was: 0.5% <1 year-old (y/o), 6% 1-17 y/o, 20.8% 18-44 y/o, 22% 45-65 y/o, 31.3% 65-84 y/o, and 19.4%  $\geq$ 85 y/o.

### *SCC workforce*

There were 2,496 SCC providers, yielding a density of 7.89 SCC providers per PMP. The ratio of SCC provider density between the top and bottom five states was 7.8. There were 177 SCC fellowship positions offered nationally, yielding a density of 0.56 PMP. Similarly, the ratio between the top and bottom five states was 8.8.

### *Trauma centers*

There were 1,987 TCs nationally; 10.7% were L1TC, 15.6% L2TC, 22.4% Level-3 (L3TC), 45.5% state-defined Level-4 (L4TC), 5.7% state-defined Level-5 (L5TC). The density of “all

TCs” and higher-level TCs were 6.28 and 1.65 PMP, respectively. The ratio between the top and bottom five states was 42.0 times for all TCs and 7.5 times for higher-level TCs.

All hospital characteristics assessed varied significantly between L1TC, L2TC, and L3/4/5TCs combined ( $p<0.001$ ). The majority of L1TC (56.1%), half of L2TC (50.3%), and approximately one seventh of L3TC (14.8%) were ACS-verified (Table 1). Compared to other hospitals, L1TCs were more likely to be co-designated as pediatric TCs (33.6%); be located in the Mid Atlantic (19.6%), South Atlantic (17.3%), or East North Central (17.8%) regions (Figure 1); be located in metropolitan statistical areas with >1 million population (61.7%); be large (>500 beds, 56.1%), private non-for-profit (64.5%) hospitals; have an American Council for Graduate Medical Education (ACGME) accredited residency (90.7%); be members of the Council of Teaching Hospitals (71%), and offer intensive care unit (ICU, 92.5%), burn care (37.9%) and transplantation (63.1%) services (Table 2). The geographic distribution of L1/L2TCs is shown in Figure 1.

#### *Association of trauma burden and mortality with the trauma provision*

The availability of trauma services was not readily explained by the geographic distribution of trauma cases, as illustrated in Figure 2. Visual inspection of the data showed that states with higher densities of SCC providers and/or L1/L2TCs did not correspond with states that had higher trauma admissions. In generalized linear regression models testing the independent association of trauma admissions density and TCs density, SCC provider density, per-capita income, and age-adjusted mortality rate, there was an increase of 75 trauma admissions (95%CI: 15.9-134.0;  $p=0.013$ ) for every unit increase in SCC provider PMP. There was an increase of

20.5 admissions PMP (95%CI: 8.4-32.5;  $p=0.001$ ) for every unit increase in age-adjusted trauma mortality rate per 100,000 population, a decrease of 54 admissions PMP (95%CI: 25.8-82.4;  $p<0.001$ ) for every \$1,000 increase in per-capita income, and no association with density of TCs or density of SCC fellowship positions with trauma admissions ( $p>0.05$ ) (Table 3). In terms of state-level age-adjusted mortality-rate, for every 100-unit increase in trauma admissions PMP, the predicted mean mortality-rate increased by 1.2% (95%CI: 0.4-1.9%;  $p=0.001$ ). For every unit increase in SCC providers PMP, there was a decrease of 2.0% in mortality (95%CI: -3.4 to -0.5%;  $p=0.007$ ) (Table 4). Extrapolated nationally, the results mean that for every unit increase in SCC providers PMP, there would be a decrease of 618-trauma deaths/year. Models restricted to higher-level TCs revealed the same trend. A summary table with the number and density PMP of trauma admissions, SCC providers, SCC fellowship positions, TCs, and higher-level TCs is provided in eTable 1.

## Discussion

It is important to support the provision of trauma centers and trauma systems based on the need of an area. Although trauma centers have an established role delivering better care for critically injured patients<sup>3,24-27</sup>, expansion of the number of hospitals alone may not improve the health of an area. This state-level ecological study found evidence of geographical variation in trauma admissions (clinical need), SCC providers and the distribution of trauma centers. States with higher burden of trauma tended to have lower per-capita income and increased mortality-rates. However, there was no association between trauma admissions and availability of trauma centers. Higher density of SCC providers was associated with lower trauma mortality rates. The results demonstrated that every unit increase in SCC providers PMP was associated with a national decrease of 618 trauma deaths per year. These findings raise the possibility that equitable distribution of trauma services could improve trauma outcomes on a national scale.

The American College of Surgeons Committee on Trauma has stated that TCs should function based on local community requirements rather than on the basis of their resources, capabilities and self-selected levels of designation.<sup>9,23</sup> Nevertheless, our study suggests that there is marked regional variation and considerable discrepancy between the clinical need and availability of trauma services across the US. Although there is only a small difference in normalized case volume between the states with the largest and smallest trauma burdens (1.5 times), the densities of higher-level (L1/L2) TCs, SCC providers, and SCC training opportunities ranged 8-fold between the states with highest and lowest levels of trauma provision. When all TCs were considered, this ratio widened to 40-fold. Additionally, our adjusted analysis showed that there was no association between the trauma need (admissions) and the availability of TCs. This

shows a disparity in the ability of states to adequately cater for their trauma burdens and suggest the need for more balanced distribution of resources within the country.

Availability of TCs<sup>4,28</sup> SCC providers<sup>29</sup> and SCC fellowship training positions<sup>30</sup> have been previously found to be associated with improved outcomes. Consistent with prior literature,<sup>29</sup> we found that higher densities of SCC providers were independently associated with reduced state trauma-specific mortality rates. However, we did not find associations of trauma need and/or mortality with TCs or SCC training distribution. These findings must be interpreted with caution, as the data did not allow for clustering of providers within states, and therefore the level of contribution of SCC providers to the decrease in trauma state mortality observed is unknown. It was beyond the scope of our study to define thresholds of optimal density of facilities or workforce per state. Future studies conducted at the hospital, community, or patient-level are warranted to help define ‘optimal levels’ and appropriate implementation/resource allocation strategies, particularly considering that states with higher levels of need also tend to have higher mortality and lower resources.

It has long been established that TCs provide the best possible care for severely injured patients.<sup>4,28</sup> Despite the overall number of TCs increasing across the US by two-fold since the last published inventory almost 15 years ago<sup>5</sup>, this updated inventory of TC provision highlights areas requiring further investment of resources. Compared with this earlier study,<sup>5</sup> the increase in overall TCs was largely due to increased accreditation of lower level (L3-L5) TCs. From 2002 to 2015, there has been a small increase in the number of L1TC and L2TC by 12% and 17%, respectively. However, trauma centers that do not routinely care for the most severely injured

patients (L3TC and L4/L5TCs) increased by a striking 77% and 126%, respectively, over the same timeframe. This dramatic expansion of lower-level TCs might not have been equal across the US and could help explain the dramatic 40-fold gap observed between states with lower and higher densities of TCs.

State-level variations in SCC workforce were also examined given the crisis in specialized trauma personnel coverage.<sup>11,12,31</sup> This is particularly important as trauma specialists are a key component of trauma systems and have been associated with improved outcomes<sup>29</sup> when treating critically ill patients. Similarly, SCC fellowship positions have been associated with improved outcomes<sup>30</sup> in large academic centers and might help increase the number of specialists available in any given region. The total number of SCC board certified providers per year has increased from 92 in 2004 to 170 in 2013.<sup>18</sup> Increases in the SCC workforce are likely explained by increased clinical need. It is unsurprising that inequities in the number of SCC providers are of a similar magnitude to the number of fellowship opportunities as large trauma departments are likely to include higher numbers of both faculty and fellows. If surgeons are more likely to settle in the regions in which they trained,<sup>13</sup> states with fewer SCC fellowship opportunities might be at a disadvantage when trying to increase their SCC workforce.

Although this study was not longitudinal and so cannot comment on changing trends in trauma epidemiology, it is important to acknowledge that over 50% of patients were aged >65 and 40% required additional inpatient care following discharge from hospital. This is consistent with epidemiological evidence that trauma is increasingly a disease of older adults<sup>32</sup>. The changing age structure of the US population will clearly bring new challenges for trauma providers,



particularly higher level TCs that might be responsible for providing a range of specialist regional services, e.g. cardiac surgery and transplant<sup>33,34</sup>.

The inequitable distribution of higher-level TCs is clearly a challenging issue to resolve, particularly given the range of individuals and institutions whose interests are vested in the TC verification process. Outside the US, some state-run trauma systems have been organised centrally by balancing existing resources and regional needs<sup>34</sup>. This is unlikely to be possible in the same way given that trauma services in the US are run by a diverse range of providers. However, one possibility would be for a central body (such as the American College of Surgeons) to incorporate assessment of local need into their TC verification processes. For example, a hospital seeking level 2 TC status might be denied formal verification if there are a number of well-functioning higher-level TCs nearby. It is possible that this approach might raise standards as hospitals compete to be designated as the principal higher-level TC in their region. Any widespread reform of TC verification should be based on the best available evidence and following extensive consultation with stakeholders.

Our study has a number of limitations that should be acknowledged. First, we used inpatient trauma admissions as a general marker of state trauma burden. Although this inevitably excludes pre-hospital and emergency department deaths, analysis of inpatient admissions is likely to capture the majority of trauma cases severe enough to require hospital admission regardless of TC designation. As this approach was used consistently throughout all states, it should serve as a marker for the overall burden of severe injuries. Second, we were unable to exclude patients that were transferred between institutions, as this is not possible using HCUPnet. However, the inter-

hospital transfer rate for patients with an injury-related primary diagnosis was small (2.0%). Since our analysis was at the state-level, it is unlikely that the proportion of patients transferred between hospitals across state lines would have affected our overall findings significantly. Third, our workforce analyses are based on data from board-certified SCC providers. It is conceivable that a proportion of practicing SCC providers have also previously been certified and this certification has since expired and not been renewed, or that a proportion have not pursued board certification. However, board-certified providers in SCC were included in the analysis because it provides a useful threshold for identifying those that have received supplementary subspecialty training, reached a minimum level of cases, maintained a continued commitment to SCC, and because it permitted a reliable identification of specialists from different backgrounds (surgeons, anesthesiologists and medical intensivists) at the state-level. Fourth, the study design prevented adjusting for rurality of each state, which could potentially contribute to worse trauma system outcomes. Fifth, we were unable to perform any external validation of the HCUP administrative datasets that contributed to the trauma burden analyses. Although coding data quality has been shown to vary in the HCUP datasets, the last study to address this was in 2000<sup>35</sup> and it is likely that there have been substantial improvements in the interim. The Nationwide Inpatient Sample is widely accepted to be the best available resource for national estimates regarding hospitalizations in the US<sup>36</sup>.

Finally, as these analyses were undertaken at the state-level, it is possible that they mask complex relationships between service provision and clinical need within individual trauma systems or within state regions. It is therefore important to be aware of the possibility of an ecological fallacy, which assumes that aggregate correlations must always reflect underlying

individual correlations. However, since individual states are the most obvious level at which to analyze data given that they often demarcate the limits of specific administrative, organizational, and legal systems; it should be appropriate to use state-level data to highlight geographic variations in trauma provision, which could then be further characterized by studies using more granular datasets.

### *Conclusion*

There is substantial variation in trauma care provision across the United States. Distribution of SCC providers, which is associated with decreases in state-level trauma mortality, is the only trauma provision measure that is associated with the state-level trauma burden. States with higher volumes of trauma warrant particular attention as they have lower resources and higher mortality. Future efforts to design trauma systems, establish criteria for TC accreditation, and allocate healthcare resources should ensure that adequate provision is made so that trauma patients receive the best possible care wherever they live in the United States.

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**Table 1.** Distribution of Trauma Centers in the US Grouped by Level of Designation

	<b>Designated by state or region</b>			
<b>Level</b>	<b>Not ACS-verified</b>	<b>ACS-verified</b>	<b>Only ACS-verified</b>	<b>Total, n (%)</b>
1	93	119	2	212 (10.7)
2	154	155	1	309 (15.6)
3	381	64	1	445 (22.4)
4	904	0	-	904 (45.5)
5	113	0	-	113 (5.7)
All	1645	342	4	1987 (100.0)

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**Table 2.** Hospital Characteristics Grouped by Trauma Center Level

Hospital characteristic	L1TC	L2TC	L3TC, L4TC, & L5TC	P Value
	(n=212)	(n=309)	(n=1462)	
ACS-verified trauma center, %	56.5	50.3	†	<0.001
Pediatric trauma center, %	33.6	7.1	0.3	<0.001
US census region, %				<0.001
New England	6.5	4.2	1.0	
Mid Atlantic	19.6	10.3	0.1	
South Atlantic	17.3	14.2	4.3	
East North Central	17.8	26.8	8.4	
East South Central	6.1	3.6	8.8	
West North Central	8.9	10.7	26.9	
West South Central	8.4	6.8	27.6	
Mountain	7.9	7.7	11.4	
Pacific	7.5	15.2	10.4	
Not reported/missing	0.0	0.7	1.2	
Rurality (as defined by county population), %				<0.001
Metro - 1 million population or more	61.7	40.0	13.3	
Metro - 250,000 to 1 million population	25.7	30.0	12.0	
Metro - Fewer than 250,000 population	7.0	21.0	11.6	
Nonmetro - Urban population of 20,000 or more, AMA	0.0	1.9	6.7	
Nonmetro - Urban population of 20,000 or more, NAMA	0.5	2.6	4.7	
Nonmetro - Urban population of 2,500 to 19,999, AMA	0.0	0.3	18.3	
Nonmetro - Urban population of 2,500 to 19,999, NAMA	0.0	0.3	15.6	
Nonmetro - Completely rural or less than 2,500 urban population, AMA	0.0	0.0	3.8	
Nonmetro - Completely rural or less than 2,500 urban population, NAMA	0.0	0.0	8.5	
Not reported/missing	5.1	3.9	5.7	
Ownership, %				<0.001
Government, non-federal	29.4	7.7	30.5	
Private non-for-profit	64.5	81.0	53.8	
Private for-profit	5.6	10.0	14.1	
Government, federal	0.5	0.7	0.5	
Not reported/missing	0.0	0.7	1.2	

Bed size, %				<0.001
<100	0.0	1.3	65.6	
100-299	12.2	38.1	25.2	
300-499	31.8	42.9	6.0	
>500	56.1	17.1	2.1	
Not reported/missing	0.0	0.7	1.2	
Teaching hospital (ACGME-accredited residency), %				<0.001
Yes	90.7	53.6	9.4	
No	9.4	45.8	89.5	
Not reported/missing	0.0	0.7	1.2	
Teaching hospital (COTH member), %				<0.001
Yes	71.0	10.3	0.8	
No	29.0	89.0	98.1	
Not reported/missing	0.0	0.7	1.2	
Services, %				
Intensive care unit				<0.001
Yes	92.5	89.4	55.6	
No	0.5	0.7	31.6	
Not reported/missing	7.0	10.0	12.9	
Burn care				<0.001
Yes	37.9	5.8	2.1	
No	55.1	84.2	85.1	
Not reported/missing	7.0	10.0	12.9	
Transplantation (any type) <sup>*</sup>				<0.001
Yes	63.1	22.3	4.2	
No	29.9	67.7	82.9	
Not reported/missing	7.0	10.0	12.9	

<sup>\*</sup>Hospital offers any of the following: bone marrow, heart, kidney, liver, lung, tissue or other transplant services.

<sup>†</sup>The ACS provides verification for L1TC, L2TC and L3TC. Therefore, ACS-verification percentage was not obtained for the L3/L4/L5TCs group.

ACS, American College of Surgeons; AMA, adjacent to a metropolitan area; NAMA, not-adjacent to a metropolitan area; ACGME, American Council for Graduate Medical Education; COTH, Council of Teaching Hospitals; L1TC, Level 1 Trauma Center; L2TC, Level 2 Trauma Center; L3TC, Level 3 Trauma Center; L4TC, Level 4 Trauma Center; L5TC, Level 5 Trauma Center

**Table 3.** Predicted Mean Difference of Density of Trauma Admissions at the State-Level

<b>Covariate</b>	<b>Predicted mean difference</b>	<b>95% CI</b>		<b>p Value</b>
Density of trauma centers	2.381	-9.74	14.50	0.7
Density of SCC providers	74.949	15.91	133.99	0.013
Density of SCC fellowship positions	-144.231	-535.03	246.57	0.469
Per capita income	-0.054	-0.08	-0.03	<0.001
Age-adjusted state mortality rate	20.448	8.40	32.50	0.001

\* Models adjusted for density of trauma services, per capita income and age-adjusted state mortality

SCC, surgical critical care

**Table 4.** Predicted Mean Difference of Age-Adjusted Mortality Rate at the State-Level

<b>Covariate</b>	<b>Predicted mean difference</b>	<b>95% CI</b>		<b>p Value</b>
Density of trauma centers	-0.025	-0.33	0.28	0.875
Density of SCC providers	-1.953	-3.37	-0.53	0.007
Density of SCC fellowship positions	-3.525	-13.03	5.98	0.467
Per capita income	0.001	0.00	0.00	0.077
Density of trauma admissions	0.012	0.00	0.02	0.001

\*Models adjusted for density of trauma services, per capita income and trauma admissions  
 SCC, surgical critical care