Supplemental Online Content

Handley TJ, Kang A, Alawa J, Arnow K, Spain DA, Choi J. For-profit status and geographic distribution of trauma centers in the US. *JAMA Surg.* Published online July 26, 2023. doi:10.1001/jamasurg.2023.2751

This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods. Supplemental methods

Data sources

We compiled the location and level of all state-designated US trauma centers using data from the 2013-2018 Trauma Information Exchange Program (TIEP)[1] and corresponding economic data from the Center for Medicare and Medicaid Services (CMS) Hospital Provider cost reports, including annual income, cost of charitable care, and for- or not-for-profit status.[2] We also compiled the crude death rate from traumatic injuries using the Web-based Injury Statistics Query and Reporting System (WISQARS)[3], and county-level median household income from U.S. Census data.[4]

Variable definition

Trauma center level

Trauma center levels (i.e., level I to V) reflect available resources and patient volume met by trauma centers. Trauma centers are identified through state level 'designation' and American College of Surgeons Committee on Trauma (ACS-CoT) 'verification'. Designation is a process that is determined at the local level and criteria varies between states. Verification is an evaluation process performed by the ACS-CoT to standardize and improve delivery of trauma care.[5] We evaluated all trauma centers designated by their respective states.

For-profit/Not-for-profit status

We classified hospitals as "for-profit" or "not-for-profit" depending on their "control type" in the CMS data set.

Charitability

We identified the charitability ratio of each hospital by dividing the dollars spent on charity care, by total expenses.[6,7] Because not-for-profit and for-profit hospitals may inherently have different charitability ratios we also accounted for charitability by profit status.

Injury-related mortality rate

We determined trauma burden as the mean injury-related death rate per 100,000 residents for the county that the trauma center was located in, between 2009-2018.[3]

Linear Regression

We used a directed acyclic graph to derive which variables to include in our model.[8] Our model used the following equation: Travel time = For Profit Status + State Designated Category (I-II vs. III-V) + Trauma Related Mortality per 100,000 county residents. We applied our model to compare travel times among any trauma center, and trauma centers of the same category.

Trauma care demand

We used injury-related mortality rate as a surrogate marker for trauma system demand. Trauma-related mortality rate is validated in the literature as a proxy for the severity and burden of trauma within a given population, enabling quantification of system demand and comparability across different regions and studies.[9] However, injury-related mortality is an imperfect proxy for trauma care demand: mortality likely reflects patients with the most severe injury but does not represent the spectrum of trauma care needs within a region and is confounded by external

factors (e.g., population age distribution, socioeconomic status, and healthcare infrastructure). It is essential to interpret our results in the context of these limitations.

Trauma care supply

We used trauma centers as a surrogate marker for trauma care supply. Trauma centers are specialized healthcare facilities equipped to provide care for injured patients. Despite variations in state trauma center verification criteria, the existence and location of trauma centers within a region can serve as a proxy for the availability and accessibility of dedicated trauma services. However, trauma centers alone are a limited measure of trauma care supply, as they are unable to account for variations in capacity, staffing, expertise, and associated services (e.g., pre-hospital care) of individual trauma centers, which could influence overall care delivery effectiveness. Similar to trauma center demand, trauma center supply should be interpreted with these limitations in mind.

Inclusion criteria

We used the American Hospital Association's identification records to find newly designated hospitals, which were defined as those present in a following years dataset, but absent from the prior dataset (e.g., a hospital that appears in 2014, but not in the 2013 dataset was considered 'newly designated' in 2014).

Exclusion criteria

Among 516 trauma centers considered for analysis during the study period, 85 were excluded

due to missingness (44 had missing cost data from CMS, 26 had missing state trauma level designation, 11 had no control type designating for-profit status, and 4 were repeated entries).

Matching and merging datasets

The CMS and TIEP datasets were matched using Fedmatch (an R package designed for 'fuzzy' matching), and the resultant dataset to census and CDC injury data by ZIP code and county.[3,4,10]

Geospatial analysis - ARCGIS

Using street addresses for all hospitals included in our analysis, we classified trauma centers designated before 2014 as "existing" and those designated between 2014 and 2018 as "newly designated". Our primary outcome was grand transport time (minutes) between an existing and a newly designated trauma center, with the upper limit of ground transport time capped at 60 minutes.[11]

Spatial data were processed using ArcGIS Pro 2.4.1 and a nationwide network data set (StreetMap North America). Ground transport time was calculated using the Esri ArcGIS Drive-Time function and Network Analyst, which uses historical average speed data produce ground transport time estimates by accounting for speed limits, lanes, illegal turns, and one-way streets. The "Time of Day" option was standardized as Monday at noon. An origin-destination cost matrix was produced with an "existing" hospital as origin and "new" hospital as destination.

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