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Geographic disparities in access to urban trauma care: defining the problem and identifying a solution for gunshot wound victims in Chicago

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Abstract

BACKGROUND: Timely transport to designated trauma centers impacts mortality following serious injury. We examined whether the distribution of trauma centers in Chicago has created disparities in access to trauma care.

METHODS: Using the Illinois State Trauma Registry, locations of Chicago-area gunshot wounds (GSWs) from 1999 to 2009 were geocoded and transport times were analyzed for pediatric (age $\leq$ 15) and adult (age $\geq$ 16) GSWs.

RESULTS: A total of 11,744 included pediatric and adult GSWs were analyzed. Adults experienced longer mean transport times (11.3 vs 10.2 minutes, $P < .001$). Disproportionate numbers of adult GSW victims experienced over 30-minute transport times on Chicago's south side. Pediatric GSWs demonstrated no such disparity, likely attributable to the presence of a pediatric trauma center on the southeast side.

CONCLUSIONS: Geographic disparities in access to trauma care exist even within urban trauma systems. The absence of an adult trauma center on Chicago's southeast side has contributed to these disparities.

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Over a decade of research has demonstrated that designated trauma centers verified by state, regional, or national authorization organizations improve survival from serious injury by 3.4% to 8%.[1,2] Timely transport of injured patients to designated trauma centers is vital to providing trauma patients with optimal quality of care. Given that the distribution of trauma centers across the United States is not uniform, some areas of the country have less favorable access to specialized trauma care and thus experience worse outcomes. Disparate access to trauma care has been shown to result in higher mortality rates for rural trauma patients when compared with similarly injured patients in urban

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settings.[3-6] Research has also shown that shorter transport times are associated with decreased mortality for patients who are injured in urban areas.[7–9] However, the distribution of transport times within urban trauma systems and the resulting access disparities are less well described. The configuration of trauma centers in Chicago, IL has left portions of the city with disparate access to trauma care, providing a unique opportunity to evaluate disparities in access to trauma care in a large, urban setting.

Chicago is served by seven Illinois-verified level I adult trauma centers in and around the city. In addition, there are 4 pediatric level I trauma centers in Chicago. There are no level II trauma centers within the city limits. Prehospital transport is provided by 60 Advanced Life Support ambulances, and 15 Basic Life Support ambulances and services are centralized by region of the city; these constitute Chicago Emergency Medical Services. The west side of Chicago houses 2 adult trauma centers, as well as 2 pediatric level I trauma centers. The south side does not have a centrally located adult level I trauma center, leaving those injured on the city's southeast side with a considerably greater distance to travel in comparison with those similarly injured in other high crime areas of Chicago. There is a pediatric level I trauma center on the southeast side of Chicago, facilitating a comparison of transport times between pediatric and adult gunshot wound (GSW) victims on the south side. Over 95% of GSW victims who survive transport are brought in by ground Emergency Medical Services. We hypothesized that[1] the geographic distribution of Chicago's trauma centers have created disparities in access to adult trauma care and[2] that an additional trauma center on the south side of Chicago would eliminate these access disparities.

Methods

Institutional Review Board approval was obtained from the Northwestern University and the Illinois Department of Public Health before conducting this research. The data source utilized for this study was the Illinois State Trauma Registry (ISTR), a mandatory reporting database that contains information about all trauma cases that present to level I and level II trauma centers in Illinois. Data from 1999 to 2009 were abstracted from the ISTR (n = 510,429) and restricted to Chicago by zip code, city, and a one-mile perimeter around the city to capture individuals injured immediately outside the city limits but within the catchment area for Chicago's trauma centers (n = 119,349). The dataset was further limited to GSWs (n = 12,475) by using the External Causes of Injury codes from the International Classification of Diseases, Ninth Revision[10] (e-codes 922.0 to 922.9, 955.0 to 955.7, 965.0 to 965.4, 968.6, 985.0 to 985.7, 970, and 979.4).

Scene address data from the ISTR was utilized to geocode all GSWs that presented to trauma centers in Chicago during the study period. Geocoding allows address data to create maps with multiple overlapping layers. For this study, we used scene address data, road and traffic patterns, and trauma center address data. These points were mapped using ArcGIS 10.0 software (Esri, Redlands, CA). More than 94% of the GSWs captured by our search were able to be geocoded in this manner (n = 11,744). Because of the unequal number of pediatric and adult level I trauma centers and their different catchment areas, these GSWs were divided into 2 groups: (1) age $\leq$ 15 (pediatric); and (2) age $\geq$ 16 (adult). In Chicago, trauma patients $\leq$ 15 years old are routinely transported to pediatric trauma centers, while those $\geq$16 are transported to adult trauma centers. We also assessed covariates of interest: sex, race/ethnicity, insurance status, injury severity, and an outcome of interest (mortality). Less than 5% of data points were missing for each of these items.

To better understand the effect of accessibility to trauma care, geospatial analysis of these GSWs was undertaken. We elected to create a visual depiction of density clusters of transport times instead of simple mean estimations to identify relevant and actionable results.

Local Moran's I Zone of Indifference was applied to each dataset using the emergency department recorded travel time from the scene to definitive care at one of the city's level I trauma centers. This type of calculation is used to identify clusters and outliers using spatial weighting. It avoids imposing sharp neighborhood boundaries by assigning a particular point maximum weight; when a critical distance is exceeded, neighboring areas are assigned smaller and smaller weights. The null hypothesis is spatial randomness and can be rejected when clusters occur.

Locations with 2 or more GSW victims whose transport times exceeded 30 minutes, occurring statistically closer to one another than can be explained by random chance, were assigned to geographic census tracts as defined by the 2010 US Census. Thirty minutes was chosen because 30 minutes is more than 2 standard deviations longer than the mean transport times for GSWs in Chicago in this study (mean 12.5 minutes, standard deviation 7.5 minutes). Because these transport times were high outliers (H) and surrounded by other high-valued transport times (H), these clusters are called "HH clusters" in Local Moran's cluster and outlier analysis. These were then mapped as a percent of the total GSWs that occurred within the same tract.

A *t* test comparing the total number of HH clusters within and beyond 5 miles of a trauma center for both sets of GSWs (pediatric and adult) was performed. Five miles was used based on previously published work demonstrating that being shot more than 5 miles from a trauma center in the city of Chicago is associated with longer prehospital transport times and higher mortality.[11] To evaluate the impact of an additional adult level I trauma center on the southeast side of Chicago, the number of adult GSW HH clusters in the current trauma network was compared with the number of pediatric GSW HH clusters within and beyond a 5-mile radius of a level I trauma center.

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