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Correlations between road crash mortality rate and distance to trauma centers

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ABSTRACT

The assumption that better outcomes are associated with a reduction in time to trauma care is the foundation of emergency medical services and trauma systems. However, previous literatures did not provide clear evidence to directly support the assumption. In this study, the data of Fatality Analysis Reporting System from 2010 to 2015 were adopted to quantify the relationship between the distance to trauma centers and the mortality of patients in fatal crashes. Utilizing the closest facility solver in the Geographic Information System, the distance from crash scene to trauma center was calculated, and the effects of trauma center on patients in fatal crashes and the difference between different levels of trauma center were examined using logistic regression. For all drivers in fatal crashes from 2010 to 2015, the results of logistic regression show that the mortality increased with each additional mile to the trauma center with the odds ratio (OR) of 1.0021 per mile, comparing to an OR of 1.0008 per mile for the passengers in fatal crashes. The Level I, II, and III trauma centers had different effects on the driver mortality with a Chi-square of 1163.8, 468.7, and 112.2 respectively, indicating that the drivers admitted to Level I trauma centers had improved survival rates relative to lower-level trauma centers.

1. Introduction

Emergency medical services (EMS) systems in the US generally adhere to strict criterions about rescue intervals, which are based on the concept that definitive medical treatment must be initiated within a certain time window for trauma patients. The foundation of EMS and trauma systems relies on the assumption that better outcomes are associated with a reduction in time to trauma care. Therefore, the goal of trauma care is to transport severely injured patients to a trauma center for diagnosis, critical care, and surgical treatment within the "golden hour." However, little evidence could be found in former literatures to directly support the assumption. Several earlier studies on this topic may have been tempered by small sample sizes, or mixed samples including patients with nontraumatic cardiac arrest (Feero et al., 1995; Esposito et al., 1995; Grossman et al., 1997; Branas et al., 1995; Pons et al., 2005; Blackwell and Kaufman, 2002).

In 2007, Jon Nicholl et al. performed a cohort study of 10,315 patients (excluding cardiac arrests) transported by four English ambulance services to hospitals (Nicholl et al., 2007). Considering the accuracy of journey time records and the possible "reverse causation" phenomenon, which occurs when the patient condition is a cause of the rescue interval rather than vice versa, they adopted the straight-line journey distances and found that increased distance was associated with increased mortality. In 2010, Craig

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D. Newgard et al. examined 3656 injured patients who were transported by EMS agencies to 51 trauma centers across North America, and no association could be found among any EMS interval and mortality (Newgard et al., 2010). In 2012, National Highway Traffic Safety Administration (NHTSA) published a report to define the correlation between the distance of a crash to a trauma center and the scene mortality of the driver by comparing two mutually exclusive groups (NHTSA, 2012). One group consisted of 9424 drivers who died at the scene and the other group consisted of 13,620 drivers who were taken to the hospital by EMS and eventually survived. It was found that the closer that a fatal crash occurs from a trauma center, the less likely it is that the driver will be recorded as "died at scene."

Another leading public health issue which has been discussed for many years is the benefits of trauma center. A trauma center can provide comprehensive emergency medical services to patients suffering traumatic injuries. In North America, trauma centers are ranked from Level I (comprehensive service) to Level III (limited-care) by the American College of Surgeons (ACS). Ideally, all individuals with life-threatening injuries should be transported to Level I or Level II trauma centers, and all patients with less serious injuries should be transported to lower-level trauma centers or local hospitals (Wang, 2009). In 2006, MacKenzie et al. collected data of 5000 patients who were transported to 18 hospitals with Level I trauma centers and 51 hospitals without trauma centers. They found a 25% reduction in mortality for severely injured patients who received care at a Level I trauma center rather than at a non-trauma center (MacKenzie et al., 2006). In the same year, a systematic literature review to evaluate trauma system performance was conducted by Celso et al., and the analysis results showed a 15% reduction in mortality due to the presence of a trauma system (Celso et al., 2006). In 2010, Haas et al. revealed that among 11,398 patients, the mortality of patients transported to a non-trauma center (undertriaged) was significantly higher than that of patients transported to a trauma center directly (Haas et al., 2010). However, the undertriage of major trauma patients remains a challenge for the EMS systems (Sasser et al., 2012). Xiang et al. found that more than one-third of US emergency department trauma patients were undertriaged in 2014 (Xiang et al., 2014). Similarly, Candefjord et al. (2016) found that the majority of trauma patients in traffic crashes were not transported to a trauma center in Sweden (Candefjord et al., 2016).

The main objective of this paper is to quantify the relationship between the distance to trauma centers and the mortality of drivers in fatal crashes. The crash data adopted in this study are from the NHTSA's Fatality Analysis Reporting System (FARS) from 2010 to 2015. Two factors, EMS intervals which are derived directly from the FARS data and the distance to trauma center which is calculated utilizing the Geographic Information System (GIS), are both identified using logistic regression. Further analyses on non-driver patients are also performed to distinguish the effects of trauma center on heterogeneous patients.

2. Data acquisition and methodology

2.1. FARS data

FARS contains data on a census of fatal traffic crashes within the 50 States and the District of Columbia. To be included in FARS, a crash must result in the death of a person (an occupant of a vehicle or a non-occupant) within 30 days of the accident. Crash data for all states between 2010 and 2015 were collected from FARS for this research, and to avoid potential differences in injury types between drivers and other persons, only drivers' data were adopted for the main part of the study. The patients in crashes can be divided into two groups: One group was patients who were not transported to any medical facility due to no or minor injuries or death at scene of the crash; the other group includes patients who were transported to medical facility by EMS ground or air or any other sources. Apparently, the second group has the target patients who require the urgent trauma care. Table 1 lists the statistical results of drivers in fatal crashes for each year. It can be seen that the proportions of each group are stable for each year.

In FARS, the following times are recorded for car accident: crash, EMS notification, EMS arrival at scene of crash, EMS arrival at hospital, and the time of death. Utilizing these time records, two intervals were generated for drivers: time of crash to EMS arrival (Arrival Interval) and EMS arrival at crash scene to medical facility arrival (Transport Interval). However, not all patients have available time records. During 2010–2015, around 7000 drivers have available time records for each year in group 2.

Table 1
Drivers data of FARS between 2010 and 2015.

Year	Group 1: Not transported to medical facility		Group 2: Transported to medical facility		Total number of drivers	Mortality (%)
	No injury	Died at scene	Survived in 30 days	Died in 30 days		
2010	13,030	12,134	10,256	8679	44,099	47.2
2011	13,175	11,858	9605	8624	43,262	47.3
2012	13,965	12,330	10048	8882	45,225	46.9
2013	14,267	12,172	9643	8721	44,803	46.6
2014	14,479	12,317	9466	8409	44,671	46.4
2015	15,953	13,195	10,556	8909	48,613	45.5
SUM	**84,869**	**74,006**	**59,574**	**52,224**	**270,673**	**46.6**