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Does crash risk increase when emergency vehicles are driving with lights and sirens?

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ABSTRACT

Introduction: Emergency vehicles, such as police, ambulances, and fire vehicles, need to arrive at the scene of emergencies as quickly as possible, and thus they often travel in emergency mode – using their lights and sirens and often bypassing traffic signals. We examined whether travelling in emergency mode increased crash risk among police, ambulance and fire vehicles.

Methods: We conducted a quasi-induced exposure analysis using data from the Iowa Crash Database for the period of 2005 through 2013. The data are maintained by the Iowa Department of Transportation (IADOT), Office of Driver Services (ODS) and includes all investigating police officer's reports of motor vehicle crashes. The quasi-induced exposure method is an approach to calculate crash risk in the absence of exposure data using vehicles without a contributing cause (did not contribute to the crash) as a proxy for the baseline driving population.

Results: From 2005 – 2013, police vehicles were involved in 2406 crashes and ambulances and fire vehicles were involved in 528 crashes. Police vehicles were 1.8 times more likely to crash while driving in emergency mode than usual mode; this was a statistically significant increase. Ambulance and fire vehicles were not more likely to crash in emergency mode compared with usual mode. For police, other factors that contributed to crash risk included gender, age, icy/snowy roads, unpaved roads, and intersections. For ambulances and fire vehicles, other factors that contributed to crash risk included gender, age, weekends, icy/snowy roads and urban locations.

Conclusion: Crash risk increased when police vehicles drove with lights and sirens but did not increase for ambulance and fire vehicles. Further research is necessary to develop and evaluate strategies to mitigate crash risk among police vehicles. Cultural approaches which prioritize transportation safety in conjunction with reaching the scene as quickly as possible may be warranted.

1. Introduction

Quick response to the scene of an emergency is a critical component of emergency response systems. To facilitate fast arrival, emergency response vehicles, including police, ambulance, and fire, often travel in emergency mode using their lights and sirens. Driving in emergency mode allows emergency vehicles to bypass standard roadway controls and thus may increase risk for crashing and may pose injury risks for emergency vehicle occupants, occupants of other vehicles, or for vulnerable road users such as bicycles and pedestrians.

According to the National Highway Traffic Safety Administration (NHTSA, 2001–2010), 368,946 emergency vehicles were involved in crashes from 2001 to 2010. Compared to the previous decade, during which 302,969 crashes were reported, this current data represents an increase of over 20% (Ray and Kupas, 2005). Reports from the National Highway Traffic Safety Administration show that 49.3% of fatalities involving emergency vehicles over the last decade in the US occurred when the vehicle was operating in emergency mode (NHTSA FARS and GES Reports, 2002-2012; NHTSA FARS and GES Reports, 2002). The 2012 data show 131 fatalities caused by emergency vehicles, with 46% occurring while driving in emergency mode (NHTSA, 2014). In ambulances, for example, health care providers and patients ride in the back with few or no restraints, and injury is exacerbated by the lack of an energy-absorbent environment. These risks, in particular for patients being transported, are contrary to the core medical principles of "first do no harm" (AMA, 1903).

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Although lights and sirens provide visual and audio stimuli to alert other vehicles of their approach, the high speeds and inability of other vehicles to respond could contribute to increased crash risk. Several studies have examined characteristics of emergency vehicle crashes during emergency mode driving (Pirrallo and Swor, 1994; Becker et al., 2003; Custalow and Gravitz, 2004; Sanddal et al., 2010). These studies found that most crashes and fatalities occurred during emergency use and at intersections and traffic signals. While some studies reported that a collision is more likely to result in injuries during emergency driving (Auerbach et al., 1987; Saunders and Heye, 1994), other studies did not observe such an association (Pirrallo and Swor, 1994; Custalow and Gravitz, 2004).

Although these studies provide characteristics of crashes, they were unable to estimate crash risk because crash risk estimates require data on driving exposure. Direct estimates of driving exposure by emergency vehicles based on emergency operation are not routinely collected, and crash databases do not contain such information. Methods to derive driving exposure using data within crash databases have been developed. The induced exposure method, proposed by Thorpe in 1964, derives indirect estimates of exposure from traffic crash data based on single and multiple vehicle crashes (Thorpe, 1964). Carr proposed a quasi-induced exposure method in 1969, which used drivers whose actions did not contribute to the crash as an exposure metric for the general driving population (Carr, 1969). The quasi-induced exposure technique derives exposure estimates from the distribution of not-at-fault drivers in two-vehicle crashes for which fault can be reasonably attributed to one driver. The rationale is that drivers involved in collisions to which they were not-at-fault represent the "control" driving population. Characteristics of this "control" population are then used to estimate risk ratios comparing the at-fault and non-at-fault driving populations. The quasi-induced exposure method has been used more frequently than the original induced exposure method, and several studies have shown that the quasi induced method yields reasonable estimates of driving risk (Stamatiadis and Deacon, 1997; Lyles et al., 1991; DeYoung et al., 1997; Chandraratna and Stamatiadis, 2009; Lardelli-Claret et al., 2006; Jiang and Lyles, 2010). We used the quasi-induced exposure method to estimate relative risks for emergency vehicle crashes driving in emergency mode compared with non-emergency mode, including police, ambulance and fire vehicles.

2. Methods

2.1. Data source

We conducted a quasi-induced exposure analysis using data from the Iowa Crash Database for the period of 2005 through 2013. The data were maintained by the Iowa Department of Transportation (IADOT), Office of Driver Services (ODS) and included all investigating police officer's reports of motor vehicle crashes. Although under-reporting of crashes has been well established, reporting of crashes involving emergency vehicles are likely to have more complete reporting. The database was comprised of three levels of data: crash, including location; roadway and environmental characteristics; vehicle/driver; and, person, including injury information. These levels were hierarchically linked. The analytic sample included all crashes that indicated involvement of an emergency vehicle, coded as police, fire, and ambulance. Due to smaller numbers of fire and ambulance crashes and similar distributions of key variables, analyses combined fire and ambulance into one category.

2.2. Study variables

The main exposure was whether or not the emergency vehicle was driving in emergency mode, identified through a vehicle-level variable in the crash database that indicates with a "yes" or "no" response if the vehicle was travelling in emergency mode. The main outcome was the relative risk of a crash, estimated using the quasi-induced exposure method based on vehicle-level contributing causes.

The crash database used in this study contains information that indicates each driver's actions that contributed to the crash occurrence. Using that information, we defined an at-fault driver as a driver whose actions led, at least in part, to the crash (eg. speeding, running traffic signal, failure to yield) a not-at-fault driver as a driver that had no contributing factor. The contributing causes variable is defined to identify any actions the driver/vehicle took that contributed to the cause of the crash. This variable is not the same as an "at fault" determination because multiple parties in the crash can have contributing causes. Contributing causes included factors such as failure to follow traffic signals, failure to yield the right-of-way, speeding, improver vehicle handling, inattention/distraction, and careless/reckless driving. Based on the quasi-exposure method, we identified two key risk groups based on mode of travel (emergency or usual) and whether or not the emergency vehicle had an identified contributing cause (indicating that the emergency vehicle in some way contributed to the crash).

Information abstracted from the database included vehicle, driver, and environmental characteristics. The characteristics of emergency vehicles involved in crashes were categorized by type of vehicle (ambulance or fire vs police vehicle) and response mode (emergency versus non-emergency). Driver characteristics included age recorded as a continuous variable and gender. We grouped drivers into 3 categories: < 30 years, 30 – 50 years, and > 50 years. Environmental factors included day (weekend vs. weekday), light (daylight, dark, twilight), rural vs. urban, road type (interstate, highway, primary road, and construction zone), road surface (dry, wet, icy vs. other), surface (paved vs not paved), and intersection (yes vs. no).

2.3. Statistical analysis

Crash risk in the quasi-induced exposure methodology is determined by computing the ratio of the proportion of at-fault drivers in a specific subgroup to the proportion of not-at-fault drivers from the same subgroup (Stamatiadis and Deacon, 1997; Chandraratna and Stamatiadis, 2009; Jiang and Lyles, 2010). The underlying assumption is that the distribution of not-at fault drivers is representative of the travel exposure of all drivers in that group. Thus, in this study, we use crashes in which the emergency vehicle was not-at-fault to represent general driving characteristics and behavior of emergency vehicles. The risk of collision was estimated by comparing the distribution of the exposure variable and covariates.

We first examined characteristics of the crashes based on whether or not the emergency vehicle was at-fault on of categorical variables with a contributing factor (Yes/No) was studied using Pearson $\chi 2$ tests of significance. Logistic regression was used to calculate unadjusted and adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs), which were used to identify factors associated with crashes for which there was a driver contributing factor. Models were run separately for police vehicles and for ambulances and fire vehicles. Covariates examined in the multivariate logistic regression models were emergency mode, driver age (< 30, 30 – 50, > 50), driver gender, day (weekday, weekend), light conditions (daylight, darkness), rural/urban, road system (interstate, route, road, construction), road surface (dry, wet, Ice/snow, other), paved/unpaved, intersection (yes/no). All analyses were performed in SAS.

3. Results

Table 1 shows the distribution of the emergency vehicle crashes by whether or not the emergency vehicle operator was at-fault. During the 9-year study period, police vehicles were involved in 2406 crashes. Of these crash reports, 53.0% identified the police vehicle driver as at-fault. Ambulances and fire vehicles were involved in 528 crashes, of which 56% identified the emergency vehicle as at-fault. The most