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Factors associated with civilian drivers involved in crashes with emergency vehicles

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ABSTRACT

Motor vehicle crashes involving civilian and emergency vehicles (EVs) have been a known problem that contributes to fatal and nonfatal injuries; however, characteristics associated with civilian drivers have not been examined adequately. This study used data from The National Highway Traffic Safety Administration's Fatality Analysis Reporting System and the National Automotive Sampling System General Estimates System to identify driver, roadway, environmental, and crash factors, and consequences for civilian drivers involved in fatal and nonfatal crashes with in-use and in-transport EVs. In general, drivers involved in emergency–civilian crashes (ECCs) were more often driving: straight through intersections (vs. same direction) of four-points or more (vs. not at intersection); where traffic signals were present (vs. no traffic control device); and at night (vs. midday). For nonfatal ECCs, drivers were more often driving: distracted (vs. not distracted); with vision obstructed by external objects (vs. no obstruction); on dark but lighted roads (vs. daylight); and in opposite directions (vs. same directions) of the EVs. Consequences included increased risk of injury (vs. no injury) and receiving traffic violations (vs. no violation). Fatal ECCs were associated with driving on urban roads (vs. rural), although these types of crashes were less likely to occur on dark roads (vs. daylight). The findings of this study suggest drivers may have difficulties in visually detecting EVs in different environments.

1. Introduction

Motor vehicle crashes between civilian and emergency vehicles (EVs), such as police, fire trucks, and ambulances, are a known concern due to high risk of fatal and nonfatal roadway injuries (Custalow and Gravitz, 2004). The National Highway Traffic Safety Administration (NHTSA, 2001–2010) reported that 368,946 EVs were involved in crashes from 2001 to 2010. This number represents an increase of over 20%, compared to the previous decade, during which 302,969 crashes were reported (Ray and Kupas, 2005). According to the National Emergency Medical Services Advisory Council (2009), identifying the rate of EV crashes is difficult because of the inadequacies of data collections systems to acquire common denominator data, such as vehicle miles traveled.

Research pertaining to emergency–civilian crashes (ECCs, crashes involving civilian and EVs) have predominantly focused on factors associated with EV drivers (Kahn et al., 2001), the environment (Kahn et al., 2001; Ray and Kupas, 2007), and health-related outcomes (Becker et al., 2003), in part, due to the high transportation fatality rate among emergency medical service personnel (Maguire et al., 2002; Slattery and Silver, 2009). Ambulance drivers have received particular attention (Studnek and Fernandez, 2008; Weiss et al., 2001) since they are at a higher risk for crashes compared to law enforcement officers and fire fighters (Sanddal et al., 2008). Other crash characteristics, such as the use of lights and sirens, have received dual consideration, examining their impact on emergency response time (Ho and Lindquist, 2001; Petzäll et al., 2011) as well as a connection with crash frequency (Custalow and Gravitz, 2004; Pirrallo and Swor, 1994).

It is important to note that an ECC combines various factors, including those that relate to the civilian driver (Custalow and Gravitz, 2004); however, such factors for civilian drivers have not been examined adequately. Identifying these factors is essential since occupants of non-EVs are more likely to be fatally wounded as a consequence of these crashes (Sanddal et al., 2010).

In light of the paucity of research examining ECCs, the purpose of this study was to identify driver, roadway, environmental, and crash factors, and consequences for civilian drivers involved in fatal and nonfatal motor vehicle crashes with in-use and in-transport EVs.

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2. Methods

2.1. Study design

To identify the characteristics of civilian crashes involving EVs, we compared ECCs to non-ECCs (civilian crashes not involving EVs) for both fatal and nonfatal crashes. This analysis is similar to proportionate morbidity or mortality analyses in which the characteristics of ill or deceased people are compared. While this study design cannot identify causal factors, because of being unable to characterize all motor vehicles at risk of being involved in a crash with an EV, it is useful for generating hypotheses about causal factors that contribute to these types of crashes.

Publicly available data from the NHTSA's Fatality Analysis Reporting System (FARS) and National Automotive Sampling System General Estimates System (NASS-GES), from 2002 through 2010, were used. The FARS data are a census of all fatal motor vehicle crashes that occurred within the United States and Puerto Rico. For a crash to be eligible within the FARS dataset, the death of a motorist or a non-motorist must have occurred within 30 days from the time of the crash. The NASS-GES data are a nationally-representative probability sample of all police-reported motor vehicle crashes. General eligibility requirements for the FARS and NASS-GES datasets can be found in the Analytical Users' Manuals (US Department of Transportation, 2010, 2011). Both datasets contain information regarding the special use of vehicles (e.g., taxi, police, military) and whether the vehicles were listed as in-use for emergencies. In-use and in-transport EVs were defined as EVs on emergency calls and in motion at the time of the crash. All fatal observations within the NASS-GES dataset were removed to form a nonfatal-only dataset.

The ECC and non-ECC type datasets contained observations only for in-transport civilian drivers who were involved in fatal or nonfatal crashes with another in-transport motor vehicle, that is, an EV or non-EV. Crashes involving EVs exclusively, and single vehicle crashes, were removed from the datasets. One nonfatal crash observation was removed due to the vehicle being listed as in-use for an emergency but listed as a non-EV.

2.2. Statistical analysis

Descriptive statistics were used to report frequencies of driver, roadway, environmental, and crash factors, and consequences between the two crash types. Multivariate logistic regression models for fatal and nonfatal crashes were used to identify potential factors associated with ECCs compared to non-ECCs (expressed as estimated odds ratios [OR] and 95% confidence intervals [CI]) while holding a priori selected covariates constant based on directed acyclic graphs (Hernán et al., 2002). The directed acyclic graphs enable identification of parsimonious models and exclude covariates that should not be entered into the regression lest they introduce bias. The resulting models estimate the odds that an individual in a crash will be more, or less likely to have a specific characteristic (e.g. age or distraction) if they are involved in an ECC rather than a non-ECC. The analyses for this study were generated using SAS® software, Version 9.2 (SAS Institute Inc, 2010).

3. Results

3.1. Vehicle crash characteristics

Examination of the two datasets revealed that ECCs represented a small proportion of all of fatal and nonfatal civilian crashes, 0.20% and 0.17%, respectively (Table 1). Sex and age distributions of ECCs and non-ECCs were similar within fatal and nonfatal crashes (Table 1). Among nonfatal crashes, higher proportions of ECCs, compared with non-ECCs involved: distracted drivers; obscured vision; traffic controlling devices; and crashes at angles. The two most reported sources of distractions for drivers were "inattentive or lost in thought" and "looked but did not see", which accounted for 37% and 17%, respectively (results not shown in table). Nonfatal ECCs also occurred at intersections, at night on dark but lighted roads, and resulted in some level of bodily injury, vehicle damage, and drivers receiving traffic violations.

Among fatal crashes, ECCs compared to non-ECCs, more frequently: indicated no source of distraction; occurred on urban roads, at intersections and at night on dark but lighted roads; involved traffic controlling devices and crashes at angles. Civilian drivers were more likely to be fatally wounded when involved in a fatal crash with an EV compared to a fatal crash with a non-EV.

3.2. Multivariate analyses

Table 2 presents results of multivariate modeling of driver, roadway, environmental, and crash factors, and consequences for civilian drivers involved in fatal and nonfatal crashes with in-use and in-transport EVs. Factors of interest were adjusted for potential confounders (see footnote in Table 2) based on directed acyclic graphs.

3.2.1. Nonfatal crashes

Driver factor analyses indicated differences between crash types for age and distraction (Table 2). Teenaged drivers in crashes were less likely to be involved in ECCs (OR = 0.7), compared to young drivers aged 20–29. Overall, drivers were more likely to be distracted (OR = 1.9). Gender was not shown to be a differentiating factor.

Analyses of roadway factors showed that physical objects obstructing drivers' vision, location within a road, and presence of traffic control devices were associated with crash types (Table 2). Emergency–civilian crashes were more likely to have driver's vision obstructed by objects on the road: buildings, billboards, and other structures (OR = 36.4); parked vehicles (OR = 3.4); trees, crops and vegetation (OR = 4.5); and other in-transport motor vehicles (OR = 2.2). Emergency–civilian crashes occurred more frequently at intersections, specifically intersections that contained four-points or more (OR = 2.1), compared to not being located at intersections. The presence of automatic traffic lights (OR = 2.4) and traffic controlling persons (OR = 6.7), compared to no controlling devices were associated with ECCs. However, the association between automatic traffic lights and ECCs may be confounded by the location within the roadway, i.e., intersection or non-intersection, given the limited data available for this variable.

Environmental factors identified for ECCs included time of day and lighting characteristics at the time of the crash (Table 2). Driving at night (9 pm to 5 am), compared to driving during midday (11 am to 4 pm), was three times more likely in ECCs (OR = 2.8). Similarly, ECCs were more likely to occur when driving on dark but lighted roads (OR = 1.6), compared to driving in daylight.

Emergency-civilian crashes were associated with: angles (OR = 4.3); head-on collisions (OR = 1.9); or sideswipes in opposite (OR = 3.0) and same (OR = 2.5) directions, compared to rear-end collisions (Table 2). Similarly, ECCs were more likely to occur when civilian and EV drivers were heading in opposite directions (OR = 4.8) and when they were crossing straight through intersections (OR = 3.1), compared to crashes in the same direction.

Consequences for drivers included increased risks for bodily injury, receiving traffic violations, and incurring disabling damage to their vehicles, as a result of ECCs versus non-ECCs (Table 2). Risks were increased for all injury outcomes (excluding fatal) when crashes involved an EV. Similarly, civilian vehicles were more likely