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Characteristics of rear-end accidents at signalized intersections using multiple logistic regression model

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Abstract

Multi-vehicle rear-end accidents constitute a substantial portion of the accidents occurring at signalized intersections. To examine the accident characteristics, this study utilized the 2001 Florida traffic accident data to investigate the accident propensity for different vehicle roles (striking or struck) that are involved in the accidents and identify the significant risk factors related to the traffic environment, the driver characteristics, and the vehicle types. The Quasi-induced exposure concept and the multiple logistic regression technique are used to perform this analysis. The results showed that seven road environment factors (number of lanes, divided/undivided highway, accident time, road surface condition, highway character, urban/rural, and speed limit), five factors related to striking role (vehicle type, driver age, alcohol/drug use, driver residence, and gender), and four factors related to struck role (vehicle type, driver age, driver residence, and gender) are significantly associated with the risk of rear-end accidents. Furthermore, the logistic regression technique confirmed several significant interaction effects between those risk factors.

Keywords: Rear-end accidents; Signalized intersections; Quasi-induced exposure; Multiple logistic regression; Striking role; Struck role

1. Introduction

Rear-end accidents are one of the frequently occurring types of accidents, accounting for almost one-third of all reported accidents in the US (1.848 million) and 11.8% of multi-vehicle fatal accidents (1923) (National Transportation Safety Board, 2001). Rear-end accidents are the most common accident type at signalized intersections since the diversity of actions taken increases due to signal change. Specific causes of rear-end accidents include the following drivers' inattentive driving and following too closely. A proper space cushion is needed to provide a driver enough reaction time to recognize a hazardous situation and make a stop decision. Typically, driver, vehicle, and roadway/environment characteristics influence accident occurrence and injury severity. Moreover, since a rear-end accident is related to both driving behaviors and performances of the leading (struck) vehicle and the following (striking) vehicle, the accident risk is possibly associated with struck or striking role that a driver or vehicle would assume in a rear-end accident.

The driver age and gender were considered as main driver characteristics that might be associated with a rear-end accident. There is general consensus among researchers that older drivers tend to process information and take a corresponding action more slowly than younger driver. Slower reaction times for older versus younger drivers contribute to a disproportionately heightened degree of risk especially when older drivers are faced with two or more choices of action (Staplin et al., 2001). However, the younger drivers, especially under 25 years, are more likely to be involved in aggressive attitude and inattentive driving. A previous study on rear-end acci-

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dents indicated that drivers younger than 18 years were most vulnerable to roadway accidents followed by 18–24-year-old drivers; the propensity of drivers involved in accidents showed a decreasing trend with increasing age until the age of 69, after which the drivers again showed a higher accident involvement propensity as compared to the drivers who were 25–69 year old (Santokh, 2003). Additionally, among 18–24-year-old drivers, male drivers were found to be more prone to accident involvement as compared to their female counterparts. It was also found that in rear-end accidents, drivers up to the age of 25 years are more likely to be in the striking role than in the struck role. As drivers get older, they tend to be in the striking role less often than in the struck role.

For different type of vehicles, steering and braking performance are critical in the avoidance of accidents. Strandberg (1998) pointed out that except for the hazards due to unpredicted change in properties within one vehicle, differences between vehicles in braking performance are responsible for many rear-end accidents. Moreover, the size of the leading vehicle may influence the behavior of the following driver. Sayer et al. (2000) examined the effect that the leading vehicle size (specifically, height and width) has on a passenger car driver's gap maintenance under near optimal driving conditions (e.g. daytime, dry weather, free-flowing traffic). Results showed that passenger car drivers followed light trucks at shorter distances than they followed passenger cars, but at the same velocities. Specifically, it appears that when dimensions of lead vehicles permit following drivers to see through, over, or around them, drivers maintain significantly longer (i.e. safer) distances. Abdel-Aty and Abdelwahab (2004) examined the relationship between vehicle type (car or LTV including light truck, van, and SUV) and the role (striking or struck) played by each vehicle in the accident. Using a nested logit structure model, they analyzed the probabilities of the four rear-end accident configurations (car–car, car–LTV, LTV–car, and LTV–LTV) as a function of driver's age, gender, vehicle type, vehicle maneuver, light conditions, driver's visibility and speed. Results showed that driver's visibility and inattention in the following (striker) vehicle have the largest effect on being involved in a rear-end collision of configuration Car–truck (a regular passenger car striking an LTV).

The critical road environment conditions could play a significant role in rear-end accidents and they may contain all kinds of non-driver related factors such as lighting conditions, the roadway surface conditions, highway characteristics, traffic volume, the weather conditions, and so on. Braking performance of vehicle is substantially reduced in icy and snowy road surface condition and deceleration capacity may decrease by more than 90% compared to dry condition (Strandberg, 1998). The heavy traffic volume results in the smaller headway between gaps between leading and following vehicles, which definitely increases the possibility of rear-end accidents. Khattak (2001) reported that a majority of the accidents (54.9%) occurred during the peak times 7:00–9:00 a.m. and 3:00–6:00 p.m. A small portion (10.8%) of the accidents occurred at night on unlit streets and a smaller portion (4.9%) occurred at night on lighted streets.

However, of those previous research findings, relatively few studies used the accident database and related statistical model to explore the propensity of rear-end accidents that occurred at signalized intersections. This paper presents the results of a thorough investigation into the relationship between the rear-end accidents and a series of potential risk factors classified by driver characteristics, road environments, and vehicle type. The quasi-induced exposure concept is used to compare the relative accident involvements between different risk conditions based on the 2001 Florida accident database. For striking role and struck role in the rear-end accidents respectively, multiple logistic regression models are used for hypothesis testing to identify the significant factors that contribute to the rear-end accidents.

2. Methodology

2.1. Accident database and rear-end accident identification

The 2001 accident database, obtained from the Florida Department of Highway Safety and Motor Vehicles (DHSMV), was used in this study. The DHSMV data constitute a relational database that includes seven files. Each file deals with a specific feature of a traffic accident. Files may be linked as needed to combine the information contained in each other. Three files used in the analysis presented here were the event (containing the characteristics and environment of the accident), drivers (containing the drivers' characteristics), and vehicles (information about the vehicles' characteristics and vehicles actions in the traffic accident) files.

In Florida, when an accident occurs and the local police department is notified, the responding officer will determine whether to fill out a long- or short-form accident report. If an accident involves an injury or a felony (e.g. hit and run), the accident must be filed on a long-form. If an accident involved only property damage (a minor accident), usually it is up to the officer to report it on a long or a short-form. Accident forms are then forwarded to the respective counties, which choose whether or not to file accidents reported on short-forms. From here, only the accidents reported on long-forms are forwarded onto the DHSMV, which maintain records based on only accidents reported on long-forms. Since most accidents that occur involve only property damage and not a serious injury or a felony, it can be argued that the FDOT and DHSMV accident databases under-represent the property-damage-only accidents. Abdel-Aty et al. (2005) investigated the significant differences in the important accident-related factors between models based solely on accidents reported on long-forms and models based on accidents reported on both long- and short-forms (i.e. models based on restricted and complete datasets). They found that for rear-end, right-turn