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Original Research Paper

# Investigating temporal trends in the explanatory variables related to the severity of drivers' injuries in single-vehicle collisions

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## HIGHLIGHTS

- Dark conditions significantly increase the severity of drivers' injuries.
- Vehicle's age significantly increases the severity of drivers' injuries.
- Unfavorable environmental conditions reduce the severity of drivers' injuries.
- Temporal instability found in driver's age as a factor to increase injury severity.
- Temporal instability found in vehicle type as a factor to increase injury severity.

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## ABSTRACT

This study identifies and quantifies the effects of different explanatory variables that increase the severity of drivers' injuries related to single-vehicle collisions involving light-duty vehicles. The research is based on utilizing logistic regression to analyze records of all traffic collisions that occurred in North Carolina for the years from 2007 to 2013. The study also investigates temporal stability of the identified explanatory variables throughout the analysis period. The identified explanatory variables include those related to the roadway, vehicle, driver, and environmental conditions. The explanatory variables related to the roadway include whether the roadway is divided or undivided, and whether it is in an urban or rural area. The explanatory variables related to the vehicle include vehicle's age, travel speed, and the type of the light-duty vehicle. The explanatory variables related to the driver include driver's age, gender, influence by alcohol or illicit drugs, and the use of seatbelt. The explanatory variables related to the environmental conditions include weather, lighting, and road surface conditions. Three of the investigated explanatory variables were found to be temporally unstable with significantly varying effects on the severity of drivers' injuries. Those temporally unstable variables include the travel speed, the type of the light-duty vehicle, and the age of the driver. All other investigated variables were found to be consistently significant throughout the analysis period. The findings of this research have the potential to help decision makers develop policies and countermeasures that reduce the severity of drivers' injuries by focusing on explanatory variables that consistently exhibit significant effects on the severity of drivers' injuries. The findings of this research also provide quantitative measures that may be used to determine the

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feasibility of implementing those countermeasures in reducing the severity of drivers' injuries related to single-vehicle collisions. Recommendations for future research are also provided.



## 1. Introduction

Single-vehicle collisions result in a significant number of fatalities and severe injuries each year, and therefore they are a major concern related to traffic safety. According to statistical data obtained from the National Highway Traffic Safety Administration (2016a), more than 46% of fatal traffic collisions in the United States are related to single vehicles.

Several research studies investigated different explanatory variables that may increase injury severity resulting from a single-vehicle collision given that such a collision has already occurred. Behnood and Mannering (2015) used mixed-logit modeling to explore the temporal stability of factors affecting the severity of drivers' injuries in single-vehicle crashes by using data from Chicago, Illinois for the years from 2004 to 2012. Several explanatory variables were tested, including variables related to drivers, roadways, vehicles, and environmental conditions. It was found that the effects of most explanatory variables were generally temporally unstable, which may be due to different factors related to temporal changes in vehicle-safety features, drivers response to those improved safety features, and drivers response to changes in microeconomic conditions, among other factors.

Islam et al. (2014) used random-parameter logit models to analyze the severity of injuries resulting from large truck at-fault collisions in Alabama for the years from 2010 to 2012. Four separate models were provided to model the severity of injuries resulted from single-vehicle and multi-vehicle collisions in rural and urban locations. Several characteristics were found to increase the severity of injuries resulted from those types of collisions. The characteristics identified include those related to driver, vehicle, roadway, land use, and time of the day.

Martensen and Dupont (2013) used logistic regression to identify explanatory variables that differentiate between single-vehicle and multi-vehicle crashes based on data from six European countries (France, Finland, Germany, Italy, Netherlands, and the United Kingdom), and they found that multi-vehicle crashes usually occurred on busy roads and junctions, while single-vehicle crashes usually occurred on empty road-sections between junctions. They also found that roads with physically divided opposite traffic lanes usually had higher proportion of single-vehicle crashes than on other road types. Furthermore, they also found that heavy vehicles and motorcycles were less likely to be involved in single-vehicle crashes than passenger cars.

Other research studies related to single-vehicle crashes include a study by Chang and Yeh (2006) who identified and quantified different explanatory variables that increased the odds of fatalities in single-vehicle crashes related to motorcycles and other light-duty vehicles by using logistic regression to analyze all fatal crashes that occurred in Taiwan in year 2000. Islam and Mannering (2006) investigated the effect of driver ageing on the injury severity resulting from single-vehicle collisions related to passenger cars based on police report data from the state of Indiana in the year 1999. Yau (2004) used logistic regression to identify risk factors that increased injury severity related to single-vehicle traffic collisions based on data from Hong Kong for the years 1999 and 2000. Separate models were developed for passenger cars, trucks, and motorcycles. Several factors were found to increase injury severity for passenger cars, including driver's age and gender, vehicle age, time of the collision, lighting conditions, and the geographical location of the collision. Renski et al. (1999) investigated the effect of speed limit increase on the severity of single-vehicle crashes on North Carolina interstate highways by comparing the severity of crashes one year before increasing the speed limit with the severity of crashes one year after increasing the speed limit. Ostrom and Eriksson (1993) investigated the effect of alcohol consumption on the severity of single-vehicle crashes in northern Sweden by comparing data related to multi-vehicle crashes with data related to single-vehicle crashes for the years 1980–1989.

Logistic regression was also used in several other recent studies related to road safety analysis. Ye et al. (2015) used logistic regression to investigate different factors affecting lower-limb injuries in traffic collisions. Wang et al. (2016) used logistic regression to investigate factors that increased injury severity of trespassers at railway crossings in the United States for the years from 2004 to 2013. Feng et al. (2016) used logistic regression to investigate risk factors associated with fatal bus accidents and their impact on different types of bus drivers in the United States.

The purpose of this study is twofold. The first purpose is to identify and quantify different explanatory variables that affect the severity of drivers' injuries resulting from single-vehicle collisions related to light-duty vehicles. The research is based on analyzing records of all traffic collisions that occurred in North Carolina for the years from 2007 to 2013. The second purpose of this research is to evaluate whether the effects of those identified explanatory variables are temporally stable throughout the analysis period that extends for seven years from 2007 to 2013. The findings of this analysis have the potential to assist decision makers identifying the more significant factors that increase the severity of drivers' injuries so that different resources may be allocated to reduce