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Roadway classifications and the accident injury severities of heavy-vehicle drivers

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A B S T R A C T

Previous heavy-vehicle (a truck with a gross vehicle weight rating greater than 10,000 pounds) injury severity studies have disaggregated data by factors such as urban/rural and time-of-day, yet a focus on contributing factors by roadway classification is lacking. Taking this into consideration, the current study aims to extend traditional heavy-vehicle driver injury severity analyses, through the application of a mixed logit modeling framework, by determining statistically significant injury severity contributing factors by roadway classification. In the course of identifying statistically significant injury severity factors, a parameter transferability test is conducted to determine if roadway classifications need to be considered separately for safety analyses. Empirical results show that roadway classifications need be modeled separately with a high level of confidence, as the estimated parameters are statistically different by classification based on corresponding chi-square statistics and degrees of freedom. The majority of significant contributing factors are exclusive to a specific road classification, however, two factors were found to impact injury severity regardless of classification while some factors were significant for two classifications. Findings from this study can prompt future work to focus on injury severity, as well as other safety measures, by roadway classification and/or other subpopulations within crash datasets.

1. Introduction

The economic impact of heavy-vehicle crashes, where a heavy-vehicle is a truck with a gross vehicle weight rating of greater than 10,000 pounds, is widely known. For instance, in 2011, heavy-vehicle crashes resulted in a total of $87 billion nationwide (Federal Motor Carrier Safety Administration, 2013). Furthermore, no injury crashes, crashes involving injuries, and fatal crashes amounted to $16 billion, $32 billion, and $39 billion, respectively (Federal Motor Carrier Safety Administration, 2013). In addition, the cost of crashes due to delay and other associated consequences totaled $28 billion (Blincoe et al., 2015). Therefore, any decrease in heavy-vehicle crashes can lead to a substantial reduction in societal costs.

More specifically, at the State level, Idaho experienced a 5.6% increase in heavy-vehicle crashes from 2010 to 2013 (Idaho Office of Highway Safety, 2014). In 2014, 65.2% of all heavy-vehicle crashes in Idaho resulted in no injury, 33.4% involved an injury, and 1.4% were fatal (Idaho Office of Highway Safety, 2014). That being said, heavy-vehicle crashes happened most often on local roads (e.g., major collectors) accounting for 50% of all heavy-vehicle crashes (Idaho Office of Highway

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Safety, 2014), while 50% of no injury crashes also took place on local roads (e.g., major collectors). In addition, 68% of all fatalities occurred on U.S. and State highways (e.g., principal arterials) and 28% of injury crashes happened on interstates (Idaho Office of Highway Safety, 2014). As seen from these statistics, there is a clear need to better understand the effect of roadway classification and the associated contributing factors (observed and unobserved) on heavy-vehicle driver injury severity.

When fitting injury severity models, roadway classification is typically modeled as an indicator variable (e.g., a factor that may influence an injury severity outcome), yet studies that extend such an analysis to focus on injury severities by roadway classification are scarce. As such, disaggregating heavy-vehicle crashes by roadway classification can provide additional insights to assist transportation engineers, planners, and agencies in mitigating these types of crashes and their coinciding costs. On account of such, the present study will use seven years of Idaho crash data to investigate heavy-vehicle crashes by roadway classification through a heavy-vehicle driver injury severity analysis on four types of roadway classifications, namely, principal arterials, major collectors, interstates, and other principal arterials.

To the best of the authors' knowledge, this is the first attempt at analyzing heavy-vehicle driver injury severity by roadway classification. Suitably, this study aims to fill the gap in literature regarding heavy-vehicle driver injury severity analysis by roadway classification. In addition to identifying contributing factors, the current study extends the literature by providing results from a parameter transferability test that determines if road classifications need to analyzed separately (see Section 5).

2. Related work

The mixed logit model is a common approach to injury severity analyses and has been used in recent efforts to investigate injury severity (Anastasopoulos and Mannering, 2011; Kim et al., 2010, 2013; Milton et al., 2008; Moore et al., 2011; Yasmin and Eluru, 2013). Still, injury severity analysis regarding drivers of heavy-vehicles (a truck with a gross vehicle weight rating greater than 10,000 pounds) is less documented. Islam and Hernandez (2013a) used the mixed logit approach to identify injury severity contributing factors for any crash involving a heavy-vehicle in Texas without disaggregating the crash data into subpopulations (e.g., roadway classification, age, urban/rural, etc.). Khorashadi et al. (2005), however, investigated heavy-vehicle injury severity by rural and urban area crashes utilizing a fixed-parameter logit model and found that urban and rural areas need to be modeled separately through a transferability test. More, Pahukula et al. (2015) separated heavy-vehicle crashes by time-of-day to fit several mixed logit models and discovered that parameter estimates are statistically different by time-of-day. Cerwick et al. (2014) expanded the heavy-vehicle injury severity analysis by introducing a latent class logit model and comparing its estimates to that of the mixed logit model. The authors based their evaluation on overall model fit, inferences based on marginal effects, and predicted crash severity outcome probabilities. The authors discovered that the mixed logit model better predicted injury severity outcomes for their crash data.

As seen above, the literature regarding heavy-vehicle injury severity analyses is acutely limited. Subsequently, the current study seeks to expand the literature on heavy-vehicle driver injury severity analysis by identifying contributing factors by roadway classification through the application of a mixed logit modeling framework. Previous works have used age, gender, rural, urban, and alcohol consumption as subpopulations, therefore the present study analyzes heavy-vehicle driver injury severity utilizing roadway classifications as subpopulations.

3. Empirical setting

Data used for analysis consisted of police-reported crash data obtained from Idaho for years 2007 to 2013. Each year was filtered by unit type and seat type to represent only the drivers of heavy-vehicles (a truck with a gross vehicle weight rating greater than 10,000 pounds). The data was then combined to create a dataset that included all seven years and used to determine the four roadway classifications with the largest number of heavy-vehicle crashes. The result was a dataset for each road classification of interest: principal arterials, major collectors, interstates, and other principal arterials. Each observation in the crash data represents the maximum injury severity for the heavy-vehicle driver.

Pertaining to injury severity, Idaho categorizes injury severities into five distinct classifications: no injury, possible injury, incapacitating injury, non-incapacitating injury, and fatal injury. However, to ensure that each injury severity had an adequate percentage of crashes for analysis, injury severities were grouped together to create three distinct severity types: no injury, minor injury (possible injury and non-incapacitating injury), and major injury (incapacitating injury and fatal injury). Table 1 shows the driver injury severity split after grouping severities and the total observations for each road classification[1].

Several variables were found to be significant in contributing to the outcome probabilities of the three injury severities. Variable descriptions and summary statistics for each road classification are shown in Tables 2 to 4.

[1] The injury severity split on other principal arterials did not allow a model to be fit (e.g., greater than 96% of the observations were no injury crashes). It was later determined that other principal arterials was a classification used by the Idaho Department of Transportation in which any uncertain classification was classified as. For this reason, contributing factors to heavy-vehicle driver injury severity could not be identified for this roadway classification.