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Original Research Paper

Factors associated with crash severity on rural roadways in Wyoming

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ABSTRACT

The ability to identify risk factors associated with crashes is critical to determine appropriate countermeasures for improving roadway safety. Many studies have identified risk factors for urban systems and intersections, but few have addressed crashes on rural roadways, and none have analyzed crashes on Indian Reservations. This study analyzes crash severity for rural highway systems in Wyoming. These rural systems include interstates, state highways, rural county local roads, and the roadway system on the Wind River Indian Reservation (WRIR). In alignment with the Wyoming strategic highway safety goal of reducing critical crashes (fatal and serious injury), crash severity was treated as a binary response in which crashes were classified as severe or not severe. Multiple logistic regression models were developed for each of the highway systems. Five effects were prevalent on all systems including animals, driver impairment, motorcycles, mean speed, and safety equipment use. With the exception of animal crashes, all of these effects increased the probability that a crash would be severe. Based upon these results, DOTs can pursue effective policies and targeted design decisions to reduce the severity of crashes on rural highways.

1. Introduction

Strategic Highway Safety Plans are implemented to establish goals and objectives for agencies and communities to reduce crash rates on their roadway systems (FHWA, 2012). In order to develop effective strategies, it is necessary to identify potential risk factors for crashes and mitigate these risks as much as possible. This study analyzes crash severity for rural highway systems in Wyoming.

Wyoming is uniquely characterized by a vast rural roadway network of over 6400 miles ranging from interstates, state and U.S. highways, county roads, and Indian reservation roads. There are approximately 800 miles of interstates and over 4000 miles of state and U.S. highways (WYDOT, 2013). Traffic volumes are relatively low across the state due to the

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sparse population. However, the vehicle miles traveled (VMT) in 2013 were 2.4 billion on the interstates and over 2.6 billion on all state and U.S. highways. Of these, 860 million were truck VMT (TVMT) on the interstates and 300 million TVMT on state and U.S. highways (WYDOT, 2013). The Wind River Indian Reservation has over 1200 miles of roadways in its inventory (NCHRP, 2007). Average daily traffic (ADT) and VMT data are not available for the local county and reservation roads. Rural roadways typically have lower population densities, longer travel distances, higher speeds, and more complex road geometrics (TRIP, 2015).

Each rural highway system has unique characteristics when crash severity is assessed. On rural roads, several factors that contribute to high severity crashes include extreme terrain, higher speeds, larger number of crashes involving alcohol use, and longer response time for emergency services (Atkinson et al., 2014; Ksaibati and Evans, 2009). Indian reservations have many similarities with rural communities concerning their roadway systems (Shinstine and Ksaibati, 2013). There are also behavioral factors that may affect crash severity. For example, alcohol and seat belt use have been identified by the native American community as some of the greatest concerns in improving highway safety (Herbel and Kleiner, 2010; Shinstine et al., 2015).

Crash severity is the level of injury experienced by the victim of the crash and can be categorized in many ways. Typically, the KABCO scale is used which divides crash severity as fatal (K), incapacitating injury (A), non-incapacitating injury (B), possible injury (C), and property damage only (O) (National Safety Council, 1970; Niessner, 2010). This paper utilizes two categories, severe (fatal and incapacitating injuries) or not severe (non-incapacitating injury, possible injury and property damage only). While this is not the common approach, there are two important reasons for using this binary representation of severity in this paper. First, Wyoming is a sparsely populated state with hundreds of miles of very low traffic volume roadways. This is reflected in the crash data which has very low frequencies in some of the categories for the KABCO scale, particularly fatalities. However, low frequencies do not equate to low risks. By combining fatal and serious injury crashes, risk factors for severe crashes can be better identified and modeled. Second, the goal of Wyoming's Strategic Highway Safety Plan (WSHSP) is to reduce critical crashes (Wyoming Highway Safety Management System Committee, 2012). Critical crashes are defined as fatal and incapacitating injury crashes that are represented in the binary response used in this paper. Reducing fatal and serious injury crashes is also the goal of the national strategy of Toward Zero Deaths (Ward et al., 2010). Binary representations of crash severity have also been used by Andreen and Ksaibati (2012) and Bham et al. (2012).

1.1. *Background*

Crash data have been analyzed through various types of statistical models to help researchers determine related factors, and to identify countermeasures to improve roadway safety. Many models have been developed for urban applications and intersections. There is extensive research analyzing crash risks and factors that concentrate on specific predictors. However, there appears to be no studies that attempt to identify significant predictors for crashes on rural highways or on Indian reservations. Savolainen et al. (2011) provided an excellent review of statistical models for crashes. A brief overview of pertinent statistical modeling of crash severity is provided below.

Andreen and Ksaibati (2012) used multiple logistic regression to model crash severity on interstates 80 and 25 in Wyoming based upon several predictor variables. Logistic regression was used on a dichotomized response in which crashes were classified as “severe” and “not severe”. These models were used to identify factors associated with crash severity on interstates in Wyoming. The predictor variables in these models were limited to those obtained from a standard report of the crash data throughout the state, and did not include many variables that were known to be of concern for severe crashes on roadways such as seat belt usage, driver distraction, and roadway geometrics. The study concluded that factors varied between the two interstates, I-80 and I-25. For example, on I-25, motorcycles and sobriety were determined to be important predictors of crash severity. It also recommended that more predictor variables could be included in the model such as roadway geometrics, driver distraction (use of cell phones), seat belt use, and emergency response time.

Logistic regression models have been used for urban applications to identify different factors contributing to crashes. Bham et al. (2012) discussed the use of logistic regression models of collision crashes on urban highways. In their study, crash severity was modeled as severe or not severe. The basis for this choice was that the crash reporting was more accurate for severe crashes than for the other three non-severe categories. Results were compared between divided and undivided urban highways. The analysis showed that alcohol involvement doubled the risk of crash severity for collision crashes on divided highways and was also significant in single vehicle crashes. Roadway geometrics were also significant in predicting crash severity. The study recommended that safety studies include collision type in the analysis as well as driver distraction.

Mooradian et al. (2012) used ordinal logistic regression to model crash severity. The response for this model included five levels for crash severity: fatal, serious injury, minor injury, possible injury, and no injury. Ordinal logistic regression was used in this study to account for the ordering associated with these categories. The analysis showed that significant trends existed for senior drivers leading to higher injury severity levels. The researchers stated that the statistical significance was not fully reliable, but provided information for long term patterns and for further investigation.

Ordered probit models can also be used to model ordered discrete response values. Here the ordinal responses are typically assumed to be unobserved measures of injury severity (Quddus et al., 2002; Weiss, 1992). Pei and Fu (2014) used an ordered probit model to model injury severity with four levels (no injury, slight injury, severe injury, and fatal injury) at unsignalized intersections. Several factors affecting crash severity were identified. These factors consisted of binary predictors indicating one of two categories. Interaction terms were introduced for lighting conditions with other variables.