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Evaluation of motorcycle safety strategies using the severity of injuries

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ABSTRACT

The growth of motorcycle fatalities in California has been especially prominent, specifically with regard to the 24 and under age group and those aged 45–54. This research quantitatively examined factors associated with motorcyclist fatalities and assessed strategies that could improve motorcyclist safety, specifically focusing on the two age groups mentioned above. Severity of injury was estimated separately for both age groups with multinomial logit models and pseudo-elasticity using motorcycle-related collision data that was collected between 2005 and 2009. The results were compared with motorcyclists aged 35–44, a group that shows a consistent trend of fatalities.

This research found that lack or improper use of helmets, victim ejection, alcohol/drug effects, collisions (head-on, broadside, hit-object), and truck involvement were more likely to result in fatal injuries regardless of age group. Weekend and non-peak hour activity was found to have a strong effect in both the younger and older age groups. Two factors, movement of running off the road preceding a collision and multi-vehicle involvement, were found to be statistically significant factors in increasing older motorcyclist fatalities. Use of street lights in the dark was found to decrease the probability of severe injury for older motorcyclists. Driver type of victim, at-fault driver, local road, and speed violation were significant factors in increasing the fatalities of younger motorcyclists. Road conditions and collision location factors were not found to be statistically significant to motorcyclist fatalities.

Based on the statistically significant factors identified in this research, the following safety strategies appear to be effective methods of reducing motorcyclist fatalities: public education of alcohol use, promoting helmet use, enforcing heavy vehicle and speed violations, improving roadway facilities, clearer roadway guidance and street lighting systems, and motorcyclist training.

1. Introduction

United States fatalities involving motorcycle crashes have increased from a long-term perspective since 1997. According to Fatality Analysis Reporting System (FARS) data from 1997 to 2007, the average yearly fatality rate involving motorcycle crashes was 32 per 100 million vehicle miles traveled (VMT); this is considerably higher than fatality rates involving any other type of vehicle (FARS, 2012). California was the leading contributor to U.S. motorcyclist fatalities from 1997 to 2007 (NCAC, 2010). Additionally, since 1995 the yearly number of California (CA) motorist fatalities involving motorcycle crashes has been greater than the national rate (FARS, 2012).

Motorcycle safety improvements have been one of the most important issues in California's Strategic Highway Safety Plan (SHSP) (Kempton et al., 2006). Hence, in 2006, the SHSP established a specific safety goal of reducing the level of fatalities by 10 percent from 2004 to 2010. California intended to reduce motorcyclist fatalities by employing strategies related to the following action items (Kempton et al., 2006): educate the public on motorcycle safety; improve motorcycle training; improve the testing and licensing of motorcyclists; enhance the enforcement of motorcyclist violations and violations by the operators of other vehicles; improve motorcyclist visibility to other roadway users; improve roadway design to enhance motorcycle safety; and promote the use of helmets that meet USDOT standards. For each action item, SHSP also discussed key implementation issues including roadway

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surface changes, enforcement of existing helmet integrity laws, and training for older motorcyclists. Some safety strategies, such as enforcement and engineering, have the potential to make an immediate impact on reducing crashes, while the effects of educating riders to wear helmets may not be visible until years later. Despite the action items, California motorcyclist fatalities have increased by 60 percent from 2004 to the end of 2009 (SWITRS, 1995–2009), suggesting that the goal of reducing motorcyclist fatalities has not been achieved.

During the last 10 years a limited number of studies have attempted to explain the undesirable shift in motorcycle-related crashes and injuries in California. A technical study summarized roadway and rider contributing factors in California motorcycle crashes, but no statistical or quantitative methods were applied to identify the contributing factors (NCAC, 2010). A different study considered only helmet use and risk compensation in motorcycle crashes that occurred in Los Angeles (Ouellet, 2011). Therefore, there is an imperative need to assess the factors affecting the levels of motorcyclist severities in California - especially fatalities.

Based on Statewide Integrated Traffic Records System (SWITRS) data from 1999 to 2004, one of the most conspicuous trends is the number of motorcyclist fatalities and the age groups in which they occurred. The 45- to 54-year-old group had the largest percentage increase in fatalities, while the 35–44 age group had the highest number of fatalities. Since 2005, however, the age group data has shown a different trend. Even though the number of fatally injured motorcyclists aged 25–34 was greatest from 2005 to 2009, the increase in fatalities for this age group was still less than the rates of the other age groups during the same period. Motorcyclists aged 45–54 still had a larger percentage increase in fatalities than any other age group, and riders aged 24-years and younger had the second largest increase in fatalities. The 35–44 year old age group, however, remained relatively consistent with regard to its number of fatalities.

As a preliminary step, this study examined the effects of contributing factors on injury levels of motorcyclist victims aged 24 years old and younger, and those aged 45–54, targeting the fatal injury level. The study also compared the risk factors of these two groups to the risk factors and injury levels of motorcyclist victims aged 35–44.

2. Literature review

The literature review focuses on the effects of motorcyclist age and other related factors on injury severities. The majority of studies focus on younger and/or older age groups. Schneider and Savolainen examined the effects of factors associated with motorcyclist injury severities for single-vehicle and multi-vehicle crashes occurring at both intersection and non-intersection locations in Ohio (Schneider IV and Savolainen, 2011). In their study, age was initially examined as a series of indicator variables. Both younger and older drivers were found to be more prone to severe injuries. That is, motorcyclist age was found to have a significant impact on a 1% increase in age resulting in a 1.1% increase in fatalities involved in single-vehicle crashes. The age effects on incapacitating and fatal injuries were also evident in multi-vehicle crashes.

Geedipally et al. identified differences in factor impacts on injury severities of motorcycle crashes that occurred in urban and rural areas of Texas (Geedipally et al., 2011). The research showed that human and roadway-related factors such as age, alcohol, gender, lighting, and horizontal and vertical curves were significant factors in both urban and rural motorcycle crashes. Riders younger than 25 years of age were less likely to be involved in a fatality in either area, whereas riders older than 55 years of age were more likely to be involved in a rural fatality. The absence of street lights and the presence of higher speed limits in rural areas were identified as contributors to the increased probability of crashes for the older group.

Pai et al. examined three characteristics of automobile–motorcycle gap-acceptance accidents, including approach-turn, angle crossing, and angle merging crashes occurring at T-intersections to investigate the contributory factors to violations of the right-of-way traffic guideline. Based on a 15-year British Stats accident injury database, mixed logit models were estimated and an indicator for a rider aged 60 or above was found to be significant throughout all observations with a fixed effect on increasing the approach turn crashes (Pai et al., 2009). Similarly, Savolainen and Mannering used nested logit models to show how increasing a motorcyclists' age resulted in a much higher likelihood of an incapacitating injury when involved in single-vehicle and multi-vehicle crashes (Savolainen and Mannering, 2007a,b).

Other studies compared a driver's age, characteristics and behavior to motorcycle crashes and motorcyclist injury severities. In these studies young riders were found to be overrepresented in crashes due to lack of experience and higher level of engagement in high-risk activities such as illegal alcohol use, speeding, and not wearing or incorrectly wearing a helmet (Rome and Senserrick, 2011; Haque et al., 2009; Chang and Yeh, 2007; Mullin et al., 2000). On the other hand, contradictory results reported that age did not significantly affect the probability of motorcyclist injury severity. Zambon and Hasselberg used data from riders aged 16–30 to measure correlations between the individual, environment, vehicle and crash factors, and injury severity. Although age was found to increase the likelihood of injury risk, it was not associated with injury severity among young motorcycle drivers (Zambon and Hasselberg, 2007). In an Ohio study by Eustace et al., motorcyclists aged 25 years and older were found to have no statistically significant differences with regard to incapacitating and fatal injuries in multinomial probit model estimations (Eustace et al., 2011).

3. Methodology

Motorcyclist injury severities were recorded in five categories: fatal injury, severe injury, other visible injury, complaint of pain injury, and no injury. This kind of response data are well-suited for discrete multiple outcome models including ordered or unordered probability approaches (Schneider IV and Savolainen, 2011).

Even though motorcyclist injury severities have multiple discrete and ordered outcomes, the conventional ordered probability approach imposes a critical restriction of proportional odds; in other words, it is too arbitrary to assume that all coefficients of the ordered probability model are the same across all injury severities (Milton et al., 2008; Wang and Abdel-Aty, 2008). Moreover, underreporting associated with low-severity injuries can cause the ordered probability models to yield biased and inconsistent coefficient estimates (Savolainen and Mannering, 2007a,b).

Alternatively, a generalized version of the standard ordered logit and sequential logistic models were introduced to relax the restrictions of the proportional odds assumption in previous studies (Eluru et al., 2008; Jung et al., 2010). The generalized ordered response model is recommended only to confirm that the proportional odds assumption is valid, as the model is very anti-conservative (Peterson and Harrell, 1990). Additionally, the sequential logistic model would be less statistically efficient than fully informational methods because data at some stages of the binary response are removed.

Due to the critical limitations of using an ordered probability approach, an unordered probability approach (e.g. multinomial,