

Analyzing Severe Injury Risk for Crashes Nationally and Within Iowa

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ABSTRACT

Two logistic regression models were used in the comparison of Iowa and U.S. crashes. Of particular interest is the risk of severe injury for male and female drivers within three age groups: middle-age (35-54), older (55-74), and elderly (75 and older). Within Iowa, male drivers have a higher risk of severe injury than female drivers (Odds Ratio = 1.15). However, nationally, male drivers have a lower risk of severe injury than female drivers (Odds Ratio = 0.85). Iowa drivers between the ages of 55 and 74 have the highest risk of severe injury, whereas nationally, drivers over the age of 75 have a greater risk. The differences in gender and age effects are discussed. Among the issues considered are the role of seatbelts in reducing injury and factors related to changes in driving patterns among older and elderly drivers.

Key words: injury severity—logistic regression—older drivers

INTRODUCTION

According to a 2002 report on older and elderly drivers in Iowa (Thompson, Pawlovich, and Triggs 2002), senior citizens account for nearly 20 percent of Iowa traffic deaths. Intersection accidents are reported to be of particular concern, especially for drivers over the age of 75. These results are consistent with studies of drivers nationally. In the year 2000, the National Highway Traffic Safety Administration (NHTSA) reported that older individuals accounted for 6 percent of traffic crash injuries and 13 percent of traffic fatalities (2001). This increased risk of injury exists despite greater seatbelt usage rates and the lower levels of intoxication (Hakamies-Blomqvist 1993). Evans (1991) showed that drivers over the age of 70 were at much greater risk for fatality than drivers at the age of 20 in a similar crash. The risk of severe injuries and fatality increases with age for both side impact crashes (Austin and Faigin 2003), and frontal impacts (Mercier, Shelley, Rimkus, and Mercier 1997).

Gender has also been shown to be a significant factor in the prediction of injury severity. In a study of Iowa crashes, Khattak et al. (2002) showed that older male drivers experience more severe injuries than older female drivers. However, in a study of national crashes, Dischinger (1996) showed that women of all ages were more susceptible to crash related injuries. Baker et al. (2003) also showed that older women have an increased risk of fatality in a crash, particularly in favorable driving conditions. This discrepancy in gender effect points to possible differences in risk factors between drivers in Iowa and the US as a whole.

In order to effectively assess the roles of gender and age on crash injury risk, it is necessary to adjust for any other factors that may differentiate Iowa from other regions of the country. Among these are age and population density. According to the 2000 US Census, Iowa ranks second in the nation in the proportion of people 85 years of age and older and fourth in the nation in proportion of adults older than 65 years of age (Iowa 2001). In terms of population density, Iowa is also a very rural state. Nationally, only 21 percent of US residents live in rural areas, but in the state of Iowa, rural residents account for almost 39 percent of the state's population (US 2000).

The goal of this study was to investigate the incidence of severe injury for crashes in the state of Iowa. Separate regression models were developed based on data from the Iowa state crash database and a national crash database. These databases include information on the severity of injury, as well as biographical information of drivers, vehicle information, and information regarding the nature of the crash. The focus of this study is to evaluate the overall severity of injury and the biographical, vehicular, and environmental factors that may have contributed to the level of severity.

METHODS

Data Sources

The primary data source for this study was the Iowa State Crash Database from the year 2000. This is a comprehensive collection of all vehicle crashes in the state of Iowa in which a minimum level of property damage was sustained regardless of injury. The Iowa crash database contained information on 115,812 injured and uninjured occupants involved in crashes in Iowa in the year 2000. The General Estimates System (GES) was used for purposes of comparing Iowa and national crash injury risks. This dataset is a stratified sample of crashes from 27 sampling units across the United States, containing injury data for over 114,000 cases. After weighting, 12,647,821 occupants involved in motor vehicle crashes in the United States during the year 2000 were represented. Only drivers were included in this analysis since the

Iowa crash database did not report demographic information such as age and gender for uninjured passengers. This information was available for drivers involved in injury-free crashes.

Model Description

The goal of this study is to predict injury severity. The injury codes for both databases are based on a five-point scale: no injury, possible injury, non-incapacitating injury, incapacitating injury, and fatality. The data was segmented into two major categories of severity. Incapacitating injuries and fatalities were considered severe injuries, while the other three categories were considered not severe.

Logistic regression models were used because of the categorical nature of the dependent variable severe injury (yes or no). The predictive models are chosen based on factors shown to be important in literature and other research on occupant injuries. The following dependent variables were included in the models: gender, age, location (rural or urban), type of collision (head on, rear end, or side impact), presence of adverse weather conditions, and vehicle type (car or light truck/van/sport utility vehicle). These variables were considered likely to be significant based on previous studies (Baker et al. 2003; Lefler and Gabler 2004; McGwin and Brown 1999) and are largely independent. Additionally, each of these variables could be either directly obtained from or derived from both databases.

Each of the listed variables is binary (present or not present as a condition of the crash) except age, which was segmented into 3 categorical variables (35-54, 55-74, and 75 and older), which are consistent with other similar studies (Cooper 1990; McGwin and Brown 1999). First-order interactions between gender, age, and various crash conditions were also considered in the model. The final model contains only those variables found to be statistically significant in predicting injury severity.

The logistic model is set up as follows:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta\mathbf{X} + \varepsilon \quad (1)$$

where p is the probability that a serious injury will occur in a crash (yes or no), β_0 is the intercept, β is the matrix of coefficient estimates for each respective predictor variable (e.g., seat track position, gender), and ε is the error (normally, and independently distributed) associated with parameters not included in the model. The coefficient β can be used to generate the relative risk of crash injury severity given the existence of some condition. Using a logistic regression model to calculate odds ratios is a powerful tool because it allows for the evaluation of many possible conditions using a single model. Additional information regarding logistic regression models can be found in Washington et al. (2003), Fox (1997), and Pampel (2000).

RESULTS

Table 1 shows the distribution of Iowa drivers involved in vehicle crashes in the year 2000 by age and gender. The distribution by age for males and females is similar. The age groups were chosen to represent three distinct populations: middle-age, older, and elderly adults. Younger drivers are not shown because this study focuses primarily on older drivers. Studies have shown that younger drivers are clearly at an increased risk for crashes (Arnett 2002). As seen in Table 1, there were more vehicle occupants in the middle-age group than in the two older age groups. However, there is still a substantive number of elderly drivers (n=5317).

Table 1. Number of male and female Iowa drivers by age in crashes

Age Group	Male		Female	
	Count	Percent Distribution	Count	Percent Distribution
35 to 54	17742	74.71%	14598	75.35%
55 to 74	2996	12.62%	2470	12.75%
75 and Older	3011	12.68%	2306	11.90%
Total	23749	100.00%	19374	100.00%

The results of the logistic regression model are shown in Table 2. Female drivers are less likely to be severely injured as a group. Age was also shown to be significant, with drivers between age 55 and 74 having the greatest risk of severe injury. While drivers 75 and older are less likely to be severely injured as a group, females in this age range are more likely to be severely injured than their male counterparts. Rural collisions were associated with a greater risk of severe injury. Head on collisions and side impacts also resulted in a greater likelihood of severe injuries, whereas rear impacts were less likely to have the same result.

Weather conditions and vehicle type were not shown to be significant in predicting injury severity for Iowa crashes. Additionally, the only interaction effect was between gender and the elderly age group. Females in the oldest age group showed a greater increase in risk as compared with elderly males. This suggests that any difference in injury risk between male and female drivers is consistent across collision types, rural and urban environments, and drivers less than 75 years of age.

For comparison, a similar model was created based on national crash data. The results of the model are shown in Table 3. The only additional parameter evaluated was seatbelt use. This was included because of the strong impact that seatbelts have on driver safety. There is also a significant difference in seatbelt usage among driver populations. Within the national database, seatbelt usage is lower for men than women ($\chi^2(1)=294.03$, $p<0.01$). This variable was not uniquely identified in the 2000 Iowa crash database. Unlike in the Iowa model, both adverse weather and vehicle type were significant in the national model. Additional interactions reported in Table 3 were significant in the national model, but not significant in the Iowa model.

Table 2. Logistic Regression Parameter Estimates-suffering severe injury in a crash (Iowa Drivers)

Variable	Parameter Estimates	p-value
Constant	-3.7176	< 0.0001
Female	-0.1362	< 0.0001
Age 35 to 54	0.1493	< 0.0001
Age 55 to 74	1.2634	< 0.0001
Age 75 and Older	-0.3398	< 0.0001
Crash in Rural Area	0.8904	< 0.0001
Rear End Collision	-0.5429	< 0.0001
Head On Collision	1.5536	< 0.0001
Side Impact Collision	0.4141	< 0.0001
Interaction: Female age 75 and Older	0.7801	< 0.0001
Log-likelihood at zero		37694.2
Log-likelihood at convergence		35205.9
Number of Observations		112815

Nationally, females were more likely to be severely injured than males. Increases in age were also associated with higher risk of severe injury, with the largest increase for those drivers over the age of 75. Again, rural crashes and head on collisions were more likely to result in severe injury, whereas these injuries were less likely to occur in adverse weather and to drivers of light trucks, vans, and sport utility vehicles. Interactions between gender and age did not change the trend of increasing injury risk with age for either gender. Females were slightly more likely to be severely injured in bad weather and slightly less likely to be severely injured in rural crashes than males, but the general trend reported in Table 2, with regard to adverse weather and rural crashes, held for both genders.

Table 3. Logistic Regression Parameter Estimates-suffering severe injury in a crash (US drivers)

Variable	Parameter Estimates	p-value
Constant	-2.0059	< 0.0001
Female	0.1632	< 0.0001
Age 35 to 54	0.0744	< 0.0001
Age 55 to 74	0.1950	< 0.0001
Age 75 and Older	0.7285	< 0.0001
Crash in Rural Area	0.7603	< 0.0001
Rear End Collision	-1.0025	< 0.0001
Head On Collision	0.8619	< 0.0001
Side Impact Collision	-0.3238	< 0.0001
Seatbelt Use	-1.9775	< 0.0001
Adverse Weather	-0.2295	< 0.0001
Light Truck, Van, Utility Vehicle	-0.2006	< 0.0001
Interaction: Female age 35-54	-0.0407	< 0.0001
Interaction: Female age 55-74	0.1108	< 0.0001
Interaction: Female age 75 and Older	-0.3012	< 0.0001
Interaction: Female wearing Seatbelt	0.1738	< 0.0001
Interaction: Female in Adverse Weather	0.0387	0.0029
Interaction: Female in a rural Crash	-0.0702	< 0.0001
Log-likelihood at zero		2144012.3
Log-likelihood at convergence		1941430.4
Number of Observations		9246898

With regards to gender, a significant difference is shown between Iowa crashes and crashes nationally. Almost all literature about gender effects, specifically increased injury risk to females, is based on national data. The Iowa data, however, indicates that females are at a decreased risk of severe injury. Additionally, differences exist between the models with regard to age effects. The national model shows a consistent increase in risk with age, whereas the Iowa model shows a significant decrease in risk for those drivers over the age of 75.

Figures 1 and 2 show changes in severe injury risk for drivers in Iowa and nationally. There is very little difference in gender among 35- to 54-year-olds in either model, or for those drivers 75 and older nationally. The difference in female injury risk between the national and state models is primarily a function of the 55 to 74 year age group. Additionally, for the Iowa model, the gender effect is actually inverted between the 55 to 74 age group and the over 75 and older group. To further investigate this, the relative difference in risk between age groups for each population will also be considered. Identifying consistencies (or the lack thereof) in changes in risk may be more useful in determining where the true differences lie between the state and national model results.

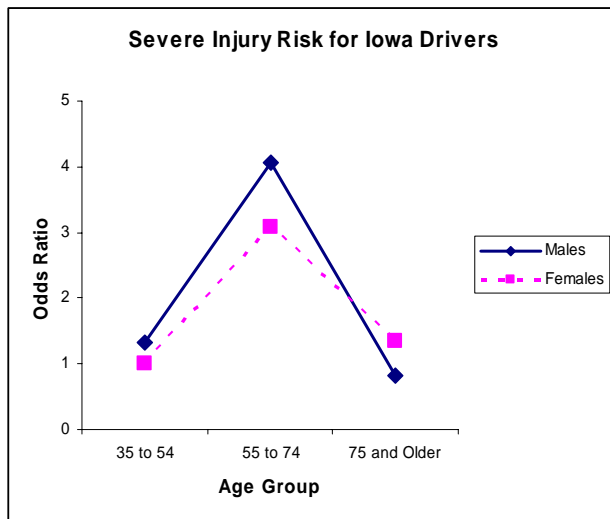


Figure 1. Odds of severe injury for Iowa drivers by age and gender

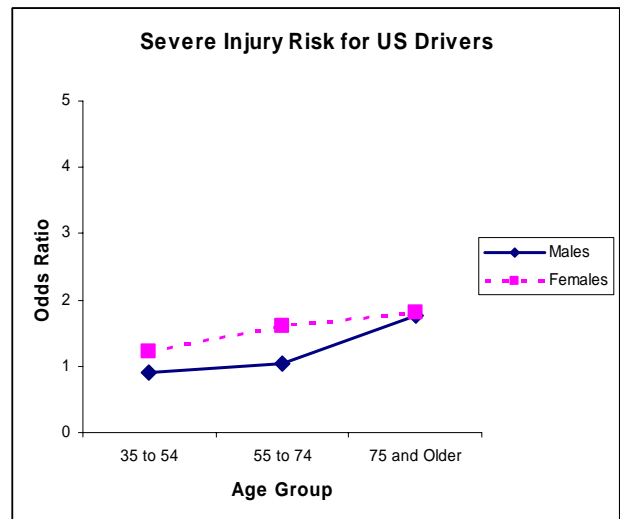


Figure 2. Odds of severe injury for U.S. drivers by age and gender

In all cases, the risk of severe injury increases for drivers in the older age group (55-74), as compared with the middle-age group (35-54). Nationally, females are at a greater risk of severe injury in both groups. Within Iowa, males are at greater risk. In comparing the two models, only the direction of change in injury risk (increase or decrease) should be considered, rather than the magnitude of the change. An increasing risk of severe injury between middle-age and older drivers is apparent in both models. The difference in risk between older drivers (55-74) and elderly drivers (75 and older) is more complicated. Within Iowa, the risk of severe injury decreases, whereas nationally, this risk increases. Among Iowa drivers, this is the one age group where females are at greater risk of severe injuries than males. At the same time, nationally, males in this group have a similar risk of severe injury as females.

The lack of information concerning seatbelt use in the State of Iowa database also must be evaluated when comparing the two models. Data for more recent years is currently being compiled and will include more specific information on seatbelt use. In the future, this data should be analyzed to determine if males are actually at higher risk for severe injury and if older drivers are at a lower risk for severe injury, or if this is an artifact of the effect of seatbelt usage rates. In the absence of this data, another means of assessing this issue is to evaluate the national data without considering seatbelt usage to see if the national risk profiles without considering seatbelt use represent the state results in Figure 1 more closely. A comparison of national models with and without considering seatbelts explicitly is shown in Figure 3.

The solid lines in Figure 3 represent the baseline national model including seatbelt use as a parameter. This is the same data as shown in Figure 2. The dashed lines represent the same national model without considering seatbelt usage. If difference in seatbelt usage rates was the primary cause for the discrepancy in gender effects seen in Figure 1, then it would be expected that the males nationally would have a greater risk when seatbelt usage is not included in the model. However, as seen in Figure 3, females have a greater reported risk of severe injury regardless of whether or not seatbelts are considered in the national model. Additionally, if failure to consider seatbelt usage was responsible for the apparent decrease in risk for the elderly in Iowa, one would expect significant decreases in injury risk for the elderly nationally,

when seatbelt usage is ignored. However, the overall risk increases with age regardless of whether or not seatbelt usage is considered nationally. Additionally, neither national model (belt usage known or unknown) shows the same crossover effect between males and females in the oldest two age groups.

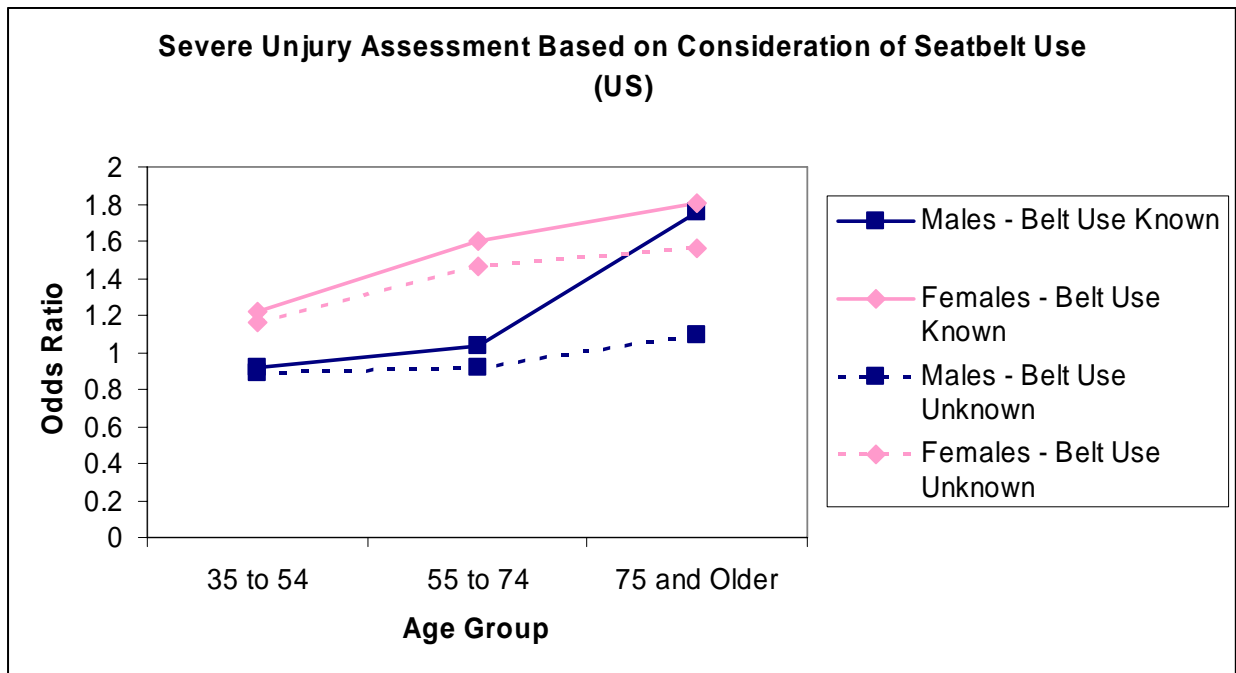


Figure 3. A comparison of severe injury risk based on the explicit consideration of seatbelt use in the logistic regression model

DISCUSSION

The investigation of severe injuries in crashes in the state of Iowa has led to some interesting findings. The first finding is that among middle-age and older drivers, males in Iowa have a greater risk of severe injuries than females. This is in contrast to trends seen nationally. One possible answer to the first question regarding the increased risk of injury for males in Iowa is that it is a function of the model parameters. The Iowa database from 2000 does not provide information that can be used to ascertain seatbelt usage. Since the national model took this into account, but the state model did not, the increased risk of males in the state model may be masking the effect of a lower seatbelt usage rate among males, particularly since the national model showed such a significant increase in the odds of injury for unbelted occupants (odds ratio = 7.2). Examination of the national model with regard to considering seatbelt usage indicates this is not a sufficient explanation, and other factors are likely involved. This may suggest a greater disparity in high-risk driving habits between males and females in Iowa than nationally.

The second finding was that injury risk for male and female drivers decreases after age 75 within Iowa, while increasing nationally. Additionally, elderly male drivers in Iowa see a more dramatic decrease than females, whereas nationally, elderly males have an increasing risk relative to females. The decrease in risk for Iowa drivers over the age of 75 may also be influenced by the affect of seatbelt usage since studies have shown that older drivers wear seatbelts more regularly (Hakamies-Blomqvist 1993). This might also explain the decrease in risk for men relative to women among the elderly. If elderly drivers of

both genders are consistently more likely to wear seatbelts, then this would negate the effect of seatbelt use on the risk associated with a particular gender.

Although including seatbelt usage as a parameter in the state model would certainly result in greater information about the injury risk for older and elderly drivers, it does not appear that the differences in injury risk between Iowa drivers and those nationally can be explained solely by considering belt use in the model. It is more likely that these differences are attributable to behavioral issues. While one of these issues could be seatbelt usage rates, which could be assessed in future studies with new state crash data, another possible explanation is related to modifications in driving behavior.

One such modification is driver self-regulation. Driver self-regulation involves adjusting driving patterns to avoid driving situations that are perceived as risky or dangerous. Several factors influence modification of driving patterns, including flexible schedules, less need to drive, and recognition of impairments which could impact safety (Ball et al. 1998). It is possible that elderly drivers in Iowa do a better job of adjusting driving patterns than those drivers nationally. This could involve avoiding rush hour traffic, highways, intersections, and trips outside of familiar areas. Additionally, older drivers may benefit from lower traffic levels and lack of highways in rural areas.

Further research is required in order to understand the role of seatbelts in preventing severe injuries as Iowa drivers age. Additionally, future studies pertaining to the manner in which Iowa drivers, particularly those in rural areas, adjust driving patterns are needed. This will help to clarify the root cause of the reduction in injury risk among elderly Iowa drivers. Once it is understood why elderly drivers (ages 75 and older) in Iowa have successfully reduced their risk of injury in a crash, recommendations can be made to reduce the risk of injury within the older driver population (ages 55-74).

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