Effect of Seat Belt Use on Injury Severity for Adult Rear-Seat Occupants Injured in Motor Vehicle Crashes

Final Report

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Project Title: Estimating the Costs of Traumatic Injuries to Unbelted Occupants in Motor Vehicle Crashes

16 Abstract
In the State of Iowa passengers age 18 and older are not required by law to use seat belts when they ride in the back seat of a motor vehicle. Only 23.1% of adult rear-seat passengers involved in fatal crashes in Iowa from 2013-2019 were belted compared to 70.5% of adult front-seat passengers.
This project aimed to estimate and compare the costs of traumatic injuries suffered by adult rear-seat occupants based on reported seat belt use. After access to the trauma data was impacted by the COVID-19 pandemic, a new data source was identified that consisted of Iowa hospital data that had been probabilistically linked to injured individuals in Iowa crash reports. However, due to low confidence in the quality of the data linkage, all results relating to the costs of injuries and length of stay in the hospital should be considered preliminary findings.
From 2016-2019, a total of 1,646 adult occupants seated in rear positions in passenger vehicles who were reported to be injured were identified from the Iowa crash data system. Ordinal regression models were used to calculate odds ratios for seat belt use while controlling for several covariates, including age, gender, vehicle damage, speed limit, crash type, and time of day. Injured adult occupants in the rear seat who were not belted were 6.2 times more likely to have a fatal injury compared to lower levels of injury and 3.6 times more likely to have a fatal or serious injury compared to a minor or possible injury. Occupants were 1.9 times more likely to receive a higher level of transport to medical care compared to those who were belted.

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Executive Summary

The use of seat belts by back-seat occupants have been estimated to reduce crash fatalities in passenger cars by 60% and in light trucks by 70% (Zhu, Cummings, Chu, & Cook, 2007). Since 1986, the State of Iowa has required occupants in the front seat to use seat belts, but passengers age 18 and older are not required to buckle up when they ride in the back seat. In 2021, the observed belt use rate for the front seat was 92.8% (Allen, Fox, & Berg, 2021). However, only 35% of Iowans surveyed about their seat belt use reported that they always use a belt in the back seat (Reyes, Marshall, & McGehee, 2015). Only 23.1% of adult rear-seat passengers involved in fatal crashes in Iowa from 2013-2019 were belted compared to 70.5% of adult front-seat passengers.

One way to quantify the impact of seat belts is to consider the costs of treating injuries due to motor vehicle crashes. NHTSA estimated that medical costs represent about 25% of the total costs associated with non-fatal motor vehicle crash injuries (Blincoe et al., 2002). An analysis of the hospital costs associated with motor vehicle crash injuries in Nebraska found that the use of a lap-shoulder seat belt resulted in 85% lower hospital costs (Han, Newmyer, & Qu, 2017).

At the outset, this project aimed to estimate the costs of traumatic injuries suffered by adult rear-seat occupants in motor vehicle crashes in Iowa and to compare costs for occupants who were reported to be belted and not belted for crashes from 2012 through 2016. Obtaining data from the State Trauma Registry, which is administered by the Iowa Department of Public Health, proved to be a challenging process even prior to the COVID-19 pandemic. In 2021 another source of data for cost of motor vehicle crash injuries was identified, and the years of analysis were updated to 2016 through 2019.

The new dataset was obtained from the University of Iowa Injury Prevention Research Center. It contained Iowa emergency room and inpatient hospital data that had been probabilistically linked to injured individuals in the Iowa crash data. However, as this analysis was conducted, concerns were raised about the data linkage process, and there is low confidence in the quality of the data linkage. Therefore, *all results relating to the costs of injuries and other hospital outcomes reported herein should be considered to be preliminary findings*.

From 2016-2019, a total of 1,646 adult occupants seated in rear positions in passenger vehicles who were reported to be injured were identified from the Iowa crash data system. Of these, 1,502 were probabilistically linked to a person in the hospital data. Ordinal regression models were used to calculate odds ratios for seat belt use while controlling for occupant age and gender, vehicle damage, speed limit, crash type, intersection, rural location, time of day, and the presence of alcohol or drugs in at least one driver's system during the crash.

For injured adult occupants in the rear seat, not using a seat belt was associated with more severe injuries. Specifically, these occupants were 6.2 times more likely to have a fatal injury compared to lower levels of injury and 3.6 times more likely to have a fatal or suspected serious/incapacitating injury compared to a suspected minor/non-incapacitating or possible injury. Additionally occupants were 1.9 times more likely to receive a higher level of transport to medical care (i.e., EMS transport versus non-EMS transport versus not transported) compared to those who were belted. Two thirds of injured adult occupants in the rear seat were younger than age 40. A total of 1,892 years of potential life (relative to an expected age of 80) were lost due to fatal injuries. After controlling for gender and crash

characteristics, the unbelted occupants (n = 34) lost significantly more years of potential life, on average, than the belted occupants (n = 8).

Analysis of total hospital inpatient and emergency room charges found no significant differences by seat belt use status. This was not the anticipated finding based on similar analyses in the literature and is just one of several reasons for low confidence in the quality of the linkage between the crash and hospital data. Nevertheless, this analysis did show that seat belt use significantly reduces the risk of fatal and severe injury for rear-seat adult passengers injured in motor vehicle crashes and provides Iowa-specific information for safety messages to promote seat belt use.

Introduction

The State of Iowa enacted the current seat belt law, which requires occupants in the front seat to use seat belts, in 1986. Children age 10 and under must be restrained in age- and size-appropriate systems (enacted 2004), and all occupants younger than 18 years must use seat belts in any seating position (enacted 2010). In Iowa, seat belt laws are primary laws, which means law enforcement can initiate a traffic stop if anyone in the vehicle subject to one of these laws is not properly belted. Currently passengers in the back seat age 18 and older are not required by law to use seat belts.

Seat belt use rates for the front seat are high in Iowa. In 2021, the observed belt use rate for the front seat was 92.8%, and the lowest rate observed since 2012 was 91.4% (Allen et al., 2021). While 85% of Iowans surveyed about their seat belt use reported that they always use a belt in the front seat, only 35% said they always buckle up when they ride in the back seat (Reyes et al., 2015). This reported difference in belt use is evident in the crash data as well. Only 23.1% of adult rear-seat passengers involved in fatal crashes in Iowa from 2013-2019 were belted compared to 70.5% of adult front-seat passengers. Additionally, the proportion of adult rear-seat passengers involved in fatal crashes in Iowa who were belted was about 25% lower than the national average for adults under the age of 70, as shown in Figure 1.

The use of seat belts by back-seat occupants have been estimated to reduce crash fatalities in passenger cars by 60% and in light trucks by 70% (Zhu et al., 2007). An analysis by Mayrose et al. (2005) reported that rear-seat passengers were 2.7 times more likely to be killed in a crash when unbelted. A passenger's seat belt use or non-use does not only impact their own risk of injury or death.

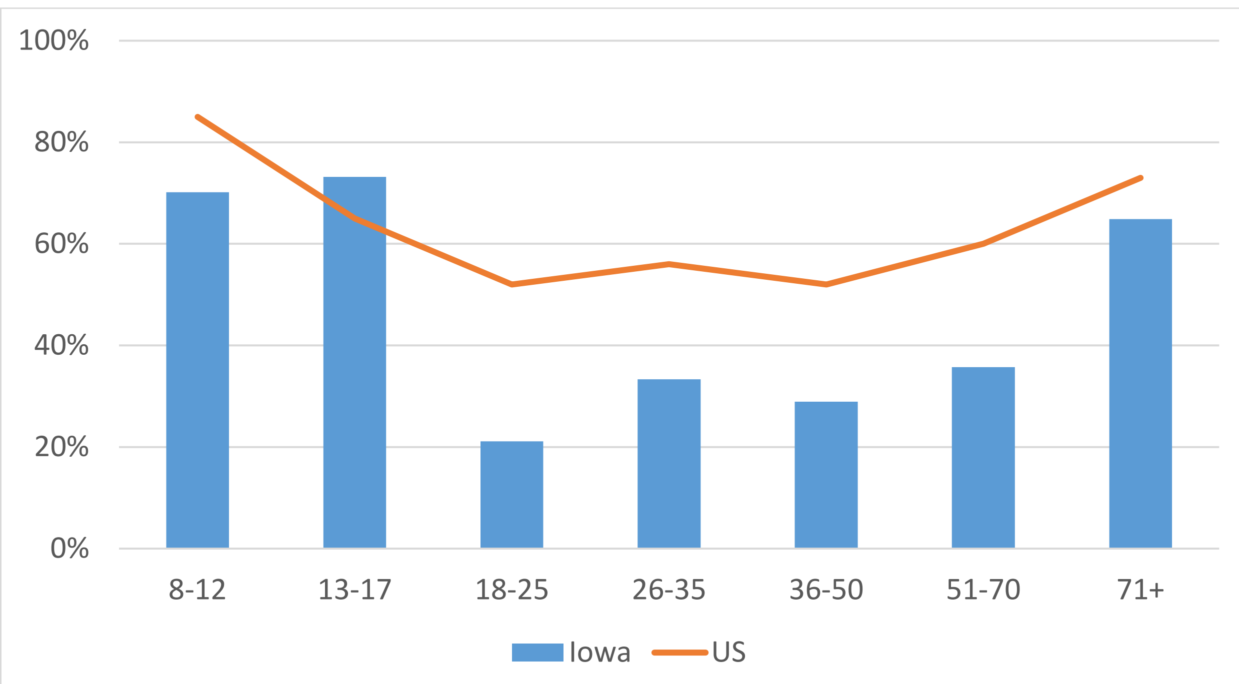

Figure 1. Rear-seat passengers with known belt status who were belted when involved in a fatal crash, by age. US percent calculated from 2018 FARS data and reported by (Hedlund, 2020).

During a crash, an unbelted occupant can collide with other occupants, leading to additional injuries or fatalities. MacLennan, McGwin, Metzger, Moran, and Rue (2004) analyzed the direction of force in a crash and occupant injuries based on where they were seated. Belted occupants in any seating position had a higher risk of injury (adjusted risk ratio of 1.9) and death (adjusted risk ratio of 4.8) when they were seated between an unbelted occupant and the direction of force in a crash. In head-on crashes, a belted driver is more than twice as likely to die from their injuries when they are seated in front of an unbelted passenger (Bose, Arregui-Dalmases, Sanchez-Molina, Velazquez-Ameijide, & Crandall, 2013; Mayrose et al., 2005). An analysis from Japan found belted drivers and front seat passengers had a five-fold increase in risk of death with unbelted rear-seat passengers (Ichikawa, Nakahara, & Wakai, 2002).

One way to quantify the impact of seat belts is to consider the costs of treating injuries due to motor vehicle crashes. The National Highway Traffic Safety Administration (NHTSA) estimated that medical costs represent about 25% of the total costs associated with non-fatal motor vehicle crash injuries (Blincoe et al., 2002). Chaudhary and Tison (2008a) have quantified the expected benefits of implementing primary seat belt laws in several states in terms of cost savings for private insurance as well as federal and state contributions to Medicaid programs. An analysis of the hospital costs associated with motor vehicle crash injuries in Nebraska found that the use of a lap-shoulder seat belt resulted in 85% lower hospital costs (Han et al., 2017).

Although several analyses of crash outcomes have been conducted using Iowa Crash Outcome Data Evaluation System (CODES) data, to our knowledge, the only in-depth analysis of the effect of seat belt use on cost of motor vehicle crash injuries in Iowa was conducted not long after the seat belt law was first enacted (Nelson, Peterson, Chorba, Devine, & Sacks, 1993). That analysis reported that about half those injured were not belted, yet their injuries accounted for 78% of the costs. The mean hospital costs for those who were not belted were 3.6 times higher than those who were belted, and more people who were not belted were uninsured or covered by Medicaid.

Objectives

At the outset, this project aimed to estimate the costs of traumatic injuries suffered by adult rear-seat occupants in motor vehicle crashes in Iowa from 2012 through 2016 and to compare costs for occupants who were reported to be belted and not belted. Unfortunately there were issues with obtaining the trauma registry data needed to conduct the analysis which were further compounded by the COVID-19 pandemic. In 2021 another source of data for cost of motor vehicle crash injuries was identified and the years of analysis were updated to 2016 through 2019.

Methods

Planned approach

When the initiated, this project planned to use the State of Iowa Trauma Registry administered by the Iowa Department of Public Health. The project application and data management plan were modified several times in order to satisfy the project needs while safeguarding the data. The approved plan consisted of two phases of data acquisition. First, a restricted set of variables from the trauma registry containing patient date of birth and gender, date of injury, and injury descriptors was received, cleaned, and reduced to include injuries to adults that were possibly related to motor vehicle crashes. Then these cases were probabilistically linked to individuals in the Iowa crash data. This step was completed for data from 2012 through 2016. In Phase 2, the identifiers for the linked cases were used to request the outcomes data from the trauma registry (e.g., costs, level of care, length of stay). However, IDPH was unable to fulfill this data request due to the COVID-19 pandemic. Although IDPH extended the project period for two additional years and approved the use of additional years of data, no additional data were received and email inquiries about data availability went unanswered.

Revised approach

In 2021 a new data source was identified. The University of Iowa Injury Prevention Research Center (IPRC) was actively working to obtain and link inpatient and emergency department data as well as fatal crash data in order to create a new dataset similar to Iowa's Crash Outcome Data Evaluation System (CODES). CODES was originally conceived by NHTSA, and Iowa's CODES was housed at the IDPH through 2016. The IPRC obtained hospital data for Iowa from the Healthcare Cost and Utilization Project (HCUP) administered by the Agency for Healthcare Research and Quality (AHRQ). Data were obtained from the State Inpatient Database (SID) and the State Emergency Department Database (SEDD). These data were probabilistically linked to injured persons in the crash data using month and year of the crash, month and year of birth, age, and gender.

The IPRC CODES datasets for 2016 through 2018 were received in December 2021. The dataset for 2019 was received in mid-February 2022. As these data were examined for the purposes of this project, concerns about the integrity of the initial data linkage process were identified. For example, the residential zip code of the injured person from the crash data matched the patient zip code from the hospital data in only 25% of the linked records. Therefore, *all results derived from the hospital data included in this analysis should be considered to be preliminary findings*.

Crash data

Crash data were obtained from the IPRC through an existing Memorandum of Understanding between the Iowa Department of Transportation and the University of Iowa. Crash-, vehicle-, and person-level data were received in the form of individual "z-tables," from which the data elements necessary to conduct the analysis were selected and merged. For instance, vehicle configuration was amended to the person-level injury data to determine whether the injured person had been the occupant of a passenger vehicle. During the course of this project it was discovered that the unit number, which is the data element that identifies which vehicle the person occupied, was incorrect for many reported individuals. For example, a passenger involved in a two-vehicle crash might be reported to be an occupant of Unit 2 even though Unit 2 was reported to have only one occupant (i.e., the driver and no passengers) and Unit 1 was reported to have two or more occupants (i.e., passenger(s) in addition to a driver). Scripts were written in SAS (Statistical Analysis Software) to correct the unit number for as many passengers as possible. However, passengers involved in crashes that included more than one vehicle containing more than one occupant could not be assigned to a specific unit.

Procedures were written in SAS to select the persons of interest for this analysis. Inclusion criteria included:

- Being recorded as an injured person (i.e.,fatal, suspected serious/incapacitating, suspected minor/non-incapacitating, possible, or unknown injuries) in a police-reported crash
- Reported age of 18 years or older

- Occupant of a passenger vehicle (i.e, car, four-tire truck (pick-up), sport utility vehicle, passenger van that seats <15, or cargo/panel van)
- Reported as seated in a rear (second row or greater) seating position

Individuals who were not associated with a specific vehicle (due to the issue with unit number described above) were included in the analysis dataset if all the vehicles involved in the crash were passenger vehicles.

Analytical methods

The primary predictor of interest in the analysis was known seat belt use (i.e., subjects who were reported belted or not belted). Descriptive statistics for the dependent measures and several covariate measures were calculated and examined using frequency tables, histograms (including density curves), and the univariate procedure in SAS. Two-way tables for these measures and reported seat belt use were constructed.

Logistical regression was conducted in SAS 9.4 to assess the effect of known seat belt use on two ordinal dependent measures from the crash data: level of injury and source of transport to receive medical attention. Both models controlled for occupant age and gender, vehicle damage, speed limit, crash type, intersection, rural location, time of day, and the presence of alcohol or drugs in at least one driver's system during the crash. Logistic regression of ordinal data (i.e., ordered categorical data) considers cumulative logits, which is the association between the predictor(s) and being in a lower (or higher level) for the outcome.

For the model examining level of injury, four levels were considered: fatal injury, suspected serious/incapacitating injury, suspected minor/non-incapacitating injury, and possible injury. Initial model results showed that the proportional odds assumption (that is, that the effect of each predictor is similar across different levels of the response) was not valid. When this assumption is met, the model can estimate one slope for each predictor. In this case, different slopes for the predictors had to be considered at different levels of response. Model selection procedures were used to examine each predictor. The final model fit unequal slopes for known seat belt use and crash type while equal slopes were estimated for all other predictors.

For the model examining source of transport, three levels were considered: EMS transport by air or ground ambulance, transport by other party (i.e., self, family, friend, or law enforcement), or not transported. The proportional odds assumption was met so the model estimated one slope for each predictor.

The third dependent measure calculated from the crash data was years of potential life lost, derived by subtracting the injured person's age from an expected age of 80 years. This dependent measure was analyzed with Poisson regression, and the model controlled for gender, vehicle damage, speed limit, crash type, intersection, rural location, time of day, and the presence of alcohol or drugs in at least one driver's system during the crash.

Dependent measures from the IPRC CODES dataset were: total emergency department and/or inpatient charges, length of stay, and overnight stay—a binary measure of whether the length of stay was greater than or equal to 1 day. Because the distribution of total charges was extremely positively skewed (γ = 16.7), the total charges were transformed with the log function, and linear regression analysis was conducted both without and without covariate measures. Length of stay was modeled using Poisson regression and overnight stay was modeled using logistic regression.

Results

A total of 1,646 adult occupants in rear seating positions of passenger vehicles with injury status other than “uninjured” were identified from the 2016-2019 crash data. Table 1 shows the reported gender and age groups for these subjects. Just over two-thirds of the subjects were under age 40 and about 58% were female.

Table 2 shows the overall frequencies of the covariate measures from the crash data as well as frequencies by the reported seat belt status. Table 3 shows the same for the dependent measures from the crash data. Less than half the subjects (46.3%) were reported to be belted, 28.6% unbelted, and 25.2% had unknown belt status. Notably, although 30% of the subjects were involved in non-collision (i.e., single vehicle) crashes, almost 48% of the subjects who were not belted were involved in this type of crash. Subjects who were not belted were also over represented in vehicles that had severe/totaled damage levels (55% compared with 43% of all subjects). Subjects with fatal injuries lost nearly 1900 years of potential life. Unbelted subjects with fatal injuries lost just over 1300 years of potential life. A histogram of years of potential life lost for subjects with known belt use status is shown in Figure 2.

Table 1. Age and gender for adult occupants of passenger vehicles in rear seating positions injured in police-reported motor vehicle crashes in Iowa, 2016-2019

		Gender		
Age	All subjects N (%)	Female N (%)	Male N (%)	Gender not reported N (%)
All ages	1646	952	684	10
18-20	378 (23.0%)	190 (20.0%)	186 (27.2%)	2 (20.0%)
21-29	461 (28.0%)	245 (25.7%)	213 (31.1%)	3 (30.0%)
30-39	263 (16.0%)	151 (15.9%)	111 (16.2%)	1 (10.0%)
40-49	168 (10.2%)	101 (10.6%)	66 (9.6%)	1 (10.0%)
50-59	170 (10.3%)	118 (12.4%)	50 (7.3%)	2 (20.0%)
60-69	107 (6.5%)	68 (7.1%)	39 (5.7%)	0 (0%)
70+	99 (6.0%)	79 (8.3%)	19 (2.8%)	1 (10.0%)

Table 2. Frequency tables for covariate measures for all subjects and by reported seat belt status

	All subjects N (%)	Belted N (%)	Not belted N (%)	Unknown belt status N (%)
Total	1646	762	470	414
Age				
18-20	378 (23%)	160 (21%)	132 (28.1%)	86 (20.8%)
21-29	461 (28%)	211 (27.7%)	137 (29.1%)	113 (27.3%)
30-39	263 (16%)	114 (15%)	80 (17%)	69 (16.7%)
40-49	168 (10.2%)	72 (9.4%)	48 (10.2%)	48 (11.6%)
50-59	170 (10.3%)	90 (11.8%)	31 (6.6%)	49 (11.8%)
60-69	107 (6.5%)	62 (8.1%)	17 (3.6%)	28 (6.8%)
70+	99 (6%)	53 (7%)	25 (5.3%)	21 (5.1%)
Gender				
Female	952 (57.8%)	458 (60.1%)	251 (53.4%)	243 (58.7%)
Male	684 (41.6%)	298 (39.1%)	216 (46%)	170 (41.1%)
Not reported	10 (0.6%)	6 (0.8%)	3 (0.6%)	1 (0.2%)
Crash type				
Non-collision	499 (30.3%)	172 (22.6%)	224 (47.7%)	103 (24.9%)
Rear end	407 (24.7%)	216 (28.3%)	78 (16.6%)	113 (27.3%)
Broadside	418 (25.4%)	218 (28.6%)	95 (20.2%)	105 (25.4%)
All other	322 (19.6%)	156 (20.5%)	73 (15.5%)	93 (22.5%)
Vehicle damage				
None or Minor	159 (9.7%)	78 (10.2%)	32 (6.8%)	49 (11.8%)
Functional or Disabling	420 (25.5%)	210 (27.6%)	106 (22.6%)	104 (25.1%)
Severe/totaled	707 (43%)	296 (38.8%)	260 (55.3%)	151 (36.5%)
Unknown or Not reported	360 (21.9%)	178 (23.4%)	72 (15.3%)	110 (26.6%)
Posted speed limit				
< 45 mph	530 (32.2%)	250 (32.8%)	127 (27%)	153 (48.7%)
45-60 mph	537 (32.6%)	225 (29.5%)	195 (41.5%)	117 (37.3%)
> 60 mph	220 (13.4%)	109 (14.3%)	78 (16.6%)	33 (10.5%)
Not reported	359 (21.8%)	178 (23.4%)	70 (14.9%)	111 (26.8%)
Intersection				
Yes	775 (47.1%)	397 (52.1%)	191 (40.6%)	187 (45.2%)
No	871 (52.9%)	365 (47.9%)	279 (59.4%)	227 (54.8%)
Time of day				
Morning, 6am-12pm	321 (19.5%)	168 (22%)	66 (14%)	87 (21%)
Afternoon, 12pm-6pm	657 (39.9%)	336 (44.1%)	159 (33.8%)	162 (39.1%)
Evening, 6pm-12am	432 (26.2%)	190 (24.9%)	144 (30.6%)	98 (23.7%)
Night, 12am-6am	236 (14.3%)	68 (8.9%)	101 (21.5%)	67 (16.2%)
Drug/Alcohol related				
Yes	201 (12.2%)	64 (8.4%)	94 (20%)	43 (10.4%)
No	1445 (87.8%)	698 (91.6%)	376 (80%)	371 (89.6%)

Table 3. Frequency tables for crash dependent measures for all subjects and by reported seat belt status

	All subjects N (%)	Belted N (%)	Not belted N (%)	Unknown belt status N (%)
Total	1646	762	470	414
Injury status				
Fatal	52 (3.2%)	8 (1%)	34 (7.2%)	10 (2.4%)
Suspected serious/ incapacitating	173 (10.5%)	44 (5.8%)	91 (19.4%)	38 (9.2%)
Suspected minor/ non-incapacitating	616 (37.4%)	290 (38.1%)	177 (37.7%)	149 (36%)
Possible or Unknown	805 (48.9%)	420 (55.1%)	168 (35.7%)	217 (52.4%)
Transport				
Funeral home/ morgue	12 (0.7%)	1 (0.1%)	9 (1.9%)	2 (0.5%)
EMS air or ground	1037 (63%)	437 (57.3%)	342 (72.8%)	258 (62.3%)
Self, family, friend, or law enforcement	190 (11.5%)	96 (12.6%)	44 (9.4%)	50 (12.1%)
Not transported	385 (23.4%)	218 (28.6%)	67 (14.3%)	100 (24.2%)
Other, Unknown, or Not reported	22 (1.3%)	10 (1.3%)	8 (1.7%)	4 (1%)
Total years of life lost (ref. age 80) for fatalities	1892	124	1305	463

The ordinal regression model analyzing injury status produced odds ratios that compared higher levels of injury to lower levels. The results are shown in Table 4 and an effect plot is shown in Figure 3. After controlling for the covariate measures, unbelted subjects were about 6.2 times more likely to have a fatal injury compared to a lower level of injury and about 3.6 times more likely to have a fatal or suspected serious/incapacitating injury compared to a suspected minor/non-incapacitating injury or a possible injury. Any level of known injury (in contrast to a recorded possible injury) was approximately 1.6 times more likely for an unbelted subject.

The ordinal regression model for level of transport, for which the equal slopes assumption was valid, produced one odds ratio that quantified the likelihood of needing a higher level of transport (EMS transport vs non-EMS transport vs not transported). Unbelted subjects were about 1.9 times more likely to have a higher level of transport than those who were belted (see Table 4). Figure 4 shows the effect plot for level of transport without controlling for covariates.

The Poisson regression analysis of potential years of life lost, which controlled for all covariates except for age (since it is confounded with the dependent measure), yielded exponentiated least squares mean estimates of 21.8 years lost for unbelted subjects and 16.3 years lost for belted subjects, a difference that was statistically significant, $X^2(1) = 5.80$ (p=0.016).

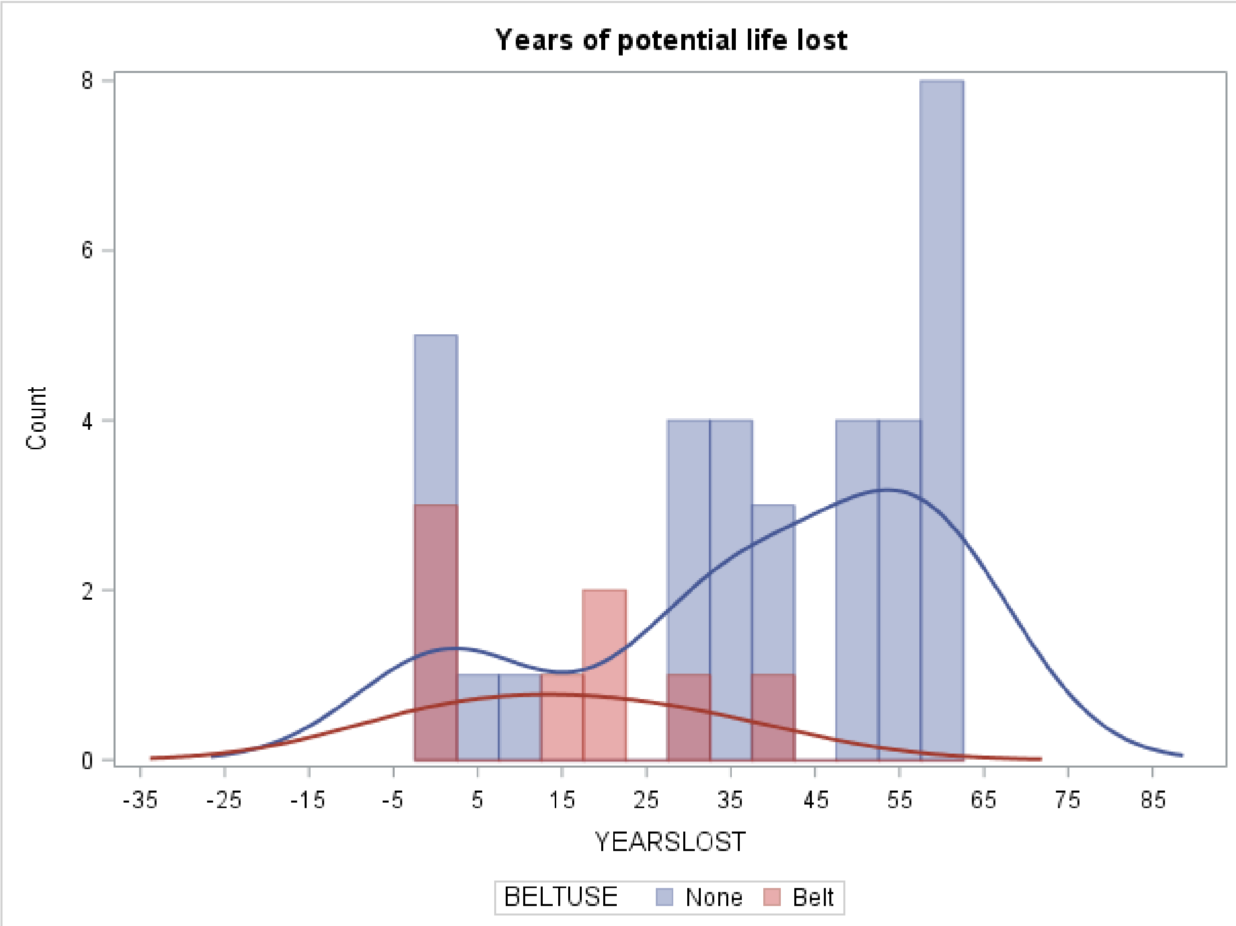

Figure 2. Histogram and density curves for potential years of life lost calculated relative to an expected age of 80 years.

Table 4. Odds ratio estimates and Wald confidence intervals for subjects reported to be unbelted relative to subjects reported to be belted.

Response level description	Odds ratio estimate	95% confidence limits
Fatal injury vs all other injury levels	6.238	(2.707, 14.370)
Fatal or serious injury vs all other levels	3.553	(2.368, 5.331)
Fatal, serious, or minor injury vs possible injury	1.592	(1.174, 2.158)
Higher level of transport to medical care	1.854	(1.359, 2.529)

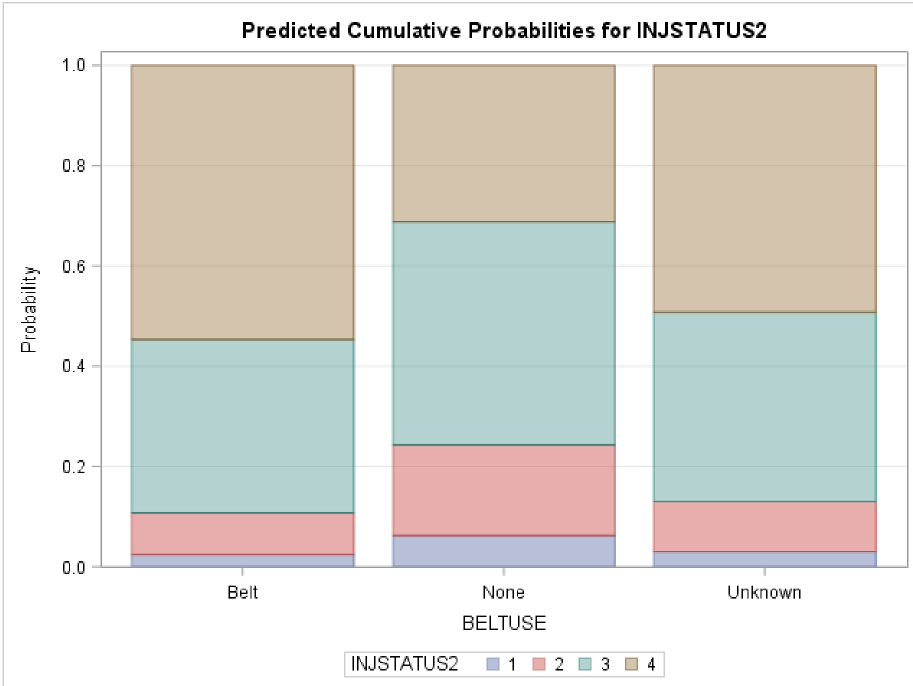

Figure 3. Effect plot for injury status by reported belt use (without controlling for covariates). Injury status 1 = fatal injury; 2 = suspected major/incapacitating injury, 3 = suspected minor/non-incapacitating injury, 4 = possible injury.

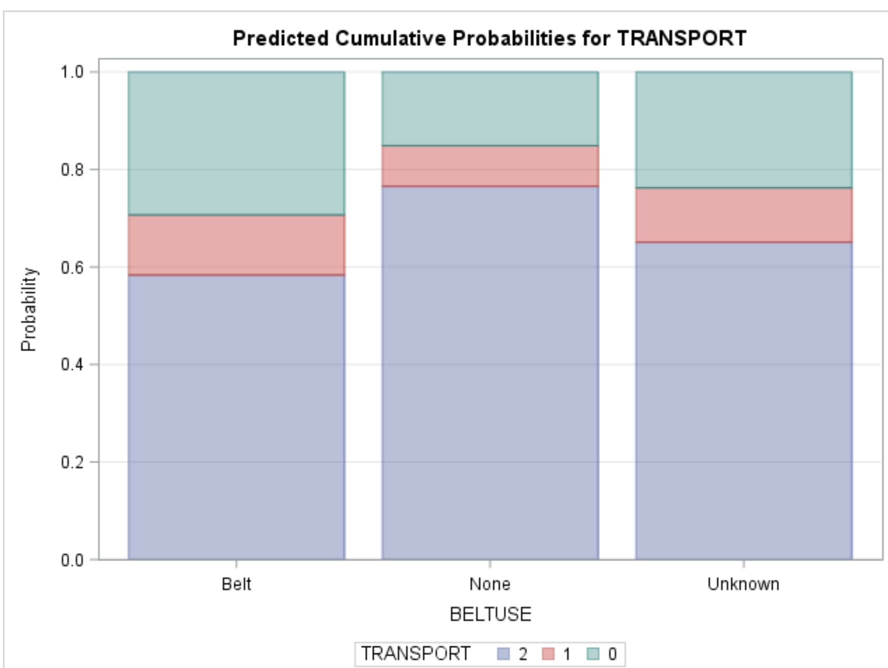

Figure 4. Effect plot for transport to medical care by reported belt use (without controlling for covariates). Transport 0 = not transported, 1 = non-EMS transport (e.g., friend, family, self), 2 = EMS transport by air or ground ambulance.

The following results pertain to the preliminary analysis of the dependent measures from the IPRC CODES data. Table 5 shows the 25th, 50th, and 75th percentiles of the total emergency department and inpatient charges. Analysis of the log-transformed total hospital charges found no statistically significant differences for reported seat belt status, both without and with controlling for covariates, $X^2(1) = 2.34$ ($p = 0.126$) and $X^2(1) = 3.11$ ($p = 0.078$), respectively.

Without considering any covariates, length of stay in at the hospital was about 2.6 times longer for unbelted subjects than belted subjects, $X^2(1) = 63.35$ ($p < 0.0001$). The model that controlled for the covariate measures estimated the length of stay was about 4.1 times longer for unbelted subjects, $X^2(1) = 98.95$ ($p < 0.0001$; 95% confidence interval: 3.0, 5.5).

Without considering any covariates, unbelted subjects were 1.5 times as likely to have an overnight stay at the hospital compared to belted subjects, $X^2(1) = 4.348$ ($p = 0.037$). After controlling for covariate measures, the results were similar, with an odds ratio of 1.6, $X^2(1) = 4.096$ ($p = 0.043$, 95% confidence interval: 1.0, 2.5).

Table 5. The 25th, 50th, and 75th percentiles of the total emergency department and inpatient hospital charges by seatbelt status.

	All subjects	Belted	Not belted	Unknown belt status
Number of subjects	1302	587	382	333
Total charges				
25th percentile	$1238.84	$1203.00	$1285.29	$1145.00
50th percentile	$2890.37	$2900.40	$2828.28	$2904.45
75th percentile	$6151.00	$5845.30	$6450.40	$6587.65

Discussion

This project aimed to estimate the costs associated with motor vehicle crash injuries for adult occupants in the back seat. Although that goal was not fully achieved, this analysis was successful in quantifying the degree to which seat belt use significantly reduces the rate of fatal and severe injury for adult rear-seat occupants in motor vehicle crashes in Iowa. In addition, gaining familiarity with the HCUP emergency department and inpatient data will aid in making improvements to the data linkage process and facilitate the efficient completion of the desired analyses when an improved version of the IPRC CODES data is available.

Having Iowa-specific information about how seat belts mitigate crash injuries may make more of an impact when communicating safety messaging to promote seat belt use. Previous research, including our own (Reyes et al., 2015), found that many people believe that the back seat is safer than the front so seat belts are not necessary (Jermakian & Weast, 2018). These findings indicate that educating passengers will be a key component to increasing belt use rates for rear-seat occupants. The results of this crash data analysis can also suggest whom to target with safety messages. Two thirds of the rear-seat occupants injured in crashes were under the age of 40. Alcohol involvement, time of day, and rural location were all covariates that contributed to injury severity.

Limitations

One major limitation of this analysis is that it only was only able to consider outcomes for individuals who were injured in motor vehicle crashes. Occupants who use seat belts are more likely to avoid injury, but information about uninjured passengers is very rarely included in crash reports. Therefore, this analysis can only estimate the impact seat belts have on reducing injury severity and type of transport to medical care given that an injury has been reported. The crash data cannot support an analysis of how many individuals avoided injury altogether due to using a seat belt.

When this analysis was first initiated, the plan was to use the Iowa Trauma Registry data, which offers several detailed measures of injury severity, in particular the Abbreviated Injury Scale (AIS), which is used to compute injury scores for different body regions, and the Injury Severity Score (ISS), which considers the most severe injuries for up to three body regions. The HCUP State Inpatient and State Emergency Department data includes ICD-10 diagnosis and procedure codes but not measures of injury severity. While other researchers have created and used software to derive AIS scores from ICD diagnosis codes (e.g., Burch, Cook, & Dischinger, 2014) and injury scores might one day be integrated into the IPRC CODES data, this analysis relies upon the investigating officers' assessments of injury severity. Previous research has shown that depending on the circumstances, officers might over- or underestimate the level of injury (Burdett, Li, Bill, & Noyce, 2015).

Unfortunately the use of the HCUP data, which restricts all date information—including date of birth—to just month and year, has a substantial impact on the ability to reliably link the hospital data with the Iowa crash data. Within the crash data, the combination of full date of birth, date of the crash, and gender is unique for 99.5% of individuals and the maximum number of people with the same combination of these variables is no more than 6. If the full dates in the crash data are restricted to month and year, the combination of birth month, crash month, and gender is unique for only 23.8% of the individuals and up to 25 people have the same combination. As mentioned above, residential zip code is a data element that is available in both the crash data and the hospital data, and this variable will be added to improve the quality of the data linkage in the future. However, in the currently available dataset, the zip codes agreed for only 25% of the matched observations.

An analysis of CODES data from Nebraska (Han et al., 2017) acknowledged several other limitations of using CODES data that apply to this analysis as well: that the hospital data indicate the amount charged for a service while the amount paid might be significantly less, likely do not include charges for professional services (e.g., physicians' fees), and may include charges related to the treatment of health conditions not related to a motor vehicle crash.

Conclusions

This analysis of crash data from 2016-2019 found that about 400 adult passengers in rear seating positions of passenger vehicles were injured in motor vehicle crashes each year. Only 46% of these individuals were reported to be belted. Two thirds of them were under the age of 40. Unbelted rear-seat passengers injured in crashes were 6.2 times likely more likely to have fatal injuries than a lower level of injury and 3.2 times more likely to have fatal or suspected serious/incapacitating injuries than suspected minor/non-incapacitating or possible injuries. Occupants were 1.9 times more likely to receive a higher level of transport to medical care compared to those who were belted. Motivating more Iowans to use seat belts when they ride in the back seat would significantly reduce crash injuries and fatalities.

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