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Age-based variability in the association between restraint use and injury type and severity in multi-occupant crashes

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Abstract

Purpose: Previous studies have shown older adults receive relatively less protection from seat belts against fatal injuries, however it is unknown how seat belt protection against severe and torso injury changes with age. We estimated age-based variability in seat belt protection against fatal injuries, injuries with maximum abbreviated injury scale greater than two (MAIS 3+), and torso injuries.

Methods: We leveraged the Crash Outcome Data Evaluation System (CODES) to analyze binary indicators of fatal, MAIS 3+, and torso injuries. Using a matched cohort design and conditional Poisson regression, we estimated age-based relative risks (RR) of the outcomes associated with seat belt use.

Results: Our results suggested that seat belts were highly protective against fatal injuries for all ages. For ages 16–30, seat belt use was associated with 66% lower risk of MAIS3+ injury (RR 0.34, 95% CI 0.30, 0.38) for occupants of the same vehicle, whereas for ages 75 and older, seat belt use was associated with 38% lower risk of MAIS3+ injury (RR 0.62; 95% CI 0.45, 0.86)

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for occupants in the same vehicle. The association between restraint use and torso injury also attenuated with age.

Conclusions: In multi-occupant crashes, seat belts were highly protective against fatal and MAIS3+ injury, however seat belt protection against MAIS3+ and torso injury attenuated with age.

Keywords

Motor vehicle crash; older adult occupants; seat belt use; fatal and severe injury; torso injury; matched cohort design

INTRODUCTION

Studies of bodily injuries in motor vehicle crashes (MVCs) show that older individuals have greater risk for severe and fatal injuries, and that a greater proportion of older adults in MVCs sustain thoracic, chest, and other torso injuries [1–13]. Furthermore, seat belts may provide less protection against fatal injuries to older vehicle occupants due to greater frailty, [14, 15] and older occupants may be more prone to torso injuries caused by seat belts [5]. For example, Ekambaram et al. (2019) attributed higher rates of skeletal chest injuries in middle aged and older occupants to forces being transmitted to the chest through the seat belt [5].

The literature on seat belt effectiveness in preventing motor vehicle fatalities and injuries is extensive. Comprehensive reviews and meta-analyses of fatal injuries and major injuries show, unsurprisingly, that seat belts are highly protective [16, 17]. Previous studies have also estimated what protection, if any, seat belts provide against torso injuries, including thoracic, abdominal, spinal, and pelvic injuries [18–22]. While epidemiological studies indicate that seat belts protect against torso injuries in various crash contexts [18, 21], torso injuries can also be caused by forces transferring from the belt to the occupant during a crash, and older, more frail occupants may be more prone to such injuries [23, 24]. Because seat belts are the most effective intervention for preventing MVC injury, and this protective effect against fatal injury has been shown to decrease with age, it is pertinent to estimate age-based variability in seat belt protection in other types of injuries, such as severe and torso injuries. Such analyses are scarce in the current literature. An analysis of crash reports from South Korea and found that those aged 65 and older who failed to wear a seat belt had higher odds of severe injury than their properly restrained counterparts, and that the effect size corresponding to seat belt protection was greater among those aged 65 and older compared to younger age groups [25]. However, to our knowledge no analogous study of severe injuries in the United States is available, and we are not aware of any study that estimates age-based variability in seat belt protection against torso injuries.

The Crash Outcome Data Evaluation System (CODES) is well-suited to address research questions about relationships between increasing age and seat belt efficacy. By linking crash data to hospital data, CODES provides detailed crash and injury information on a large sample of MVC occupants, overcoming the limitations other MVC data systems. CODES has great utility in a variety of traffic safety applications beyond the analysis of fatal MVCs,

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such as over-reporting of seat belt use [26], motorcycle helmet laws and brain injuries [27], and extremities injuries to bicyclists [28]. With a primary goal of better understanding how seat belt effectiveness against different injury types varies with age, the present study analyzes CODES data to assess age-based variability in the associations between seat belt use and three types of injuries – fatal, severe, and torso – in motor vehicle crashes.

MATERIALS AND METHODS

Data Source and Probabilistic Record Linkage:

CODES was initiated in 1992 by the National Highway Traffic Safety Administration [29]. It links crash data, obtained via police crash reports, and hospital data from emergency departments, as well as inpatient and outpatient clinics [29, 30]. Specifically, CODES links crash and hospital data via probabilistic linkage, a method which uses properties of variables common to both databases to determine the probability that two records refer to the same person and event and should be linked [31, 32]. CODES linkages are based on several factors including incident date, sex, age, date of birth, first and last name, seat position, hour of incident, vehicle type, and home zip code, and are executed using LinkSolv software [33].

Record linkage methods, including probabilistic linkage, are prone to several pitfalls that can introduce bias and underestimate variance when performing statistical inference with linked data. It is common to use a high probability cutoff (e.g., 0.9) to link records, and to treat linked records “true” links. Bias can occur when records that meet this threshold are systematically different from records that do not meet the threshold. Furthermore, treating links as “true” will yield variance estimates that do not account for uncertainty in the linkages, and underestimate the total variance. To mitigate these issues as much as possible, CODES data consider all possible records to potentially be linked. Linkage between a crash report and a hospital record occurs with probability equal to the estimated linkage probability. The procedure is repeated five times, resulting in five data sets, and a multiple imputation approach is used to propagate additional variability due to uncertain linkage (see the Statistical Analysis subsection for additional detail) [30]. Table S1 in the Supplemental Materials contains summary statistics about linkage probabilities.

Study Sample and Design:

We analyzed CODES data from Ohio, Utah, Maryland, and Kentucky. We included all occupants aged 16 and older of passenger vehicles (e.g., sedans, SUVs, pickup trucks, minivans) with model year 2000 or newer that were involved in police reported MVCs. We restricted the study period to span years 2009–2016, however Kentucky data were only available up to year 2014. Data were standardized according to the General Use Model format [30], allowing each site to share common variables.

Our study applied a matched cohort design [34], which is appealing for studies of MVC injury for several reasons. First, matching subjects by vehicle controls for vehicle- and crash-level characteristics, including crash severity, weather conditions, and emergency vehicle response time, which can be strongly associated with injury [34]. Second, it allows users to estimate relative risk using only vehicles in which at least one of the

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occupants experienced the outcome [34–38]. The estimates of relative risk are conditioned on occupants being in the same vehicle. Additional details on how the matched cohort data were used to estimate relative risks are provided later in the Statistical Analysis subsection.

Use of a matched cohort design required us to create three data sets, one for each of the three outcomes in our study (see the Study Variables subsection). These data sets consisted of multi-occupant vehicles in which one or more of the occupants experienced the respective outcomes, i.e., the data set for fatal injury consisted of multi-occupant vehicles in which at least one occupant died, and so on.

Study Variables:

We considered three binary outcome variables that were defined as follows:

1. Fatal Injury was equal to 1 when the hospital record or PAR indicates that the occupant died, and zero otherwise.
2. MAIS 3+ Injury was equal to 1 when the occupant's maximum abbreviated injury scale (MAIS) is equal to three or above, and zero otherwise [39]. Most injury scores were obtained from hospital diagnosis codes, however we also included occupants for whom no hospital injury data are available, but whose police-reported injury severity was fatal. Although we could have included those who were coded by police as having incapacitating injury, there is evidence that police-reported injuries do not align with diagnosed injuries, and that they tend to over-report severity [40, 41].
3. Torso Injury was equal to 1 when the occupant's International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code indicates they experienced an injury to their torso, and zero otherwise, for years 2009–2014. For years 2015 and 2016, we instead used the ICD-10 code. Torso injury was derived based on Barell Matrix body regions [42] and was defined as hospital diagnosed injury to the chest (thorax), abdomen, pelvis & urogenital region, trunk, back and buttock, or hip.

Our exposure variable was seat belt use, which was coded as binary (belted or not). Occupant age was an effect modifier, and was categorized into five groups: 16–30, 31–49, 50–64, 65–74, and 75 years or older. Sex (male vs. female), seating position (driver seat, right-front passenger seat, or rear passenger seat), and airbag deployment (yes vs. no) were included as possible confounders. In addition, potential vehicle- and crash-level confounders were controlled via matching.

Statistical Analysis:

We estimated the relative risks of the outcomes using conditional Poisson regression [34], which stratifies the analysis by vehicle and conditions on the number of occupants per vehicle that experienced the outcome. The models were fit via the PHREG procedure in SAS Ver. 9.4 [43]. First, we fit a model with the following linear component to data from all occupants:

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$$\log\left(E\left(Y_{ij}\right)\right) = \beta_{0j} + \beta_1 Restraint_{ij} + \boldsymbol{\gamma}\mathbf{x}_{ij}, \tag{1}$$

where Y_{ij} is an indicator of the outcome of interest for occupant i in vehicle j (either fatal, MAIS 3+, or torso injury), $Restraint_{ij}$ is an indicator of belt use, and $\mathbf{x}_{ij}$ is a covariate vector which encodes information about age (18–30, 31–49, 50–64, 65–74, 75), sex (male vs. female), seating position (driver seat, right-front passenger seat, or rear passenger seat), and airbag deployment (yes vs. no). β_1 measures the association between restraint use and injury for occupants in the same vehicle. We note that, although each vehicle has its own intercept, β_{0j}, because the model conditions on the number of injuries per vehicle, it has no bearing on the estimation of β_1 (see, for example, Chapter 11 of Agresti for additional details [44])

Next, we estimated age-based relative risks associated with seat belt use by adding an interaction term between age and seat belt use. We reported both adjusted and unadjusted relative risks for each age group, with adjusted relative risks controlling occupant-level factors sex, seating position, and airbag deployment, which could not be accounted for through the study design.

Crucially, the data likelihood for the models relied only on information from vehicles in which one or more occupants experienced the outcome, and not from the unobserved pairs in which no occupant experienced the outcome. This occurs because the data likelihood is conditioned on the number of injuries in each vehicle, therefore vehicles in which none of the occupants experienced an injury contribute nothing to the likelihood with respect to β_1. Additional details on estimating relative risk using matched cohort data is available in works by Cummings et al. [34, 45], and details on conditional regression with matched data is available in Chapter 11 of Agresti [44].

For each of the five linked data sets, links were treated as imputed values, and their corresponding estimates were combined into a single estimate using a multiple imputation approach [46]. We illustrate this process using the simplest version of our modeling framework, presented in equation (1). Let $\hat{\beta}_1^{OH(m)}$ denote the parameter estimate from the Ohio data resulting from imputation m, $m = 1, \ldots, 5$. Let $V^{OH(m)}$ denote the variance of $\hat{\beta}_1^{OH(m)}$. The combined parameter estimate for Ohio is:

$$\bar{\beta}_1^{OH} = \frac{1}{5}\sum_{m=1}^{5} \hat{\beta}_1^{OH(m)}$$

The average within-imputation variance is:

$$\bar{V}^{OH} = \frac{1}{5}\sum_{m=1}^{5} V^{OH(m)}$$

The between-imputation variance is:

$$B^{OH} = \frac{1}{5-1}\sum_{m=1}^{5}\left(\beta_1^{OH(m)} - \overline{\beta}_1^{OH}\right)^2$$

Finally, the total variance is

$$T^{OH} = \overline{V}^{OH} + \left(1 + \frac{1}{5}\right)B^{OH}$$

Using of T^{OH} to estimate the variance of $\overline{\beta}_1^{OH}$ accounted for both within- and between-imputation, assuring that the additional uncertainty resulting from probabilistic linkage was reflected. This estimation procedure occurred at each of the four sites.

To maintain subject privacy, individual data were not shared between sites. Rather, each site analyzed their data individually using a common SAS script. Results were then shared and combined via a fixed effects meta-analytic approach [47]. The approach begins by defining weights equal to the inverse variance of the site-specific parameter estimate, for example:

$$W^{OH} \equiv \frac{1}{T^{OH}}$$

Next, the overall parameter estimate is a weighted average of the site-specific parameter estimates:

$$\overline{\beta}_1 = \frac{W^{OH}\overline{\beta}_1^{OH} + W^{KY}\overline{\beta}_1^{KY} + W^{MD}\overline{\beta}_1^{MD} + W^{UT}\overline{\beta}_1^{UT}}{W^{OH} + W^{KY} + W^{MD} + W^{UT}}$$

Finally, the total variance of $\overline{\beta}_1$ is:

$$Var\left(\overline{\beta}_1\right) = \frac{1}{W^{OH} + W^{KY} + W^{MD} + W^{UT}}$$

Figure S1 summarizes our analysis strategy using a process flow diagram and is available in a Supplemental Document.

RESULTS:

The fatal injury data set consisted of 12,746 individuals on average (5,571 from Maryland, 4,735 from Ohio, 1,442 from Kentucky, 997 from Utah); the MAIS 3+ injury data set consisted of 43,664 individuals on average (21,780 from Maryland, 15,275 from Ohio, 4,362 from Kentucky, 2,247 from Utah); and the torso injury data set consisted of 218,626 individuals on average (93,184 from Maryland, 89,683 from Ohio, 27,308 from Kentucky, 8,451 from Utah). Variability in sample sizes were due to (i) state populations; (ii) types

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of hospitals included in the data set; (iii) cleanliness and comprehensiveness of PAR data, which affected the success of the linkage procedure; and (iv) years of data available.

Table 1 presents the percentage of occupants in the fatal injury, MAIS 3+ injury, and torso injury data sets sustaining the respective injuries. Due to the matched pairs study design, approximately 50% of subjects in their respective data set experienced the outcome, which does not reflect the true population prevalence of these injuries. For all three injury types, there is an apparent gradient relationship between higher age and higher percentage sustaining injuries.

Table 2 presents age-based relative risks (**RR**) of each injury outcome associated with seat belt use. The adjusted estimates corresponding to fatal injuries indicate that seat belts are strongly associated with lower risk of fatal injuries for occupants in the same vehicle, and there is little evidence that the relative risks vary by age. In contrast, while seat belt use was associated with lower risk of MAIS 3+ injury for all age groups, the association attenuated with age. Among the youngest age group, seat belt use was associated with 66% lower risk of MAIS 3+ injury (RR 0.34, 95% CI 0.31, 0.38) for occupants in the same vehicle, whereas among those aged 75 and older, seat belt use was associated with 36% lower risk of MAIS3+ injury (RR 0.64; 95% CI 0.47, 0.89) for occupants in the same vehicle. The attenuation in effectiveness is illustrated in Figure 1, which plots the adjusted relative risks with 95% confidence limits of fatal injury (Figure 1a), MAIS3+ injury (Figure 1b), and torso injury (Figure 1c).

The association between restraint use and torso injury also appeared to attenuate with age (Table 2; Figure 1c). In the youngest age groups (aged 16–30 and 31–49), seat belt use was associated with 19% lower risk of torso injury for occupants in the same vehicle (RR = 0.81; 95% CI 0.76, 0.87 for ages 16–30; RR = 0.81; 95% CI 0.75, 0.88 for ages 31–49). For those aged 50–64, seat belt use was only associated with 12% lower risk of torso injury (RR = 0.88; 95% CI 0.79, 0.99). Finally, for the older two age groups, there was practically no evidence to suggest that seat belt use or non-use was associated with risk of torso injury (RR = 0.93; 95% CI 0.75, 1.15 for ages 65–74; RR = 1.07; 95% CI 0.84, 1.36 for ages 75+).

DISCUSSION:

Using data from the CODES database, we estimated age-based associations between seat belt use and fatal, MAIS 3+, and torso injuries in multi-occupant crashes. To our knowledge it is the first study of US data that examines age-based variability in seatbelt protection against MAIS 3+ and torso injuries, as well as one of the first to use leverage hospital-diagnosed injuries for this purpose. As with other studies, we found strong evidence that seat belts are protective for fatal and MAIS 3+ injuries, however protection against MAIS 3+ injuries appeared to attenuate with age. There was also some evidence that restraints were protective for torso injuries among younger occupants, however this protection also attenuated with age. We did not find evidence that seat belts were protective against torso injuries for those aged 65 and older.

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The main strengths of our study were twofold. The first was the quality and scope of the data. When CODES was initiated in 1992, the primary data sources for studies of MVC outcomes in the United States were (i) FARS, a census of fatal MVCs; and (ii) police crash reports. Although FARS are gold standard data for studying fatal crashes, they exclude any crashes in which no occupant died, limiting their utility in studies of non-fatal injuries. Because seat belt benefit attenuates with crash severity [48], using FARS to estimate seat belt protection against MAIS3+ or torso injuries could have resulted in biased estimates of relative risk. On the other hand, while PAR data may provide a more complete set of injury crashes than FARS, police reported injuries may not accurately characterize true injury type and severity [40, 41]. The CODES database contains a wide set of injurious crashes, and include hospital diagnosed injuries. The second strength was the study design. Unlike more recent and publicly available crash databases such as the Crash Injury Research and Engineering Network and the Crash Investigation Sampling System, CODES had enough data that we could leverage a matched cohort design without sacrificing statistical precision. This design was used to control for potential confounding due to all crash- and vehicle-level factors, including those that could not easily by recorded in a crash report. Furthermore, by using matching to control for these factors rather than adjusting for them in a regression model, we did not need to impose a linear relationship between the outcomes and vehicle- and crash-level factors, which may not have accurately characterized their true relationships.

Our study contributes to the already strong evidence in support of seat belts as an effective means of reducing fatalities and injuries in occupants of motor vehicle crashes. We found that seat belts were associated with 74% lower risk of fatality overall for occupants in the same vehicle. This is consistent with previous studies of restraint use and fatality, many of which were included in a meta-analysis by Høye (2016) [17], whose summary effect indicated that seat belts were associated with 65% lower risk of fatal injury. It is noteworthy that, in contrast to Kahane (2013), we did not find evidence that seat belt protection against fatal injuries attenuated with age [14]. This may be due to our study consisting of newer vehicles on average (Kahane’s study included cars from 1960 through 2011), with a greater proportion of vehicles equipped with modern technology such as load limiters and pretensioners [49]. We also found that seat belts were associated with 64% lower risk of MAIS 3+ injury for occupants of all ages, which fell within confidence interval for the summary effect in a meta-analysis by Fouda Mbarga et al. (2018) [16].

The critical finding of this work was that seat belt protection against MAIS 3+ injury and torso injuries attenuated with age. Our findings with respect to MAIS 3+ injuries contrasted with Noh et al., who found that seat belt offered the greatest protection against severe injury for those aged 65 and older [25]. We found the opposite: seat belts exhibited the strongest protection against MAIS 3+ injuries among younger occupants, and the protection attenuated with age. Echoing previous calls to action by, for example, Carter et al. (2014) [3], the implications of our findings with respect to MAIS 3+ and torso injury are twofold. First, our results, like studies that found age-based variability in injury severity by age, underscore the need for accurate human conceptual models for all ages and body types. This assertion has been supported by studies of belt positioning [50, 51], body scans [52], and comparison of post-mortem subjects to crash-test dummies [53]. Second, injury prevention

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systems in motor vehicles should continue to be refined towards vulnerable populations such as older adults.

It is likely that a primary reason for the age-based attenuation in seat belt protection against MAIS 3+ and torso injuries is that older occupants are frailer than their younger counterparts [15]. As people age, both bone morphology and the mineral composition of their bones change, with older bones being stiffer but more brittle [54]. These changes mean that older individuals have lower tolerance to deflect forces from the seat belt that lead to torso injuries [55]. Non-epidemiological studies offer additional insight into why age-based variability in restraint effectiveness may exist. Bohman et al. (2019) found that posture changes due to aging can lead to suboptimal belt use [50]. Similarly, Brown et al. (2017) found that discomfort due to musculoskeletal morbidities in older motor vehicle occupants led to repositioning and use of external seat accessories [56]. Because repositioning can lead to suboptimal belt fit, Brown and colleagues underscored the importance of older adults being aware of proper belt fit. Innovations in seat belt design [57, 58] and increased availability of technology like pretensioners and load limiters [49, 59–61], may also improve torso and other injury outcomes in older adults.

Limitations:

Our study had several limitations. First, our data contained limited information about seating position, so we could not control for occupant seating position relative to impact location, which is well-established to be associated with injury. If it were also associated with seat belt use, seating position relative to impact location could have confounded the associations in our study. To test if our study conclusions could have been impacted by unmeasured confounding, for example due to seating position relative to impact location, we computed E-values [62] for each of the adjusted relative risks whose confidence intervals did not contain one (Table S2 in the Supplemental Materials). Based on this supplemental analysis, we find it unlikely that our conclusions could have been impacted by not including seating position relative to impact location, although unmeasured confounding of any type remains a limitation. Additional discussion is available in the Supplemental Materials.

Our second limitation was that torso injuries and most MAIS 3+ injuries could only be recorded for subjects whose PAR was linked to a hospital record. It is possible that, due to not being linked, seeking medical attention at a hospital not in our database, or failure to seek medical attention altogether, some subjects with these injuries were not coded as such or even excluded from the study. However, because we identified injuries using medical evaluation at the hospital, our definitions are likely more accurate/complete than studies utilizing only data derived from police narrative. Third, our data were drawn from only four states, and were not representative of the entire United States. While we have little reason to believe that true seat belt effectiveness varies between states, additional data from other states would have improved our study. However, on balance, to our knowledge no set of linked crash and hospital data have national scope (except for FARS, which only includes fatal crashes), and a strength of our data is that they draw from states representing three out of four United States Census regions, providing a variety of geographic of geographic and urban/rural driving environments. Fourth, seat belt use was only available as a binary

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variable. We could not assess proper use, nor if the vehicle was equipped with technology such as load limiters and pretensioners, which were installed in all US vehicles made in 2008 or later [49]. Fifth, while our linkage methodology aimed to mitigate as much as possible issues of bias and underestimation of variance that can arise when using linked data, it cannot fully overcome all issues related to incorrect or incomplete linkage. Finally, our study design only included individuals in multi-occupant vehicles, most of whom were treated in hospital. Those in single-occupant vehicles, and those who sustained MAIS 3+ or torso injuries but were not treated in hospital could have differed from our study population in terms of crash, vehicle, and/or driver characteristics, hence our results may not be generalizable to the entire population of motor vehicle occupants.

CONCLUSIONS:

Our study suggests that, while seat belts are highly protective against fatal and MAIS 3+ injuries in multi-occupant crashes, older occupants do not receive the same seat belt benefits as their younger counterparts for MAIS3+ and torso injuries. We caution that results may not be generalizable beyond those in multi-occupant crashes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data Statement

The data that support the findings of this study were provided from various entities. They contain protected health information and cannot be made publicly available. Ohio data were provided by the Ohio Department of Public Safety and Ohio Hospital Association, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Abbreviations:

MVC	Motor Vehicle Crash
CODES	Crash Outcome Data Evaluation System
PAR	Police Accident Report
FARS	Fatal Analysis Reporting System
ICD	International Classification of Diseases
MAIS	Maximum Abbreviated Injury Scale

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RR	Relative Risk
CI	Confidence Interval

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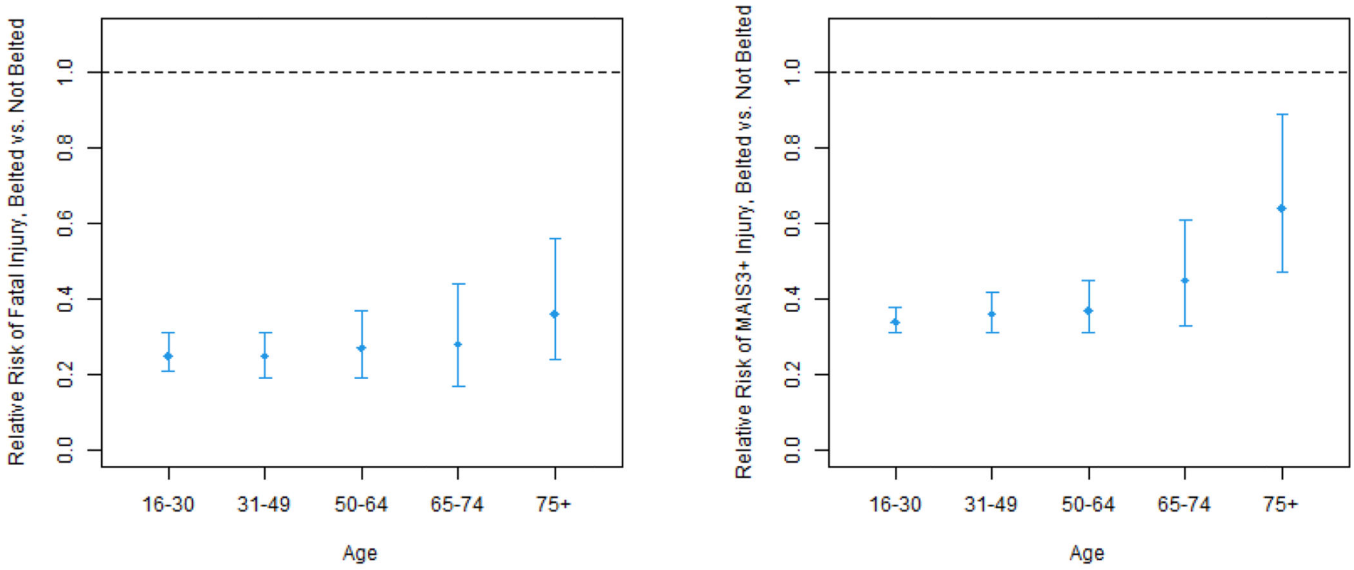
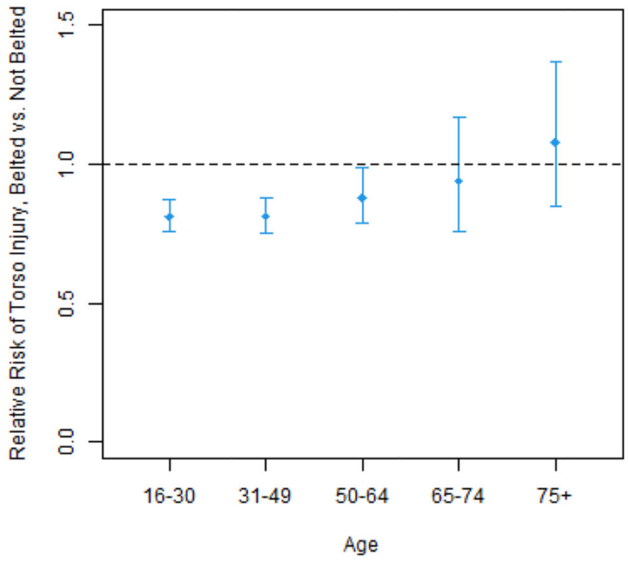


(a) Fatal Injury

(b) MAIS 3+ Injury



(c) Torso Injury

Figure 1:

Adjusted relative risks and confidence intervals of fatal injury (a), MAIS 3+ injury (b), and torso injury (c) for belted vs. non-belted occupants by age group.

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Table 1:

Percentages of injuries sustained among subjects in the fatal, MAIS 3+, and torso injury data sets by age and restraint use.

Age	Belt Use	Fatal Injury (n = 12,746)[a]	MAIS 3+ Injury (n = 43,664)[a]	Torso Injury (n = 218,626)[a]
All	Any	51.2	49.5	48.7
16–30	Any	47.1	45.2	44.9
31–49	Any	49.1	49.8	50.2
50–64	Any	49.3	53.1	52.9
65–74	Any	55.7	55.2	54.0
75+	Any	67.7	62.4	57.0
All	Belted	45.1	45.2	49.9
All	Unbelted	58.1	55.7	43.5
16–30	Belted	38.1	39.2	46.1
	Unbelted	54.1	51.4	40.8
31–49	Belted	40.0	43.4	50.8
	Unbelted	56.7	58.0	47.1
50–64	Belted	48.4	49.5	53.6
	Unbelted	60.8	62.3	46.7
65–74	Belted	49.8	52.8	54.6
	Unbelted	71.3	65.6	47.6
75+	Belted	63.8	60.9	57.9
	Unbelted	82.4	72.8	48.6

[a] Because sample sizes can vary due to probabilistic linkage, n refers to the average sample size across the five data sets that were generated.

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Table 2:

Unadjusted and adjusted relative risks of fatal, MAIS 3+, and torso injury associated with belt use for the full samples and broken up by age groups. Asterisks denote that there is age-based variability in the association between restraint use and the outcome.

Outcome	Age Group	Unadjusted RR: belted vs. unbelted	Adjusted RR: belted vs. unbelted
Fatal Injury	All	0.27 (0.24, 0.31)	0.26 (0.23, 0.30)
	16–30	0.27 (0.22, 0.32)	0.26 (0.21, 0.31)
	31–49	0.26 (0.20, 0.32)	0.25 (0.19, 0.31)
	50–64	0.27 (0.20, 0.37)	0.27 (0.19, 0.37)
	65–74	0.26 (0.16, 0.40)	0.28 (0.17, 0.44)
	75+	0.36 (0.23, 0.55)	0.36 (0.24, 0.56)
MAIS3+*	All	0.36 (0.33, 0.40)	0.36 (0.33, 0.39)
	16–30	0.33 (0.30, 0.38)	0.34 (0.31, 0.39)
	31–49	0.35 (0.30, 0.40)	0.36 (0.31, 0.42)
	50–64	0.38 (0.31, 0.46)	0.37 (0.31, 0.45)
	65–74	0.43 (0.32, 0.57)	0.45 (0.33, 0.61)
	75+	0.62 (0.46, 0.86)	0.64 (0.47, 0.89)
Torso Injury	All	0.90 (0.85, 0.94)	0.84 (0.80, 0.89)
	16–30	0.85 (0.80, 0.90)	0.81 (0.76, 0.87)
	31–49	0.86 (0.80, 0.93)	0.81 (0.75, 0.88)
	50–64	0.94 (0.84, 1.06)	0.88 (0.79, 0.99)
	65–74	0.98 (0.79, 1.21)	0.94 (0.76, 1.17)
	75+	1.10 (0.87, 1.40)	1.08 (0.85, 1.37)