CHARACTERISTICS OF INJURIES IN FATALLY INJURED RESTRAINED OCCUPANTS IN FRONTAL CRASHES

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Paper Number 13-0349

ABSTRACT

Frontal crashes have been studied extensively and have been the target of many regulatory and motor vehicle safety-enhancement efforts. While fatalities in frontal crashes, and in crashes in general, have decreased over time, there is still interest in understanding the issues that lead to these continued fatalities. This study is an extension of a prior effort that involved in-depth reviews of frontal crash fatality cases, but is conducted from an injury perspective.

Occupants who were involved in frontal crashes and restrained by a seat belt and deployed frontal air bag of late-model vehicles were selected from the National Automotive Sampling System-Crashowrhtiness Data System and Crash Injury Research and Engineering Netork databases. The cases were individually reviewed, and key factors that contributed to the fatal nature of the crash were identified based on coded data elements and other evidence in the case. Cause of death information was further analyzed along with the coded injury causation data and occupant time-to-death.

INTRODUCTION

Fatalities resulting from motor vehicle crashes have been on a downward trend, with the most recent year-over-year comparison representing a 1.9% decrease to 32,367 for 2011 [NHTSA, 2012]. While the decrease in the total number, as well as the rate per mile traveled, is an encouraging sign, the safety community continues to work towards reducing those numbers as much as possible. Frontal crashes make up the largest subset of fatal crashes, and have thus been the subject of much research.

The National Highway Traffic Safety Administration (NHTSA) undertook a large study of fatal frontal crashes and published the findings in Bean et al. [2009] and Rudd et al. [2009]. This study focused on restrained occupants, and sought to identify the factors that led to their death despite being in a modern vehicle with frontal air bags. Brumbelow et al. [2009] conducted a similar study looking at the frontal crash performance in the field of vehicles that had received the top rating in the Insurance Institute for Highway Safety (IIHS) offset deformable barrier frontal crash test. The NHTSA and IIHS studies both identified similar factors that were common among fatal frontal crashes, namely issues related to the extent of engagement across the front plane of the vehicle and occupant-related factors. As a result of these studies, NHTSA and IIHS both began the development of test procedures to evaluate vehicle and occupant performance in small overlap frontal and oblique crashes [IIHS, 2012; Saunders et al. 2012]

It was desired to take the work presented in Rudd et al. [2009] further by looking at the cases from an injury perspective. Injuries were considered in the review of the cases in the earlier study, but the findings did not address the nature of the injuries and their causation. The objectives of this study were to evaluate the cause of death and injury causation associated with fatalities of properly restrained occupants in frontal crashes. By focusing on the injuries and their associated causal factors, the outcome of this study can help guide efforts to improve vehicle and restraint performance as well as determine human injury research priorities.

METHODS

The fatality cases making up this study were selected from the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) and the Crash Injury Research and Engineering Network (CIREN) data systems. Both data systems collect

vehicle- and crash-based data using the same protocols, and differ primarily in the collection of occupant-based data. Since CIREN is a trauma center-based data collection program, cases include more comprehensive occupant injury and treatment data. NASS-CDS cases were selected from case years 2000 through 2011 and CIREN cases were selected from all available cases in the system.

While this study was an extension of that presented in Bean et al. [2009] and Rudd et al. [2009], slightly different case inclusion criteria were employed to meet this study's injury-focused objectives. The occupants selected for this study must have been seated in either of the outboard front-row seating positions of a passenger vehicle of model year 2000 or newer, and must have been restrained by an appropriately-worn manual three-point belt restraint and deployed frontal air bag. Furthermore, the crash inclusion criteria were enhanced to capture additional frontal crashes using a slightly less restrictive filter. The filter in the prior study required the General Area of Damage for the most significant event (GAD1) to be the frontal plane only, while this study utilized the algorithm presented by Halloway et al. [2011]. The revised criteria captured a few additional crashes where the coded GAD1 was to the frontal portion of the left or right plane and the principal direction of force was between 320° and 0° on the left and 0° and 40° on the right.

Bean et al. [2009] assigned each occupant fatality to one or two high-level crash-classification bins in order to best characterize the most important feature of the crash experience. The five bins created were: exceedingly severe crash or anomaly, corner and/or oblique impact, narrow object impact, underride rear/side of heavy vehicle, and vulnerable occupant. For the cases that were evaluated in Bean et al. [2009] that were also included in this study, the classification(s) were carried over for this evaluation. Cases that were new to this study were evaluated by the author and assigned to the categories based on the same evaluation criteria. Some cases from the prior study, as well as a few of the additional cases identified with the expanded crash criteria, were deemed anomaly cases due to unusual crash circumstances, and were removed from this injury-focused study. Furthermore, the category for impact to the side or rear of a heavy vehicle was expanded to include impacts to the front of a heavy vehicle as well in order to capture those crashes where the mass and geometric mismatches play a role.

Following the initial query, the cases were reviewed individually to confirm coherence with the study's objective of evaluating properly belted and air bag-restrained occupants in frontal impacts. Some of the crashes were removed from the study based on unusual crash configurations, such as being struck at the windshield level by an airborne vehicle during a rollover, or cases in which the occupant died in a post-crash fire. Cases that were identified in Bean et al. [2009] as anomaly cases were also removed.

The primary focus of this analysis was cause of death, injury sourcing, and hospital stay data, which were extracted when available, but were not coded in all cases. Injury severity was based on the Abbreviated Injury Scale (AIS; AAAM, 2005) and multi-system trauma was indicated by the Injury Severity Score (ISS). The NASS-CDS and CIREN cases were combined for this analysis, as the intent was not to conduct any nationally-representative analysis of the data.

RESULTS

A total of 189 fatalities, from 184 vehicles in 182 crashes, were selected from the CDS and CIREN databases for analysis in this study. Fifty-eight percent (58%) of the occupants were male and 85% were in the driver's seat. There were 161 case occupants from the CDS database and 25 from CIREN, while there were three that exist in both data systems. The occupants ranged in age from 16 to 89 years of age. Figure 1 shows a breakdown of occupant age. A full listing of the cases is provided in Appendix A.

Most of the fatally injured occupants were riding in passenger cars, with about one third riding in light trucks and vans. The large majority of the case vehicles struck other vehicles (81%), while 13% struck trees or poles and 6% struck a building, bridge support, or embankment. The breakdown of the vehicle type is shown in Figure 2, and the model year breakdown is shown in Figure 3. Due to the severity and circumstances of many of these crashes, velocity

change (delta-v) was only available for less than half of the case vehicles. Of those vehicles with a coded delta-v, the lowest was 17 km/h (11 mph) and the highest was 145 km/h (90 mph). Occupants over 65 years of age comprised the majority of occupants in crashes with delta-v below 45 km/h (28 mph).

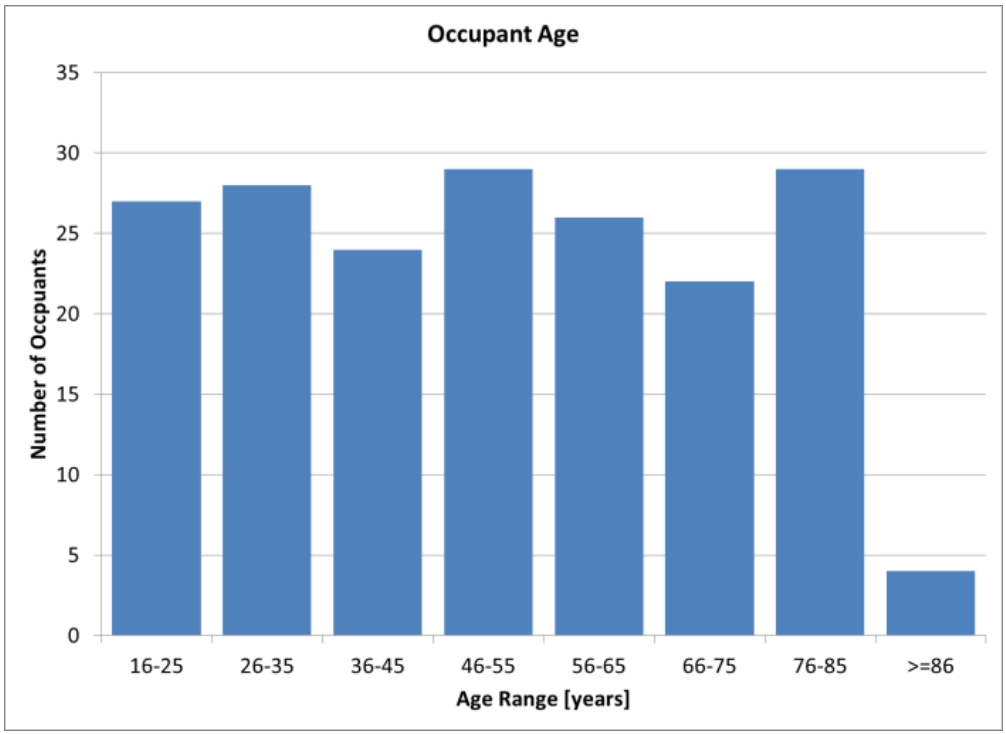

Figure 1. Breakdown of occupant age.

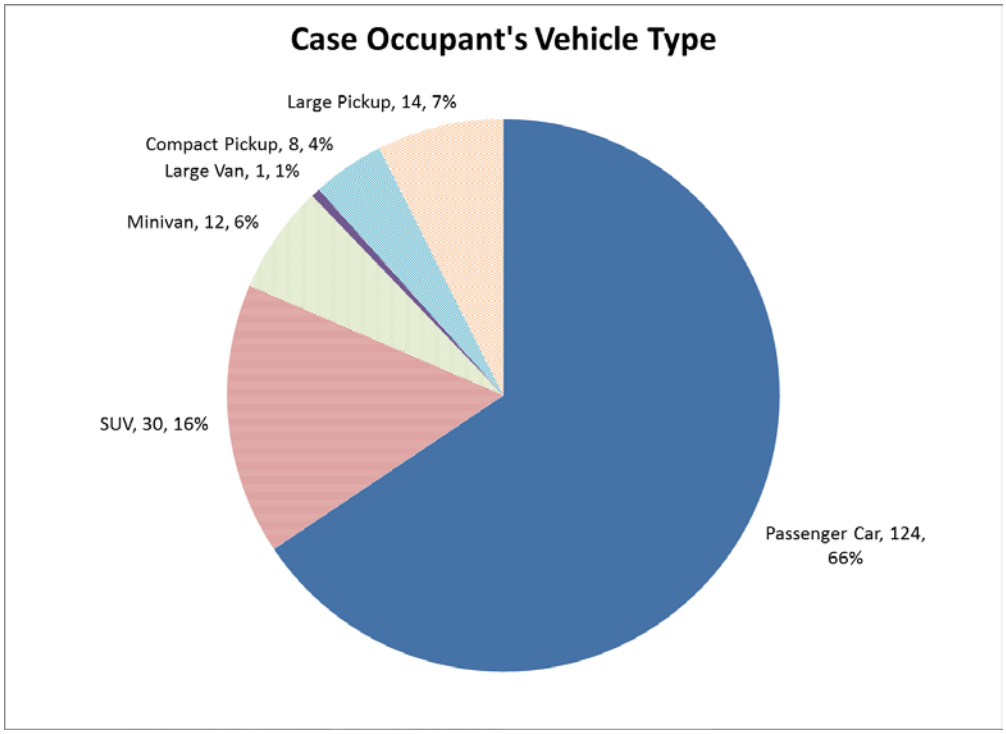

Figure 2. Vehicle type breakdown.

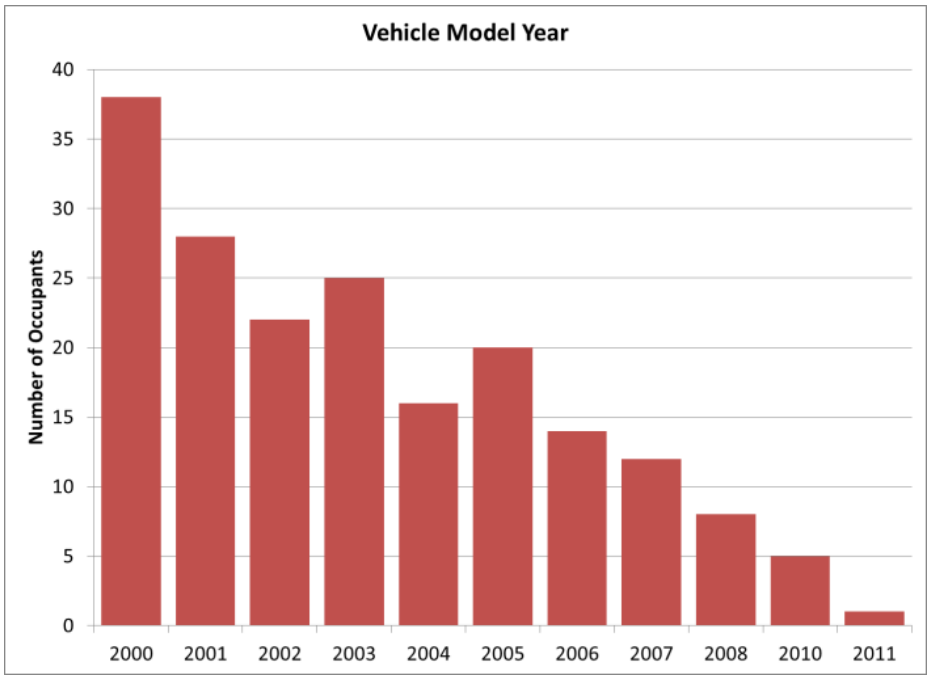

Figure 3. Vehicle model year breakdown.

Occupant outcome in the form of Injury Severity Score (ISS) and Maximum Abbreviated Injury Scale (MAIS) is shown in Figures 4 and 5. Some of the cases did not contain complete injury information because of limited ability to obtain adequate records in some fatal cases. Furthermore, the level of detail varies given that some occupants who are hospitalized will have more thorough documentation than those who may undergo only an external autopsy. The majority of the occupants in this study either died on scene or did not survive to be admitted to a hospital. Figure 6 shows the breakdown of length of stay for different initial medical facilities. It should be noted that CDS does not consider a fatality that occurs after 30 days to be a crash fatality, but CIREN did have one case occupant who was hospitalized for 57 days. The duration of the hospital stay was shown as a function of age in Figure 7, where it is evident that younger occupants did not have as many long-duration hospital stays prior to death as older occupants.

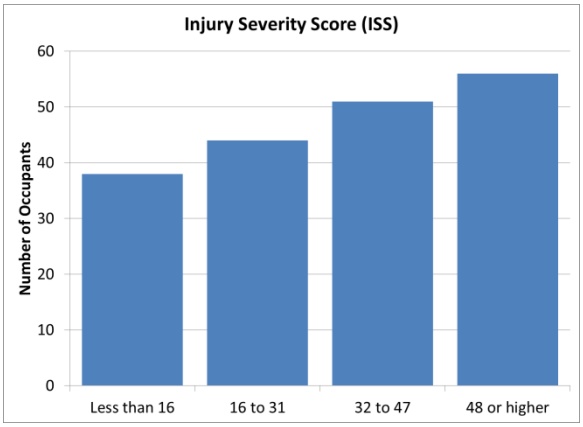

Figure 4. Injury Severity Score (ISS) breakdown.

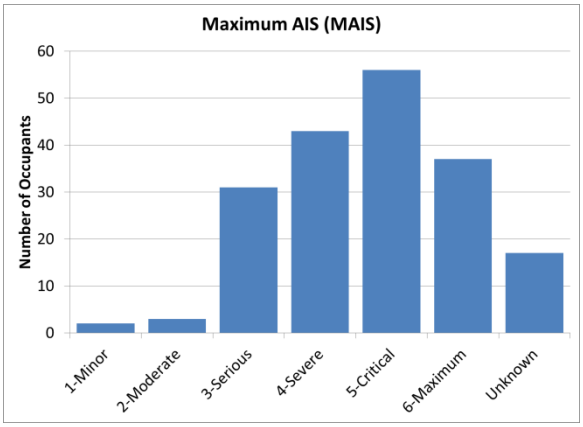

Figure 5. Maximum AIS severity breakdown.

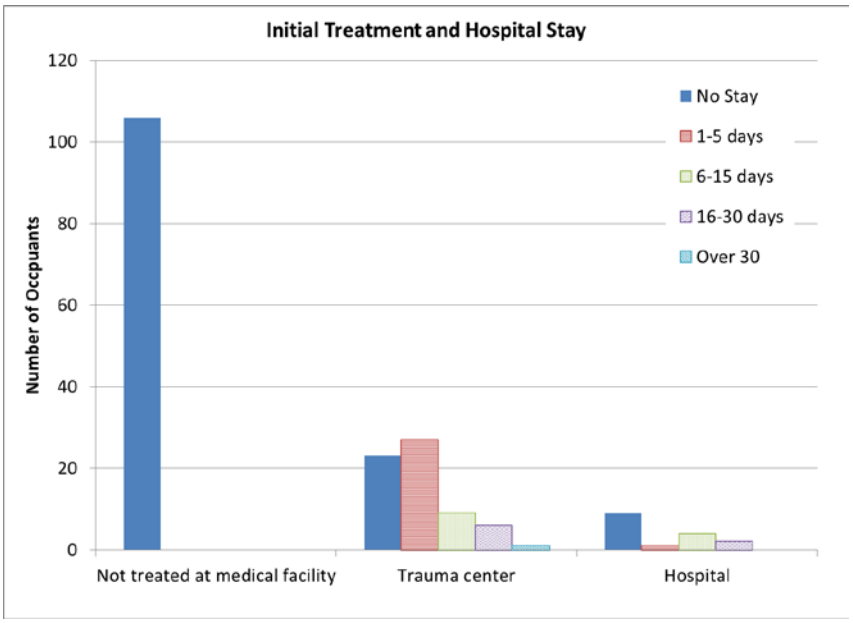

Figure 6. Initial medical facility and duration of hospital stay.

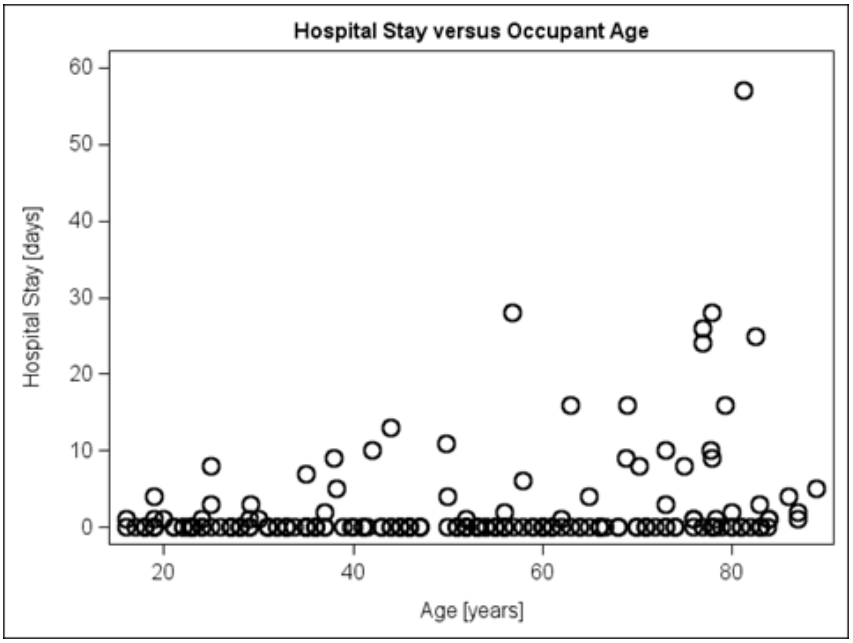

Figure 7. Hospital stay versus age.

Most of the fatalities were attributed to either a head or chest injury based on the first coded cause of death, which is shown in Figure 8. The occupants are broken down into four age ranges to show an age effect. In some cases, the victim's death was the result of complications that were not tied to a specific injury sustained in the crash, but were related to complications that arose during treatment.

The injury source associated with the first coded cause of death, for those occupants who did not die of complications, was most often the steering assembly, seat belt or part of another vehicle. The injury sources associated with the cause of death are shown for all occupants who did not die of complications in Figure 9.

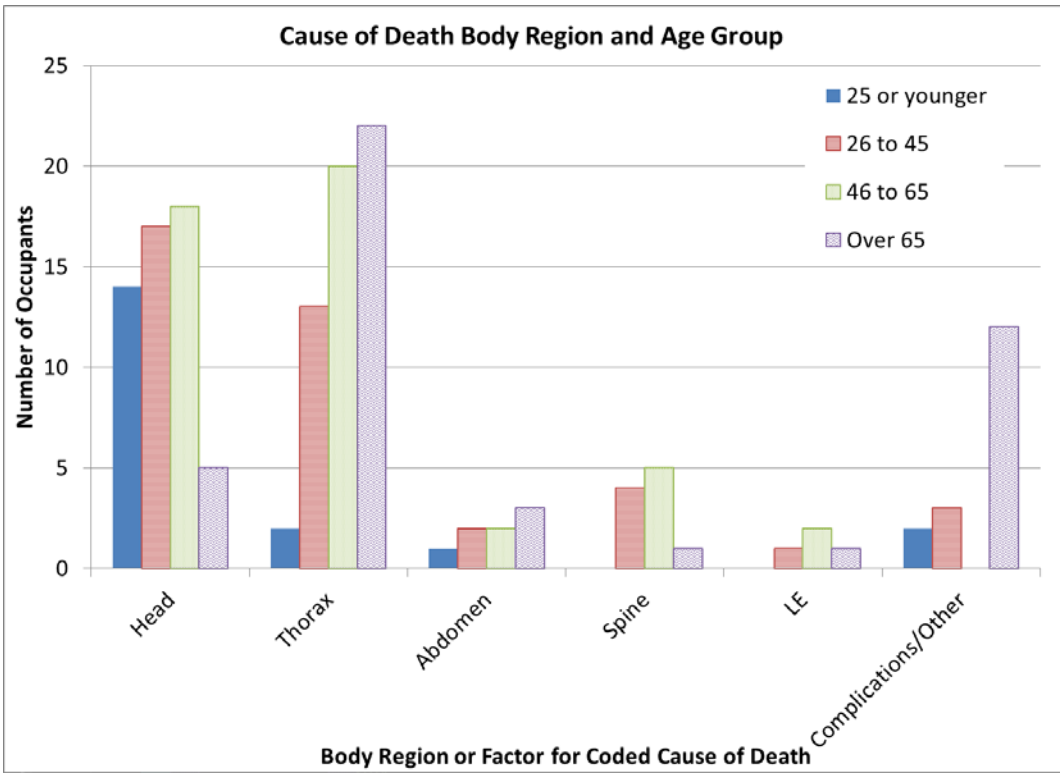

Figure 8. Occupant cause of death by body region (or complication) broken down into age ranges.

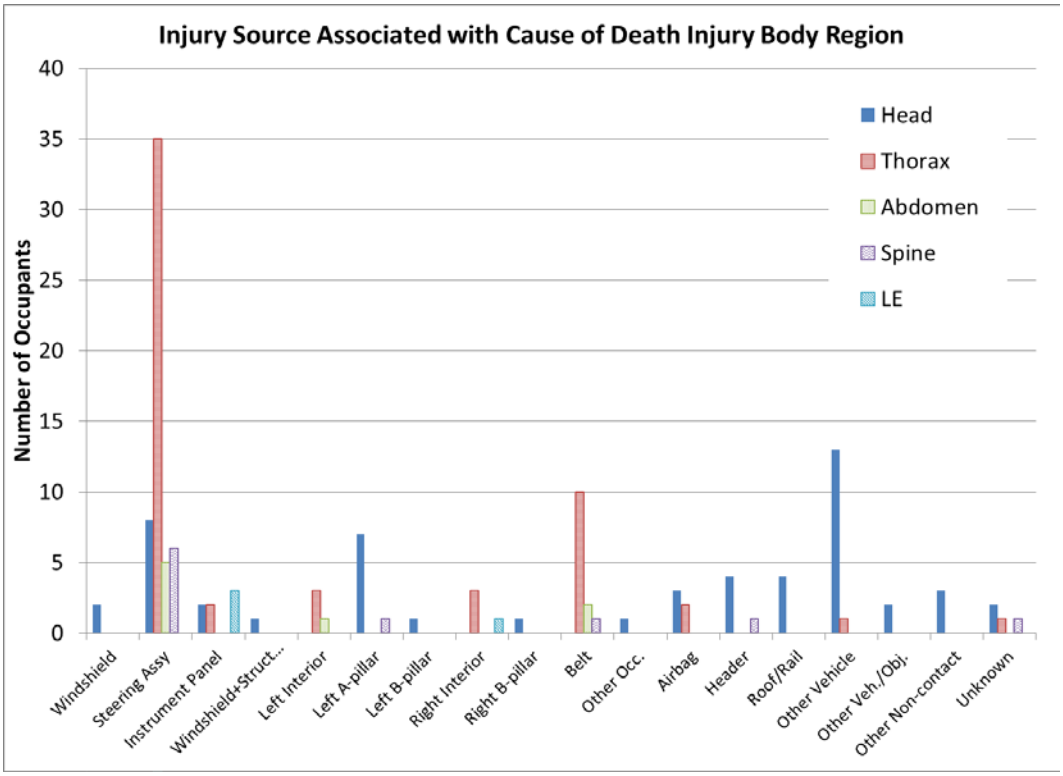

Figure 9. Coded injury source associated with first cause of death injury.

Each of the crashes was assigned to one or more categories to characterize the nature of the fatality. Table 1 shows the number of crashes in each category. Some crashes were in multiple categories if more than one relevant factor applied. Due to the size of the dataset and the small numbers in each category, combined categories were also developed to aid in analysis. For example, since impacts to heavy vehicles typically involve mass and geometric mismatch, regardless of whether the side, front, or rear of the heavy vehicle was involved, a single heavy vehicle category was created that contained all three.

Table 1.
Fatality categorization – note that each crash may be assigned to multiple categories

	Corner/Oblique		Heavy Vehicle Impact/Underride				Occupant Vulnerability		
Exceedingly Severe	Corner Crash	Oblique Crash	Heavy Vehicle Front	Heavy Vehicle Side	Heavy Vehicle Rear	Narrow Object	Occupant Age	Occupant Health	Other
55 (29%)	43 (23%)	31 (16%)	14 (7%)	5 (3%)	21 (11%)	14 (7%)	40 (21%)	8 (4%)	6 (3%)
	67 (35%)		40 (21%)				45 (24%)		

DISCUSSION

The overall demographics of the study set was evenly distributed from young to old, and all of the primary passenger vehicle classes were represented. Most of the deaths occurred either on scene or on the day of the crash without an overnight stay in a hospital. While some of the cases included in this study did not include thorough injury coding, there was sufficient data to investigate the injuries that led to the occupants' deaths.

Injury, Injury Severity Measures, and Injury Sources

The severity of the occupants' injuries, as assessed by AIS and ISS metrics, was generally severe in nature, but there were some MAIS and ISS values that were low relative to what would be expected for a fatally injured occupant. This is largely due to the number of cases where the decedent does not undergo a full autopsy or when full injury records were not received, and the full extent of injuries is not coded in the database. There are a few instances in which the initial injury severity was not very high, but the occupant died later of complications related to their injuries. In such a situation, the AIS and ISS wouldn't necessarily suggest a fatality. The cases shown in Figure 5 with only AIS 1 or 2 injuries were instances in which a thorough assessment of the injuries was not available.

The first coded cause of death was most commonly coded to the thorax, followed by the head and then spinal cord. Of note from Figure 8 is that the oldest occupant group (over 65 years of age) died more often as a result of thoracic injuries or complications whereas the younger occupants typically died of head injuries, which is in agreement with the findings of Kent et al. [2005] for drivers in all crash modes.

The most commonly coded head injury was a brain stem laceration, and all brain stem injuries accounted for more than one third of the fatalities for which a head injury was the coded cause of death. Injuries to the cerebrum also accounted for about a third of the head-related fatalities, with the remainder being vault and basilar skull fractures as well as head crush injury. The fatal head injuries were coded to many sources inside the vehicle as shown in Figure 9, but the most common single source was the other vehicle. This primarily represents the cases involving underride of a heavy vehicle, where the structure of the other vehicle interacts with the upper portions of the case vehicle's occupant compartment. In these cases, large intrusions result, and the occupant's head interacts directly with the rear or side surface of the opposing heavy vehicle. The

steering assembly and A-pillar were also common sources, the former occurring in cases where the steering column moves up and toward the occupant as the occupant compresses the air bag while the latter occurring primarily in crashes with oblique occupant kinematics.

Thoracic injuries coded as cause of death involved mostly heart lacerations and vascular (aorta) injuries, each accounting for nearly one third of thorax-related deaths. Rib fractures also accounted for nearly one third of the thorax-related deaths, though this was likely a result of many cases not undergoing a full internal autopsy to document the injuries to the thoracic contents, which were more likely to have been the true reason for death. The thoracic injuries implicated with the death were almost always sourced to the steering assembly or seat belt.

While fewer in number than deaths linked to the head or thorax, those associated with a spinal cord injury occurred mostly in the middle-aged occupant group. All of these fatalities occurred on the day of the crash with no overnight hospital stay. The most common source of the cord injuries was the steering assembly.

Fatalities that were coded as a result of abdominal injuries occurred in eight cases, and the steering assembly was the most common source associated with the injury. These injuries were mostly severe internal organ injuries with significant bleeding. The fatalities that were associated with the injuries to the lower extremities involved a pelvic fracture in three cases and an amputation in one case. These injuries were associated with instrument panel contact or door contact, and resulted in death via excessive bleeding or complications.

Exceedingly Severe Classification

When the cases were segregated by their exceedingly severe classification, one notable finding was that the crash severity was not as much of a factor for occupants in the oldest age group (Figure 10). Due to their fragility and frailty, older occupants comprised over 35% of the cases not considered to be exceedingly severe, but accounted for only 13% of exceedingly severe crashes. The body regions associated with the cause of death were generally similar regardless of crash severity group, though the spinal cord injuries were more prevalent in the exceedingly severe cases.

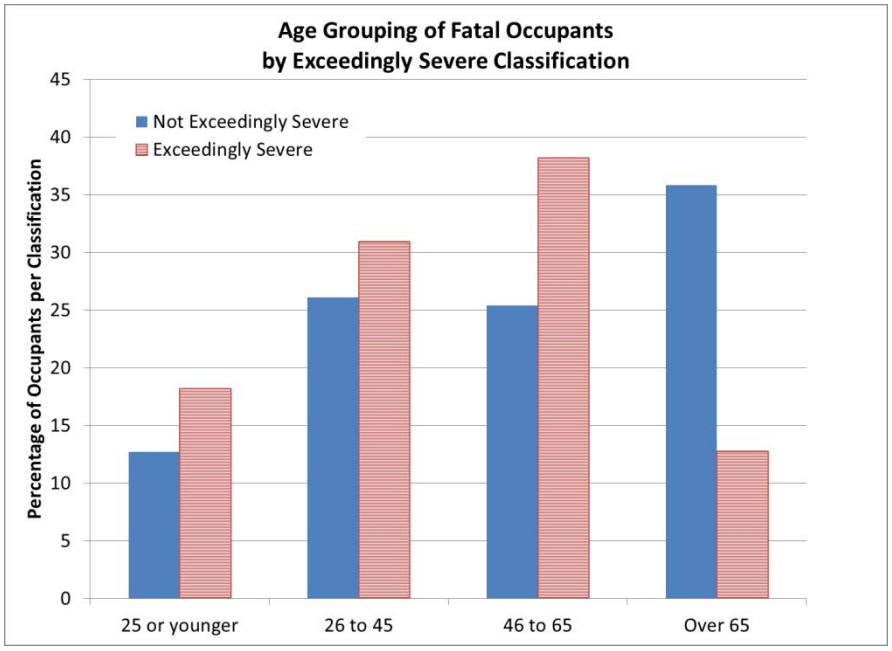

Figure 10. Frequency of occupants in exceedingly severe crashes by age groups.

As discussed in Rudd et al. [2009], crashes in the exceedingly severe category were typically those at higher speeds and involve a delta-v greater than vehicles would be exposed to in frontal crash tests required by Federal motor vehicle safety standards or the New Car Assessment Program, in which the vehicle's structure and restraints were taxed far beyond their design targets. In these crashes, it is common for the occupant compartment to deform such that any occupant restraint system could not effectively manage the occupant's ride-down of the crash. CDS occupant 2009-49-102-1-1 was the 28 year old female driver of a 2001 Jeep Grand Cherokee, which impacted a 2008 Mercury Milan. The Jeep was traveling in the wrong direction on a high-speed divided highway prior to the crash, and the resulting impact led to a major wheelbase reduction and collapse of the occupant compartment space (Figure 11a). This collapse caused the floor under the driver's seat to move downward while the steering column likely moved rearward and upward (Figure 11b), though the unknown extent of extrication damage makes such an assessment uncertain. Regardless, the development of countermeasures for crashes of this severity poses challenges in the crashworthiness realm.

Figure 11. Left image (a) shows front right oblique view of 2009-49-102-1 and right image (b) shows case occupant's seating position.

Corner/Oblique Classification

A number of recent studies have focused on small overlap and oblique frontal crashes and the associated challenges to the structure and restraint systems. Crashes in this study were originally classified as corner and/or oblique, but the categories were combined since the occupant kinematics and vehicle interaction have been found to be similar [Rudd et al. 2011]. Figure 12 shows the frequency of fatalities for the body region associated with the first coded cause of death by the corner/oblique classification. There is a notable increase in the proportion of head-related fatalities in the corner/oblique group. When the associated injury sources are compared, as in Figure 13, there is a trend towards more contacts towards the sides of the vehicle with the A-pillars, roof rails and side door panels accounting for a greater share of the injury sources. This finding is coincident with other studies that have demonstrated the occupants' sub-optimal interaction with the frontal air bag due to their oblique kinematics.

CIREN case 431208557 is an oblique crash between a 2010 Toyota Prius and a 2009 Pontiac G6. The driver and right-front passenger of the Prius were both enrolled as CIREN occupants, and both succumbed to their injuries. Figure 14a shows the exterior damage and Figure 14b shows the driver's seating position. On impact, the 49 year old male driver moved forward and to the left in response to the 340° direction of force such that his head made contact with the left roof side rail (adjacent to upper A-pillar). The driver suffered a traumatic brain injury and remained deeply comatose until he died ten days after the crash upon removal from life support.

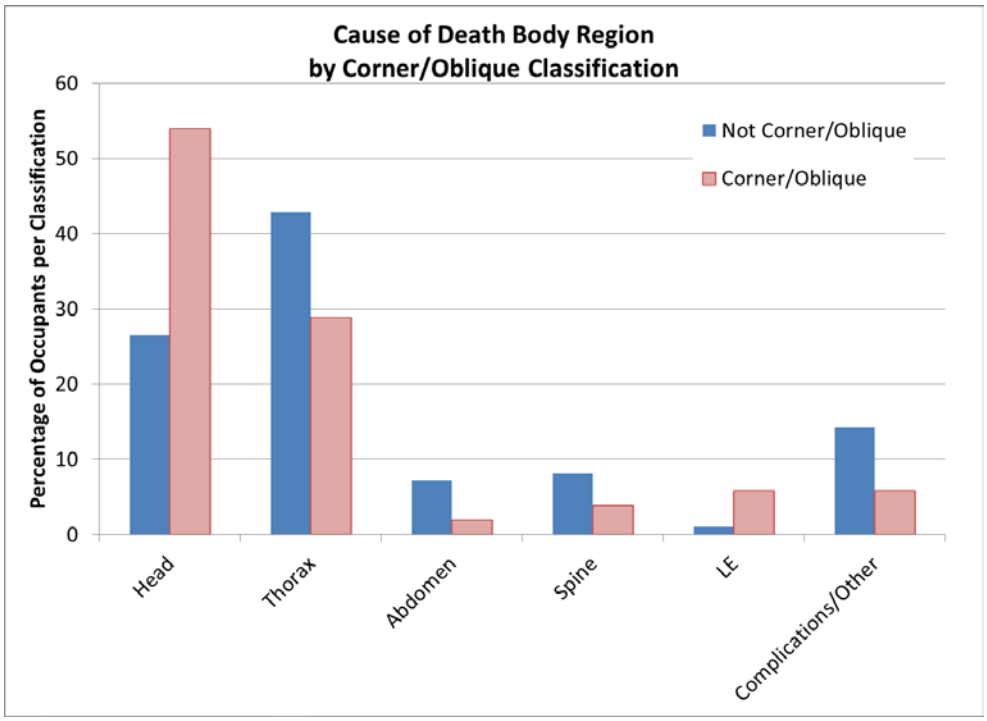

Figure 12. Occupant cause of death by body region (or complication) based on whether the crash was considered a corner or oblique impact.

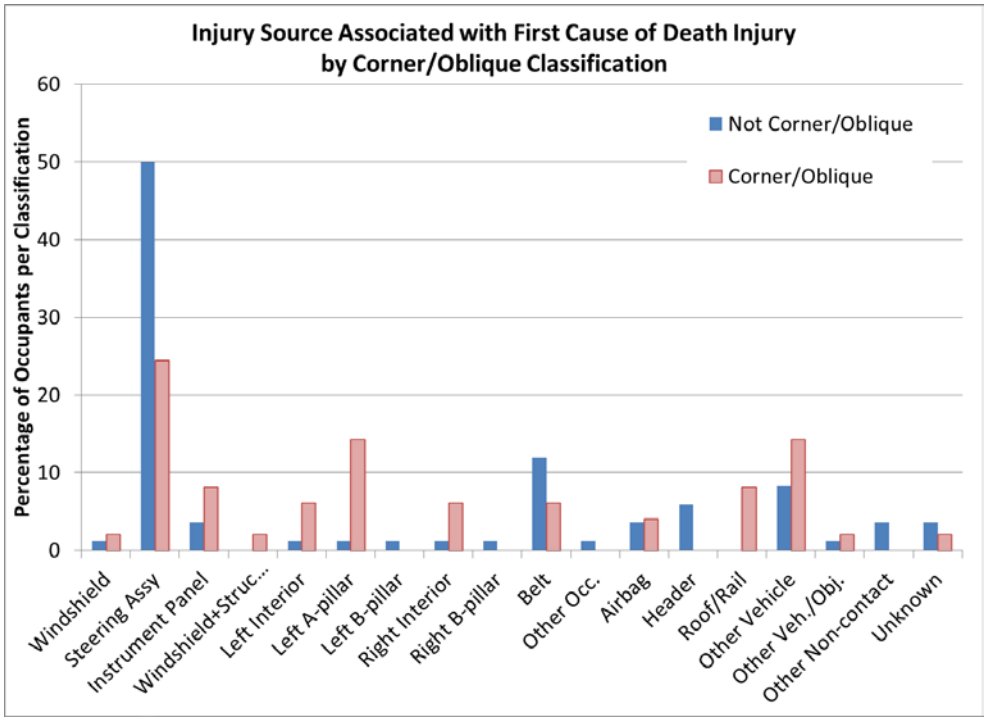

Figure 13. Sources of injury for cause of death injuries based on whether the crash was considered a corner or oblique impact.

The side curtain air bag did not deploy in this crash, but it is uncertain whether it would have provided cushioning for this particular head impact. While this was a severe crash, the occupant's slightly lateral head motion in conjunction with the intrusion of the A-pillar was deemed to be the critical feature leading to the head injury. Aside from the head injuries, none of the driver's other injuries would likely have resulted in death.

Figure 14. Left image (a) shows front left oblique view of 431208557 and right image (b) shows case occupant's seating position.

Vulnerable Occupant Classification

Another combined category was created for vulnerable occupants to include those with vulnerabilities associated with their age or health. Some occupants were determined to have vulnerabilities associated with their age and health, but the vast majority of the occupants in this category were there due to their age alone. The average age of the vulnerable occupants was 76 years compared to 43 for the base group. Vulnerable occupants were more likely to die of thoracic injuries or complications compared to younger occupants (Figure 15), and a greater proportion of vulnerable occupants had extended hospital stays prior to their death (Figure 16). These findings echo those found by Kent et al. [2005]

While a comparison of ISS is somewhat limited in its utility due to the number of cases without full injury data, the vulnerable occupant group did demonstrate a general trend toward a lower ISS value than the non-vulnerable occupant group in all age ranges. A comparison of the injury sources for the occupant vulnerability groups indicates that the seat belt was responsible for the cause of death in a greater portion of the vulnerable occupant fatalities.

CIREN case 852131345 involves an 82 year old female right front passenger in a 2004 Nissan Maxima which contacted the front of a large truck. There was some underride of the occupant's vehicle relative to the truck, but it was not considered a factor for this occupant since the intrusions at her seating position were minor (Figure 17). She sustained several rib fractures, lung contusion and laceration, and fractures to the lower extremities and lumbar spine. The thoracic injuries were attributed to belt loading, and the number of fractured ribs resulted in an AIS 5 code. She survived 25 days in the hospital and died of acute respiratory distress syndrome after removal of life support. The 81 year old male driver of this vehicle survived, and was hospitalized for six days for sacral and lumbar spine fractures.

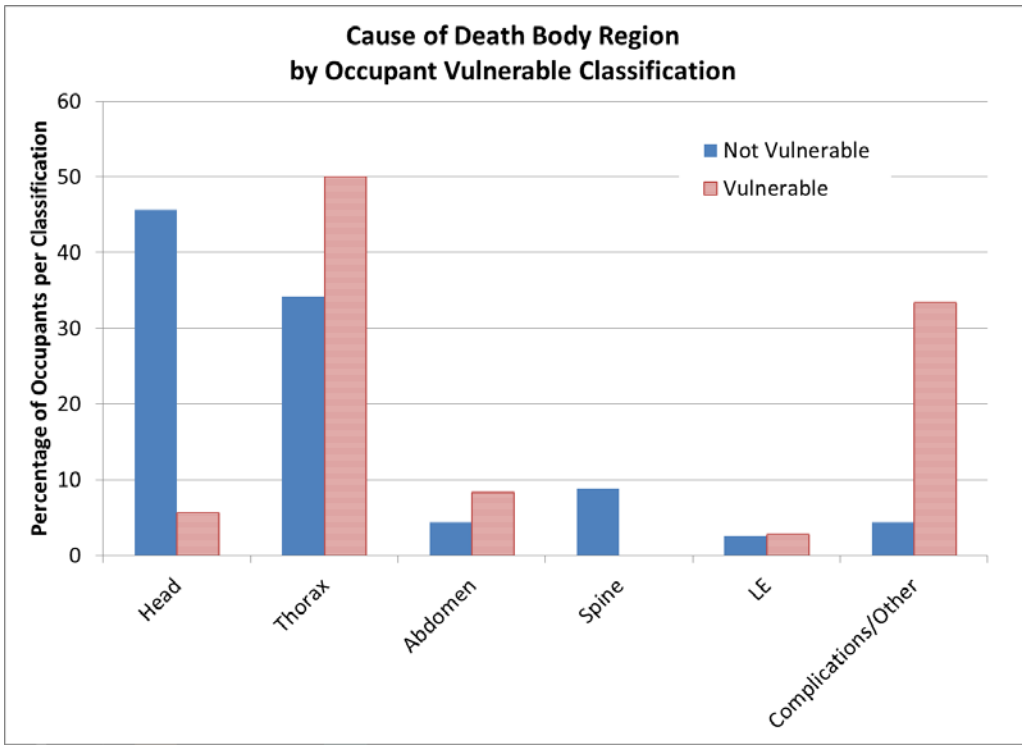

Figure 15. Occupant cause of death by body region (or complication) based on occupant vulnerability.

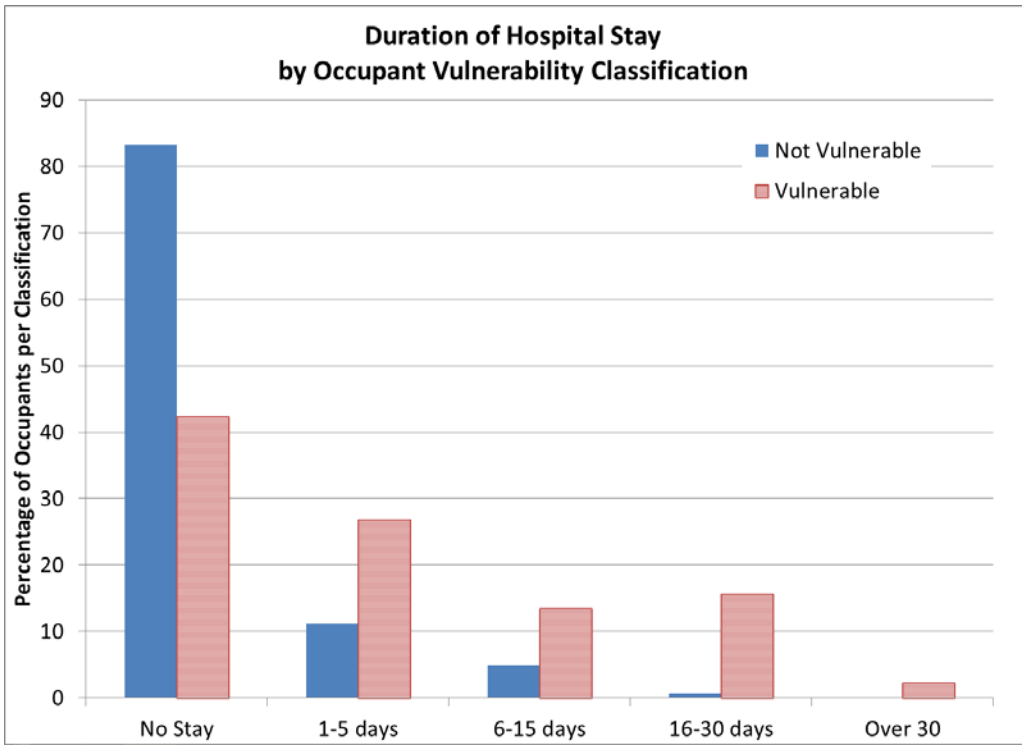

Figure 16. Duration of occupant's hospitalization before death based on occupant vulnerability.

Figure 17. Left image (a) shows front right oblique view of 852131345 and right image (b) shows case occupant's seating position.

Limitations

This study was undertaken to gain a better understanding of the injuries that lead to the death of restrained occupants in frontal crashes. While the cases studied do represent what is happening in field crashes, this study was not intended to utilize the case weights in order to develop nationally representative findings. Furthermore, the analysis of coded data fields is based on the data provided in each of the cases, and in many cases the limited autopsy data or incomplete medical records lead to causes of death that don't accurately capture the occupant's experience. In some of these cases, inferences could be made or the cases could otherwise be reclassified to eliminate ambiguity, but that was not done in this study.

Since this study involved manual review of cases, along with subjective classification of the cases, it must be understood that a certain amount of author bias may exist in the findings. While every effort was made to consistently assign categories, arguments could be made to justify alternate categorical assignments. This limitation is exacerbated by the fact that the case data that was collected may not contain key pieces of evidence relevant to the occupants' crash experience. For example, one factor that may play a large role in occupant response is their exact seating position at impact, which is almost always impossible to know with any degree of certainty.

CONCLUSIONS

This detailed review of injury and causation was an extension of a prior study of fatal occupants. One hundred and eighty nine fatal occupants were studied and of those 55 (29%) were deemed to be in crashes of extreme severity. Deaths attributed to head and thorax injuries each accounted for about 37% of the total, with 11% occurring as a result of complications from injury. Older occupants died more often from thoracic trauma, while younger occupants more commonly died from head injuries. The older occupants in this study were also more likely to be injured in crashes of lower severity compared to their younger counterparts and they were more likely to have an extended hospital stay prior to death. In the cases identified as corner or oblique crashes, the occupants died more often from head injuries caused by contact with outboard vehicle structures.

Future work with this dataset will consider multi-system trauma as well as the specific types of injuries, intrusions of components and their role in injury causation, and detailed restraint analysis.

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APPENDIX A

Year	PSU	Case	Veh.	Occ.	CIREN ID	Age	Gender	Seat	ISS	Model Year	Make and Model	Exceedingly Severe	Narrow Impact	Corner/ Oblique	Heavy Vehicle	Vulnerable Occupant
2000	.	.	1	1	54567	33	2	11	75	2000	HOND Odyssey	✓			✓	
2000	8	226	1	1	.	42	1	11	17	2000	NISS Altima	✓		✓		
2000	11	130	1	1	.	33	2	11	75	2000	HOND Odyssey	✓				
2000	12	78	1	1	.	45	1	11	1	2000	GMC C,K,R,V-series P/U	✓				
2000	43	243	1	1	.	51	2	11	5	2000	CHRY Voyager				✓	
2000	49	254	2	1	.	41	1	11	14	2000	DODG Ram 1500 P/U				✓	
2000	76	139	3	1	.	54	1	11	75	2000	GMC Jimmy fullsize			✓		
2000	78	80	1	1	.	71	1	11	4	2000	DODG Intrepid	✓				
2001	11	178	2	1	.	45	2	11	35	2000	MERC Cougar	✓				
2001	73	33	1	2	.	46	1	13	50	2001	DODG Stratus				✓	
2001	75	113	1	1	.	53	1	11	75	2001	TOYT Avalon			✓		
2001	76	111	1	1	.	56	1	11	9	2001	NISS Sentra			✓		
2001	81	117	2	1	.	52	1	11	75	2002	TOYT Tundra			✓		
2002	.	.	1	1	551081358	22	2	11	45	2000	MITS Mirage			✓		
2002	2	114	1	1	.	68	1	11	36	2000	FORD Ranger		✓	✓		
2002	9	43	2	1	.	55	1	11	45	2001	CHEV Caprice/Impala				✓	
2002	9	131	2	1	.	33	1	11	45	2001	FORD Taurus/Taurus X			✓		
2002	12	94	2	1	.	50	1	11	21	2000	GMC Jimmy/S-15 based					
2002	12	186	2	1	.	60	1	11	43	2000	PONT J-2000	✓				
2002	12	186	2	2	.	60	2	13	75	2000	PONT J-2000	✓				
2002	42	25	1	2	57335	29	2	13	34	2002	JAG X-Type	✓				
2002	42	34	3	1	377059731	33	2	11	29	2001	DODG Intrepid			✓		
2002	42	34	3	2	377061232	61	2	13	36	2001	DODG Intrepid			✓		
2002	45	16	1	1	.	35	1	11	14	2000	CHEV S-10	✓				
2002	47	39	2	1	.	44	2	11	0	2000	FORD Taurus/Taurus X	✓				
2002	47	134	1	1	.	61	1	11	0	2002	CHEV Astrovan	✓				
2002	49	100	1	1	.	66	2	11	43	2000	CHRY Town & Country		✓			
2002	75	53	1	2	.	71	2	13	29	2000	TOYT 4-Runner					✓
2002	76	97	1	2	.	18	1	13	0	2001	CHEV Cavalier	✓				
2003	.	.	1	1	378074980	78	2	11	75	2001	MITS Galant			✓		✓
2003	.	.	1	1	857069084	29	1	11	22	2003	FORD Expedition		✓	✓		
2003	2	141	2	1	.	39	1	11	75	2000	HOND Civic/CRX	✓				
2003	9	47	1	1	.	27	1	11	75	2001	FORD F-series P/U	✓				
2003	42	61	1	2	.	47	1	13	26	2002	VW Jetta				✓	
2003	48	158	1	2	.	81	2	13	21	2002	TOYT Tacoma					✓
2003	76	134	1	1	.	46	1	11	19	2001	DODG Intrepid	✓				
2003	79	139	1	1	.	18	1	11	10	2000	CHEV G-series Van				✓	
2003	81	41	1	1	.	46	1	11	75	2003	CHEV S-10	✓				
2003	81	44	1	1	.	19	1	11	43	2003	DODG Neon			✓		

Year	PSU	Case	Veh.	Occ.	CIREN ID	Age	Gender	Seat	ISS	Model Year	Make and Model	Exceedingly Severe	Narrow Impact	Corner/ Oblique	Heavy Vehicle	Vulnerable Occupant
2004	.	.	1	1	142061704	41	2	11	59	2001	JEEP Cherokee84-			✓	✓	
2004	.	.	1	1	558014121	56	2	11	29	2000	DODG Durango					✓
2004	.	.	1	1	857078140	22	1	11	75	2000	HYUN Tiburon	✓				
2004	2	62	2	1	.	81	2	11	35	2000	HOND Accord			✓		✓
2004	9	62	1	1	.	70	1	11	75	2001	TOYT Avalon		✓			
2004	41	15	2	2	.	78	2	13	21	2000	TOYT Corolla					✓
2004	42	113	1	1	.	23	1	11	43	2004	DODG Stratus				✓	
2004	43	253	1	1	.	31	1	11	14	2004	HOND Accord			✓		
2004	43	291	1	1	.	33	2	11	22	2003	DODG Caravan				✓	
2004	45	113	1	1	.	37	1	11	50	2000	HOND Civic/CRX			✓		
2004	47	83	1	2	.	76	2	13	0	2003	CHEV C/K-series Pickup		✓	✓		
2004	49	168	2	2	.	56	2	13	59	2004	MERZ S Class			✓		
2004	50	32	1	2	.	65	2	13	34	2001	SUBA Forester		✓	✓		
2004	50	147	1	1	.	80	2	11	33	2001	HOND Civic/CRX					✓
2004	73	165	1	1	.	52	1	11	59	2002	FORD Bronco II				✓	
2004	73	241	2	1	.	52	1	11	30	2004	NISS Altima			✓		
2004	76	57	1	1	.	19	2	11	29	2002	CHEV Cavalier	✓				
2004	76	157	1	1	.	68	1	11	26	2002	CHEV Cavalier	✓				
2004	79	49	1	1	.	72	2	11	14	2001	TOYT Camry					✓
2004	79	244	1	1	.	70	1	11	14	2003	CADI Deville/Fleetwood					✓
2004	82	16	1	2	.	25	2	13	33	2000	VW Jetta				✓	
2005	.	.	1	1	160121660	70	2	11	30	2003	HOND Civic/CRX					✓
2005	2	54	2	1	.	60	2	11	21	2004	DODG Neon			✓		✓
2005	4	119	1	1	.	86	1	11	10	2003	CHEV Caprice/Impala					✓
2005	9	189	1	1	.	43	1	11	75	2005	FORD Escape				✓	
2005	43	231	1	1	.	31	1	11	14	2000	JEEP Cherokee84-		✓	✓		
2005	45	116	1	2	.	87	2	13	22	2003	DODG Neon					✓
2005	45	142	1	1	.	63	2	11	22	2003	ACUR CL/TL	✓				
2005	45	196	2	1	.	69	1	11	17	2005	CHEV Caprice/Impala			✓		✓
2005	47	102	3	1	.	22	1	11	0	2001	FORD F-series P/U			✓		
2005	47	134	2	1	.	44	2	11	0	2002	PONT Firebird/Trans AM			✓		
2005	47	137	1	1	.	19	2	11	0	2001	FORD Mustang/Mustang II				✓	
2005	50	125	2	1	.	41	1	11	75	2002	PONT Grand Prix	✓				
2005	72	36	1	1	.	35	1	11	19	2004	CHEV Cavalier				✓	
2005	74	138	1	1	.	47	2	11	59	2005	TOYT Corolla	✓				
2005	75	170	1	1	.	64	2	11	29	2002	FORD Mustang/Mustang II	✓				
2005	79	139	1	1	.	74	2	11	26	2000	HOND Accord					✓
2006	.	.	1	2	852131345	82	2	13	43	2004	NISS 810/Maxima					✓
2006	4	45	1	1	.	19	2	11	38	2001	SATN LS			✓	✓	
2006	9	59	2	1	.	35	1	11	75	2006	FORD Escape			✓		
2006	11	150	1	2	.	17	2	13	35	2002	CHEV Trail Blazer				✓	

Year	PSU	Case	Veh.	Occ.	CIREN ID	Age	Gender	Seat	ISS	Model Year	Make and Model	Exceedingly Severe	Narrow Impact	Corner/ Oblique	Heavy Vehicle	Vulnerable Occupant
2006	11	163	1	1	.	35	1	11	26	2006	LINC Zephyr				✓	
2006	12	161	1	1	.	30	1	11	41	2005	CHRY Town & Country			✓		
2006	41	64	1	1	.	78	2	11	33	2005	LEXS ES-250/300		✓			
2006	42	138	1	1	.	32	2	11	75	2004	KIA Sedona			✓		
2006	42	138	2	1	.	29	2	11	41	2006	CHRY 300M			✓		
2006	45	59	2	1	.	23	2	11	14	2005	FORD Focus			✓		
2006	49	137	1	1	.	19	1	11	75	2002	PONT Aztek		✓	✓		
2006	49	201	1	1	.	52	2	11	57	2006	KIA Rio	✓				
2006	50	83	1	1	.	28	1	11	34	2000	HYUN Tiburon			✓		
2006	75	22	1	2	.	27	1	13	25	2006	MITS Eclipse		✓			
2006	75	23	2	1	.	22	1	11	0	2005	MITS Lancer			✓		
2006	75	96	1	1	.	31	1	11	0	2000	CHRY Concorde			✓		
2006	75	98	2	1	.	25	2	11	0	2001	CHEV Malibu(97-)	✓				
2006	78	62	1	1	.	50	2	11	21	2000	DODG Ram 1500 P/U				✓	
2006	78	132	1	1	.	66	2	11	0	2003	FORD F-series P/U	✓				
2006	82	4	1	1	.	47	1	11	34	2003	CHEV C/K-series Pickup	✓				
2007	.	.	1	1	160134344	79	1	11	29	2002	BUIC Electra/Park Avenue					✓
2007	.	.	1	1	160140683	77	1	11	50	2007	LINC TownCar/Continental	✓				✓
2007	.	.	1	1	160141238	81	1	11	30	2003	MERZ E					✓
2007	.	.	1	1	385107159	83	1	11	50	2005	BUIC Electra/Park Avenue					✓
2007	.	.	2	1	385102796	53	1	11	66	2001	CHRY PT Cruiser	✓				
2007	2	139	1	1	.	79	2	11	38	2001	NISS Sentra					✓
2007	9	63	1	1	.	60	1	11	75	2006	TOYT Avalon				✓	
2007	11	39	1	1	.	64	1	11	75	2006	SUBA Legacy	✓				
2007	11	72	1	1	.	18	1	11	57	2002	HOND Accord	✓				
2007	11	135	1	1	.	80	1	11	22	2004	CHEV Malibu(97-)					✓
2007	12	180	1	1	.	56	2	11	75	2000	DODG Dakota	✓				
2007	41	160	1	1	.	54	1	11	38	2000	MAZD GLC/323/Protege			✓		
2007	42	9	1	1	.	46	1	11	38	2004	INFI FX35/45	✓				
2007	42	120	2	1	.	76	1	11	6	2003	CHRY Sebring					✓
2007	47	61	2	1	.	58	1	11	38	2005	HOND C-RV			✓		
2007	47	119	1	1	.	36	1	11	0	2001	DODG Ram 1500 P/U	✓				
2007	48	186	2	1	.	66	1	11	48	2003	TOYT Tacoma			✓		
2007	72	101	1	1	.	71	2	11	25	2001	BUIC Lesabre/Wildcat/Cen					✓
2007	72	126	1	1	.	82	1	11	19	2005	FORD Focus			✓		✓
2007	73	37	1	1	.	46	1	11	75	2000	TOYT Celica				✓	
2007	73	137	1	1	.	52	1	11	43	2005	DODG Stratus	✓				
2007	74	107	1	1	.	20	2	11	45	2000	FORD Taurus/Taurus X	✓				
2007	74	107	2	1	.	62	1	11	75	2000	BUIC Electra/Park Avenue	✓				
2007	74	107	2	2	.	62	2	13	41	2000	BUIC Electra/Park Avenue	✓				
2007	78	24	1	1	.	27	1	11	14	2000	NISS Pickup/Frontier			✓	✓	

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2008	.	.	1	2	852156114	83	2	13	35	2003	HOND Odyssey				✓	✓
2008	2	143	1	1	.	55	1	11	54	2007	HYUN Elantra	✓				
2008	4	10	2	1	.	63	1	11	17	2002	MERC Sable			✓	✓	
2008	9	53	2	1	.	37	2	11	50	2008	PONT G5			✓		
2008	9	134	1	1	.	24	1	11	75	2008	HYUN Accent				✓	
2008	9	144	1	2	.	37	1	13	75	2006	HOND Civic/CRX		✓	✓		
2008	11	103	1	1	.	51	2	11	75	2004	PONT Aztek	✓				
2008	11	211	1	1	.	21	1	11	50	2002	SATN SL	✓				
2008	12	77	1	1	.	77	2	11	75	2005	TOYT Camry	✓	✓			
2008	13	222	1	1	.	16	1	11	75	2005	CHEV Malibu(97-)	✓				
2008	43	157	2	1	.	52	1	11	13	2006	MINI COOPER				✓	
2008	43	303	1	1	.	38	2	11	14	2008	TOYT RAV-4					
2008	73	81	3	1	.	53	1	11	75	2003	FORD Mustang/Mustang II			✓		
2008	78	22	1	2	.	43	1	13	2	2004	CADI CTS				✓	
2008	78	31	1	1	.	51	1	11	0	2006	CHEV C/K-series Pickup			✓		
2008	78	31	2	1	.	36	2	11	0	2002	LEXS RX300			✓		
2008	81	65	1	2	.	83	2	13	35	2003	HOND Odyssey			✓		✓
2009	.	.	1	1	385138077	38	1	11	45	2010	HYUN GENESIS			✓		
2009	.	.	1	1	385145571	39	1	11	45	2004	NISS Titan			✓		
2009	.	.	1	1	459036835	73	2	11	45	2002	TOYT Highlander					✓
2009	2	155	1	1	.	87	1	11	34	2003	FORD Focus			✓		✓
2009	9	99	1	1	.	36	1	11	75	2007	HOND Accord				✓	
2009	11	191	1	2	.	16	2	13	45	2001	HOND Odyssey			✓	✓	
2009	41	60	1	1	.	89	1	11	10	2005	MERC Marquis/Monterey					✓
2009	43	250	3	1	.	35	1	11	43	2008	DODG Ram 1500 P/U			✓		
2009	48	32	1	1	.	57	2	11	26	2005	BUIC Rendezvous					✓
2009	48	100	1	1	.	56	2	11	0	2006	CHEV Caprice/Impala				✓	
2009	49	102	1	1	.	28	2	11	41	2001	JEEP Cherokee84-	✓				
2009	49	130	2	1	.	45	2	11	45	2001	JEEP Cherokee84-	✓				
2009	49	186	1	1	.	24	1	11	75	2005	MITS Lancer	✓				
2009	73	74	1	1	.	25	2	11	34	2008	HOND Civic/CRX	✓				
2009	73	84	2	1	.	40	2	11	43	2007	CHEV Malibu(97-)			✓		
2009	74	50	2	1	.	55	1	11	38	2002	FORD Windstar	✓				
2009	76	115	1	1	.	53	2	11	75	2003	VW Passat				✓	
2009	76	128	1	1	.	58	2	11	0	2007	HOND Fit	✓				
2009	81	58	2	2	.	56	2	13	75	2004	HOND Accord			✓		
2009	82	10	2	1	.	65	2	11	48	2007	HOND C-RV			✓		
2010	.	.	1	1	385165500	77	1	11	34	2006	FORD Ranger		✓			✓
2010	.	.	1	1	431208557	49	1	11	29	2010	TOYT Prius			✓		
2010	.	.	1	2	431208606	76	1	13	27	2010	TOYT Prius			✓		✓
2010	2	69	1	1	.	59	1	11	75	2004	CHEV Aveo				✓	

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2010	9	144	1	1	.	74	1	11	24	2003	FORD Expedition				✓	
2010	12	64	1	1	.	83	1	11	17	2005	BUIC Century					✓
2010	41	170	2	1	.	78	2	11	21	2007	CADI CTS					✓
2010	41	212	1	1	.	77	1	11	29	2007	TOYT Camry					✓
2010	45	16	2	1	.	80	1	11	0	2003	BUIC Century				✓	
2010	45	180	1	1	.	78	1	11	22	2005	LEXS LS-400					✓
2010	49	170	1	1	.	29	1	11	75	2007	CHEV Fullsize Blazer	✓				
2010	74	131	1	1	.	28	2	11	75	2007	JEEP Liberty	✓			✓	
2010	74	167	1	1	.	24	2	11	38	2001	VW Passat			✓	✓	
2010	78	38	1	1	.	21	1	11	75	2007	HOND Accord		✓	✓		
2010	79	70	1	2	.	84	2	13	75	2002	HOND Civic/CRX					✓
2010	81	85	1	1	.	73	1	11	43	2002	TOYT Tundra					✓
2011	.	.	1	1	317101783	59	1	11	29	2008	NISS Altima			✓		
2011	.	.	1	1	357137502	78	1	11	43	2010	LINC TownCar/Continental			✓		✓
2011	.	.	1	1	360206546	68	1	11	41	2006	ACUR CL/TL	✓		✓		
2011	.	.	1	2	360208690	66	1	13	29	2003	TOYT Highlander					✓
2011	3	88	1	1	.	84	2	11	27	2008	HOND Accord			✓		✓
2011	3	98	1	1	.	61	1	11	22	2010	HOND C-RV			✓		
2011	4	95	1	1	.	73	2	11	34	2006	HYUN Sonata	✓				✓
2011	11	244	2	1	.	73	1	11	34	2011	FORD Fiesta				✓	
2011	45	3	1	2	.	44	1	13	26	2005	NISS Altima					✓
2011	48	96	1	1	.	75	2	11	34	2007	NISS Altima					✓
2011	49	139	1	1	.	35	1	11	75	2008	FORD Focus	✓		✓		
2011	73	138	1	1	.	26	2	11	14	2005	FORD Taurus/Taurus X				✓	
2011	78	19	1	1	.	23	2	11	59	2003	CHEV Suburban				✓	
2011	78	19	1	2	.	32	1	13	9	2003	CHEV Suburban				✓	
2011	81	57	3	1	.	36	1	11	50	2004	HOND Pilot			✓		
							1=Male 2=Female	11=Driver 13=Passenger								