Declining Statewide Trends in Motor Vehicle Crashes and Injury-Related Hospital Admissions

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ABSTRACT – Numbers of crashes, rates of police-reported injury severity, and hospital admission rates were calculated for the ten year period between 2001 and 2010 in Maryland. Comparisons were made for two 5-year periods of 2001-2005 and 2006-2010. Crash characteristics remained similar for the two five-year periods, but there was a significant increase in occupant age. Declines in police-reported injury severity were noted for each of four age groups: 16-29, 30-54, 55-64, and 65+, with smaller declines among older occupants. In addition, there were significant declines in hospital admissions, comparing the two time periods. Although reductions in crashes may be attributable to various roadway, behavioral, and other safety improvement efforts, reductions in hospital admission rates most likely reflect major improvements in crashworthiness implemented during the past decade. For those admitted to hospitals, significant increases in injury severity were noted between the first and second time periods. There was an association between age and ISS, a measure of total bodily injury, with the highest ISS scores noted for the youngest and oldest groups (16-29 and 55+, respectively). In addition, there was a significant increase in the mean age over time, from 39 in 2001 to 43 in 2010, $p<.001$. In general, the incidence and severity of injuries increased for all body regions. There was also a significant increase in hospital mortality, although length of hospital stay remained the same. Given these trends, increased efforts need to focus on both injury prevention and treatment for the increasing population of older, sometimes frail, vehicle occupants.

INTRODUCTION

Despite increasing traffic on U.S. roadways since the mid-1990s, there has been a marked decline in motor vehicle crash fatalities; this ongoing trend has been considered to be the result of various factors, including changes in roadway design, campaigns to reduce drunk driving and increase seatbelt use, and vehicle crashworthiness, among others. (CDC, 1999, Waller, –2002). Some of the vehicular design changes, such as the anti-lock braking system (ABS) and electronic stability control (ESC), are intended to prevent the occurrence and reduce the severity of crashes, while others, such as airbags, are designed to mitigate occupant behavior once a crash has occurred. Several studies have associated this decline in mortality with improved vehicle design (NHTSA, 2008; Crandall, Olson and Sklar, 2001; Farmer and Lund, 2006; Ryb and Dischinger, 2009). However, most of these studies have been limited somewhat because it is unclear how much of the reduction in mortality is attributable to declines in crashes, better occupant protection, or other crash or occupant characteristics (e.g.,age) that may have changed simultaneously with the observed changes in mortality. As pointed out by Farmer (2005), there has been significant improvement over time in the ability of vehicles to protect occupants in crashes, and most vehicles manufactured since 2005 rate "good" with respect to crash test ratings.

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However, little is known regarding non-fatal injuries, and whether or not hospital admissions have also declined during the same period; in addition it is not known whether any declines in injury are attributable to reduction in crashes, or reduced crash severity, or harm. An analysis of three major NHTSA databases, published in 2008, showed that from 1996-2005, the annual number of "incapacitating" injuries due to motor vehicle crashes decreased by 25-28%, in spite of a 20% increase in vehicle miles traveled (NHTSA, 2008). A 2011 NHTSA report further revealed that highway deaths had reached their lowest level since 1949, and a 26% decline since 2005. The purpose of this analysis was to examine statewide police-reported crash characteristics, injury severity and hospital admission rates for drivers and passengers for the 10-year period of 2001-2010, and to determine whether there are differences in these trends by occupant age. In addition, for those admitted to hospitals, trends in injuries and injury severity to the various body regions were ascertained, again stratified by the age of the patient.

METHODS

Crash data were obtained from statewide police crash reports, for all police-reported crashes occurring between 2001-2010 in the state of Maryland. The minimum threshold for completing a crash report is if

a vehicle needs to be towed away for repairs; this ensures that all injury and fatal crashes have a report completed and entered into the statewide database. Vehicle types included passenger vehicles, sport utility vehicles (SUVs), pickup trucks, and large trucks; occupants of motorcycles were excluded. Hospital admissions were obtained from the statewide hospital discharge database, selecting all cases with an injury diagnosis and an E-code indicating that the injury occurred in a motor vehicle crash (there is a specific E-code for motorcyclists but not other vehicle types). The Maryland hospital inpatient database is comprehensive and includes all non-military hospitals in the state. The files are maintained by the Health Services Cost Review Commission, which regulates rates at all hospitals. A validation study conducted in 2005, comparing hospital discharge and trauma registry data, concluded that, with the possible exception of minor head injuries, the Maryland hospital discharge data are a valid source for documenting the nature and severity of injuries sustained by trauma patients. These data are frequently used to determine the statewide incidence of various types of injuries requiring hospitalization. (McCarthy et al, 2005).

Admission rates were then computed for each year, with the numerator of crash-related hospital admissions and the denominator of all police-reported crashes. ICD9-CM diagnostic codes were translated into AIS pre-dot codes, injury descriptors, and severity scores using ICDMAP software, and Injury Severity Scores (ISS) computed (Mackenzie and Sacco, 1997).

Subsequent analyses were based on a comparison of the first and last five-year time periods, i.e. 2001-2005 vs. 2006-2010. Police-reported KABCO scores were used as a measure of severity for the total crash population. The KABCO score was introduced by the National Safety Council (1966) as a suggested standard for injury severity classification. While this scale certainly does not have the degree of specificity of ICD-9 or AIS scores, a comparison of police coding with medical findings suggests that the police at the scene of the crash do a good job of discriminating the more serious crashes from the majority of minor ones (Compton,, 2005).For those admitted, ISS as well as specific injury types and length of stay were determined. These variables were examined for each of the following age groups: 16-29, 30-54, 55-64, and 65+.

Chi square and Mantel-Haenszel statistics and analysis of variance were used to compare groups and to determine the significance of trends for normally distributed data. Wilcoxon's rank-sum statistic was used to compare non-normal data.

RESULTS

During the 10-year period, there were a total of 1,881,548 occupants involved in police-reported crashes and 4,057 fatalities. During the same period there were 46,807 admissions to hospitals due to crash-related injuries in Maryland, and 800 in-hospital fatalities. The number of police-reported crashes declined by nearly 35,000 and the number of crash-related fatalities dropped by nearly 40% from 2001 to 2010 (Figure 1). The total number of occupants aged 16 and older who were involved in crashes declined from 990,126 in 2001-2005 to 891,422 in 2006-2010 (-9.6%).

A comparison of driver and crash characteristics is shown in Table 1, for each of the two five-year time periods. Although the distributions by occupant type (i.e., driver/passenger) and gender remained similar, there was an increase in the proportion of drivers aged 55 or greater (15.1% in 2001-2005 vs. 17.0% in 2006-2010). The distribution of crash types, first harmful event, and direction of impact were quite similar for the two groups. There was a slight increase in SUVs, vans and large trucks over time. As expected, there has been a large increase in vehicles with the newest safety measures, i.e., vehicles manufactured since 2005, which comprise approximately 20% of the vehicles in the 2006-2010 group. However, it is also apparent that drivers are holding on to vehicles longer, as there was a significant increase in vehicles aged 6 years or greater. Restraint use improved somewhat, with an increase of combined belt and airbag usage/availability. Tests of significance are not included in the table, since even very minor changes would be significant due to the large number of crashes over time.

Table 2 shows the distribution of police-reported injury severity (i.e., KABCO score) by 5-year group and occupant age. For each age group there was a significant decline in police-reported injury severity in recent years ($p<.001$); those with no or "possible" injuries increased, while "non-incapacitating" (with the exception of age group 55-64, where rates remained the same) and "incapacitating" injuries declined from 3.3% overall in earlier years to only 2.1%. Overall the proportion of police-reported crashes resulting in fatalities remained similar (despite slight declines for ages 16-29 and 55+). There were double-digit declines in the proportions of persons under age 55 who were involved in a crash while crash involvement among those aged 55-64

increased by 3.7% and among persons aged 65+ showed a small decrease. Total statewide admissions for crash-related injuries declined by approximately one-third from 5,203 in 2001 to 3,466 in 2010, for an average decrease of 4.4% per year (Figure 2). In-hospital deaths resulting from crash involvement decreased by nearly 25% over the same time period. The average percent of occupants admitted, by age group, was 2.4 for ages 16-29, 2.1 for 30-54, 2.7 for 55-64, and 4.9 for 65+. As shown in Table 3, declines in admission rates were noted for all age groups, comparing the two five-year periods, with more marked declines in occupants younger than age 55.

For all motor vehicle occupants admitted to hospitals, injury severity, as represented by maximum ISS scores, increased over time (Table 4a). Although the median scores remain very much the same, the differences are statistically significant based on an increasing shift in the distribution of the scores; these increases are noted for each age group in terms of the inter-quartile range. Length of hospital stay, on the other hand, did not increase as a result of this increase in severity, probably due to the fact that the median ISS is still relatively low, as well as ongoing efforts to decrease hospital stays. Table 4b reveals an increase in the in-hospital mortality rate, which seems primarily attributable to the 30-54 age group.

Table 5 shows the incidence and maximum severity (MAIS) for injuries to the various body regions, again comparing the two study periods. Data in the table are presented for all age groups, but some variations within age groups were noted for specific injuries (data not shown). For both time periods, the highest incidence rates were for lower extremity, upper extremity, and head injuries. With the exception of facial injuries, which did not change over time, increases in severity (MAIS) were noted for all other body regions. The incidence of facial injuries decreased for occupants aged 55 and older. The incidence of spinal injury increased (but severity decreased) for all age groups, except those aged 65+, among whom severity remained unchanged. Also, for lower extremity injuries, both the incidence and severity increased among the youngest occupants (ages 16-29); for all other groups there was a decrease in lower extremity injury severity.

DISCUSSION

There has been a significant decline in crashes as well as police-reported crash severity during the past decade in the state of Maryland. This decline is apparent for all age groups. Crash and occupant characteristics have primarily remained the same over this period, although there has been an improvement in restraint use, as well as an increase in the proportion of vehicles more than 6 years old; in addition there has been an increase in the age of occupants over time.

It is difficult to quantify driving levels by age group other than by using the number of licensed drivers. There is no accurate comprehensive measure of vehicle miles travelled by age because the National Household Travel Survey estimates travel based on a representative nationwide sample of drivers. While licensed driver data were not incorporated into this analysis, the number of older drivers has increased significantly in Maryland over the past 12 years. Among licensed drivers aged 16-54, there was a 5.8% increase from 2000-2012. In contrast, for those aged 55 plus, there was a 41.9% increase. The mean age of all occupants increased from 36.9 in the period 2001-2005 to 37.7 for 2006-2010 ($p<.001$). .

There has also been a decline in the rate of hospital admissions due to motor vehicle crashes during the same period. Among those hospitalized, there has been a concomitant increase in injury severity, due to decreased admissions for more minor injuries and a relative increase in the proportion of older patients, whose injuries tend to be the most severe The mean age for those hospitalized increased from 39.7 in 2001-2005 to 41.0 for 2006-2010. With respect to specific injuries, increased attention should be devoted to spinal injuries for older occupants, which, unlike all other age groups, have not declined in severity. In addition, lower extremity injuries for the youngest group, among those hospitalized, have increased in severity over time.

If these trends are a reflection of improvements in crashworthiness, it seems probable that the age of those hospitalized following crashes will continue to increase as the driving population ages and newer vehicles increasingly enter the fleet. There are several implications of these findings. While overall crash severity rates have declined for all ages, hospital admission and mortality rates remain highest for older occupants aged 65+ (although their mortality rates remained stable during the study period). In a previous study of the Crash Injury Research and Engineering Network (CIREN), the authors showed that older drivers identified as frail sustained injuries at lower changes in velocity (i.e., delta v), implying that further improvements in vehicle safety may need to address features specifically designed for the growing population of older drivers (Ryb et al., 2012). In addition to frailty, other factors, such as increased anticoagulation use in the older population,

may also come into play, but accurate data on medication usage are not currently available for analysis.

Further efforts in reducing mortality need to focus on primary prevention efforts, since the majority of deaths now occur at the scene, rather than in-hospital. Such efforts could target specific problems such as distracted driving, or specific age groups such as teenaged drivers.

A secondary implication is for trauma triage. Older individuals injured in car crashes have been shown in various studies to be historically undertriaged to trauma centers (Ryb and Dischinger, 2011)), despite the fact that triage guidelines specifically address the elderly and the current data show that they are more likely to sustain more serious injuries. In addition, their injury outcomes are often complicated by the increasing comorbidities (and their treatments) associated with aging.

Finally, this trend also portends a need for specialists in geriatric trauma, whose numbers are currently very numbered, as well as the availability of rehabilitation services for this age group. In an earlier analysis of long-term injury outcomes in a population of CIREN patients, findings showed that recovery was primarily a function of frailty, and not age per se (Andersen et al., 2010).

CONCLUSION

Reductions in total crashes during the past 10 years probably reflect a multitude of targeted safety efforts, including roadway improvements, campaigns against drunk driving, and vehicle safety improvements, among others. Decreases in police-reported injury severity, and overall hospital admission rates, on the other hand, are most likely attributable to improvements in crashworthiness that have been introduced during the past 10-15 years. Among those hospitalized, injury severity has increased, a trend primarily attributable to three factors: (1) the aging of the driving population, (2) the relative increase in older drivers due to greater police-reported injury severity declines among younger occupants, and (3) higher hospital admission rates among those 55 and older.

Further efforts should be focused on mitigating crash circumstances and injury patterns that are more prevalent among this growing number of older, often more frail, drivers and passengers. In addition, there will be an increasing need for specialists in geriatric trauma, in order to treat patients in the acute setting, as well as provide specialized rehabilitation services.

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Table 1 – Occupant and Crash Characteristics (N=1,881,548)

Characteristics	2001-2005 Total Persons Involved % (n=990,126)	2006-2010 Total Persons Involved % (n=891,422)
Age (Years)		
16 – 29	40.0	39.8
30 – 54	44.9	43.3
55 – 64	8.1	9.4
65+	7.0	7.6
Gender		
Male	57.2	56.6
Female	42.8	43.4
Type of Occupant		
Driver	81.1	81.6
Passenger	18.9	18.4
Crash Type		
Single Vehicle Crash	15.2	16.2
Multiple Vehicle Crash	77.9	80.3
Unknown/Missing	7.0	3.5
First Harmful Event		
Non-Collision Harmful Event	2.1	2.5
Collision With Motor vehicle in transport	75.4	74.6
Collision With Non-Fixed Object	8.2	8.7
Collision With Fixed Object	11.0	11.3
Other	3.2	2.9
Direction of Impact		
Frontal	51.8	52.3
Lateral	23.4	23.0
Other	24.8	24.7
Type of Vehicle		
Passenger Car	61.6	58.3
Light Truck, Passenger Van, SUV	30.0	32.5
Large Truck	6.6	7.0
Other	1.8	2.3
Vehicle Model Year		
<=2000	75.7	41.4
2001-2005	23.3	38.0
2006-2011	0.2	19.6
Unknown/Missing	0.8	1.0
Age of Vehicle at Time of Crash		
<=1 year	15.8	12.8
2 – 5	33.0	31.1
6 – 10	30.6	32.7
10+	19.8	22.4
Unknown/Missing	0.8	1.0
Restraint Use*		
Belt Only	81.8	79.9
Airbag Only	0.3	0.4
Belt and Airbag	13.8	16.7
Neither Belt or Airbag	4.0	3.0

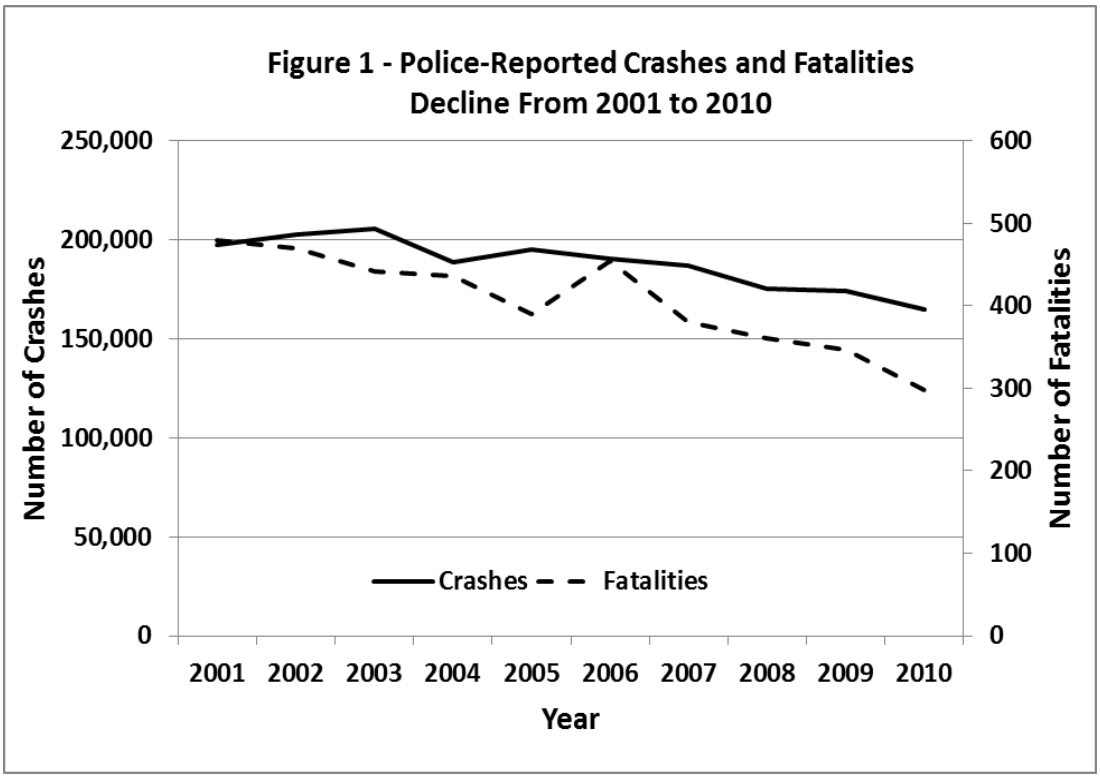
Figure 1 - Police-Reported Crashes and Fatalities
Decline From 2001 to 2010
250,000
200,000
150,000
100,000
50,000
0
Number of Crashes
600
500
400
300
200
100
0
Number of Fatalities
Crashes
Fatalities
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year

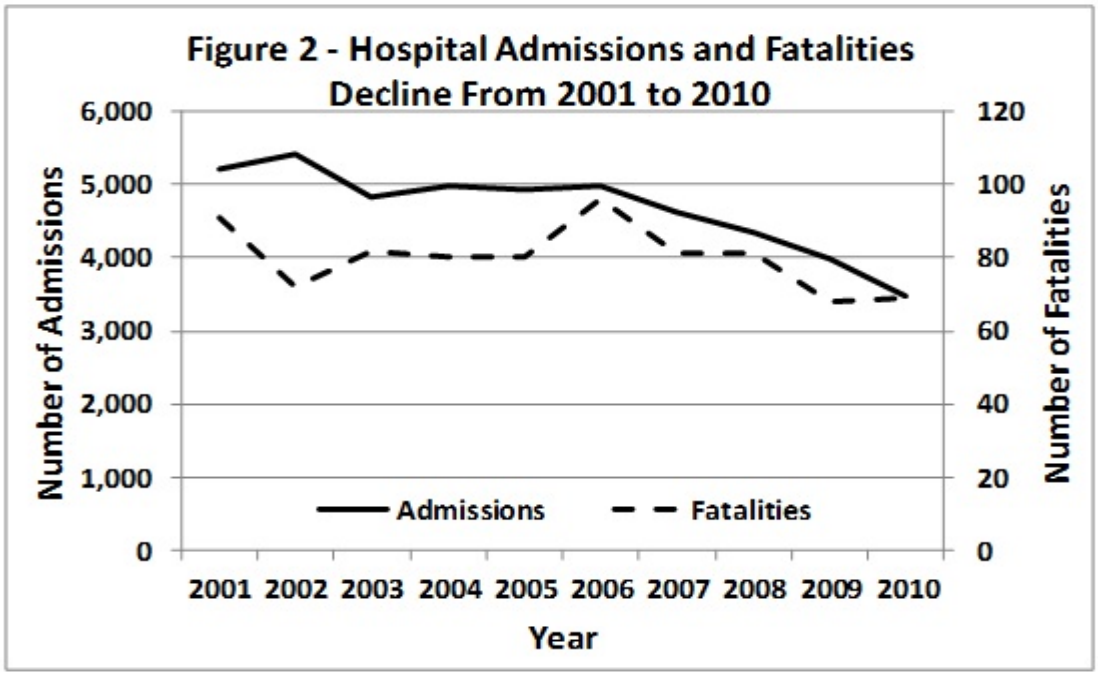
Figure 2 - Hospital Admissions and Fatalities
Decline From 2001 to 2010
6,000
5,000
4,000
3,000
2,000
1,000
0
Number of Admissions
120
100
80
60
40
20
0
Number of Fatalities
Admissions
Fatalities
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year

Table 2 – Measures of Injury Severity (N=1,881,548)

Injury Severity by Age Group	2001-2005 Total Persons Involved	2006-2010 Total Persons Involved	p-Value	% Change in Number of Persons in Crashes
Age 16-29	**% (n=395,830)**	**% (n=354,390)**		**-10.5%**
Not Injured	76.0	77.2		
Possible	11.6	11.7		
Non-Incapacitating	8.9	8.3		
Incapacitating	3.3	2.1		
Fatal	0.22	0.19	<.001	
Age 30-54	**% (n=444,835)**	**% (n=386,177)**		**-13.2%**
Not Injured	76.6	77.9		
Possible	11.8	11.9		
Non-Incapacitating	8.3	8.0		
Incapacitating	3.2	2.0		
Fatal	0.16	0.17	<.001	
Age 55-64	**% (n=80,472)**	**% (n=83,437)**		**+3.7%**
Not Injured	75.9	77.2		
Possible	12.1	12.0		
Non-Incapacitating	8.4	8.4		
Incapacitating	3.4	2.1		
Fatal	0.26	0.22	<.001	
Age 65+	**% (n=68,989)**	**% (n=67,418)**		**-2.3%**
Not Injured	73.6	74.9		
Possible	12.3	12.7		
Non-Incapacitating	9.7	9.5		
Incapacitating	3.7	2.5		
Fatal	0.63	0.48	<.001	
Total	**% (n=990,126)**	**% (n=891,422)**		**-10.0%**
Not Injured	76.1	77.5		
Possible	11.8	11.9		
Non-Incapacitating	8.6	8.3		
Incapacitating	3.3	2.1		
Fatal	0.22	0.21	<.001	

Table 3 - Hospital Admission Numbers and Rates By All Drivers/Passengers, Age Groups and Time Period (N=1,881,548)

Age Group	2001-2005			2006-2010			p-Value
	Admitted (N)	In Crash (N)	% Admitted	Admitted (N)	In Crash (N)	% Admitted	
16-29	9,916	395,830	2.5	8,204	354,390	2.3	<.0001
30-54	9,819	444,835	2.2	7,848	386,177	2.0	<.0001
55-64	2,212	80,472	2.8	2,170	83,437	2.6	0.06
65+	3,458	68,989	5.0	3,180	67,418	4.7	0.01
Total	25,405	990,126	2.6	21,402	891,422	2.4	<.0001

Table 4a – Injury Severity Score (ISS) and Length of Stay by Age Groups Among Hospitalized Motor Vehicle Occupants
(N=46,807)

Age Group (Year)	2001 – 2005 (n=25,405)		2006 – 2010 (n=21,402)		p-Value
	Median	IQR*	Median	IQR*	
Injury Severity Score (ISS)					
16-29	5	2 – 10	5	4 – 13	<.001
30-54	5	2 – 9	5	4 – 10	<.001
55-64	5	4 – 10	5	4 – 13	0.002
65+	5	4 – 13	6	4 – 13	0.001
Total	5	4 – 10	5	4 – 13	<.001
Length of Stay (day)					
16-29	2	1 – 5	2	1 – 4	NS
30-54	3	2 – 5	3	2 – 5	NS
55-64	3	2 – 6	3	2 – 6	NS
65+	4	2 – 7	4	2 – 7	NS
Total	3	2 – 6	3	2 – 6	NS

Table 4b – Mortality Rate Among Hospitalized Vehicle Occupants (N=46,807)

MAIS of Body Region	2001-2005 Total Persons Admitted % (n=25,196)	2006-2010 Total Persons Admitted % (n=21,164)	p-Value
16-29	1.3	1.4	NS
30-54	0.7	1.2	0.002
55-64	2.0	2.0	NS
65+	4.7	4.7	NS
Total	1.6	1.9	0.034

Table 5 – Incidence and Maximum Severity of Specific Injury Body Region Among Hospitalized Vehicle Occupants (N=46,807)

MAIS of Body Region	2001-2005 Total Persons Admitted % (n=25,196)	2006-2010 Total Persons Admitted % (n=21,164)	p-Value
Head			
0	64.2	58.7	
1-2	25.8	29.3	
3	3.0	3.8	
4-6	7.0	8.2	<.001
Neck			
0	99.4	98.9	
1-2	0.4	0.4	
3-6	0.2	0.7	<.001
Face			
0	71.0	71.1	
1-2	29.0	28.9	
3-6	0.04	0.1	NS
Thorax			
0	73.9	69.1	
1-2	12.0	13.0	
3	12.8	15.9	
4-6	1.4	2.0	<.001
Abdomen			
0	85.5	84.6	
1-2	12.0	12.3	
3	0.7	1.0	
4-6	1.7	2.2	<.001
Spine			
0	78.4	75.9	
1-2	19.7	22.5	
3-6	1.9	1.6	<.001
Upper Extremity			
0	72.6	70.5	
1	12.2	13.8	
2-3	15.2	15.7	<.001
Lower Extremity			
0	64.7	64.2	
1	10.5	11.2	
2-4	24.8	24.6	0.04