CHANGES IN CRASH PROTECTION WITH VEHICLE MODEL YEAR

Kennerly Digges
Automotive Safety Research Institute
USA

George Bahouth
Amin Vahabaghaie
Impact Research, LLC
USA

Paper Number 19-0269

ABSTRACT

NASS 1993-2015 was queried for frequency of exposed vehicles with belted driver injuries separated by injury severity and vehicle model year. Vehicle model-years were aggregated by 3 model year groupings – 1985 -1994; 1995-2000; 2001-2015. These percentages of the crash exposed populations for the 3 groups were: 27%, 34% and 39%. The total exposed population was 27,347,705. The total and Mean AIS 3+ HARM for each model year grouping was calculated for each crash mode – frontal, near-side, far-side, rear and rollover. Changes in total AIS 3+ HARM distribution and Mean AIS 3+ HARM by crash mode and model year grouping were reported.

The largest source of AIS 3+ HARM to belted drivers in the 2001-2015 NASS population remains the frontal crash mode. Near-side and rollover injury rates have dramatically decreased in recent model years. Frontal and far-side crash mode injury rates have decreased slightly and rear has remained relatively constant, but at a low injury rate.

The data suggests that for light trucks, the near-side Mean AIS 3+ HARM has increased during the 2001-2015 model years. However, the level remains below that of passenger cars which have experienced dramatic reductions in near-side Mean AIS 3+ HARM during the same period.

BACKGROUND

The analysis to follow examines vehicle safety trends based on changes to the HARM that was present in groupings of motor vehicles from three successive time periods. The concept of HARM was introduced in a landmark paper by key NHTSA staff [Malliaris, 1982]. A frequent alternative to the use of HARM is to categorize all severe injuries greater than AIS 3 in a single group labeled AIS3+ injuries. An issue with this categorization is that the AIS 3+ population is overwhelmed by AIS 3 injuries and the AIS 4+ population is not given increased priority. Alternatively, the HARM weighting scheme is applied to injuries of different severity based on the average cost of the injury. This injury weighting system has the advantage of increasing the priority for preventing the most severe injuries.

The mean HARM is defined as the total HARM for a grouping divided by the exposure for that grouping. The mean HARM is a measure of the combined injury risk and has been widely used to conduct benefits analyses. The mean HARM is a weighted injury risk and is useful for determine how the safety has changed. HARM and mean HARM were used extensively at NHTSA and elsewhere in the 80's and 90's to assess priorities for safety systems. GM Australia used HARM calculations in designing the first air bag introduced in Australia and the Australian Ministry of Transport used HARM to establish frontal and side impact regulations [Fildes, 1992].

The analysis in this paper follows the methodology of an earlier analysis by Eigen [Eigen, 2007]. However, the Eigen analysis examined HARM to injured body regions and, therefore, considered all of the multiple injuries that were coded for each individual. The present analysis uses the Malliaris methodology and considers only the most severe injury to each occupant.

.

In 2012, NHTSA stopped doing reconstructions for NASS/CDS included vehicles 10 years old and older at the time of the crash. For that reason, even though the vehicles would be stored in the dataset, the general area of damage (GAD) and principal direction of force (PDOF) were not computed for these vehicles. These components of the collision deformation classification (CDC) were used in this analysis to categorize cases into crash modes. Consequently some of the very oldest vehicles were excluded from the counts by crash mode for crashes occurring in 2012 and later.

Another limitation of this longitudinal HARM analysis is that it assumes that the mean crash severity has not changed with model year.

METHODS AND DATA SOURCES

The source for exposure and injury data was the NASS/CDS (National Automotive Sampling System/Crashworthiness Data System) years 1993 to 2015. NASS/CDS is a weighted estimate of tow-away crashes occurring in the United States. The NASS/CDS weighted data contains approximately 59 million drivers of passenger cars, SUV's, passenger vans or light trucks (pickups) who were exposed to crashes. NASS/CDS data were disaggregated by vehicle model year and crash mode. Since this study focused on the safety changes for belted drivers, only vehicles with belted drivers were included. The resulting exposed population of belted drivers including those with unknown injury was 27,347,705.

The resulting data permitted the assessment of changes in injury distributions and rates by model year, crash mode and body region for belted drivers. The front, side and rear crash mode categories excluded all rollovers. The rollover crash mode contains all rollovers including those with planar impacts as an earlier or later event.

The HARM calculations applies a weighting factor to each AIS 3+ injury in the database. The weighting factor is proportional to the cost of the occupant's most serious injury. In general, minor and moderate injuries (AIS 1 and 2) are high frequency, events that tend to cloud the analysis of serious injury reduction by safety systems. For this reason, AIS 1 and 2 injuries were excluded from the AIS 3+ HARM calculations. The AIS 3+ HARM, measured in equivalent fatalities, was based on NHTSA's data on average cost of injuries. The equivalent fatality measurement is obtained by normalizing the average cost of a given injury by the cost of a fatality. The average cost of each injury severity was obtained from a Table E-1 in the 1995-1997 NASS/CDS Summary [NHTSA 2001]. The injury cost values are: MAIS 3, $98,011; MAIS 4, $221,494; MAIS 5, $697,533; and MAIS 6, $822,328.

In order to examine how the HARM content has changed with model year, it is necessary to examine how the injury rate or some equivalent factor has changed. The rate of AIS 3+ injuries is a commonly used injury risk factor. For the 1985 to 2015 population of interest the distribution of AIS 3, 4, 5 and 6 was 74%, 18%, 8% and 2%, respectively. When HARM weights are applied, the distributions become: 40%, 22%, 29% and 9%. By applying HARM weighting, the influence of AIS 3 injuries is reduced and the more severe injuries are given added priority. The Mean AIS 3+ HARM per exposed occupant provides an injury rate similar to the AIS 3+ rate but with more priority on the AIS 4+ injuries.

The Mean HARM for each category of interest was calculated by dividing the HARM suffered by drivers by the number of drivers exposed to that category. The Mean HARM results were multiplied by 100 to simplify the presentation.

The total and mean AIS3+ HARM for each model year grouping was calculated for each crash mode – frontal, near-side, far-side rear and rollover. The data was further disaggregated by vehicle class – passenger cars (PC), sport utility vehicles (SUV), light trucks (LT) and minivans (MV). The distribution of belted drivers by vehicle class was: PC-66%; SUV-16%; LT-11% and MV-7%. Since the entire populations of LT, SUV and MV constituted about one third of the vehicle population and they were combined in a single group. Changes in total AIS 3+ HARM distribution and Mean HARM by crash mode, model year grouping and vehicle class were computed and reported.

RESULTS

Vehicle model-years were aggregated by 3 model year groupings – 1985-1994; 1995-2000; 2001-2015. The NASS/CDS was queried for all injuries by AIS including AIS 0 (no injury) and unknown injury. This total population was 27,347,699. The total AIS 3+ HARM for the three model year groupings were 27%, 34% and 39%. The total AIS 3+ HARM for each model year grouping was calculated for each crash mode – frontal, near-side, far-side, rear and rollover. Changes in total AIS 3+ HARM distribution and Mean AIS 3+ HARM by crash mode and model year grouping were reported.

Figure 1 shows the total AIs3+ HARM distribution by crash mode and how it has changed with the model year groupings. The percentages for each model year grouping add to 100%, consequently the Figure shows the distribution for each model year grouping but not the total content for that group.

The changes in Mean AIS 3+ HARM by Crash Mode and Model Year Groupings are displayed in Figure 2.

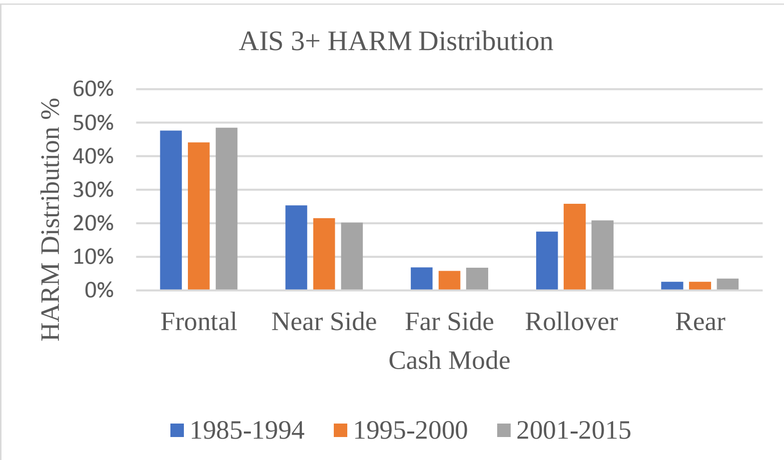

Figure 1. Distribution of Restrained Driver AIS 3+ HARM by Crash Mode and Vehicle Model Years

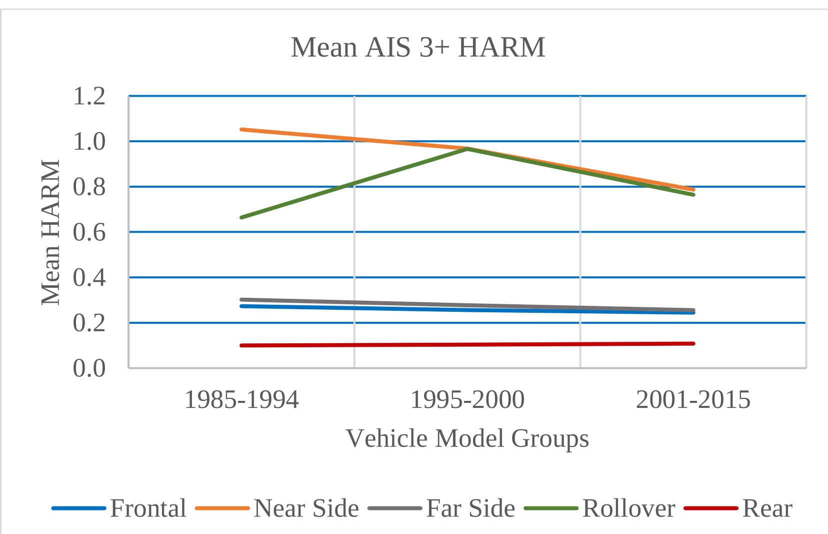

Figure 2. Distribution of Restrained Driver Mean AIS 3+ HARM by Crash Mode and Vehicle Model Years

Table 1 shows how the distribution AIS 3+ HARM has varied among vehicle types for the three vehicle model year groupings.

Table 1.
Distribution of Belted Drivers and AIS 3+ HARM by Vehicle Classes and Model Year Groups

	Pass Car		Lt Truck, SUV, Van	
Model Years	Drivers	HARM	Drivers	HARM
1985-1994	67.1%	71.7%	32.9%	28.3%
1995-2000	68.0%	71.1%	32.0%	28.9%
2001-2015	63.7%	67.2%	36.3%	32.8%

Table 2 shows how the distribution mean HARM has varied among vehicle types for the three vehicle model year groupings.

Table 2.
Belted Driver Mean AIS 3+ HARM by Crash Mode and Model Year Groups for Passenger Car and Light Truck, SUV and Van Groupings

Lt Truck, SUV, Van					
Model Year	**Frontal**	**Near Side**	**Far Side**	**Rollover**	**Rear**
1985-1994	0.275	0.413	0.241	0.445	0.065
1995-2000	0.242	0.407	0.245	0.720	0.026
2001-2015	0.208	0.749	0.192	0.701	0.050
Average	0.236	0.547	0.220	0.647	0.047
Pass Car					
Model Year	**Frontal**	**Near Side**	**Far Side**	**Rollover**	**Rear**
1985-1994	0.272	1.377	0.319	0.958	0.111
1995-2000	0.263	1.154	0.288	1.204	0.126
2001-2015	0.265	0.804	0.281	0.971	0.135
Average	0.266	1.081	0.294	1.058	0.126

DISCUSSION

Figure 1 shows that the largest source of AIS 3+ HARM to belted drivers in the 2001 and later NASS population remains the frontal crash mode. Figure 2 indicates that the reduction in Mean AIS 3+ HARM has been relatively small for frontal crashes. Table 2 shows that for frontal crashes, most of the reductions in Mean AIS 3+ HARM have been in vehicles other than passenger cars.

Figure 2 shows that near-side and rollover injury rates have dramatically decreased for recent vehicle model years. Frontal and far-side crash mode injury rates have decreased slightly and rear has remained relatively constant, but at a low injury rate.

Table 1 permits the comparison of belted driver exposure and total AIS 3+ HARM distributions by crash mode for the three model year groupings. Each row adds to 100%, so the extent of safety improvements cannot be determined from this table. It may be noted that passenger cars still comprise the largest fraction of vehicles in the NASS/CDS – 63.7% in the 2001-2015 model year grouping. They also account for 67.2% of the total AIS 3+ HARM.

Safety initiatives that may have influenced the side crash mode improvements include the IIHS side impact rating, the NHTSA FMVSS 214 upgrade, and widespread incorporation of air curtains. The changes to comply with standards may have been more extensive for cars than for light trucks. The reason for the increase in near-side Mean AIS 3+ HARM for the non-passenger car category cannot be explained from the data in this paper. However, the near-side Mean AIS 3+ HARM for the combined group of light truck, SUV and van was lower than the passenger car near-side Mean AIS 3+ HARM.

For rollovers, the large reduction in Mean AIS 3+ HARM occurred in both vehicle groupings. Safety initiatives that may have influenced rollover improvements include the roof strength rating by IIHS, FMVSS 216 upgrade, voluntary incorporation of air curtains that function in rollover and widespread introduction of electronic stability controls.

REFERENCES

Eigen A, and Digges K, (2013) Safety changes in the us vehicle fleet by vehicle model year 2013 ESV Conference, Paper Number 13-0062, 2013

Fildes B, et. al. (1992) Feasibility of occupant protection meassures, Monash University Report to Federal Office of Road Safety, Australia, CR100, June 1992.

Malliaris A, Hitchcock R, Hedlund J, (1982) A search for priorities in crash protection.SAE International paper #820242. Society of Automotive Engineers, Warrendale, PA.

National Highway Traffic Safety Administration (2001) National Automotive Sampling System Crashworthiness Data System 1993 – 1997, DOT HS 809 203, page 152, February 2001.

National Highway Traffic Safety Administration, National Automotive Sampling System Crashworthiness Data System Data Set, 1995 – 2015, Washington, DC.