Effect of Minimizing Driver Airbag Deployments at Low Crash Severity On Facial and Upper Extremity Injuries - A Field Data Analysis

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BACKGROUND

In recent years, there has been an increase of concern over deaths produced by airbag deployments. Though airbags have been shown to be effective in reducing the number of fatalities, as of February 1998, the National Highway Traffic Safety Administration (NHTSA) in the US reported 40 cases where drivers sustained fatal or serious injuries due to an airbag deployment. These cases have become a sensitive issue since most occurred at a moderate or low crash severity.

Minimizing the number of airbag deployments below 10 mph may have reduced the fatal/serious injuries. However, what would be the counter-effect on other driver injuries in the above situation? Of particular interest would be the potential increase in facial injuries and possibly in head/neck injuries. Since there is an increased concern for upper extremity (UX) injuries, would UX injury risk decrease? What about the risk for thorax/abdomen/spine injuries?

AIM

In this study, the incidence, risk and rate of sustaining a facial, head/neck, upper extremity, and thorax/abdomen/spine injury were investigated for deployed and undeployed driver cases. This analysis was carried out to better understand the risk and severity of injuries at low delta-V. The safety benefit of eliminating driver airbag deployments for less than 10 mph was also investigated. Although the sample size was too small to produce statistically significant results, the trends observed may be used to support and prioritize the need to increase airbag deployment thresholds or minimize the gray zone. The gray zone is the delta-V range between the threshold for no airbag deployment and the threshold for an airbag deployment. These threshold requirements are usually tested in laboratory crash tests.

MATERIAL AND METHOD

Data - The data consists of 1,640 injured driver cases in frontal or offset frontal, non-rollover, non-ejection crashes that occurred in the years 1995 and 1996. For these cases, the total number of injuries was 3,319. The data included cases with autos and light trucks equipped with airbags on the driver side. The data was obtained from the National Highway Traffic Safety Administration's (NHTSA) Crashworthiness Data System (CDS). The injuries in the database were classified using the NASS-93 system.

To compare the results between different categories, the data was normalized. The following definitions were used:

- *Rate*: Rate is the ratio between the number of injuries per delta-V range and the total number of injuries per body area for all delta-V.
- *Risk:* Risk is the ratio of the number of injuries per body area to the total number of injured occupants.

RESULTS

Facial Injuries – In the database, facial injuries accounted for about 14% of all driver injuries. There were about 7 times more facial injuries in the deployed cases than undeployed cases, while there were 3 times more drivers involved with an airbag deployment than without (Table 1). The risk of sustaining a moderately severe (MAIS 3) facial injury was slightly higher for undeployed cases than deployed, at 0.3% and 0.1% respectively. However, at low delta-V (<10 mph), only minor facial injuries (MAIS 1) occurred. Though the majority of facial injuries occurred at low delta-V for undeployed cases, the risk was 3 times higher for deployed cases than undeployed cases at delta-V < 10 mph. At a delta-V between 10 and 13 mph, the risk was higher for deployed cases than undeployed, at 28% and 9% respectively.

Table 1.
Incidence, rate and risk of driver facial injuries for deployed and undeployed cases

	Delta-V									
	< 10 mph		10-13 mph		14-17 mph		18-23 mph		>=24 mph	
	U	D	U	D	U	D	U	D	U	D
MAIS 1 Facial Injuries	14	34	9	66	9	44	3	69	2	45
MAIS 2 Facial Injuries				1				2		1
MAIS 3 Facial Injuries			1							1
Total Facial Injuries	14	34	10	67	9	46	3	71	2	47
Total Injuries	116	226	105	445	63	358	31	431	18	322
Injured Occupants	137	129	115	236	37	169	14	168	5	107
Rate	0.12	0.15	0.10	0.15	0.15	0.13	0.10	0.17	0.12	0.15
Risk	0.10	0.26	0.09	0.28	0.24	0.27	0.21	0.42	0.40	0.44

D: Deployed; U: Undeployed

Upper Extremity - Upper extremity injuries accounted for about 24% of all injuries. For all crashes involving an airbag deployment, upper extremity injuries were most frequent in the 10-13 mph delta-V range, while they were most frequent in the 0-13 mph delta-V for undeployed cases (Table 2). For deployed cases, 16% of UX injuries occurred at delta-V above 24 mph, while, for undeployed cases, 7% occurred at delta-V above 24 mph. About 5% of UX injuries were moderately severe injuries (MAIS 2+). At a delta-V <10 mph, MAIS 2+ upper injuries accounted for 6% of the upper extremity injuries for both deployed (4/71) and undeployed (1/18) cases.

Table 2.
Incidence, rate and risk of driver upper extremity (UX) injuries
for deployed and undeployed cases

	Delta-V									
	< 10 mph		10-13 mph		14-17 mph		18-23 mph		>=24 mph	
	U	D	U	D	U	D	U	D	U	D
MAIS 1 UX Injuries	17	67	17	114	9	81	5	78	4	57
MAIS 2 UX Injuries	1	4	1	8		5	2	8		8
MAIS 3 UX Injuries				5		3		10		7
Total UX Injuries	18	71	18	127	9	89	7	96	4	72
Total Injuries	116	226	105	445	63	358	31	431	18	322
Injured Occupants	137	129	115	236	37	169	14	168	5	107
Rate	0.16	0.31	0.17	0.29	0.15	0.25	0.23	0.23	0.24	0.23
Risk	0.13	0.55	0.16	0.54	0.24	0.53	0.5	0.57	0.8	0.67

D: Deployed; U: Undeployed

For deployed cases, the risk for an upper extremity injury did not seem sensitive to delta-V, while, for undeployed cases, the risk increased with delta-V. At delta-V < 18 mph, the risk for a driver to sustain an upper extremity injury was about 2-3 times higher when the airbag deployed than when it did not. This suggests a possible correlation between airbag deployments and upper extremity injuries. However, at delta-V > 18 mph, the risks for an UX injury was similar for both deployed and undeployed. This indicates that crash severity may be a significant factor in the upper extremity injury mechanism when airbags are not deploying. However, the number of UX incidences was small at a delta-V above 18 mph. For these cases, further investigation may be required to better identify the injury causation and to determine why the airbag did not deploy at such crash severity.

Safety Benefit - To estimate the benefit of reducing driver airbag deployments below 10 mph, NASS-CDS reported injuries in the face, head/neck, upper extremities and thorax/abdomen/spine were compared to injuries calculated for a non-airbag deployment condition. Calculations of the injuries were based on two assumptions: 1) there were no airbag deployments below 10 mph and 2) the total number of injured drivers remained the same. The risk of sustaining an injury also assumed to remain constant. The number of injuries without an airbag deployment was calculated by multiplying the number of injured drivers with the risk associated with each injury. In this study, the net benefit of eliminating airbag deployments at < 10 mph delta-V was a reduction of 100 injuries, 97 MAIS 1 and 3 MAIS 2.

Table 3. Reported injuries and calculated injuries assuming no airbag deployments
D: Deployed; U: Undeployed

				Reported Data (NASS-CDS)		**Calculated Data (Without Airbags)**		
		Risk		**Number**		**Number**		**Injury**
Injuries	**MAIS**	D	U	D	U	D	U	**reduction**
Face	1 2 3	26%	1%	34	14		27	21
Head/Neck	1 2 3	9%	9% 1%	12	12 2		24 3	0 -1
Upper Extremities	1 2 3	52% 3%	12% 1%	67 4	17 1		32 3	52 2
Thorax/ Abdomen/ Spine	1 2 3	51% 1% 1%	33% 1%	66 1 1	45 2		88 3	23 1 0
Injured Drivers	NA	NA	NA	129	137		266	

DISCUSSION

Airbags have been shown to be effective in reducing the risk for severe or fatal injuries. However, as of February 1998, 40 cases have been reported where a driver sustained fatal or serious injuries due to an airbag deployment. These few cases have become a sensitive issue since most occurred at a low or moderate crash severity. To address this issue, minimizing airbag deployments at low delta-V is a continuing concern in the safety community. But, what should be the threshold for no deployment? What injuries may be generated if airbag deployments are minimized at low delta-V? The trends observed in this study may help answer these questions.

Since the risk of sustaining a facial or upper extremity injury was higher for deployed cases than undeployed at delta-V < 10 mph, eliminating driver airbag deployments below 10 mph seems beneficial. Furthermore, in the safety benefit analysis carried out in this study for head/neck, face, UX and thorax/abdomen/spine injuries, the elimination of deployed cases reduced the number of MAIS 1 and MAIS 2 injuries by 36% and 37% respectively. Reducing the number of airbag deployment cases at delta-V < 10 mph could be accomplished by either by increasing the non-deployment threshold speed or minimizing the gray zone. Historically, the ability to minimize the gray zone has been limited by the technology, and the threshold for no airbag deployment has been constrained by the need to assure timely deployment in certain high speed events. The data presented in this study supports and helps in prioritizing the need for new airbag technologies.

The data obtained in this study further suggested that the threshold for non-deployments could be increased to 14 mph. However, there was one incidence (out of 10) where the driver sustained a MAIS 3 facial injury when the airbag did not deploy in the 10-13 mph delta-V. It should be noted that the analysis is limited due to the small sample size. The results obtained in this study show trends in the field and make no reference to vehicle specific performance. Vehicle specific analysis could yield different results. Future work is necessary to investigate the effect of increasing the threshold speed for airbag deployments in the 10-13 mph delta-V range. Such work may include laboratory tests with anthropomorphic dummies or cadavers and mathematical simulations at low crash severity. Also, as more field data become available, an analysis of belt use could be carried out. In this study, the effect of belt use on upper body injuries was determined but the findings were limited by the sample size. Belt use did not seem to have an affect on upper body injury risks for deployed cases. However, there was a trend for higher injury risk for unbelted drivers than belted in undeployed cases.

CONCLUSIONS

The results of this study indicated the following trends:

- Eliminating airbag deployments for a delta-V < 10 mph:
  - reduced the number of face/neck/head/UX injuries.
  - reduced the number of MAIS 1 and MAIS 2 thorax/abdomen/spine injuries. (No effect was observed on the number of MAIS 3+, however, the number of MAIS 3+ was limited.)
  - may potentially reduce societal costs.
- At delta-V's < 14 mph:
  - driver risk for facial and UX injuries was lower for non-deploy than deploy. Thus, there may be a benefit in minimizing airbag deployments for this range.
- Increasing threshold speed for deployment or reducing gray zone:
  - will potentially reduce the serious or fatal injuries at low delta-V reported in the SCI data.