HSIS

HIGHWAY SAFETY INFORMATION SYSTEM

The Highway Safety Information Systems (HSIS) is a multi-State safety data base that contains accident, roadway inventory, and traffic volume data for a select group of States. The participating States, California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington, were selected based on the quality of their data, the range of data available, and their ability to merge data from the various files. The HSIS is used by FHWA staff, contractors, university researchers, and others to study current highway safety issues, direct research efforts, and evaluate the effectiveness of accident countermeasures.

U.S. Department of Transportation
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Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike • McLean, Virginia 22101-2296

SUMMARY REPORT

The Effects of Airbags on Severity Indices for Roadside Objects

COLLISIONS WITH ROADSIDE OBJECTS ACCOUNT FOR ALMOST ONE-THIRD OF THE TRAFFIC fatalities in the United States, and a large amount of serious injury and accident costs. A measure of the average severity of these impacts, the Severity Index (SI), is used by highway safety engineers in determining where best to spend roadside improvement funds. Since airbags have been shown to reduce the severity of driver injury in roadside crashes, a question of interest is how an airbag will affect the SI. Such knowledge could be used to refine estimates of the SIs as the vehicle fleet changes to total airbag protection.

In an earlier large-scale study of Severity Indices by Council and Stewart,[1,2] North Carolina data were used to develop preliminary estimates of how the presence of an airbag might affect SIs. Indices were developed for trees, utility poles, and guardrails (faces and ends combined) based on the proportion of serious and fatal driver injury. The data indicated that there is indeed a difference in the proportion of drivers who are seriously injured in cars equipped with airbags vs. those not equipped with airbags in fixed-object collisions. The SI for guardrails showed the greatest decrease due to the airbag, approximately 74 percent; trees and utility poles had decreases of approximately 36 percent and 42 percent, respectively. The results, however, indicated a clear need for a larger sample of airbag-equipped vehicles, a more recent vehicle fleet, and a multi-State data base for validation purposes. This current study was designed in an attempt to meet those needs.

STATE DATA BASES USED

HIGHWAY SAFETY INFORMATION SYSTEM (HSIS) DATA FROM NORTH Carolina were used to facilitate comparison between this study and the earlier Council and Stewart study, and data from Illinois and Utah were added to determine the level of consistency across the States. These three States are the only HSIS States that have a Vehicle Identification Number (VIN) for each vehicle, which allows the identification of vehicles equipped with airbags. To ensure a more recent vehicle fleet (which would result in a comparison of newer and safer vehicles in both categories), vehicles were restricted to include only model years 1989 and later. All three States also had variables that made it possible to identify those accidents in which the primary cause of injury was a collision with a specific fixed object. This led to the development of “cleaner” SIs than would be the case if the data used included multiple-object impacts. Finally, pickup trucks were dropped from the analysis since they would only be found in the non-airbag sample.

The final data set for each State was restricted to those fixed-object classes for which there were at least 50 airbag-equipped vehicle crashes, which translated into many more than 50 non-airbag vehicle crashes. The fixed objects that remained in the three data bases included trees, utility poles, highway signs, light poles, catch basins, guardrails (faces and ends), concrete barriers, bridge rail faces, and ditchbanks.

Based on the availability of data in the HSIS system at the time of the analysis, the final database included four years of Illinois data (1990-1993), and five years of North Carolina and Utah data (1990-1994).

ANALYSIS METHODS

In order to be consistent with the earlier Council and Stewart study, two different severity indices were developed in the initial analysis—one defined by the proportion of severe injuries experienced in fixed-object crashes, and one related to injury costs for the entire distribution of injuries experienced. The injury cost index used was based on the figures defined by the Federal Highway Administration's (FHWA's) "Motor Vehicle Accident Costs."[3] In both cases, driver injury was used in the index, since the study compared the SI for driver-side airbags versus no airbags. Because of the need to control the analysis by vehicle weight, and because the initial analyses indicated similar findings between the severe injury and injury cost indices, only the severe injury indices were used in the remaining analyses reported below.

Since the SI for a given object will depend on combination of several vehicle and roadway factors present in a crash, initial attempts involved controlling for rural/urban crash location, speed limit, and vehicle type using a classification and regression methodology (CART) developed by Breiman, et al.[4] However, the small sample sizes precluded the meaningful use of this method. In addition, since vehicle weight is often associated with driver injury, detailed analyses were conducted to determine if the presence of an airbag was associated with vehicle weight in the sample for each State, and if serious injury rate was also associated with weight class. If so, then any measured airbag effect would also contain the effect of vehicle weight. These analyses indicated that airbag presence and weight were associated with serious and fatal injury rates in both the North Carolina and Illinois data, but not in the sample of Utah data used. Because of this, comparison injury rates from the non-airbag samples in these two States were adjusted to account for these weight differences. (Details of the adjustment are provided in the full Transportation Research Board article noted at the end of this Summary Report.)

Finally, because the distinction between urban and rural crash locations would be related to vehicle speeds, it was necessary to control for crash location by conducting basic contingency table analyses for both total crashes and for rural-only crashes. It was felt that by isolating rural-only crashes, we could homogenize speed limits and thus control for vehicle speeds.

RESULTS

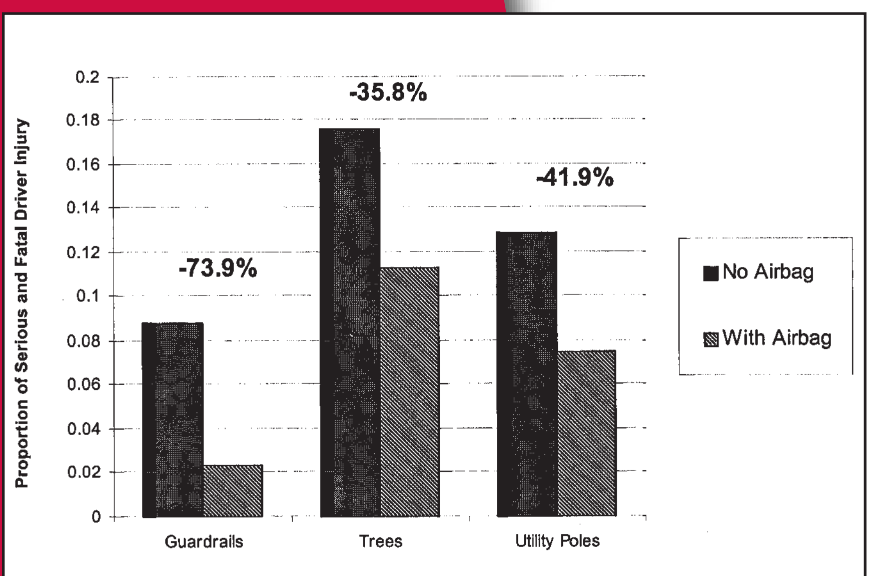

Figure 1. Proportion of serious and fatal injury for passenger vehicles, and the percent difference due to airbags (North Carolina data).

The results of the earlier Council and Stewart study, displayed in **figure 1**, showed that the airbag-related proportion of the severe and fatal injuries category was consistently lower than the corresponding non-airbag proportion. The percent decrease of serious and fatal injuries was 36 percent for trees, 42 percent for utility poles, and 74 percent for guardrails.

In tabulating the results of the current study, the authors examined the effectiveness of airbags on reducing the severity indices of driver injury due to collisions with the 10 classes of roadside objects (trees, utility poles, highway signs, light poles, catch basins, guardrails (faces and ends), concrete barriers, bridge rail faces, and ditch-banks). While analysis of most object classes yielded insignificant results, **table 1** presents results that were found to be significant at the $p < 0.10$ level. Point-type objects are at the top of the table, with longitudinal objects at the bottom. The table presents the sample size and the percent A + K injuries for the vehicles not equipped with airbags, and the sample size, number, and percent of A + K injuries for airbag-equipped cars/vans. The last column presents the decrease in the percentage of A + K injuries related to the airbag. Numbers in parentheses represent increases for airbag-equipped vehicles. **Figure 2** presents the same results graphically, and can be compared to **figure 1**.

All comparisons are within the same object class, rather than between objects, since comparisons between objects can be affected by other factors, such as the proportion of unreported crashes in the police data (e.g., collisions with highway signs might be reported less often than collisions with utility poles). Unfortunately, there is no way to accurately determine the direction or degree of the effect of under-reporting, and since the effects are assumed to be relatively minor within the same object class, the results will be stated based on the available data.

Statistically significant decreases in serious or fatal driver injuries are seen when an airbag-equipped car strikes a tree (Illinois), a utility pole (North Carolina), a guardrail (North Carolina and Illinois), a guardrail end (North Carolina), or a ditchbank (North Carolina). In contrast to the latter finding, there is an increase in serious or fatal driver injuries when an airbag-equipped car crashes into a ditch/embankment in Illinois. None of the Utah findings were significant. Where these reductions exist, we see decreases from 20 to 55 percent due to airbags. This is somewhat less than the percentages found in the earlier study (i.e., 36 to 74 percent).

In general, the airbag seems to result in a decrease in serious injury across the objects, in that all differences except one indicate airbag-related decreases. However, there are inconsistencies in the data. The greatest inconsistency noted is the finding related to ditchbanks/embankments. Here, airbag-equipped cars in North Carolina experienced a 20-percent decrease in serious/fatal injuries, while similar vehicles in Illinois experienced a 54-percent increase. While satisfactory explanation in the data has not been found, it is noted that this class of "object" is not as specifically defined as the other classes. The category is also a "catch-all" category, which is the object struck when all other roadside objects have been "missed". This could contribute to some of the inconsistency.

Total consistency is also lacking among the findings in the Illinois and North Carolina data. For example, the findings for trees, utility poles, highway signs, and light poles (since all are point objects) might be expected to be somewhat similar across States. Likewise, the data for continuous barriers, such as guardrails, bridge rails, and concrete barriers, could be similar. This is not always the case. For point objects, a significant difference is seen for vehicles striking utility poles in North Carolina, but not for utility pole impacts in Illinois. In contrast, although a significant 29.6-percent reduction is observed for airbag-equipped cars striking trees in Illinois, a non-significant 10.2-percent reduction is observed in North Carolina (not shown in the table). This latter finding differs from the North Carolina data collected in the earlier analysis (shown in **figure 1**), which indicated a significant 35.8-percent reduction

	NO AIRBAG		AIRBAG				
Object Struck	N	Percent[1]	N	A+K	Percent	p-Value	Percent Change
Tree (IL)	424	21.6%	138	21	15.2%	0.097	-29.6
Utility Pole (NC)	731	10.5%	291	20	6.8%	0.081	-35.2
Guardrail (NC)	625	6.9%	312	10	3.2%	0.042	-53.6
Guardrail (IL)	959	9.9%	287	17	5.9%	0.047	-40.4
Guardrail End (NC)	139	14.3%	62	4	6.5%	0.092	-55.0
Ditchbank (NC)	3155	7.2%	1159	66	5.7%	0.063	-20.5
Ditch/Embankment (IL)	594	8.2%	222	28	12.6%	0.057	+53.6

[1] *Percent adjusted by vehicle weight in North Carolina and Illinois data.*

Table 1. Comparison of serious or fatal (A+K) driver injuries for non-airbag and airbag passenger vehicles by object class [statistically significant results only (North Carolina and Illinois data)].

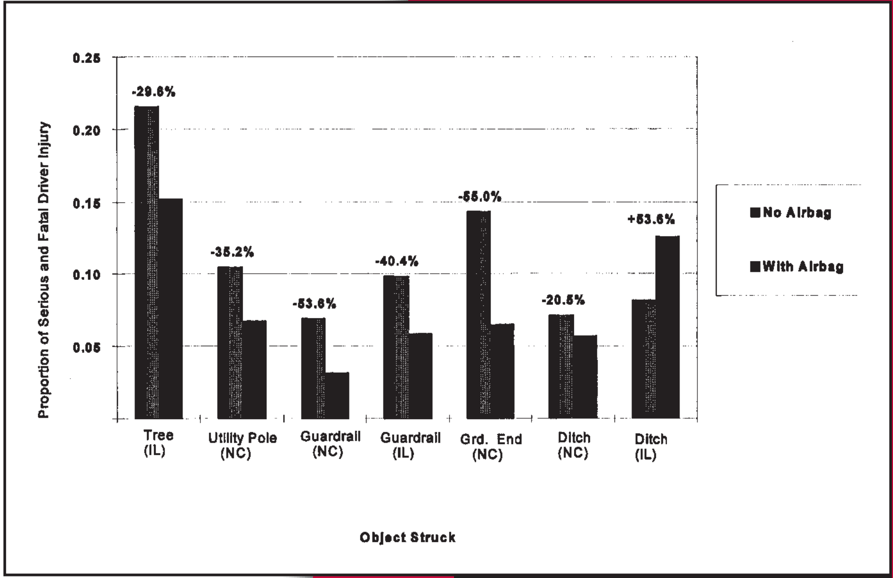

Figure 2. Proportion of serious and fatal injury for passenger vehicles, and the percent difference due to airbags [statistically significant results only (North Carolina and Illinois data)].

when airbag-equipped vehicles struck trees. While this could be related to greater increases in seatbelt use in North Carolina since the last study, the airbag effect should therefore be consistently greater in Illinois. It is not. Thus, the inconsistency cannot be explained by the authors.

Looking at the longitudinal barriers studied, the North Carolina and Illinois results are similar. Both indicated a significant difference in injury caused by guardrail impacts due to the airbag (40 percent and 53 percent, respectively).

In order to control for vehicle speed, rural crashes were isolated and analyzed on their own (not shown in a table). It was felt that this would homogenize speed limits and vehicle speeds to some extent. Both point-object and longitudinal barrier impacts were examined, and the rural findings generally parallel the findings for all impacts in both North Carolina and Illinois, but are sometimes of greater magnitude. For point objects, the North Carolina testing revealed a significant airbag effect for utility pole impacts (51.6 percent, $p = 0.09$). For barrier impacts, the rural North Carolina testing indicated a significant airbag effect in total guardrail impacts, which was very similar to the overall effect noted in **table 1** (55.0 percent, $p = 0.05$), and a nearly significant and similar effect with guardrail ends (57.7 percent, $p = 0.113$). A 28.0-percent reduction due to airbags was noted in North Carolina ditchbank impacts ($p = 0.02$), again contrasting with a 60.1-percent increase in injury rates in ditchbank crashes in Illinois ($p = 0.03$).

While the data across the States and across object types were not totally consistent, the authors concluded that airbags would indeed reduce the severity indices for fixed objects. The best estimate of the reduction would be in the range of 10 to 30 percent for point objects, 40 to 50 percent for guardrails, and 10 to 20 percent for other longitudinal barriers. No conclusions concerning impacts into ditchbanks/embankments can be drawn.

STUDY IMPLICATIONS

Because of questions raised by the roadside safety research community concerning the predicted effects of airbags as reported in the earlier paper, this analysis attempted to expand that earlier work by including additional years of data and additional States. In addition, the data selected reflects a more current and more homogeneous vehicle population by restricting the analysis to crashes from later years involving more recent vehicle models and controlling for vehicle weight by including only passenger cars, stationwagons, and passenger vans. Where necessary, the analyses were controlled for vehicle weight in order to remove possible biases.

As was expected, the results here were somewhat different from the earlier work, which estimated airbag effects at between 35 and 75 percent. The current range of effect is estimated at a more conservative 10 to 50 percent, depending on the object. The difference in the two estimates can be partially attributed to the newer, safer cars in the current study (both with and without airbags), and the increase in seatbelt use between the two samples. In the current study, it appears that the airbag effects for longitudinal barrier (guardrail) impacts may be slightly greater than for point objects.

In summary, these data have provided additional information concerning the expected future effects of airbags on severity indices for roadside objects. Clearly, it would continue to be beneficial to have even larger samples of data in order to better verify effects for individual objects across the States and to better define differences (if any) between airbag effects for different objects. As has been noted before, the Highway Safety Information System will continue to provide this opportunity for further work.

REFERENCES

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FOR MORE INFORMATION

This research was conducted by Forrest M. Council and J. Richard Stewart of the University of North Carolina Highway Safety Research Center and Yusuf M. Mohamedshah of LENDIS Corporation. The final report, *The Effects of Airbags on Severity Indices for Roadside Objects,* was recently published in *Transportation Research Record 1581* (October 1997). For more information regarding the research, contact Forrest Council at (919) 962-0454. For further information about HSIS, contact Michael S. Griffith, HSIS Program Manager, HSR-20, at (703) 285-2382, *mike.griffith@fhwa.dot.gov*.

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