

# Analysis of the Performance of 1981 and 1982 Automotive Bumpers on the Basis of Bumper Design and Manufacturer

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## ABSTRACT

The effectiveness of the crash-protecting automobile bumpers required by the National Highway Traffic Safety Administration (NHTSA) for 5-mph impacts was studied through an analysis of insurance claims filed with the State Farm Insurance Company, Inc. Claims were analyzed for model year 1981 and 1982 vehicles. The performance of bumper systems was compared on the basis of bumper design and automotive manufacturer. Performance was measured on the basis of the proportion and average repair costs of insurance claims involving bumper damage. Other factors influencing bumper performance were studied including (a) criteria used to identify bumper damage claims, (b) market class, and (c) impact point.

Under a contract with the National Highway Traffic Safety Administration (NHTSA), insurance claim data were analyzed to assess the performance of automotive bumpers designed to conform to NHTSA's exterior protection standards for 5-mph impacts (1).

These standards establish requirements for bumper protection of both safety and nonsafety items in low-speed collisions. Effective with model year 1980 passenger cars, requirements were added to minimize damage to the bumper face bar itself.

Although NHTSA has issued various standards for bumper performance since 1973, this study analyzed bumper systems conforming to the version of the standards in effect for model years 1980 through 1982. Although all bumpers manufactured during this period were required to meet identical protection standards, considerable variations in bumper performance were observed among different bumper designs and automotive manufacturers. Differences were also observed on the basis of market class and impact direction.

In this paper bumper performance is compared in terms of design and manufacturer. Performance is measured on the basis of the proportion and average repair costs of insurance claims involving bumper damage.

Data for this study were obtained from the State Farm Insurance Company, Inc., and represent a nationwide sample of insurance claims from the company's claim service centers. Data for model years 1981 and 1982 were used for the design and manufacturer analyses.

An additional source of information for this study was the published results of a detailed description (2) of 1982 automotive bumpers performed for NHTSA by the Pioneer Engineering and Manufacturing Company. That study represented a "tear-down" analysis of the bumper systems of 49 different 1982 makes and models. Results of the tear-down analysis provided the basis for identification of bumper designs.

## EXPERIMENTAL DESIGN

In this study, only claims involving current model year vehicles in which a bumper was either repaired or replaced were considered. Claims with damage to front bumpers from rear impacts or vice versa were not considered. Experiments were designed to stratify

and compare insurance claims on the basis of bumper design and bumper manufacturer. Within these experiments, other factors were considered:

1. Impact point (front, rear);
2. Vehicle size (subcompact, compact, intermediate, full size); and
3. Criteria determining bumper involvement (damage to face bar, fascia, or both).

Vehicle size classes were defined by the accepted criteria used by the insurance industry as follows:

Vehicle Size	Wheelbase (WB) Length (in.)
Subcompact	< 101
Compact	101 < WB < 111
Intermediate	111 < WB < 120
Full size	> 120

These classifications were consistent with those used in previous bumper claim studies (3-5) and offered the ability to easily compare results of studies.

Two measures of effectiveness (MOEs) were employed to judge bumper performance. These included (a) the proportion of property damage claims involving a bumper and (b) the average repair costs of bumper-involved claims.

Statistical comparisons were performed by using hypothesis tests with a 95 percent confidence level for the differences between claim proportions and mean costs.

## ANALYSIS OF BUMPER DESIGNS

Several questions were addressed by this analysis and are as follows:

1. Did any designs perform substantially better or worse than others?
2. How do newer soft face designs influence bumper performance?
3. Are different criteria needed to identify bumper-involved claims based on design? If so, which criteria are best suited to each design?

To gain an understanding of the relationship between bumper design and bumper claim involvement,

three different criteria were examined to classify an insurance claim as involving bumper damage. These criteria included repair or replacement of (a) the bumper face bar (fascia may or may not be damaged), (b) only the bumper fascia (excludes cases in which both fascia and face bar damage occurs), and (c) the face bar, the bumper fascia, or both.

Ludtke and Kaminski (2) provided the basis for the identification of bumper designs. That study was a tear-down analysis of the bumper systems of 49 different 1982 subcompacts and compacts. The following three categories of bumper designs were identified:

- Hard face bar or fascia (H),
- Soft cover over bumper only (S/B), and
- Grille integral with bumper soft cover (S/G).

Hard (H) designs are typically found in traditional bumpers in which a metal material such as aluminum or steel serves as an exposed face bar. A newer version of this design uses plastic instead of metal. In such cases the plastic surface is often considered a hard fascia.

Soft designs generally employ a polyurethane surface (fascia) to cover a metal face bar or bumper reinforcement. These designs fall into two categories. In the more prevalent case the soft fascia covers only the bumper (S/B). In a variation of this design, vehicles such as the Chevrolet Camaro and the Pontiac J2000 integrate the soft bumper cover with the front grille (S/G).

Ludtke and Kaminski (2) identified and categorized the front and rear bumper systems of each of 49 makes and models by design. In some cases only the front bumper employed a soft design whereas in other cases only the rear bumper did.

Insurance claims were found for 38 of these 49 makes and models. These were all either subcompacts or compacts. Claims for each of these classes were compared by design. No compacts were found with the integral grille and soft cover design. Claims for front and rear impacts were analyzed separately.

Statistical comparisons examined both the proportion of bumper-involved claims and the average repair costs of these claims. For the proportion analysis, the number of front and rear bumper claims was aggregated for each market size class and design. Claim proportions relative to the total number of claims for each market class were then computed. Within each market class, the claim proportions by design and impact point were statistically compared using the hypothesis test for proportion differences.

The same statistical comparisons were performed for the analysis of average repair costs. In each case the average repair cost was computed for each market class-design-impact point combination. The differences among average costs were statistically tested using the hypothesis test for the difference between means at the 95 percent confidence level. Each set of statistical comparisons was performed three times to test each of the three criteria used to identify bumper-involved claims.

#### PROPORTION ANALYSES OF BUMPER DESIGNS

The results of the three sets of statistical comparisons performed on bumper claim proportions are given in Table 1. Also given are claim proportions for each involvement criteria by market class, design, and impact point.

##### Face Bar Damage

In soft cover designs (S/B and S/G) the face bar is shielded behind the soft bumper fascia. In studying

TABLE 1 Summary of Claim Proportion Analyses for Bumper Designs, 1982 Model Year

Involvement Criteria and Vehicle Size	Claims by Design, Size and Involvement Criteria (% of total)			Total Bumper-Related
	Design	Front	Rear	
Face bar damage				
Subcompact	H	21.4	9.7	31.0
	S/B	10.0 <sup>a</sup>	6.4	16.3 <sup>a</sup>
	S/G	16.2 <sup>b</sup>	0.0	16.2 <sup>a</sup>
Compact	H	31.0	16.5	47.5
	S/B	9.1 <sup>a</sup>	2.9 <sup>a</sup>	12.0 <sup>a</sup>
Fascia only damage				
Subcompact	H	5.4	2.9	8.3
	S/B	21.9 <sup>a</sup>	13.0 <sup>a</sup>	34.8 <sup>a</sup>
	S/G	36.0 <sup>a,b</sup>	0.0	36.0 <sup>a</sup>
Compact	H	2.5	1.6	4.2
	S/B	24.5 <sup>a</sup>	6.8 <sup>a</sup>	31.3 <sup>a</sup>
Face bar and/or fascia damage				
Subcompact	H	26.8	12.6	39.3
	S/B	31.8 <sup>a</sup>	19.3 <sup>a</sup>	51.1 <sup>a</sup>
	S/G	52.2 <sup>a,b</sup>	0.0	52.2 <sup>a</sup>
Compact	H	33.6	18.1	51.7
	S/B	33.6	9.7 <sup>a</sup>	43.2 <sup>a</sup>

Note: H = Hard Fascia, S/G = Grille Integral with Bumper Soft Cover, and S/B = Soft Cover over Bumper. Numbers may not sum to total due to rounding.

<sup>a</sup>Difference in claim proportions relative to 1982 Hard Bumper Design is significant at a 5 percent confidence level.

<sup>b</sup>Difference in claim proportions relative to 1982 S/B Bumper Design is significant at a 5 percent confidence level.

soft designs, the face bar damage criterion would likely identify the more severe claims in which both the fascia and the face bar were damaged. Therefore it was not surprising that the proportion of face bar involvement was shown to be lower for both soft designs than for the hard design.

For compact vehicles only the hard fascia (H) and soft-cover bumper (S/B) designs could be compared. The sample size for this analysis was extremely small. In both front and rear comparisons, the S/B design had significantly lower claim proportions than the hard design. In total, claim proportions for the compacts using S/B design were 35 percent lower than those with a hard design.

Subcompact vehicles using the S/B design also had a significantly smaller proportion of claims than those with the hard design. This was shown primarily for front impacts. The S/G design was used for front bumpers only and the claim proportions for this design fell between the S/B and the hard fascia values. In comparing both soft designs (front impacts only), the integral grille and bumper cover design exhibited a significantly higher proportion of face bar damage. Therefore, considering subcompact claims for front impacts, vehicles with the S/B design had the lowest proportion of bumper-involved claims.

##### Fascia-Only Damage

This criterion considered claims in which the bumper fascia was damaged but the face bar was not. (This set of claims is mutually exclusive from the claims identified by the previous criterion.) Fascia damage for hard designs is applicable only to a few makes and models such as the Honda Civic and Accord, which have hard plastic fascia. Hard plastic fascia exhibit substantially lower claim proportions than either soft fascia independent of impact point and market class. Again, it is observed that the S/G design exhibited significantly higher claim proportions than the S/B design.

### Face Bar and/or Fascia Damage

This criterion considered claims in which either the face bar or fascia, or both, were damaged. The sample sizes for this case were numerically equal to the sum of the sample sizes for the previous two criteria. This criterion accounts for all makes and models equipped with some type of hard face bar or fascia. In addition, this criterion accounts for all bumper-involved claims for soft designs because it includes consideration of the more extreme cases in which both the face bar and fascia are damaged as well as cases in which only the fascia is damaged.

For the first time, important differences emerged between subcompacts and compacts. Subcompacts with the S/B soft design exhibited significantly higher claim proportions than did those with the hard design regardless of impact point. Subcompacts with the S/G design exhibited a further significant increase in proportions relative to those with the S/B design.

Interestingly enough, none of these findings were observed for compacts. In that case there was no difference in claim proportions for front impacts between the hard and the soft cover designs. Vehicles with the S/B design exhibited significantly lower claim proportions for rear impacts than did those with a hard fascia design. However, the sample size for this result was small.

### REPAIR COST ANALYSIS OF BUMPER DESIGNS

Table 2 gives the results of the comparisons of average repair costs for the three bumper designs. The same three criteria for bumper involvement employed in the proportion analysis were also used here.

### Face Bar Damage

This criterion identifies claims in which both fascia and face bar damage is likely in soft designs. Therefore, it might be expected that the average

repair costs for soft designs would be higher than for those vehicles with a hard design. Although both soft designs appeared to have higher repair costs than the hard design for subcompacts, only the higher costs for the S/G design were statistically significant. According to the data in Table 2, a subcompact experiencing a front collision with face bar damage was approximately \$540 more expensive to repair if it had an S/G bumper instead of a hard bumper. No significant differences were observed for compacts.

### Fascia Damage

This criterion identifies claims on the basis of fascia damage (excluding claims with face bar damage). It provides the opportunity to compare repair costs for fascia damage claims for hard and soft fascia designs. In this case, S/B designs exhibited significantly higher costs than hard designs for rear impacts to subcompacts and front impacts to compacts. When results for both impact points were averaged, repair costs for vehicles with S/B bumpers were significantly higher than for those with the hard design. Subcompacts with S/B bumpers were approximately \$170 more expensive to repair than those with hard bumpers. Compacts with S/B bumpers were \$400 more expensive to repair than those with hard fascia bumpers. In a reversal of the previous findings, repair costs for the S/G design were numerically lower than those for both other designs and significantly lower than the S/B design.

### Face Bar and/or Fascia Damage

There were no statistically significant cost differences in any comparison in this case.

### RESULTS OF DESIGN COMPARISONS

As a result of the comparison of claim proportions and average repair costs of designs, the following observations were noted:

1. Results for each design differed on the basis of the criteria used to identify bumper-involved claims. Each criterion offers different implications for understanding the performance of each design.

2. The face bar-fascia damage criterion appears overall to be the single, most useful means for comparing the three bumper designs. Considering only face bar damage eliminates claims for vehicles using newer hard-plastic fascia. In the case of soft fascia designs, the consideration of face bar damage only would eliminate claims in which only the fascia was damaged.

3. Using the face bar-fascia damage criterion, both of the newer soft face designs exhibit significantly higher claim proportions for subcompacts than does the traditional hard design. This is true regardless of impact point.

4. These findings did not hold for compact vehicles. In that case there was no difference in front impact claim proportions between the hard and soft cover designs. Vehicles with the S/B design exhibited significantly lower claim proportions for rear impacts than those with the hard fascia design.

5. In terms of damage to the bumper face bar, both soft face designs had lower claim proportions for front impacts than did the hard fascia design. In the case of the soft cover over the bumper (S/B), this reduction was significant.

6. Of the two soft designs, vehicles equipped

TABLE 2 Summary of Repair Cost Analyses for Bumper Designs for 1982 Model Year Vehicles

Involvement Criteria and Vehicle Size	Average Repair Costs (\$) (1982 \$)			Average Bumper-Related
	Design	Front	Rear	
Face bar damage Subcompact	H	1,300	933	1,186
	S/B	1,445	984	1,265
	S/G	1,840 <sup>a</sup>	0	1,840 <sup>a,b</sup>
	H	1,391	922	1,228
	S/B	1,264	869	1,170
Fascia-only damage Subcompact	H	1,190	668	1,006
	S/B	1,332	902 <sup>a</sup>	1,172 <sup>a</sup>
	S/G	976 <sup>b</sup>	0	976 <sup>b</sup>
	H	735	538	658
	S/B	1,132 <sup>a</sup>	784	1,056 <sup>a</sup>
Face bar and/or fascia damage Subcompact	H	1,278	872	1,148
	S/B	1,368	929	1,202
	S/G	1,244	0	1,244
	H	1,342	888	1,183
	S/B	1,167	810	1,088

Note: H = Hard Fascia, S/G = Grille Integral with Bumper Soft Cover, and S/B = Soft Cover over Bumper.

<sup>a</sup>Difference in claim costs relative to 1982 Hard Bumper Design is significant at a 5 percent confidence level.

<sup>b</sup>Difference in claim costs relative to 1982 S/B Bumper Design is significant at a 5 percent confidence level.

with front bumpers of the S/G design consistently experienced higher claim proportions for both fascia and face bar damage.

7. No significant differences in average repair costs were found among designs on the basis of the face bar-fascia damage criterion. The maximum repair cost difference among designs was approximately \$100.

8. Claims with face bar damage appeared to be more costly for subcompacts with soft designs than for hard designs. The increase for S/G designs was significant. Bumper design differences among compacts did not have any significant effect on average bumper claim costs.

9. Claims with fascia damage without face bar damage were significantly more costly to repair for the S/B design than for the hard design. In this case the S/G design was cheaper to repair than either of the other two and significantly cheaper than the S/B design.

#### ANALYSIS BY BUMPER MANUFACTURER

This experiment examined the 1981 claim experience of different manufacturers to determine whether any discernible difference exist. If so, certain approaches to the manufacture of bumpers might be found to be more effective than others. Differences among manufacturers might be explained in terms of the mix of designs within each manufacturer's sample.

This experiment differed from manufacturer analyses performed in the previous insurance claim studies (3-5) by providing direct statistical comparisons of manufacturers. In previous studies, each manufacturer was considered separately. Comparisons focused on a manufacturer's claim experience between model years representing different versions of the bumper standards. The emphasis was on determining how the changing standards were influencing the claim experience of each manufacturer.

Because this study examined a period during which the standard remained unchanged, the experiment was revised to compare the claim experience of each manufacturer within a single model year. The larger 1981 sample was chosen for analysis.

Comparisons, which were similar to the analysis of bumper designs, were undertaken to determine whether the proportion of bumper-involved claims and the average repair costs of these claims differed between manufacturers. The following comparisons were included:

1. General Motors (GM) versus Ford,
2. GM versus Chrysler,
3. GM versus foreign manufacturers,
4. Ford versus Chrysler,
5. Ford versus foreign manufacturers, and
6. Chrysler versus foreign manufacturers.

Each comparison stratified claims by market class and impact point. The criterion used for bumper involvement was damage to the bumper face bar or fascia, or both.

Not every make and model produced by each manufacturer was represented in the insurance claim sample. A total of 36 makes and models were available for the GM sample, 27 for Ford, 15 for Chrysler, and 64 for the foreign manufacturers. A complete listing of all makes and models included in this experiment is available in Abramson and Yedlin (1).

#### PROPORTION ANALYSES OF BUMPER MANUFACTURERS

Table 3 contains a summary of the statistical comparisons of claim proportions among the four manu-

TABLE 3 Summary of Claim Proportion Analyses for Bumper Manufacturers for 1981 Model Year Vehicles

Vehicle Size and Manufacturer	Claims by Manufacturer and Size (% of total)		Total Bumper-Related
	Front	Rear	
Subcompact			
GM	28.9 <sup>a</sup>	11.0	39.9
FD	23.9 <sup>b,c,d</sup>	13.3	37.3 <sup>c,d</sup>
CH	30.8 <sup>a</sup>	12.6	43.5 <sup>a</sup>
FN	28.5 <sup>a</sup>	14.1	42.6 <sup>a</sup>
Compact			
GM	30.5 <sup>a</sup>	17.0 <sup>d</sup>	47.5 <sup>a,d</sup>
FD	21.0 <sup>b</sup>	16.2	37.1 <sup>b</sup>
FN	27.4	10.3 <sup>b</sup>	37.7 <sup>b</sup>
Intermediate			
GM	23.5	18.3	41.9
FD	18.4	19.6	38.0
Full size			
GM	22.7	18.8	41.4
All classes			
GM	28.8 <sup>a</sup>	16.5 <sup>c,d</sup>	45.2 <sup>a,c</sup>
ED	22.3 <sup>b,c,d</sup>	15.0	37.3 <sup>b,c,d</sup>
CH	30.5 <sup>a</sup>	12.5 <sup>b</sup>	43.0 <sup>a</sup>
FN	28.4 <sup>a</sup>	14.1 <sup>b</sup>	42.5 <sup>a,b</sup>

Note: GM = General Motors, FD = Ford, CH = Chrysler, and FN = foreign manufacturers.

<sup>a</sup>Difference in claim proportions relative to Ford is significant at a 5 percent confidence level.

<sup>b</sup>Difference in claim proportions relative to GM is significant at a 5 percent confidence level.

<sup>c</sup>Difference in claim proportions relative to Chrysler is significant at a 5 percent confidence level.

<sup>d</sup>Difference in claim proportions relative to Foreign is significant at a 5 percent confidence level.

facturer categories. Cases with minimal sample sizes were eliminated from this table.

A comparison of GM with Ford (Table 3) shows that Ford subcompacts and compacts exhibited a significantly lower proportion of front bumper-involved claims. Because of the prevalence of subcompacts and compacts in the sample, these results were also reflected in the aggregate market class sample. No significant differences emerged for rear bumpers. In a comparisons of GM with Chrysler, Chrysler appeared to have a significantly lower (4 percent) proportion of rear bumper-involved claims in aggregate. However, a small sample size was available for Chrysler, which precludes assigning much weight to this finding.

An examination of GM and foreign makes revealed no significant differences for subcompacts, and the sample sizes for other classes were insufficient for analysis; however, in aggregate, the samples were sufficient and it was shown that the proportion of rear impact claims was significantly less (2 percent) for the foreign makes than for GM.

A review of GM and these other manufacturers showed that Ford subcompacts and compacts had lower claim proportions for front impacts. In aggregate, Chrysler and the foreign makes exhibited lower claim proportions for rear impacts. Compared with Chrysler, Ford subcompacts experienced significantly lower (7 percent) claim proportions for front impacts. In aggregate, Ford had significantly lower (6 percent) claim proportions for all bumper-involved claims in the two manufacturers' samples. Comparing Ford vehicles with foreign makes, it was again found that Ford subcompacts had a significantly lower (approximately 5 percent) proportion of claims for front impacts. This was also reflected in lower claim proportions for all bumper-involved claims in the sample. Sample sizes were insufficient for a comparison between Chrysler and foreign vehicles except for subcompacts and aggregate manufacturer claims. In these cases there were no discernible differences between Chrysler and the foreign makes.



## REPAIR COST ANALYSES OF BUMPER MANUFACTURERS

The same six sets of comparisons were performed on the average repair costs of bumper-involved claims by manufacturer. These are given in Table 4. All 1981 costs are given in 1982 dollars and an inflation rate of 9.36 percent was used.

Comparing GM and Ford, Table 4 reveals that GM had significantly lower average repair costs for its subcompacts and compacts. This was due primarily to differences of between \$300 and \$400 in the costs of repairing front impacts. The small number of Ford compact vehicles in the sample, however, diminishes the weight of these findings for compacts. When all available claims for Ford and GM vehicles were examined, GM's repair costs were a significant \$133 less than Ford's.

TABLE 4 Summary of Repair Cost Analyses for Bumper Manufacturers for 1981 Model Year Vehicles

Vehicle Size and Manufacturer	Average Repair Costs (1982 \$ assuming a 9.36 percent inflation rate)		Average All Bumper- Related
	Front	Rear	
Subcompact			
GM	1,168 <sup>a,b</sup>	864	1,084 <sup>b</sup>
FD	1,451 <sup>c,d</sup>	998	1,289 <sup>c,d</sup>
CH	1,115 <sup>a,b</sup>	939	1,064 <sup>a,b</sup>
FN	1,368 <sup>c,d</sup>	881	1,207 <sup>c</sup>
Compact			
GM	1,224 <sup>a,b</sup>	829	1,083 <sup>a,b</sup>
FD	1,659 <sup>d</sup>	868	1,312 <sup>a,d</sup>
FN	2,111 <sup>d</sup>	1,040	1,819 <sup>b,d</sup>
Intermediate			
GM	1,564	1,043	1,334
FD	1,322	1,047	1,180
Full size			
GM	2,568	1,044	1,864
All classes			
GM	1,300 <sup>a,b</sup>	884	1,148 <sup>a,b</sup>
FD	1,495 <sup>c,d</sup>	964	1,281 <sup>c,d</sup>
CH	1,194 <sup>a,b</sup>	919	1,114 <sup>a,b</sup>
FN	1,409 <sup>c,d</sup>	897	1,240 <sup>c,d</sup>

Note: GM = General Motors, FD = Ford, CH = Chrysler, and FN = foreign manufacturers.

<sup>a</sup>Difference in claim proportions relative to Foreign is significant at a 5 percent confidence level.

<sup>b</sup>Difference in claim proportions relative to Ford is significant at a 5 percent confidence level.

<sup>c</sup>Difference in claim proportions relative to Chrysler is significant at a 5 percent confidence level.

<sup>d</sup>Difference in claim proportions relative to GM is significant at a 5 percent confidence level.

No important differences were noted between claims for GM and Chrysler vehicles. Sample sizes permitted inferences only for subcompacts and the aggregate vehicle category. In aggregate, the difference between these manufacturers was \$34.

As it did in comparison with Ford, GM showed a pattern of significantly lower costs than its foreign counterparts. Again, this was due to lower repair costs for front impacts involving subcompacts and compacts. The small number of foreign compacts diminishes these results for compacts.

A review of Ford and Chrysler revealed that Chrysler subcompacts apparently had significantly lower repair costs for bumper-involved claims resulting from front impacts. Repair costs for Chryslers in this case were approximately \$335 less than for their Ford counterparts.

A comparison of average repair costs for Fords and foreign cars revealed little of significance. Although Ford compacts displayed significantly lower

repair costs, the sample sizes for this comparison were small.

In a comparison of Chryslers and foreign cars, the Chryslers exhibited significantly lower repair costs due to lower costs for front impacts involving subcompacts. Sample sizes were too small to draw inferences for other market classes.

## RESULTS OF MANUFACTURER COMPARISONS

Ford 1981 subcompacts experienced a significantly lower proportion of bumper-involved claims for front impacts than did all other manufacturers studied. Because of the prevalence of subcompacts in the samples for each manufacturer, this result was also found to be true for the aggregate set of vehicles for each manufacturer.

In terms of claims for rear impacts, there were no important differences among Ford, Chrysler, and the foreign makes studied. However, when the aggregate set of vehicles by manufacturer was considered, both Chrysler and the foreign makes showed a significantly smaller proportion of bumper-involved claims than did GM for rear impacts.

The notable differences in average repair costs were in front-impact claims involving subcompacts. There appeared to be a two-tiered cost structure for the four manufacturer categories. One level of costs existed around the range of \$1,115 to \$1,168 for Chrysler and GM. A second higher level of costs in the range of \$1,368 to \$1,451 existed for foreign cars and Fords. Comparisons within each level were not significant. Any comparisons between manufacturers at different levels were significant. Therefore, GM's and Chrysler's repair costs for front-impact subcompact claims were significantly lower than either foreign manufacturers' or Ford's.

For compact vehicles, GM exhibited significantly lower repair costs than did the Ford and foreign vehicles studied. This was due primarily to the lower repair costs for front impacts and was based on a small sample.

## CONCLUSIONS

During a period of time when all bumpers were required to meet NHTSA's exterior protection standards for 5-mph impacts, differences were observed in bumper performance among various bumper designs and manufacturers. These differences were found by examining insurance claim data to identify the proportion and average repair costs of bumper-involved claims by both design and manufacturer.

By employing hypothesis tests for both proportions and means at the 95 percent confidence level, the following important observations were noted for each factor:

Bumper Design

1. Subcompacts with newer soft face designs exhibited significantly higher bumper claim proportions than did those with traditional hard designs. This was observed for both front and rear impacts using the face bar-fascia damage criteria (Table 1).

2. Compacts exhibited no difference in claim proportions for front impacts between hard and soft designs. Compacts with soft face designs indicated a significantly lower (8 percent) proportion of rear-impact bumper claims. These results were determined using the face bar-fascia damage criterion for bumper involvement (Table 1).

3. Vehicles equipped with bumpers in which the

grille is integral with a soft bumper cover experienced the highest claim proportions for front impacts on the basis of the face bar-fascia damage criterion (Table 1).

4. No significant differences in average repair costs were found between designs by the face bar-fascia damage criteria. The maximum repair cost differences between designs were approximately \$100 (Table 2).

#### Bumper Manufacturer

1. Ford 1981 subcompacts exhibited a significantly lower proportion of front-impact bumper claims than did subcompacts studied from GM, Chrysler, and foreign manufacturers. These differences ranged from approximately 5 to 7 percent (Table 3).

2. Aggregating claims by manufacturer revealed that Chrysler and foreign models had a significantly lower proportion of rear-impact bumper claims than the GM vehicles in the sample. These differences ranged from 2 to 4 percent (Table 3).

3. Notable differences in average repair costs between manufacturers appeared for front-impact claims involving subcompacts. A two-tiered cost structure emerged with Chrysler and GM at a level between \$1,115 and \$1,168 and foreign and Ford vehicles between \$1,368 and \$1,451, respectively. Chrysler's and GM's costs for these front-impact subcompact claims are significantly lower than those for either foreign manufacturers or Ford (Table 4).

Because differences were noted among bumper designs, these might explain some of the differences observed among manufacturers. This presumes that the sample for each manufacturer contained a different mix of bumper designs. However, other factors may also play a role in understanding bumper performance differences among manufacturers. Another experiment performed under this research effort examined the performance of bumpers on an individual make-model basis (1). When individual models from different

manufacturers were compared, significant claim differences were still observed even when the same bumper designs and materials were used. This suggests that differences in overall car design could also explain bumper claim differences among manufacturers. The role of general automotive design in bumper claim experience is an area that requires further investigation.

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