IIHS Side Crash Test Ratings and Occupant Death Risk in Real-World Crashes

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ABSTRACT

Side impact crashes accounted for 27 percent of passenger vehicle occupant deaths in the United States in 2009. Although the fronts and rears of most passenger vehicles have substantial crumple zones, the sides have relatively little space to absorb impact forces or limit occupant compartment intrusion. Side airbags help to absorb impact forces and are highly effective in reducing driver death risk, but must work well with vehicle structures to maximize occupant protection. The Insurance Institute for Highway Safety (IIHS) has been evaluating passenger vehicle side crashworthiness since 2003. In the IIHS side crash test, a vehicle is impacted perpendicularly on the driver (left) side by a moving deformable barrier weighing 1,500 kg (3,300 lb) and traveling at 50 km/h (31 mi/h). Dimensions of the barrier, especially height, are designed to simulate the front of a typical SUV or pickup. Injury measures are taken from 5th percentile female test dummies in the driver and left rear seating positions, and injury ratings are computed for the head/neck, torso, and pelvis/leg based on biomechanical and crash research. Vehicles also are rated based on their ability to protect occupants' heads and resist occupant compartment intrusion. These component ratings are combined into an overall rating of good, acceptable, marginal, or poor. A driver-only rating was recalculated by omitting rear passenger dummy data.

To evaluate how well IIHS side crash test ratings predict real-world occupant death risk, data were extracted from the Fatality Analysis Reporting System (FARS) and National Automotive Sampling System/General Estimates System (NASS/GES) for years 2000-09. Analyses were restricted to vehicles with driver side airbags with head and torso protection as standard features. The risk of driver death was computed as the number of drivers killed (FARS) divided by the number involved (NASS/GES) in left side impacts and was modeled using logistic regression to estimate the effect of crash test rating while controlling for the effects of driver age and gender and vehicle type and curb weight. Death rates per million registered vehicle years were computed for all outboard occupants, and these were compared across the overall test rating for each vehicle.

Based on the driver-only rating, drivers of vehicles rated good were 70 percent less likely to die when involved in left side crashes than drivers of vehicles rated poor, after controlling for driver and vehicle factors. Driver death risk was 64 percent lower for vehicles rated acceptable compared with poor and 49 percent lower for vehicles rated marginal compared with poor. All three results were statistically significant. The vehicle registration-based results for drivers were similar, suggesting the benefit largely was due to crashworthiness improvements and not to differences in crash risk. The same pattern of results held for outboard occupants in nearside crashes per million registered vehicle years and, with the exception of marginal-rated vehicles, also held for other crash types. This suggests design changes that improved side crashworthiness also benefited occupants in other types of crashes. Among component ratings, the vehicle structure rating exhibited the strongest relationship with driver death risk. In sum,

results show that IIHS side crash test ratings encourage designs that improve crash protection in meaningful ways beyond encouraging head protection side airbags, particularly by promoting vehicle structures that limit occupant compartment intrusion. Results further highlight the need for a strong occupant compartment and its influence in all types of crashes.

INTRODUCTION

The rate of passenger vehicle occupant deaths per registered vehicle has declined steadily during the past three decades among 1-3-year-old passenger vehicles (Insurance Institute for Highway Safety (IIHS), 2010a), and this decline was similar when partitioned into front, side, rear, and single-vehicle rollover crash types. Side impacts accounted for 27 percent of the 23,437 people killed in passenger vehicles in 2009 (IIHS, 2010a).

Improvements in passenger vehicle crashworthiness have been an important factor in declining death rates (Farmer and Lund, 2006), but protecting vehicle occupants in side impacts is especially challenging. Most passenger vehicles have substantial crumple zones in the front and rear, but the sides have relatively little space to absorb impact forces while limiting occupant compartment intrusion. Severe head and thoracic injuries are common and result from impacts with the intruding side structure or objects outside the vehicle (Laberge-Nadeau et al., 2009). Side airbags are designed to improve occupant protection by spreading impact forces over a larger area of an occupant's body and preventing an occupant from colliding with vehicle interior structures or objects outside the vehicle. Side airbags, particularly those that protect both head and torso, are highly effective in reducing driver death risk (Braver and Kyrychenko, 2004; Kahane, 2007; McCartt and Kyrychenko, 2007).

Side airbags and vehicle structures should work well individually and together to optimize occupant protection. Published since 2003, IIHS side crashworthiness ratings are based on this principle. In the IIHS side crash test, the subject vehicle is struck at a 90-degree angle on the driver side by a moving deformable barrier weighing 1,500 kg (3,300 lb) and traveling at 50 km/h (31 mi/h). Dimensions for the barrier, especially height, are designed to simulate the front of a typical SUV or pickup because side impacts by these vehicles types, compared with cars, result in higher death risk for occupants of the struck vehicles (Mandell et al., 2010). Injury measures are taken from 5th percentile female test dummies in the driver and left rear seating positions, and injury ratings are computed for the head/neck, torso, and pelvis/leg. Vehicles also are rated based on their ability to protect occupants' heads and resist occupant compartment intrusion. Head protection ratings for front and rear occupants are based on whether the dummies' heads are prevented from contacting the barrier and vehicle interior structures. The ability of the vehicle structure to maintain occupant compartment integrity is evaluated by measuring residual intrusion of the B-pillar. These component ratings are combined into an overall rating of good, acceptable, marginal, or poor (IIHS, 2010b).

Performance in the IIHS side crash test has improved since the program began in 2003, when only 17 percent of vehicles tested earned a good rating. By 2007, more than half of the vehicles tested earned a good rating, as did every vehicle tested in 2010. The current study evaluated the extent to which IIHS side crash test ratings are related to the risk of fatal injury in side crashes. The IIHS test was developed, in part, to encourage installation of side airbags with head protection, and manufacturers have responded by increasingly providing such airbags as standard equipment. The increased availability of head protection side airbags also was driven by other factors, including a commitment by automakers to install them as a countermeasure to the incompatibility between SUVs and passenger cars in side impacts (IIHS, 2009) and, more recently, to federal side impact protection regulations that take effect in 2010 (National Highway Traffic Safety Administration (NHTSA), 2010).

The IIHS test was intended to drive countermeasures in addition to head protection side airbags and to ensure side airbags worked with these other countermeasures to protect occupants in side impacts with taller passenger vehicles like SUVs and pickups. It is noteworthy in this regard that some vehicles with head protection side airbags have been rated poor in the IIHS test, although no vehicles have achieved a good rating without them. In the current study, vehicles with standard head and torso protection side airbags provide the baseline. The primary research question was the extent to which the IIHS side impact test captures improvement in side crash protection, beyond the protection offered by side airbags. This ignores some of the potential benefits achieved by the IIHS test, but results will be more applicable to the modern fleet, where side airbags are standard equipment in most new vehicles.

METHODS

Vehicles

Study vehicles were 1997-2009 model year passenger vehicles for which IIHS had developed side crash ratings and on which side airbags with head and torso protection were standard equipment. Vehicle nameplates with the same rating across model years were grouped together for analysis. For example, 2008-09 Ford Taurus models, which were rated good and shared the same component ratings for side crash protection, constituted one make/series/model year combination in the analysis. Of the 72 make/series/model year combinations, 43 were rated good, 14 acceptable, 7 marginal, and 8 poor.

Fatality Data

Counts of fatally injured occupants for each of the make/series/model year combinations were extracted from the Fatality Analysis Reporting System (FARS) for calendar years 2000-09. FARS is a census of fatal crashes on US public roads maintained by NHTSA. The make/series/model year combinations were identified from the 10-digit vehicle identification number (VIN) in FARS using VINDICATOR, a proprietary VIN-decoding program maintained by the Highway Loss Data Institute

(HLDI), an affiliate of IIHS. Fatality counts for each make/series/model year combination were further categorized by occupant seating position (driver, right front, left rear, right rear), vehicle type (SUV/pickup vs. car/minivan), curb weight, driver age (15-29, 30-64, 65+), driver gender, and initial point of impact (clock position). Information on vehicle type, curb weight, and side airbag availability were obtained from a HLDI database of vehicle features that can be associated with make/series/model year.

Vehicle Exposure Data

National vehicle registration counts for each of the make/series/model year combinations during 2000-09 were obtained from R.L. Polk and Company. Death rates per million registered vehicle years were computed for drivers and all outboard occupants for each make/series/model year combination. These rates normalize the fatalities in a particular make/series/model year combination by the number of vehicles on the road and frequently are used to assess differences in fatal crash risk among vehicles. However, vehicle exposure rates have some weaknesses. First, vehicle registration data do not provide information on registrants, and registrants may not be the drivers in crashes. This means that important factors such as driver age and gender cannot be controlled for in analysis. Second, vehicle exposure-based death rates can be affected by features related to crash likelihood as well as crashworthiness. Thus, for example, if vehicles with better side crash ratings also were more likely to have features such as electronic stability control, which is known to reduce fatal crash risk, then a vehicle exposure-based analysis mistakenly would attribute any effect to the rating. It usually is not possible to control for technologies like electronic stability control or other safety features because registration data are not sorted by these features.

Crash Exposure Data

Fatality rates per crash also were calculated for drivers involved in police-reported crashes using 2000-09 data from NHTSA's National Automotive Sampling System/General Estimates System (NASS/GES). NASS/GES is a nationally representative sample of about 50,000 crashes per year that can be weighted to produce national estimates (6 million police-reported crashes per year, on average, during the study years). The fatality rates per crash provided a means to remove the influence of factors that might affect crash likelihood.

As with FARS, vehicle make/series/model year can be decoded from the 10-digit VIN captured in NASS/GES. Driver age/gender and crash type also can be decoded, allowing these variables to be controlled for in analyses. A disadvantage of analyses using fatality rates per crash is that the number of crashes is an estimate, so the rates are more variable. Another disadvantage is that NASS/GES has limited or missing information on occupants other than the driver. As a result, the current analyses are limited to drivers.

Vehicle Ratings

Overall side crash test ratings of good, acceptable, marginal, and poor are intended to reflect the relative level of protection afforded to outboard occupants when struck by another vehicle on their side of the vehicle. The overall rating is derived from component ratings of vehicle structure (residual intrusion measured at the B-pillar), head contact protection for driver and left rear dummies, and injury risk measures from both dummies for the head/neck, torso (chest/abdomen), and pelvis/leg regions. The component ratings (good, acceptable, marginal, or poor) then are combined into the overall, published rating (see Appendix 1).

For analyses of driver fatality risk, injury measures and/or head contact protection ratings for the left rear dummy may not be meaningful. Therefore, an alternative rating was computed that omitted results applying only to the left rear occupant. This driver-only rating combines rating results for vehicle structure, driver head contact protection, and driver injury measures for the head/neck, torso, and pelvis/leg into a rating of good, acceptable, marginal, or poor based on the same cutoff values as for the overall rating (IIHS, 2010b). The weighting system used to determine the two ratings is outlined in Appendix A. The driver-only rating is used by IIHS to evaluate side crashworthiness in vehicles without rear seating positions such as the Smart Fortwo.

Analyses

The primary analysis estimated driver fatality risk per left side crash exposure as a function of driver-only side crash rating because this is the most direct measure of improvement in crashworthiness associated with the rating. However, driver fatality risk per vehicle exposure also was examined, as was outboard occupant fatality risk per vehicle exposure, based on the overall side crash rating.

Logistic regression was used to estimate the percentage change in driver fatality risk in left side crashes associated with better driver ratings while controlling for vehicle type and curb weight and driver age and gender. Logistic regression also was used with individual components of the driver-only rating to assess their relative importance. Results are presented as odds ratios. Death is a relatively rare crash outcome (e.g., less than 10 percent in left side crashes), so odds ratios would be expected to closely approximate the corresponding risk ratios.

Because NASS/GES is a structured sample, conventional estimates of standard errors may underestimate the true values, resulting in a type-1 error rate higher than expected. Counts from NASS/GES were used in the denominator of the logistic regression model, and one method for obtaining more precise standard error estimates relies on subsampling the data (Kahane, 2007). However, this method would not work in the present study because of loss of degrees of freedom in some subsamples. Instead, a conservative type-1 error rate of 0.01 was chosen as the level of statistical significance.

RESULTS

Driver Death Rates by Overall Side Crash Rating

Table 1 lists results of two analyses of driver deaths in left side impacts by overall IIHS side crash test rating. The first tabulates driver deaths per million registered vehicle years by overall rating, which decreased monotonically with better ratings. Vehicles with an overall rating of poor had the highest driver death rate per registered vehicle year (15.53), and the rate was reduced by about a third with each higher rating. Vehicles with an overall rating of good had a driver death rate for left side crashes (4.30) that was 72 percent lower than for poor-rated vehicles.

The second analysis presented in Table 1 tabulates driver deaths per 100,000 drivers involved in police-reported left side crashes by overall rating. Again, driver death risk was highest for poor-rated vehicles (277) and lowest for good-rated vehicles (91, about 67 percent lower), but the death rate did not decrease monotonically with the rating. Drivers of marginal-rated vehicles had a slightly lower death rate (126) than drivers of acceptable-rated vehicles (135).

Driver Death Rates by Driver-Only Side Crash Rating

Table 2 lists results for the same two analyses of driver deaths in left side crashes but using the driver-only side crash test rating instead of the overall rating. With regard to the distribution of driver deaths by rating, the driver-only rating system moved many poor-rated vehicles to marginal, compared with the overall rating system analyzed in Table 1. This had the effect of increasing the driver death rate, whether per million registered vehicle years or per 100,000 drivers involved in left side crashes, for both marginal- and poor-rated vehicles. As a result, the driver death rates calculated for either exposure measure decreased monotonically with the driver-only side crash rating. Moreover, the strength of the relationship between side crash rating and driver fatality risk appeared very similar whether measured per vehicle exposure or per crash exposure. For each measure of risk, each level of improvement from a poor rating reduced driver death risk in left side crashes by about 30-40 percent. For driver death risk per registered vehicle year, the reduction between poor- and good-rated vehicles was about 75 percent, whereas the reduction was about 73 percent for driver deaths per left side crash involvement.

Logistic Regression for Driver Deaths per Crash by Driver-Only Side Crash Rating

The relationships shown in Tables 1 and 2, although stable across the two measures of risk, could be affected by other variables related to crash risk or vulnerability in a crash. Tables 3 and 4 provide the age and gender distributions of drivers killed in driver side crashes by driver-only side crash test rating. The age of drivers killed in left side impacts was not distributed equally across driver-only rating. Specifically, fatally injured drivers of poor-rated vehicles tended to be younger compared with drivers of good-, acceptable-, and marginal-rated vehicles. Drivers of poor-rated vehicles also were slightly more likely to be female compared with drivers of other vehicles. Variation in the age and gender distributions suggests the need to account for these driver characteristics when assessing the relationship between vehicle ratings and driver death risk. Other factors also could be important. Drivers of SUVs and pickups may have an inherently lower risk of serious injury in left side crashes because their seating positions, on average, are higher off the ground and potentially further from direct load paths of striking vehicles. Also, although the IIHS test results are independent of vehicle mass, or weight, many left side impacts are not exactly like the IIHS test configuration, and mass could be important in some of these crashes.

Table 5 lists results of several logistic regression models on the risk of driver fatality in a left side crash. Each column lists a model containing the covariates for which odds ratios are provided. The first column lists results of a model with the only predictor variable being the driver-only side crash test rating. The effects of this rating did not substantially change when controlling for driver age/gender, vehicle type/curb weight, or both driver and vehicle factors (columns 2-4). This indicates that these factors, while affecting side impact death risk, do not confound the observed association of side crash test rating and driver death risk. The effects of driver-only IIHS side crash test rating were statistically significant for all models. In the fourth column, with all covariates in the model, vehicles rated good, acceptable, and marginal all had significantly lower risk of driver death given a left side crash than vehicles rated poor. The pattern of odds ratios indicated a 49 percent reduction for vehicles rated marginal versus poor, a 30 percent reduction for vehicles rated acceptable versus marginal, and a 16 percent reduction for vehicles rated good versus acceptable. Compared with poor-rated vehicles, good-rated vehicles were estimated to have a 70 percent lower risk of driver death in a left side (struck side) crash.

Relationships of the individual components of the driver-only rating with real-world driver death risk were examined using the remaining logistic regression models in Table 5. When looked at singly (columns 5-8), the component ratings most strongly related to driver death risk were those for vehicle structure and driver torso (chest/abdomen) injury. Each of the individual components, with the exception of driver head/neck rating, had the highest driver fatality risk for poor-rated vehicles and the lowest risk for good-rated vehicles. However, the effect of improved rating was not monotonic for the driver torso or pelvis/leg ratings. The vehicle structure rating had the most systematic relationship to driver fatality risk and was the only component with a statistically significant relationship in the model with all of the component ratings (column 9). In fact, controlling for the other component ratings appeared to increase the strength of the relationship between structure rating and driver death risk in left side crashes.

With study vehicles restricted to those with standard head and torso protection side airbags, only two vehicles did not receive a good rating for driver head/neck injury measures; they had an acceptable rating. This suggests the unexpected, and not statistically significant, result that a good head/neck rating was associated with a higher driver death risk than an acceptable rating is likely an anomaly of uncontrolled factors related to those two make/series/model year vehicle combinations.

In all regression models in Table 5 containing driver age and gender as covariates, drivers ages 30-64 had the lowest risk of death in left side impacts, followed by drivers ages 15-29 with a slightly higher death risk. Drivers 65 and older were about twice as likely to die in left side crashes as drivers ages 30-64. The risk of death for male drivers in these crashes was about 50 percent higher than that for female drivers. SUV/pickup drivers had a substantially lower death risk than car/minivan drivers in left side impacts, though this was not statistically significant. Each 500-lb increase in curb weight was associated with substantial and statistically significant reductions in driver death risk in left side impacts.

Side Crash Test Rating and Fatality Risk for Other Occupants and Other Crash Types

Table 6 examines the relationship between side crash test rating and death risk for all outboard occupants. Because occupants other than the driver are included, the overall rating, rather than the driver-only rating, is used. This expands the registration-based analysis in Table 1 for drivers, but it also considers five impact types: in addition to those crashes where the initial impact is to the side nearest the occupant, farside, frontal, rear, and other crash deaths are tabulated.

Among outboard occupants killed in nearside crashes, the crash type most closely represented by the IIHS side crash test, the death rate per million registered vehicle years was 68 percent lower for occupants in vehicles rated good versus poor. This result was very close to the risk reduction estimated for drivers only (72 percent), and the pattern of risk reduction as overall rating improved also was similar for outboard occupants. The risk of death for outboard occupants was 35 percent lower for vehicles rated marginal versus poor, 32 percent lower for vehicles rated acceptable versus marginal, and 28 percent lower for vehicles rated good versus acceptable.

There also was evidence of fatality risk reduction for outboard occupants in other crash types. Although the relationship often was not monotonic, good-rated vehicles had lower fatality risk per million registered vehicle years than poor-rated vehicles in all crash types. The size of the benefit estimated ranged from a low of 53 percent for other crashes to a high of 65 percent for rear crashes.

DISCUSSION

Occupant protection in side crashes remains an important highway safety challenge. Side airbags, especially those that protect the head, were introduced to improve occupants' chances of survival in side impact crashes and have been shown to be greatly effective. Seventy-seven percent of 2010 passenger vehicle models were equipped with head and torso protection side airbags as standard equipment (IIHS, 2010c). However, different airbag designs may respond differently to crash forces, which also would affect occupant death risk. Therefore, the current study investigated the real-world benefits of improved side crashworthiness, as measured by the IIHS side crash test, beyond the benefits of head and torso protection side airbags.

Results of the analyses confirm there is substantial benefit from better performance in the IIHS side crash test that goes beyond the addition of side airbags. Overall, the estimated reduction in fatality risk for vehicle drivers struck on the driver side was 70 percent, even after controlling for driver age and gender and vehicle type and curb weight. In other words, the risk of driver fatality was more than three times greater for vehicles rated poor for side crashworthiness than for vehicles rated good.

Although this estimate was derived from fatal crash risk per crash involvement, the pattern of results was quite similar for analyses of driver fatal crash risk per million registered vehicle years and for analyses of fatal crash risk to all outboard occupants when struck on their side of the vehicle. This indicates that the kinds of design changes introduced by automakers to improve performance in the IIHS side crash test are having large, real-world benefits in reduced injury in side crashes for most occupants.

Given that all of the study vehicles had side airbags, the primary benefit appears to derive from improvements in vehicle structural performance — that is, the increased resistance of side structures to intrusion. Although ratings for both the torso and lower extremity injury measures from the test dummies were related to fatality risk, the vehicle structure rating was the only significant predictor of fatality risk when all of the side crash test component ratings were examined simultaneously. Thus, the effects of torso and lower extremity ratings on fatality risk appear to be an indirect result of better structural performance, which logically would result in better injury measures from the test dummies.

The centrality of structural improvements in the relationship between test ratings and real-world side crashes also may explain the surprisingly strong relationship between side crash ratings and protection in many other types of crashes (Table 6). Structural improvements — that is, design changes that increase occupant compartment integrity in crashes — are likely to be important in crash types other than those for which they are specifically designed.

Potential Limitations of Study

One limitation of the analyses is that the ways in which vehicles are driven, including annual mileage, may vary by crash test rating. For instance, if riskier drivers tend to drive poor-rated vehicles than good-rated ones, then the death rate for poor-rated vehicles may be artificially high. However, the similarity of results for vehicle and crash exposure rates indicates this likely was not an issue. In particular, death rates per crash eliminated much of the variation that would be expected from differences in driving styles, although there still is the possibility that drivers of poor-rated vehicles get into more serious side crashes. In a further effort to control for this possibility, the main analyses in the current study used driver age and gender as covariates. No confounding was observed, but driver age and gender do not entirely control for any differences in risk-taking propensities.

Another limitation of the analysis of individual component ratings is that no information was available in the crash databases on the location or type of specific injuries. For example, when evaluating the effect of the torso rating, it makes sense to look specifically at thoracic injuries. Because the outcome measure was death, the effect estimates for torso rating could not be attributed to a reduction in thoracic injuries. If data on specific injuries were available, it may have been possible to further disentangle the effects of various component ratings.

The finding that side crashworthiness ratings were related to occupant fatality risk in other types of crashes might suggest a limitation. It could be hypothesized that this general reduction in occupant death risk per vehicle exposure suggests other factors might be responsible for the observed reductions. However, the reductions in fatality risk by rating category generally were not as well ordered for other crash types as for nearside crashes, showing that the effects were not exactly parallel. In addition, as discussed above, the side crash death reductions appeared due primarily to increased resistance to intrusion, and increased structural strength can be expected to affect survival rates in many kinds of crashes, especially those involving multiple impacts. Finally, it also is noteworthy that the magnitude of the reduction in driver death risk estimated in this study is consistent with the serious injury risk observed for Volvo drivers with improvements in side crashworthiness (Jakobsson et al., 2010).

In summary, results of the analyses indicate the IIHS side crashworthiness evaluation program encourages vehicle designs that offer real-world safety benefits to occupants. These benefits extend beyond the introduction of side airbags and are due in large part to the ability of vehicle structure to resist intrusion. Occupant compartment strength is widely recognized as a first principle of crashworthiness. Brumbelow et al. (2009) and Brumbelow and Teoh (2009) provided a direct example of this by showing that stronger roofs were associated with lower serious injury and death risk in single-vehicle rollover crashes. Occupant compartment strength, measured as the ability to resist intrusion in the IIHS side crash test, was the best predictor of driver mortality in driver-side crashes among component ratings of the IIHS test rating in the present study. This finding highlights the importance of occupant compartment strength and shows that dummy measures alone are not sufficient to predict side impact crashworthiness.

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Table I Left side impact crash experience of drivers by overall IIHS side crash test rating, 2000-09

Overall rating	Driver deaths	Registered vehicle years	Driver deaths per 1,000,000 registered vehicle years	Drivers in police-reported crashes (left)	Driver deaths per 100,000 left side crashes
Good	144	33,459,066	4.30	158,380	91
Acceptable	46	7,204,334	6.39	34,125	135
Marginal	32	3,338,153	9.59	25,343	126
Poor	135	8,690,693	15.53	48,704	277

Table II Left side impact crash experience of drivers by driver-only IIHS side crash test rating, 2000-09

Driver-only rating	Driver deaths	Registered vehicle years	Driver deaths per 1,000,000 registered vehicle years	Drivers in police-reported crashes (left)	Driver deaths per 100,000 left side crashes
Good	150	34,452,019	4.35	163,657	92
Acceptable	44	6,462,959	6.81	32,390	136
Marginal	99	8,036,545	12.32	52,072	190
Poor	64	3,740,723	17.11	18,433	347

Table III Age distribution (in percent) of drivers killed in left side impact crashes by driver-only IIHS side crash test rating, 2000-09

Driver-only	Drivers killed				Drivers involved			
Rating	15-19	20-39	40-64	65+	15-19	20-39	40-64	65+
Good	9	31	35	25	5	42	42	11
Acceptable	9	32	18	41	11	41	37	11
Marginal	8	35	38	18	13	41	36	11
Poor	12	31	39	17	10	48	31	11

Table IV Gender distribution (in percent) of drivers killed in left side impact crashes by driver-only IIHS side crash test rating, 2000-09

Driver-only	Drivers killed		Drivers involved	
rating	Male	Female	Male	Female
Good	59	41	47	53
Acceptable	57	43	49	51
Marginal	59	41	42	58
Poor	45	55	41	59

Table V Logistic regression analyses (odds ratios) of driver death risk in left side impact crashes, 2000-09

IIHS driver-only side crash test rating and sub-ratings	Driver-only	Good	0.242*	0.240*	0.294*	0.299*					
		Acceptable	0.328*	0.319*	0.364*	0.358*					
		Marginal	0.519*	0.520*	0.514*	0.510*					
		Poor	1	1	1	1					
	Structure	Good					0.217*				0.129*
		Acceptable					0.329*				0.178*
		Marginal					0.452*				0.235*
		Poor					1				1
	Driver head/neck	Good						2.110			3.802
		Acceptable						1			1
	Driver torso	Good							0.422*		0.767
		Acceptable							0.547*		1.105
		Marginal							0.450		0.806
		Poor							1		1
	Driver pelvis/leg	Good								0.457*	1.596
		Acceptable								0.820	2.009
		Marginal								0.676	1.990
		Poor								1	1
Age		65+		2.083*		2.120*	2.194*	2.241*	2.124*	2.130*	2.062*
		30-64		1		1	1	1	1	1	1
		15-29		1.103		1.040	1.009	1.097	1.086	1.038	1.056
Gender		Male		1.523*		1.566*	1.560*	1.543*	1.558*	1.553*	1.540*
		Female		1		1	1	1	1	1	1
Vehicle type		SUV/pickup			0.654	0.668	0.678	0.585	0.691	0.533	0.743
		Car/minivan			1	1	1	1	1	1	1
Curb weight		500-lb increase			0.855	0.816*	0.774*	0.699*	0.831*	0.822*	0.782*

*Effect statistically significant at 0.01 level

Note: 25 driver deaths from Table 2 were excluded because their make/series/age/gender combinations did not occur in the denominator (drivers in police reported crashes).

Table VI Outboard occupant deaths by crash type and overall IIHS side crash test rating, 2000-09

	Outboard occupant deaths					Registered	Outboard occupant deaths per 1,000,000 registered vehicle years				
Overall rating	Near side	Far side	Front	Rear	Other	vehicle years	Near side	Far side	Front	Rear	Other
Good	240	139	791	63	297	33,459,066	7.17	4.15	23.64	1.88	8.88
Acceptable	72	45	244	13	92	7,204,334	9.99	6.25	33.87	1.80	12.77
Marginal	49	49	186	10	83	3,338,153	14.68	14.68	55.72	3.00	24.86
Poor	195	93	474	47	163	8,690,693	22.44	10.70	54.54	5.41	18.76

Appendix A Weighting of individual components for overall and driver-only IIHS side crash test ratings

	Rating			
Component	Good	Acceptable	Marginal	Poor
Vehicle structure	0	2	6	10
Driver				
Head protection	0	2	4	10
Head/neck	0	2	10	20*
Torso	0	2	10	20*
Pelvis/leg	0	2	6	10
	Driver total = *d*			
Passenger				
Head protection	0	2	4	10
Head/neck	0	2	10	20*
Torso	0	2	10	20*
Pelvis/leg	0	2	6	10
	Passenger total = *p*			
Overall rating cutoffs (*d*+*p*)	0-6	8-20	22-32	34+
Driver-only rating cutoffs (*d*)	0-6	8-20	22-32	34+

*Poor rating to the head/neck or torso body regions result in no better than marginal overall or driver-only rating