



Volvo City Safety loss experience – an update

An earlier study reported that Volvo XC60s fitted with City Safety, a low-speed collision avoidance technology, had lower than expected loss frequencies for property damage liability (-27 percent), bodily injury liability (-51 percent) and collision (-22 percent). Updated results for the XC60 as well as initial results for the Volvo S60 confirm that City Safety is reducing losses substantially, although the effects are somewhat smaller than in the initial XC60 report. In the new study, property damage liability loss frequency was estimated to be 15 percent lower than relevant control vehicles for the XC60 and 16 percent lower for the S60. Collision frequencies were reduced by an estimated 20 percent for the XC60 and 9 percent for the S60. Both vehicles also showed reductions in collision claim severity and reductions in overall losses for collision and property damage liability. Under bodily injury liability, frequency was 33 percent lower for the XC60 and 18 percent lower for the S60.

► Introduction

This Highway Loss Data Institute (HLDI) bulletin provides an updated look at the effects of Volvo's City Safety technology on insurance losses for the XC60. It also provides an initial look at the results for the S60, newly equipped with City Safety. Prior HLDI results found that Volvo's City Safety system on the XC60 appeared to be preventing crashes (Vol. 28, No. 6). For this bulletin the loss experiences for Volvo XC60s and S60s equipped with City Safety were compared with losses for comparable vehicles without the system. Losses under property damage liability, bodily injury liability, and collision coverage were examined. A supplementary analysis using Volvo vehicles as the comparison group was also conducted and served to verify City Safety's effect.

City Safety, a low-speed collision avoidance system, was released as standard equipment on the 2010 Volvo XC60, a midsize luxury SUV and on the 2011 S60, a midsize luxury car. The system was developed by Volvo to reduce low-speed front-to-rear crashes, which commonly occur in urban traffic, by assisting the driver in braking. According to a Volvo news release, 75 percent of all crashes occur at speeds up to 19 mph, and half of these occur in city traffic (Volvo, 2008). The City Safety system has an infrared laser sensor built into the windshield that detects other vehicles traveling in the same direction up to 18 feet in front of the vehicle. The system initially reacts to slowing or stopped vehicles by pre-charging the brakes. The vehicle will brake automatically if forward collision risk is detected and the driver does not react in time, but only at travel speeds up to 19 mph. If the relative speed difference is less than 9 mph, a collision can be avoided entirely. If the speed difference is between 9 and 19 mph, the speed will be reduced to lessen the collision severity. City Safety is automatically activated when the vehicle ignition is turned on but can be manually deactivated by the driver.

When examining the effect of City Safety on insurance losses, it is important to consider that the system is not designed to mitigate all types of crashes and that many factors can limit the system's ability to perform its intended function. City Safety works equally well during the day and at night, but fog, heavy rain, or snow may limit the ability of the system's infrared laser to detect vehicles. The driver is advised if the sensor becomes blocked by dirt, ice, or snow.

► Methods

Insurance data

Automobile insurance covers damage to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on property damage liability, bodily injury liability, and collision coverages. Data are supplied to HLDI by its member companies. Property damage liability results are based on 52,050 insured vehicle years and 1,395 claims for the XC60 and 18,033 insured vehicle years and 365 claims for the S60.

Property damage liability coverage insures against physical damage that at-fault drivers cause to other people's vehicles and property in crashes. Bodily injury liability coverage insures against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or others on the road. In the current study, bodily injury liability losses were restricted to data from traditional tort states. Collision coverage insures against physical damage to an at-fault driver's vehicle sustained in a crash with an object or other vehicle.

Subject vehicles

In the main analyses, loss results for the XC60 with City Safety were compared with other midsize luxury SUVs while loss results for the S60 with City Safety were compared with other midsize luxury cars. As a check on a possible "Volvo buyer effect," secondary analyses also compared the XC60 and S60 loss experience with that of other Volvos.

Sales of the 2010 Volvo XC60 began in February 2009, when other brands still were marketing 2009 models. Consequently, the control populations for the XC60 analyses included vehicles starting in model year 2009. The total study population for the XC60 was model years 2010-12 during calendar years 2009-12 with control vehicle model years of 2009-12. The loss experience of the model year 2009 vehicles in calendar year 2008 was excluded because no XC60s were on the road during this time period.

City Safety was added as standard equipment to the Volvo S60 in model year 2011. The analyses considered model years 2011-12 for the S60 and its control vehicles during calendar years 2011-12. Calendar year 2010 was not included in the S60 analysis because of the very small number of model year 2011 S60s insured that year.

Total exposure measured as insured vehicle years and the total number of claims for the XC60 and S60 are shown by insurance coverage type in [Table 1](#). [Appendix A](#) contains the same information for the comparison vehicles.

Coverage	XC60		S60	
	Exposure	Claims	Exposure	Claims
Property damage liability	52,050	1,395	18,033	365
Bodily injury liability	16,700	86	3,863	21
Collision	52,050	2,974	18,033	1,236

Because previous HLDI analyses have shown them to have different loss patterns, hybrids, convertibles, and two-door vehicles were excluded from the control groups. Additionally, the XC60 analysis excluded City Safety-equipped S60s from the Volvo control group while the S60 analysis excluded XC60s from the Volvo comparison vehicles. For both the XC60 and S60, the Volvo comparison groups did not include the 2012 S80 or the 2012 XC70. Both these vehicles were excluded because they had standard City Safety beginning in the 2012 model year. Vehicle models with two and four-wheel drive versions were combined to provide sufficient data for analysis.

The study and control vehicles in this analysis can also be equipped with optional collision avoidance features that have been shown to affect frequency and severity in other studies by HLDI. It should be noted that this analysis does not account for their presence or absence because the information needed to identify the vehicles with the optional features is not available in the HLDI database. Furthermore, the take rate for these features is thought to be low.

Analysis methods

Regression analysis was used to model claim frequency per insured vehicle year and average loss payment per claim (claim severity) while controlling for various covariates. Claim frequency was modeled using a Poisson distribution, and claim severity was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. They were calculated by multiplication because the estimate for the effect of City Safety on claim frequency and claim severity were in the form of ratios relative to the reference categories (baseline). The standard error for overall losses was calculated by taking the square root of the sum of the squared standard errors from the claim frequency and severity estimates. Based on the value of the estimate and the associated standard error, the corresponding two-sided p-value was derived from a standard normal distribution approximation.

The covariates included calendar year, model year, garaging state, vehicle density (number of registered vehicles per square mile), rated driver age, rated driver gender, marital status, collision deductible, and risk. To estimate the effect of City Safety, vehicle series was included as a variable in the regression models, with the Volvo XC60 or S60 assigned as the reference group. The model estimate corresponding to each comparison vehicle indicates the proportional increase or decrease in losses of that vehicle relative to the XC60 or the S60, while controlling for differences in the distributions of drivers and garaging locations. For example, in the analysis of property damage liability claim frequency, the model estimate comparing the XC60 to the BMW X5 was 0.2815, which translates to an estimated increase in claim frequency of 33 percent for the X5 compared to the XC60 ($e^{0.2815} = 1.33$). Given the actual property damage liability claim frequency for the Volvo XC60 equaled 2.7 claims per 100 insured vehicle years, the comparable claim frequency for the X5 if it had the same distribution of drivers and garaging locations as the XC60 is predicted to have been $2.7 \times 1.33 = 3.6$ claims per 100 insured vehicle years.

Weighted averages of the model estimates for individual vehicles in the analysis also were calculated for midsize luxury SUVs and for midsize luxury cars. The weights in the averages were proportional to the inverse variance of the respective estimates, meaning that the estimates with high variance (those with large confidence intervals, typically due to little exposure and/or claims) contributed less than estimates with low variance (those with small confidence intervals). These calculations estimate the average effect for each vehicle group of *not having* City Safety. Because it is often useful to state the results in terms of the estimated benefit of *having* a feature, the inverse of the average City Safety effect also was calculated. That is, the weighted average property damage loss frequency for other midsize luxury SUVs was 1.17 times that of the XC60; the inverse of that, $(1/1.17)-1$, or -0.15 , indicates that the estimated benefit of having City Safety is a 15 percent reduction in claim frequency compared to other SUVs. The estimated benefit for each overall comparison and the 95 percent confidence bounds are shown in [Tables 4-6](#).

► Results

[Tables 2-3](#) illustrate the pattern of results available from the analyses performed. In [Table 2](#) it can be seen that all independent variables in the model had statistically significant effects on property damage liability loss frequencies of midsize luxury SUVs. [Table 3](#) lists estimates and significance levels for the individual values of the categorical variables from the regression model. The intercept outlines losses for the reference (baseline) categories: the estimate corresponds to the claim frequency for a 2012 Volvo XC60, garaged in a high vehicle density area in Texas, and driven by a married female age 40-49 with standard risk during calendar year 2012. The remaining estimates are in the form of multiples, or ratios relative to the reference categories. [Table 3](#) includes only an abbreviated list of results by state. Only states with the five highest and five lowest estimates are listed, along with the comparison state of Texas. Detailed results for all states and all regressions are available in a separate [Appendix](#).

Table 2: Summary results of linear regression analysis of property damage liability claim frequencies for XC60 vs. other midsize luxury SUVs

	Degrees of freedom	Chi-Square	P-value
Calendar year	3	105.75	<0.0001
Model year	3	46.66	<0.0001
Vehicle make and series	20	293.95	<0.0001
State	50	924.87	<0.0001
Registered vehicle density	6	681.76	<0.0001
Rated driver age	10	698.24	<0.0001
Rated driver gender	2	99.31	<0.0001
Rated driver marital status	2	194.64	<0.0001
Risk	1	203.87	<0.0001

Table 3: Detailed results of linear regression analysis of property damage liability claim frequencies for Volvo XC60 vs. other midsize luxury SUVs

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept	1	-9.4038		0.0361	-9.4746	-9.3330	67847.10	<0.0001
Calendar year								
2009	1	0.0528	5.4%	0.0182	0.0172	0.0885	8.43	0.0037
2010	1	0.0950	10.0%	0.0129	0.0696	0.1203	53.95	<0.0001
2011	1	0.1071	11.3%	0.0108	0.0858	0.1283	97.56	<0.0001
2012	0	0	0	0	0	0		
Model year								
2009	1	0.1311	14.0%	0.0212	0.0895	0.1727	38.11	<0.0001
2010	1	0.0834	8.7%	0.0204	0.0434	0.1234	16.70	<0.0001
2011	1	0.0705	7.3%	0.0207	0.0300	0.1111	11.61	0.0007
2012	0	0	0	0	0	0		
Vehicle make and series								
Acura MDX	1	0.1583	17.2%	0.0300	0.0996	0.2170	27.91	<0.0001
Acura RDX	1	0.1202	12.8%	0.0345	0.0525	0.1879	12.11	0.0005
Acura ZDX	1	0.2459	27.9%	0.0799	0.0893	0.4025	9.48	0.0021
Audi Q5 4WD	1	0.0291	3.0%	0.0338	-0.0370	0.0953	0.75	0.3880
BMW X3	1	0.0784	8.2%	0.0384	0.0031	0.1537	4.16	0.0414
BMW X5	1	0.2815	32.5%	0.0306	0.2216	0.3414	84.82	<0.0001
BMW X6	1	0.3300	39.1%	0.0457	0.2405	0.4196	52.21	<0.0001
Cadillac SRX	1	0.1474	15.9%	0.0309	0.0868	0.2080	22.75	<0.0001
Infiniti EX35	1	-0.0447	-4.4%	0.0459	-0.1346	0.0451	0.95	0.3292
Infiniti FX35	1	0.1878	20.7%	0.0364	0.1165	0.2592	26.61	<0.0001
Infiniti FX50	1	0.2131	23.8%	0.0914	0.0339	0.3923	5.43	0.0198
Land Rover LR2	1	0.2947	34.3%	0.0498	0.1970	0.3924	34.96	<0.0001
Lexus RX 350	1	0.1363	14.6%	0.0283	0.0809	0.1917	23.24	<0.0001
Lincoln MKT	1	0.0977	10.3%	0.0556	-0.0112	0.2066	3.09	0.0787
Lincoln MKX	1	0.1618	17.6%	0.0345	0.0942	0.2295	21.99	<0.0001
Mercedes-Benz GLK class	1	0.1517	16.4%	0.0324	0.0883	0.2151	21.99	<0.0001
Mercedes-Benz M class	1	0.0777	8.1%	0.0311	0.0168	0.1387	6.25	0.0124
Saab 9-4X	1	0.6464	90.9%	0.3176	0.0240	1.2688	4.14	0.0418

Table 3: Detailed results of linear regression analysis of property damage liability claim frequencies for Volvo XC60 vs. other midsize luxury SUVs

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Saab 9-7X	1	0.2384	26.9%	0.0882	0.0656	0.4112	7.31	0.0068
Volvo XC90	1	0.2878	33.3%	0.0354	0.2183	0.3572	65.93	<0.0001
Volvo XC60	0	0	0	0	0	0		
State								
Michigan	1	-1.4864	-77.4%	0.0617	-1.6072	-1.3655	581.18	<0.0001
Wyoming	1	-0.5156	-40.3%	0.2256	-0.9577	-0.0735	5.23	0.0223
Idaho	1	-0.3545	-29.8%	0.1454	-0.6395	-0.0695	5.94	0.0148
Nebraska	1	-0.3463	-29.3%	0.0827	-0.5084	-0.1843	17.54	<0.0001
Delaware	1	-0.3136	-26.9%	0.0851	-0.4803	-0.1469	13.60	0.0002
Arkansas	1	-0.0243	-2.4%	0.0717	-0.1649	0.1163	0.11	0.7351
Massachusetts	1	0.0183	1.8%	0.0356	-0.0513	0.0880	0.27	0.6060
Vermont	1	0.0762	7.9%	0.1314	-0.1813	0.3336	0.34	0.5622
District of Columbia	1	0.1090	11.5%	0.0681	-0.0245	0.2424	2.56	0.1094
North Dakota	1	0.3529	42.3%	0.1756	0.0087	0.6971	4.04	0.0445
Texas	0	0	0	0	0	0		
Registered vehicle density								
Unknown	1	-0.5713	-43.5%	0.4475	-1.4484	0.3057	1.63	0.2017
<50	1	-0.5130	-40.1%	0.0291	-0.5701	-0.4559	310.19	<0.0001
50-99	1	-0.3726	-31.1%	0.0229	-0.4175	-0.3276	264.17	<0.0001
100-249	1	-0.2906	-25.2%	0.0170	-0.3238	-0.2574	293.83	<0.0001
250-499	1	-0.2215	-19.9%	0.0140	-0.2490	-0.1940	248.60	<0.0001
500-999	1	-0.1156	-10.9%	0.0141	-0.1432	-0.0880	67.29	<0.0001
1,000+	0	0	0	0	0	0		
Rated driver age								
Unknown	1	-0.0311	-3.1%	0.0247	-0.0796	0.0173	1.59	0.2080
15-19	1	0.3649	44.0%	0.0370	0.2924	0.4374	97.24	<0.0001
20-24	1	0.2262	25.4%	0.0295	0.1682	0.2841	58.58	<0.0001
25-29	1	0.1170	12.4%	0.0233	0.0714	0.1625	25.29	<0.0001
30-39	1	0.0301	3.1%	0.0135	0.0037	0.0564	4.99	0.0255
50-59	1	-0.1323	-12.4%	0.0134	-0.1585	-0.1061	97.80	<0.0001
60-64	1	-0.1035	-9.8%	0.0172	-0.1372	-0.0698	36.19	<0.0001
65-69	1	-0.0027	-0.3%	0.0186	-0.0391	0.0338	0.02	0.8860
70-74	1	0.0866	9.0%	0.0224	0.0428	0.1305	15.02	0.0001
75+	1	0.3202	37.7%	0.0219	0.2772	0.3631	213.51	<0.0001
40-49	0	0	0	0	0	0		
Rated driver gender								
Male	1	-0.0891	-8.5%	0.0106	-0.1098	-0.0683	70.68	<0.0001
Unknown	1	-0.1681	-15.5%	0.0256	-0.2182	-0.1180	43.25	<0.0001
Female	0	0	0	0	0	0		
Rated driver marital status								
Single	1	0.1640	17.8%	0.0125	0.1394	0.1885	171.12	<0.0001
Unknown	1	0.1644	17.9%	0.0250	0.1155	0.2133	43.39	<0.0001
Married	0	0	0	0	0	0		
Risk								
Nonstandard	1	0.1953	21.6%	0.0137	0.1685	0.2221	203.87	<0.0001
Standard	0	0	0	0	0	0		

Property damage liability: Figures 1-2 show the results from the analyses of property damage liability claim frequency for the XC60 and the S60, respectively. In these figures, the actual property damage liability claim frequency (per 100 vehicle years exposure) for the Volvo XC60 and S60 are plotted, along with the estimated claim frequencies of each comparison vehicle and the average of all comparison vehicles derived from the regression models. The results were very similar, with the XC60 having an actual claim frequency 15 percent lower than the average of midsize luxury SUVs while the S60's claim frequency was 16 percent lower than the average of midsize luxury cars. Among comparison midsize luxury SUVs, only the Infiniti EX35 had a lower estimated claim frequency than the XC60, and that difference was not statistically significant. Analogously, only the Audi S4 4WD and the BMW M3 had lower estimated claim frequencies than the S60, and again, those differences were not statistically significant. In addition, these two vehicles are high performance variants of the Audi A4 4WD and the BMW 3 that may be driven only recreationally and therefore may have low-mileage exposure. Notably, the S60 had a claim frequency that was significantly lower than the base variants of these vehicles (Audi A4 4WD and BMW 3). Note that the vertical I-bars for each comparison group are the 95 percent confidence limits for the comparison of that group with the Volvo study vehicle, not the 95 percent confidence interval for that group's frequency estimate. This is true for all of the figures .

Figure 1: Property damage liability claim frequencies per 100 insured vehicle years for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

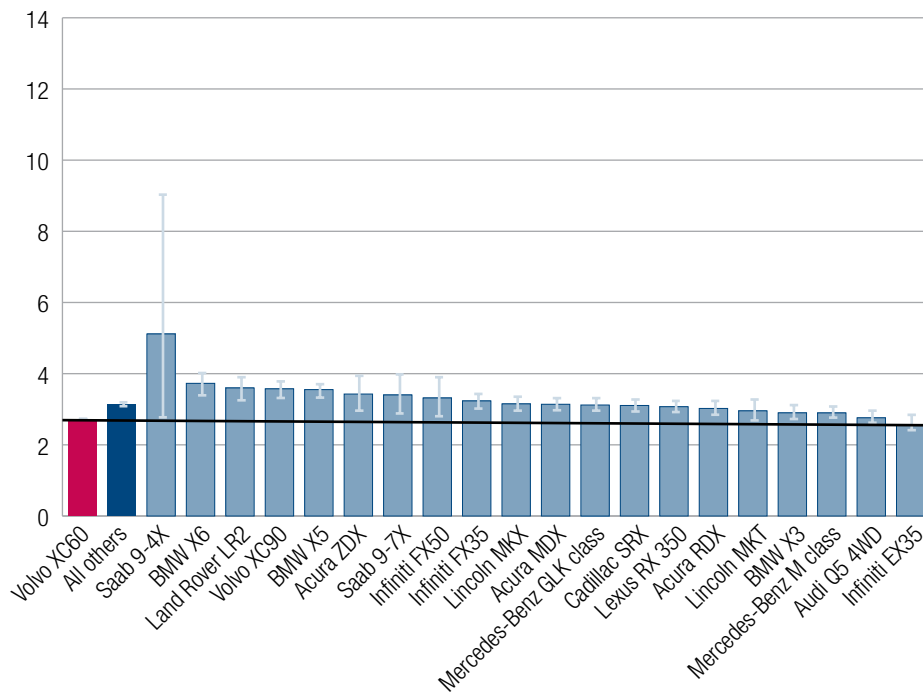
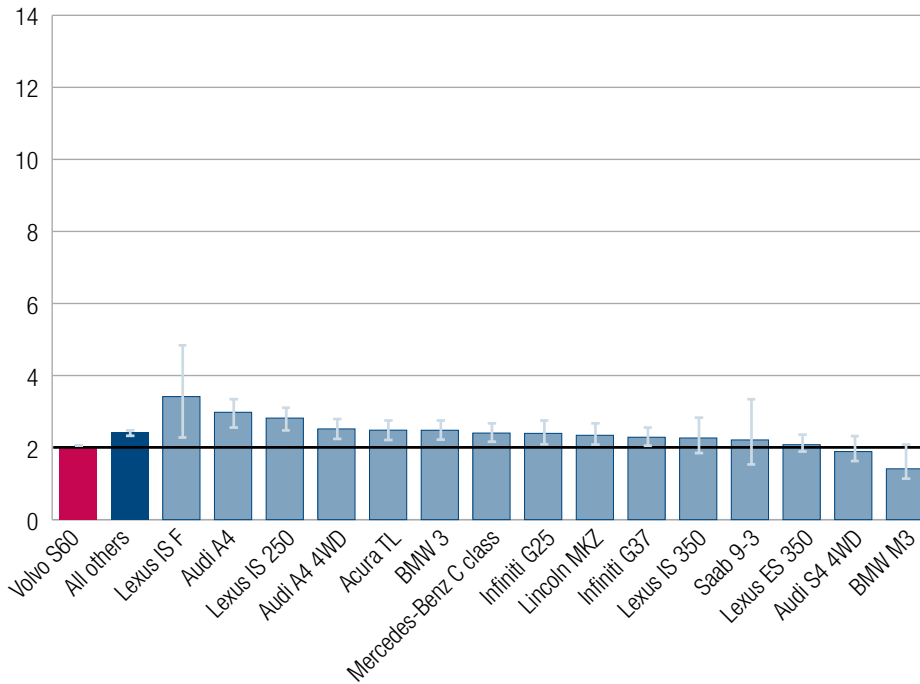


Figure 2: Property damage liability claim frequencies per 100 insured vehicle years for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars



Figures 3-4 show the results of the analyses of property damage liability claim severity for the Volvo XC60 and S60, respectively. As for the frequency analyses above, the actual average cost per claim is plotted for the XC60 and S60 against the model-derived estimates for each of the comparison vehicles as well as their weighted average. The XC60 average loss per claim fell near the middle of the range of other midsize luxury SUVs (1 percent lower than the average) while the S60 claim severity was typically higher than other midsize luxury cars (13 percent higher than the average).

Figure 3: Property damage liability claim severities for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

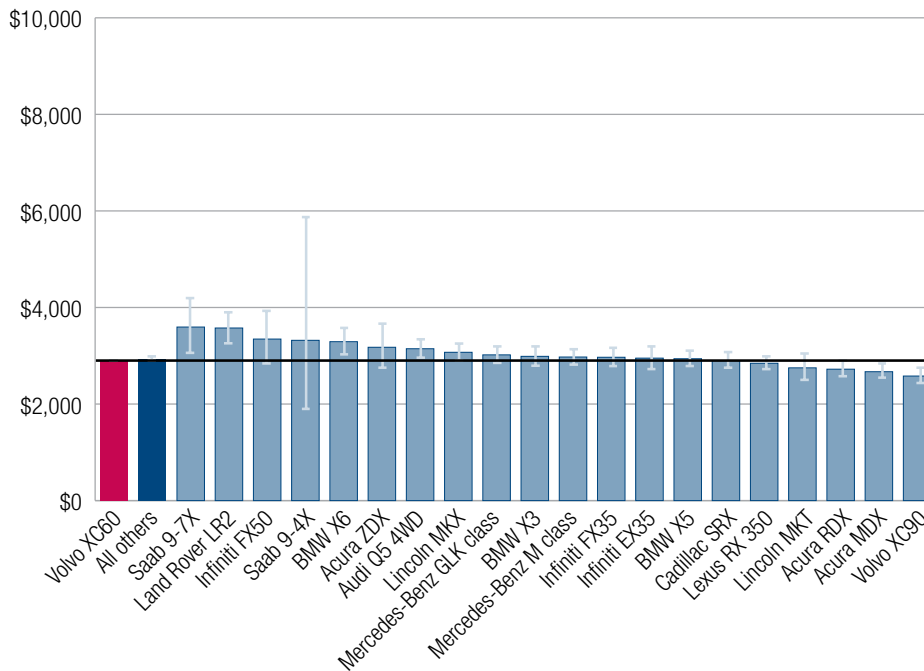
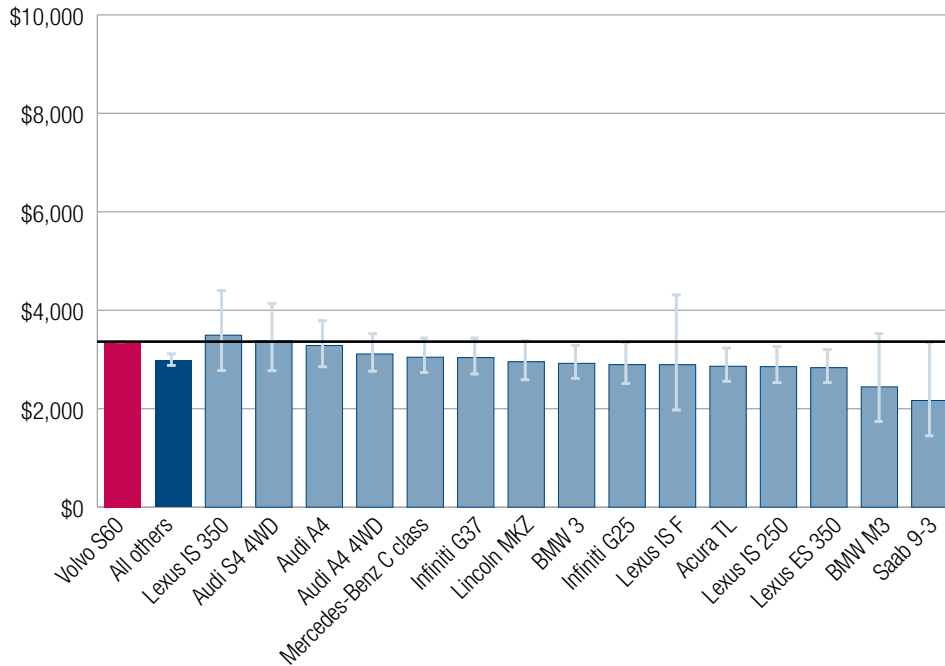


Figure 4: Property damage liability claim severities for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars



Figures 5-6 provide more detail about the differences in property damage liability claim severity results by examining the frequency of claims in different severity ranges. In Figure 5, the XC60 compared to other midsize luxury SUVs had fewer claims in low, medium and high severity ranges, with the greatest percentage reduction (21 percent) in claims costing at least \$7,000. In contrast, the S60 (Figure 6) had lower claim frequency only in the low and medium severity ranges. For claims of at least \$7,000, frequencies were slightly higher for the S60 compared to other midsize luxury cars. The claim severity results for the S60, but not the XC60, fit the pattern expected for a crash prevention system that is active only at low speeds (<20 mph) and indicates that the increase in average severity is the result of mean shifting associated with the elimination of many inexpensive claims. The differences at all claim severity ranges were statistically significant.

Figure 5: Property damage liability claim frequencies by claim severity range, Volvo XC60 vs. other midsize luxury SUVs

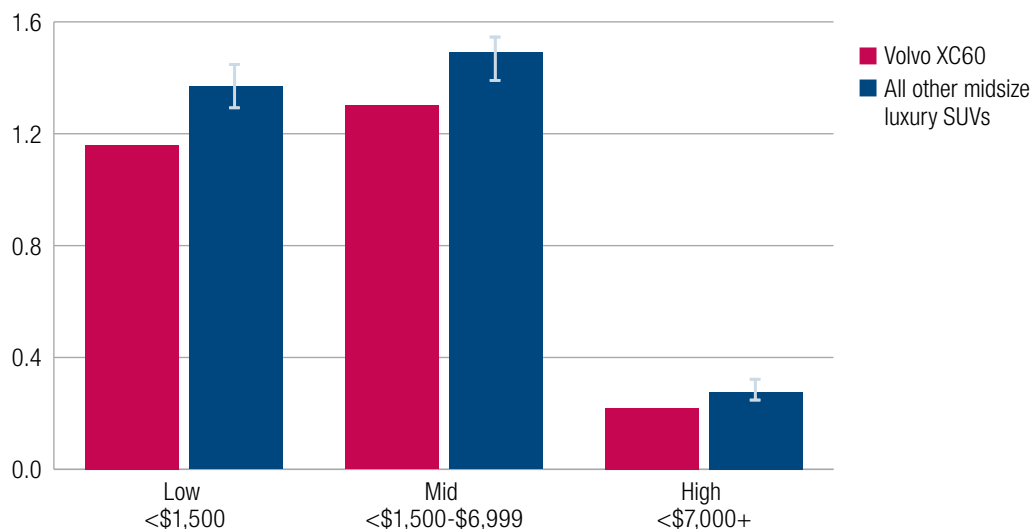
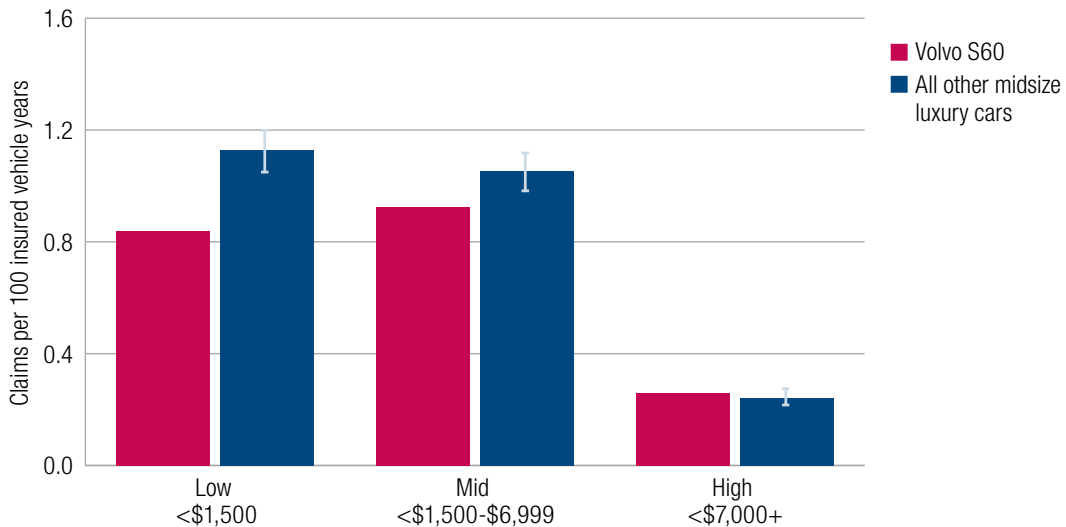


Figure 6: Property damage liability claim frequencies by claim severity range, Volvo S60 vs. other midsize luxury cars



Figures 7-8 show the result of combining the regression results from the frequency and severity analyses to obtain a comparison of overall property damage liability losses for the Volvo XC60 and S60 and their respective comparison vehicles. At \$78 per insured vehicle year, the actual overall loss for the Volvo XC60 (Figure 7) was lower than almost all other midsize luxury SUVs and 16 percent lower than the weighted average of those vehicles. The actual overall loss for the Volvo S60 (\$68 per insured vehicle year) was only 6 percent lower than that for all other midsize four-door luxury cars combined (Figure 8), as the decrease in claim frequency was offset somewhat by the fact that the more expensive claims had not decreased.

Figure 7: Property damage liability overall losses for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

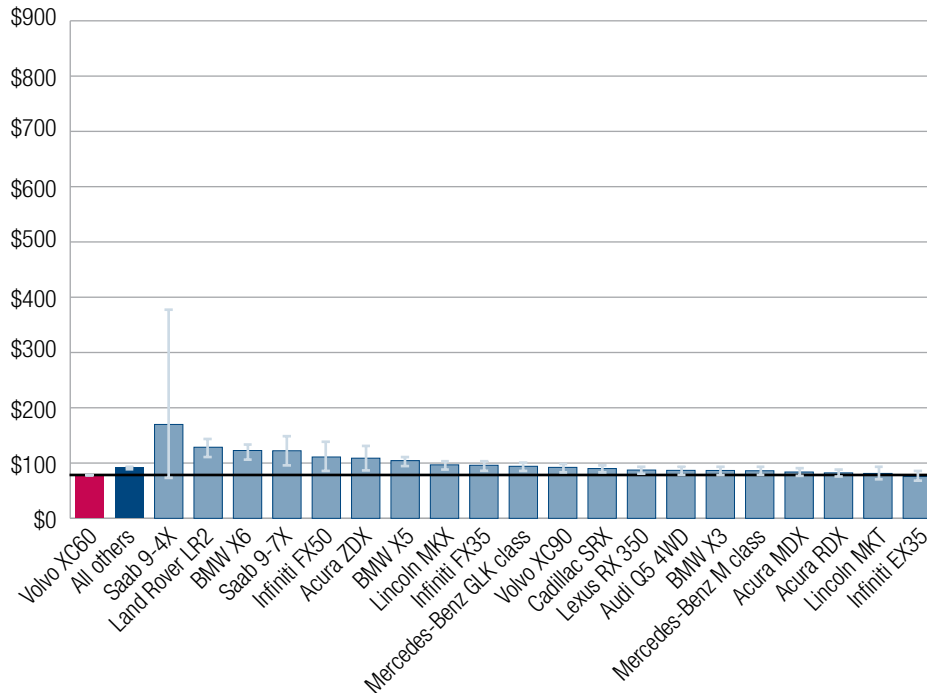


Figure 8: Property damage liability overall losses for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars

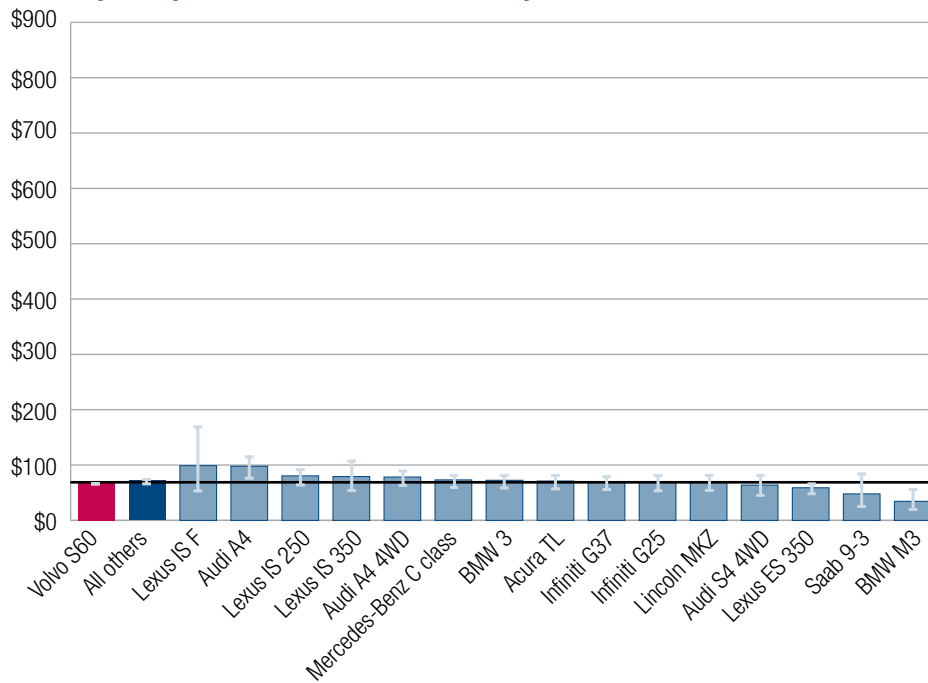


Table 4 summarizes the property damage liability results for the Volvo XC60 and S60 with City Safety. Note that the first two columns provide the weighted average estimates from the regressions and the standard error of those estimates. The third column is the effect estimate expressed as the percent increase or decrease in claim frequency, severity and overall losses (e**estimate); this is the effect of not having City Safety. In the final two columns, the effect of City Safety is expressed in terms of the estimated percent benefit of the technology (i.e., $100 \times (1/e^{\text{estimate}} - 1)$) and the 95 percent confidence bounds of the estimated benefit.

Table 4: Property damage liability loss results - City Safety versus weighted average of comparison vehicles					
	Estimate	Standard Error	Estimated change of control vehicles relative to study vehicles	City Safety benefit	
				Estimate	95% confidence interval
XC60 vs. midsize luxury SUVs					
Claim frequency	-0.1575	0.0087	17%	-15%	-16%, -13%
Claim severity	-0.0145	0.0081	1%	-1%	-3%, 0%
Overall loss	-0.1720	0.0119	19%	-16%	-18%, -14%
Claims <\$1,500	-0.1654	0.0132	18%	-15%	-17%, -13%
Claims \$1,500-\$6,999	-0.1360	0.0124	15%	-13%	-15%, -11%
Claims \$7,000+	-0.2342	0.0297	26%	-21%	-25%, -16%
S60 vs. midsize luxury cars					
Claim frequency	-0.1778	0.0200	19%	-16%	-20%, -13%
Claim severity	0.1179	0.0196	-11%	13%	8%, 17%
Overall loss	-0.0598	0.0280	6%	-6%	-11%, -1%
Claims <\$1,500	-0.2984	0.0304	35%	-26%	-30%, -21%
Claims \$1,500-\$6,999	-0.1289	0.0298	14%	-12%	-17%, -7%
Claims \$7,000+	0.0809	0.0590	-8%	8%	-3%, 22%

Bodily injury liability: Figures 9-10 show the results for the analyses of bodily injury liability claim frequency. The actual bodily injury claim frequency for the XC60 and S60 are typically lower than the estimated frequencies for their comparison vehicles. However, for the S60, most individual comparison cars were not significantly different. As with property damage liability, the Audi S4 4WD and the BMW M3 had lower claim rates than the S60.

Figure 9: Bodily injury liability claim frequencies per 1,000 insured vehicle years for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

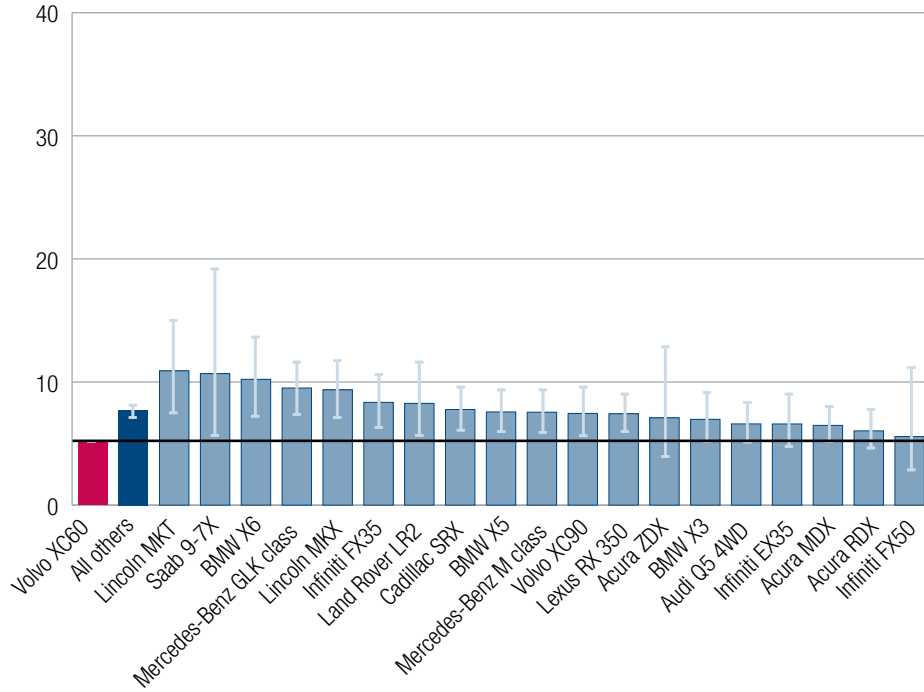


Figure 10: Bodily injury liability claim frequencies per 1,000 insured vehicle years for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars

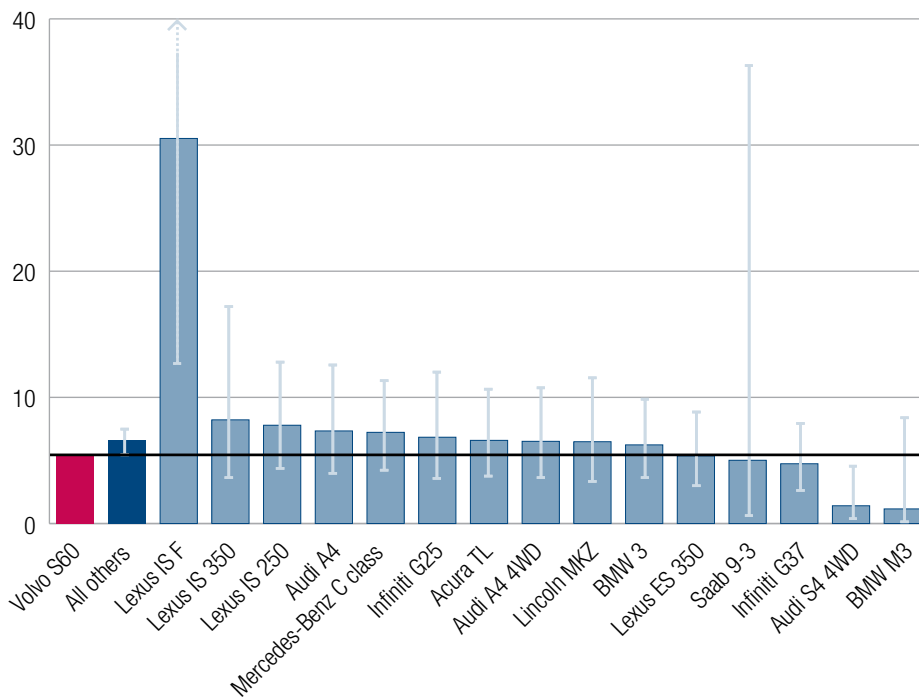


Table 5 summarizes results of the regression analysis conducted for bodily injury liability coverage. Note that analyses of claim severity were not conducted because of the relative recency of these claims and the length of time it takes for claims costs to fully develop. The layout of **Table 5** is analogous to **Table 4**, with the estimated benefits of City Safety in the Volvo XC60 and S60 shown in the final two columns. Compared to other midsize luxury SUVs, it is estimated that the XC60 bodily injury liability claims frequency was reduced by 33 percent with City Safety. For the S60, bodily injury claims frequency was 18 percent lower than would have been expected based on the weighted average experience of other midsize luxury cars.

Table 5: Bodily injury liability loss frequency results - City Safety versus weighted average of comparison vehicles					
	Estimate	Standard Error	Estimated change of control vehicles relative to study vehicles	City Safety benefit	
				Estimate	95% confidence interval
XC60 vs. midsize luxury SUVs	-0.4050	0.0337	50%	-33%	-38%, -29%
S60 vs. midsize luxury cars	-0.2005	0.0827	22%	-18%	-30%, -4%

Collision damage: Figures 11-16 show the results for the analyses of collision damage claim frequency, claim severity, and overall losses for the XC60 and S60. For both vehicles fitted with City Safety, the actual loss frequency and severity are lower than the estimated frequencies and severities associated with most of the comparison vehicles. As a result, overall losses for the City Safety vehicles also are lower than the overall losses of most comparison vehicles.

Figure 11: Collision claim frequencies per 100 insured vehicle years for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

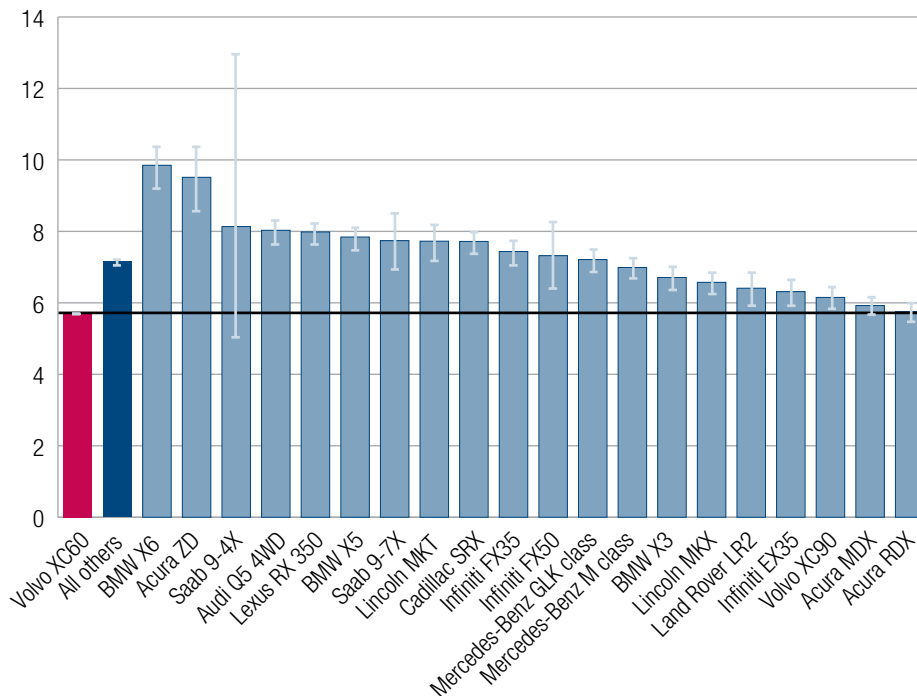


Figure 12: Collision claim frequencies per 100 insured vehicle years for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars

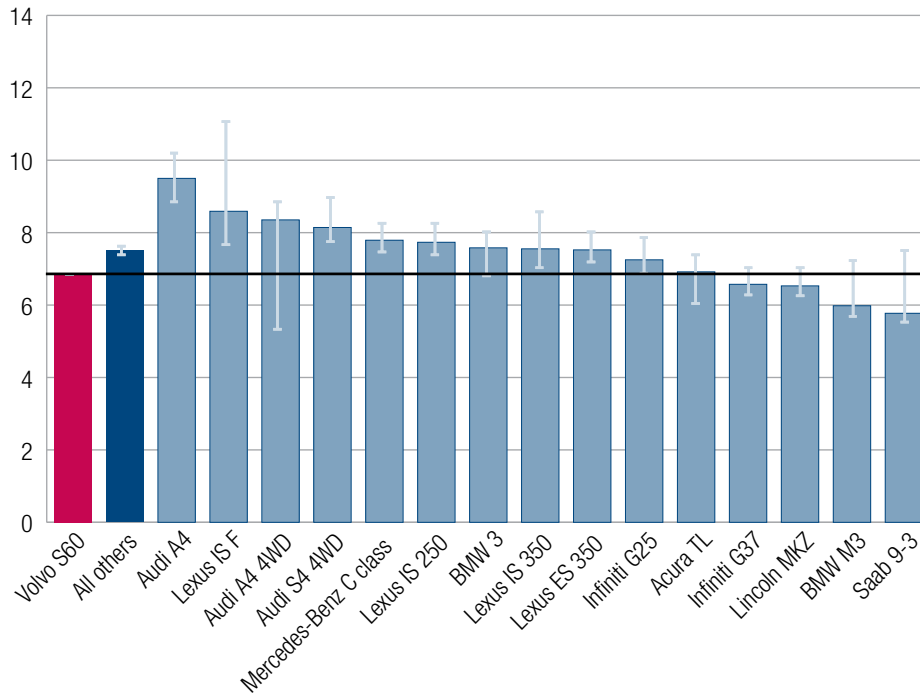


Figure 13: Collision claim severities for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

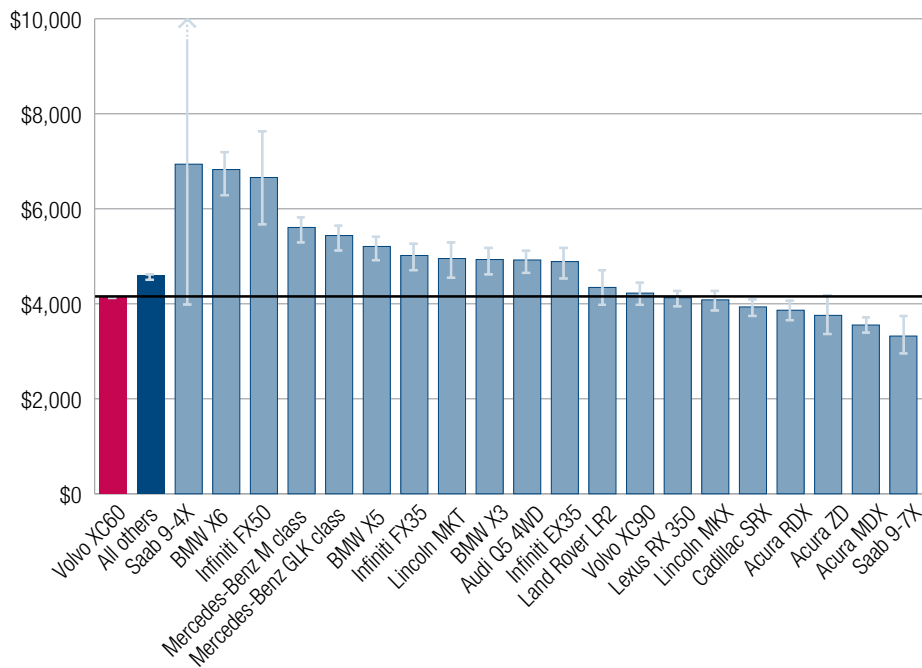


Figure 14: Collision claim severities for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars

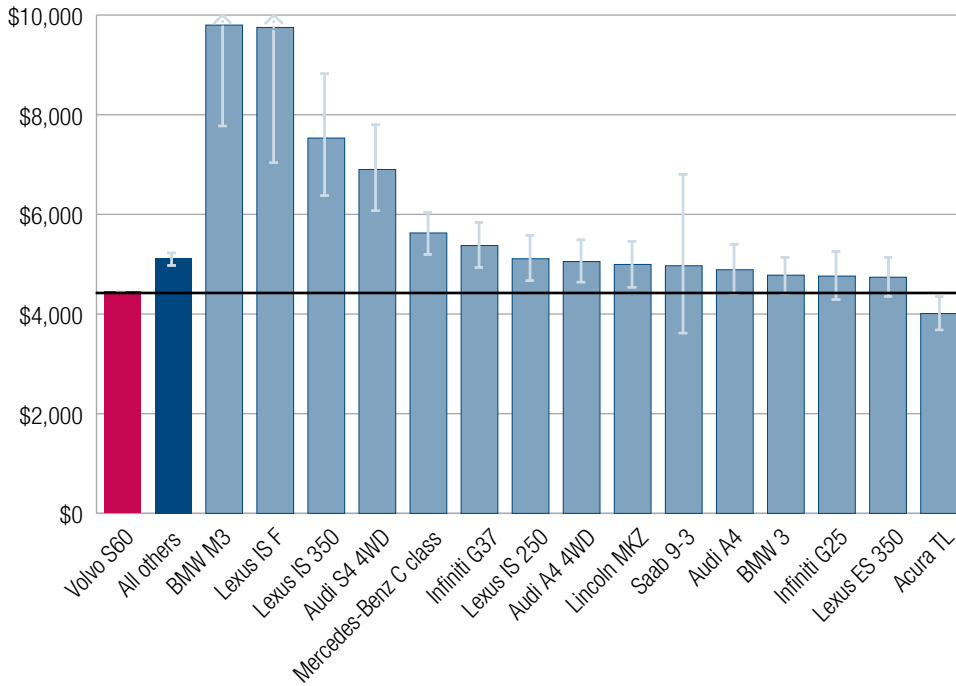


Figure 15: Collision overall losses for 2010-12 Volvo XC60 with City Safety vs. other 2009-12 midsize luxury SUVs

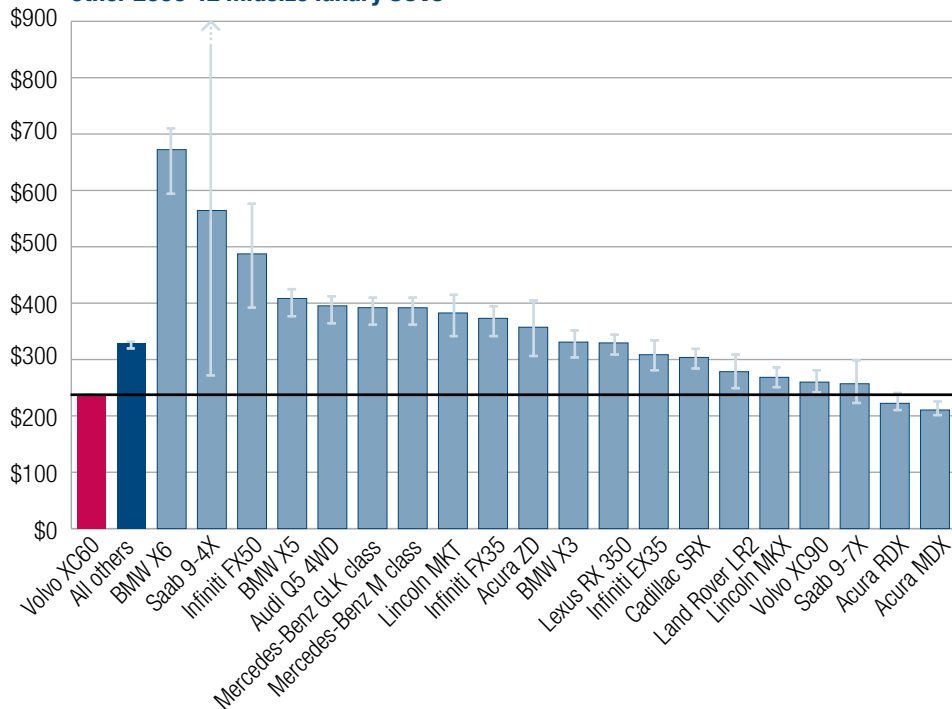


Figure 16: Collision overall losses for 2011-12 Volvo S60 with City Safety vs. other 2011-12 midsize luxury cars

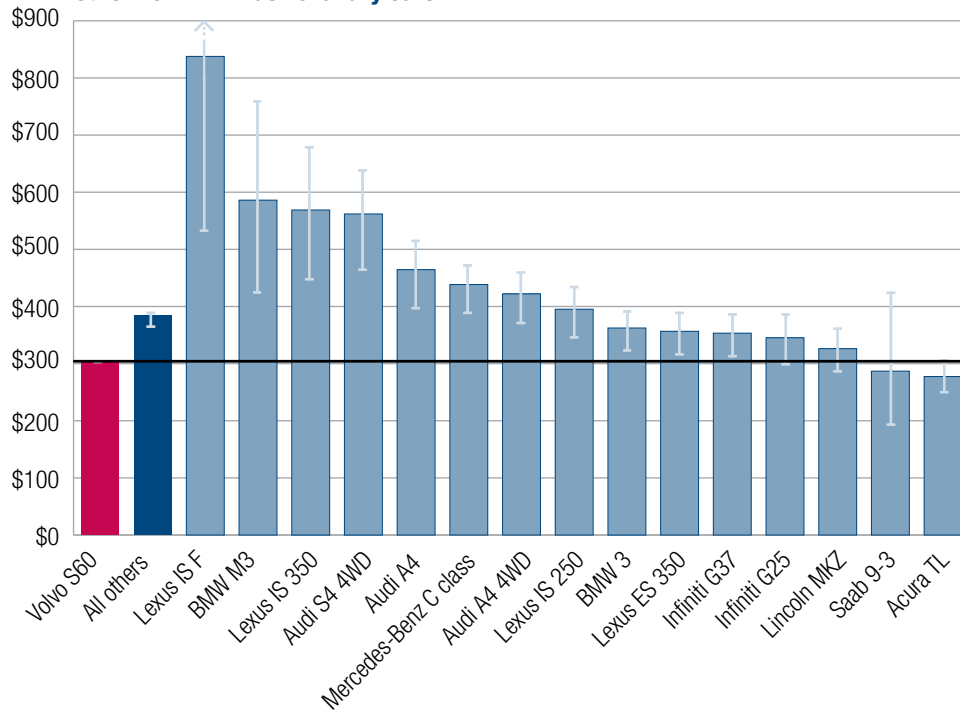


Table 6 summarizes the collision coverage results in an analogous manner to the property damage liability results. Compared to the weighted average estimate of comparison vehicles, the Volvo XC60’s actual collision frequency was 20 percent lower, claim severity was 10 percent lower, and overall losses were reduced by 28 percent. Similarly, the S60’s actual collision frequency was 9 percent lower than the weighted average of other midsize luxury cars, claim severity was 13 percent lower, and overall losses were 21 percent lower. Reductions in claims appear to have occurred across most of the severity spectrum, although the reductions in claims costing less than \$2,000 are much less (only 13 percent for the XC60 and a 2 percent increase – not significant – for the S60).

Table 6: Collision loss results - City Safety versus weighted average of comparison vehicles					
	Estimate	Standard Error	Estimated change of control vehicles relative to study vehicles	City Safety benefit	
				Estimate	95% confidence interval
XC60 vs. midsize luxury SUVs					
Claim frequency	-0.2256	0.0059	25%	-20%	-21%, -19%
Claim severity	-0.1031	0.0068	11%	-10%	-11%, -9%
Overall loss	-0.3287	0.0090	39%	-28%	-29%, -27%
Claims <\$2,000	-0.1403	0.0082	15%	-13%	-14%, -12%
Claims \$2,000-\$4,999	-0.2689	0.0122	31%	-24%	-25%, -22%
Claims \$5,000-\$11,999	-0.3885	0.0160	47%	-32%	-34%, -30%
Claims \$12,000+	-0.2846	0.0184	33%	-25%	-27%, -22%
S60 vs. midsize luxury cars					
Claim frequency	-0.0907	0.0112	9%	-9%	-11%, -7%
Claim severity	-0.1397	0.0132	15%	-13%	-15%, -11%
Overall loss	-0.2304	0.0173	26%	-21%	-23%, -18%
Claims <\$2,000	0.0182	0.0158	-2%	2%	-1%, 5%
Claims \$2,000-\$4,999	-0.2186	0.0246	24%	-20%	-23%, -16%
Claims \$5,000-\$11,999	-0.1924	0.0291	21%	-18%	-22%, -13%
Claims \$12,000+	-0.1966	0.0306	22%	-18%	-23%, -13%

► Discussion

The updated loss experience for the Volvo XC60 equipped with standard City Safety, coupled with these first results for the S60 similarly fitted, strengthen the conclusion that City Safety is preventing front to rear crashes in these vehicles. The benefit of City Safety is reflected in fewer claims for property damage liability (15 percent and 16 percent for the XC60 and S60, respectively), for bodily injury (33 percent and 18 percent), and for collision (20 percent and 9 percent). Overall losses for the XC60 and S60 were lower for both property damage liability (16 percent and 6 percent, respectively) and collision (28 percent and 21 percent). Although some of these effects are not as large as those reported initially for the XC60 in 2011, they still represent quite large reductions in claims. Also, the pattern of results for the XC60 and S60 was reasonably similar, suggesting these findings are robust.

Nevertheless, there were some differences and some unexpected findings. One unexpected finding was the large benefit of City Safety for collision coverage. This substantial effect could indicate that City Safety is preventing collisions with some nonvehicle objects as well as vehicle-to-vehicle collisions. This is feasible considering that City Safety sometimes is demonstrated with nonvehicle crash targets even though it is designed to address vehicle-to-vehicle collisions.

However, the updated effects of City Safety on collision experience of the XC60 are not only large but they are larger than those for property damage liability. In the early results for the XC60 (2011), property damage liability claim frequency was reduced more than collision claim frequency. Although the difference was not large (27 percent and 22 percent), that pattern was consistent with the greater representation of front-to-rear collisions in property damage liability claims. Past HLDI (2007) research has shown that in multiple-vehicle collisions, the most common configuration is front-to-rear (49.3 percent). The next most frequent configuration is front-to-front at only 13.5 percent. In the current update, City Safety is associated with greater reductions in property damage liability claim frequency only for the S60, while the collision claim reduction is greater for the XC60. The overall loss reductions are larger for collision coverage for both vehicles. At this time, all that can be said with confidence is that City Safety is having larger than expected benefits for collision claims experience, and further research is needed to understand the mechanism of those benefits.

Another unexpected finding was that City Safety appeared to reduce property damage liability claim frequency across the severity spectrum for the XC60, with the result being a statistically significant reduction in average claim severity. This is a change from the early XC60 findings (2011) when only claims costing less than \$7,000 were reduced. The reduction in lower cost claims is the expected finding with City Safety, given the low speed at which it is operative (<20 mph), and the reversal was unexpected. It is especially surprising because the property damage liability claims severity results for the S60 did follow the expected pattern, similar to the early results from the XC60. It could be that the shift in pattern of the XC60 results is a statistical aberration that additional data will correct even though the 95 percent confidence interval for the claim severity analysis is fairly tight. Alternatively, it is possible that this pattern of results is characteristic for vehicles that are newly designed, and that longer-term S60 results will follow those of the XC60.

Loss results for City Safety compared with other Volvos: Loss results for the XC60 and S60 were also compared with other Volvo vehicles to test for the possibility of a “Volvo effect.” For claim frequency, the results were largely similar to those found when comparing the XC60 and S60 to their comparable vehicles. The main exception was an increase in collision claim frequency for the S60 compared to the weighted average of other midsize luxury cars. Summary results of the Volvo analysis along with the other comparison groups are found in [Appendix B](#). These results are not discussed further here as this analysis was conducted primarily to assure that the subject vehicles with City Safety appeared generally to have lower loss experience versus other Volvos as well as compared to other similar vehicles. Further development of comparisons with other Volvos would require more investigation into how Volvo vehicles typically differ in loss experience than was included here.

► Limitations

All of the XC60s and S60s included in the current study were equipped with the City Safety technology, but there was no way to know whether any drivers in the crash-involved vehicles had manually turned off the system prior to the crash. Also, most of the vehicles in this study, including the XC60 and S60, can be equipped with a variety of collision avoidance features that might also affect claim frequencies, and it was not possible, based on data available to HLDI at the time of the study, to control for the presence of these other features. The study and control vehicles may have other collision avoidance features that could be influencing the results. To fully understand the benefits of City Safety, subsequent analysis will be required as additional loss data become available involving more and potentially different drivers. This analysis controlled for a variety of possible demographic differences (rated driver age, gender, marital status, and risk) between the study and control populations. It still is possible that rated drivers that chose to purchase vehicles with City Safety differ in other ways that could affect crash likelihood – perhaps drivers who are more concerned about safety or who have experienced front-to-rear collisions in the past and want to avoid them in the future.

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- Volvo cars. 2008. Volvo cars presents City Safety – a unique system for avoiding collisions at low speeds

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Appendix A: Exposure and claims by coverage type for comparison vehicles						
	Property damage liability		Bodily injury liability		Collision	
	Exposure	Claims	Exposure	Claims	Exposure	Claims
Midsize luxury SUVs						
Acura MDX	194,960	6,364	64,118	411	194,960	10,982
Acura RDX	67,090	2,174	21,069	131	67,090	3,878
Acura ZDX	5,037	177	1,516	11	5,037	478
Audi Q5 4WD	83,698	2,424	26,910	186	83,698	6,620
BMW X3	45,411	1,351	12,891	87	45,411	2,938
BMW X5	139,991	5,220	44,149	343	139,991	10,284
BMW X6	18,481	749	5,489	61	18,481	1,727
Cadillac SRX	156,871	4,548	46,675	327	156,871	11,564
Infiniti EX35	26,799	726	8,437	58	26,799	1,691
Infiniti FX35	50,995	1,745	16,258	141	50,995	3,537
Infiniti FX50	3,837	132	1,443	8	3,837	246
Land Rover LR2	14,464	578	4,637	41	14,464	909
Lexus RX 350	481,315	15,389	161,053	1192	481,315	36,724
Lincoln MKT	15,986	426	4,929	47	15,986	1,194
Lincoln MKX	79,826	2,261	22,556	181	79,826	5,083
Mercedes-Benz GLK class	95,219	3,074	31,765	322	95,219	6,825
Mercedes-Benz M class	144,237	4,403	40,655	321	144,237	9,582
Saab 9-4X	223	10	43	0	223	17
Saab 9-7X	5,237	145	1,177	11	5,237	423
Volvo XC90	51,456	1,915	16,549	123	51,456	3,042
Midsize luxury cars						
Acura TL	32,079	833	7,206	50	32,079	2,239
Audi A4	9,454	384	2,856	37	9,454	1,019
Audi A4 4WD	26,798	783	6,245	50	26,798	2,491
Audi S4 4WD	5,758	125	1,596	3	5,758	504
BMW 3	92,996	2,821	23,655	204	92,996	7,856
BMW M3	1,832	31	618	1	1,832	117
Infiniti G25	12,143	364	2,883	27	12,143	991
Infiniti G37	34,584	927	7,581	46	34,584	2,465
Lexus ES 350	42,313	1,048	9,947	64	42,313	3,323
Lexus IS 250	21,953	793	5,105	61	21,953	1,916
Lexus IS 350	3,127	84	929	10	3,127	253
Lexus IS F	606	25	177	8	606	55
Lincoln MKZ	22,649	547	3,826	25	22,649	1,683
Mercedes-Benz C class	65,034	1,890	14,734	147	65,034	5,585
Saab 9-3	876	21	181	1	876	57

► Appendix B: Summary loss results

XC60 summary loss results relative to other midsize luxury SUVs									
Vehicle damage coverage type	Lower bound	Claim frequency	Upper bound	Lower bound	Claim severity	Upper bound	Lower bound	Overall losses	Upper bound
Property damage liability	-16%	-15%	-13%	-\$89	-\$42	\$4	-\$17	-\$15	-\$12
Bodily injury	-38%	-33%	-29%						
Collision	-21%	-20%	-19%	-\$512	-\$450	-\$389	-\$98	-\$92	-\$86

XC60 summary loss results relative to other Volvos									
Vehicle damage coverage type	Lower bound	Claim frequency	Upper bound	Lower bound	Claim severity	Upper bound	Lower bound	Overall losses	Upper bound
Property damage liability	-9%	-6%	-3%	\$219	\$304	\$386	\$0	\$4	\$7
Bodily injury	-41%	-34%	-25%						
Collision	-14%	-12%	-10%	-\$278	-\$164	-\$53	-\$51	-\$41	-\$32

S60 summary loss results relative to other midsize luxury cars									
Vehicle damage coverage type	Lower bound	Claim frequency	Upper bound	Lower bound	Claim severity	Upper bound	Lower bound	Overall losses	Upper bound
Property damage liability	-20%	-16%	-13%	\$257	\$373	\$486	-\$8	-\$4	\$0
Bodily injury	-30%	-18%	-4%						
Collision	-11%	-9%	-7%	-\$802	-\$668	-\$537	-\$92	-\$79	-\$66

S60 summary loss results relative to other Volvos									
Vehicle damage coverage type	Lower bound	Claim frequency	Upper bound	Lower bound	Claim severity	Upper bound	Lower bound	Overall losses	Upper bound
Property damage liability	-20%	-13%	-5%	\$581	\$811	\$1,021	\$1	\$9	\$16
Bodily injury	-46%	-22%	13%						
Collision	6%	12%	19%	-\$2	\$281	\$546	\$28	\$51	\$72

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