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Analysis of the Crash Experience of Vehicles Equipped with All Wheel Antilock Braking Systems (ABS)-A Second Update Including Vehicles with Optional ABS

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16. Abstract

This analysis updates the 1998 ABS analysis (Hertz et al, 1998) by including vehicles whose owners had selected it as an option.

The inclusion of the vehicles with optional ABS does not seem to make very much difference in the estimation of the effect of all wheel ABS in crashes of all severities. ABS still seems to have a beneficial effect in preventing each crash type except for side impacts, where it is appears to be associated with a higher response rate especially for passenger cars. However, it appears to be beneficial in preventing pedestrian crashes, rollovers, run-off-road crashes and frontal crashes with another moving vehicle.

The previous study indicated several disbenefits in fatal crashes. The only statistically significant one remaining is rollovers of LTVs. As with all protective devices, NHTSA plans to update these estimates periodically as more data become available.

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Summary

This analysis updates the 1998 ABS analysis (Hertz et al, 1998) by the same authors by including vehicles with optional anti-lock braking systems (ABS). Previous work had used only vehicles with standard ABS or none. The Motor Vehicle Safety Advisory Committee, which includes vehicle manufacturers and insurance companies, as well as NHTSA, asked about the effect of ABS among vehicles whose owners had selected it as an option. To obtain this information, seventeen digit VINs of vehicles that had optional ABS were sent to manufacturers. Ford, General Motors, Chrysler, Mazda, Mitsubishi, Nissan, Volkswagen and Toyota supplied us, to the extent that they could, the information about the selection or non-selection of ABS on the part of these individual customers.

There were not sufficient data to look at standard and optional ABS separately. Therefore, optional and standard ABS were combined and a single ABS effect was estimated. Vehicles without ABS, whether by choice or non-availability, were similarly combined as non-ABS.

The inclusion of the vehicles with optional ABS does not seem to make very much difference in the estimation of the effect of all wheel ABS in crashes of all severities. ABS still seems to have a beneficial effect in preventing each crash type except for side impacts, where it is appears to be associated with a higher response rate especially for passenger cars. However, it appears to be beneficial in preventing pedestrian crashes, rollovers, run-off-road crashes and frontal crashes with another moving vehicle.

The previous study indicated several disbenefits in fatal crashes. The only statistically significant one remaining is rollovers of LTVs. As with all protective devices, NHTSA plans to update these estimates periodically as more data become available.

Background

This analysis updates the 1998 ABS analysis (Hertz et al, 1998) by the same authors by including vehicles with optional ABS. The 1998 ABS analysis, in turn, updated the1995 studies (Hertz et al, 1995) by using data from 1995 and 1996 and by including pedestrian-involved crashes.

As discussed in the earlier studies, five vehicle crash modes are identified that are considered to be possibly affected by braking. They are rollovers, side impacts, run-off-road, frontal impacts with another motor vehicle in motion (also called unable-to-stop) and pedestrian involved crashes. Also, a vehicle crash mode is identified that is considered not to be apt to be affected by braking. These vehicles, called controls, are vehicles that were hit either while standing still or slowing down or emerging from a parking space.

This present analysis proceeds in exactly the same way as described in Hertz et al, 1998 and uses the same data with the following exceptions:

- Since the differences in the ABS effects between surface types were not dramatic, and since road surface is frequently not a matter of choice, the databases were aggregated over road surface. This also permitted inclusion of vehicles with unknown road surface condition.

- The VINs that did not decode as standard or unavailable ABS were sent to the manufacturers who supplied, wherever possible, the final ABS status of the vehicle based on the owner's selection where ABS was an option. These VINs were merged with their vehicles in the crash databases and were included in this analysis.

Since no vehicles were designated by manufacturers as having optional rear wheel ABS selected, the 1998 analysis already made use of all the available data on rear wheel ABS. For that reason, this analysis is restricted to all wheel ABS. Since Pennsylvania did not supply 17 digit VINs for 1996, the Pennsylvania data do not contain any optional ABS for 1996.

As before, the data were from 1995 and 1996. For each state (Florida, Maryland, Missouri and Pennsylvania) and for FARS, for each crash type (positive response), and each type of passenger vehicle (PC and LTV), the data were divided into five databases each consisting only of crashes that crash type and control crashes, and a logistic regression was performed with the model

LOGIT(P) = ABS AGE YOUNG MALE CURVED RURAL VEH AGE where P is the probability of a positive response as opposed to a control vehicle and the logit function is defined by logit (x) = log(x/(1-x)).

As explained in the previous works, the coefficient, beta, of ABS represents the increase (or decrease if it is negative) in the log odds of the occurrence of a positive response, for example rollover, that occurs when all wheel ABS is added to the vehicle and no other changes are made. Also, 100*(exp(beta)-1) approximately represents the expected percent change in the probability of that positive response. Finally, for each vehicle type and positive response, the coefficients of ABS were combined statistically across all four states (Fleiss, 1981). This resulted in overall estimates of the all wheel ABS effects. Note that no assumption is made that the rate of positive responses (say rollovers) is the same from state to state, only that the effect of ABS on that rate is the same from state to state.

At first we hoped to look at optional and standard ABS separately. However, there were not sufficient data. For example, in FARS, there were only seven LTVs in control type crashes and twenty PCs in control type crashes. These cell sizes are too small to make credible statistical inferences and, also, the data are subdivided further because of the other covariates in the model. Therefore, optional and standard ABS were combined and a single ABS effect was estimated. Vehicles without ABS, whether by choice or non-availability, were similarly combined as non-ABS.

In each of the logistic regressions, the stepwise option was used so that only ABS and covariates that turned out to be statistically significant were retained. The coefficients of ABS along with standard errors, Z’s and chi squares are displayed in Table 1.

Table 1

ABS Coefficients by State and Vehicle Type 1

STATE	RESPONSE	VEHICLE TYPE	BETA	SE	Z	CHI SQUARE
FL	PEDESTRIAN	LTV	-0.02440	0.0553	-0.4412	0.195
MD	PEDESTRIAN	LTV	-0.04450	0.1301	-0.3420	0.117
MO	PEDESTRIAN	LTV	-0.04160	0.0780	-0.5333	0.284
PA	PEDESTRIAN	LTV	0.04110	0.1521	0.2702	0.073
FL	PEDESTRIAN	PC	-0.19170	0.0231	-8.2987	68.868
MD	PEDESTRIAN	PC	-0.11660	0.0394	-2.9594	8.758
MO	PEDESTRIAN	PC	-0.02620	0.0373	-0.7024	0.493
PA	PEDESTRIAN	PC	-0.16440	0.0710	-2.3155	5.362
FL	ROLLOVER	LTV	-0.78510	0.1704	-4.6074	21.228
MD	ROLLOVER	LTV	0.00620	0.3723	0.0167	0.000
MO	ROLLOVER	LTV	-0.27280	0.1663	-1.6404	2.691
PA	ROLLOVER	LTV	0.07180	0.2396	0.2997	0.090
FL	ROLLOVER	PC	0.03050	0.0701	0.4351	0.189
MD	ROLLOVER	PC	-0.24300	0.1501	-1.6189	2.621
MO	ROLLOVER	PC	-0.27290	0.0707	-3.8600	14.899
PA	ROLLOVER	PC	0.01090	0.0712	0.1531	0.023
FL	RUN OFF ROAD	LTV	-0.09190	0.0815	-1.1276	1.271
MD	RUN OFF ROAD	LTV	-0.12150	0.2208	-0.5503	0.303
MO	RUN OFF ROAD	LTV	-0.20380	0.1008	-2.0218	4.088
PA	RUN OFF ROAD	LTV	-0.01110	0.1616	-0.0687	0.005
FL	RUN OFF ROAD	PC	-0.03150	0.0269	-1.1710	1.371
MD	RUN OFF ROAD	PC	-0.04460	0.0575	-0.7757	0.602
MO	RUN OFF ROAD	PC	-0.11060	0.0344	-3.2151	10.337
PA	RUN OFF ROAD	PC	-0.07640	0.0493	-1.5497	2.402
FL	SIDE IMPACT	LTV	0.13620	0.1301	1.0469	1.096
MD	SIDE IMPACT	LTV	0.00231	0.1252	0.0185	0.000
MO	SIDE IMPACT	LTV	0.21730	0.1081	2.0102	4.041
PA	SIDE IMPACT	LTV	-0.66720	0.4317	-1.5455	2.389
FL	SIDE IMPACT	PC	0.38200	0.0461	8.2863	68.663
MD	SIDE IMPACT	PC	0.06010	0.0340	1.7676	3.125
MO	SIDE IMPACT	PC	0.06780	0.0496	1.3669	1.869
PA	SIDE IMPACT	PC	-0.04830	0.1196	-0.4038	0.163
FL	UTS(FRONTAL)	LTV	-0.05490	0.0351	-1.5641	2.446
MD	UTS(FRONTAL)	LTV	-0.22470	0.0856	-2.6250	6.891
MO	UTS(FRONTAL)	LTV	-0.16260	0.0568	-2.8627	8.195
PA	UTS(FRONTAL)	LTV	-0.02140	0.0735	-0.2912	0.085
FL	UTS(FRONTAL)	PC	-0.28970	0.0126	-22.9921	528.635
MD	UTS(FRONTAL)	PC	-0.22070	0.0339	-6.5103	42.384
MO	UTS(FRONTAL)	PC	-0.21540	0.0210	-10.2571	105.209
PA	UTS(FRONTAL)	PC	-0.27820	0.0283	-9.8304	96.637

Table 2 displays the FARS ABS coefficients. Since ABS appears to affect fatal crashes in a different way, these are displayed separately.

Table 2

ABS Coefficients in Fatal Crashes by Vehicle Type

VEHICLE TYPE	RESPONSE	BETA	SE	Z	CHI SQUARE
PC	PEDESTRIAN	-0.00445	0.0884	-0.05034	0.0025
PC	ROLLOVER	0.11590	0.1553	0.74630	0.5570
PC	RUN-OFF-ROAD	-0.14420	0.0945	-1.52593	2.3284
PC	SIDE-IMPACT	0.28090	0.1486	1.89031	3.5733
PC	FRONTAL(UTS)	-0.05070	0.0815	-0.62209	0.3870
LTV	PEDESTRIAN	-0.25800	0.2231	-1.15643	1.3373
LTV	ROLLOVER	0.72520	0.1660	4.36867	19.0853
LTV	RUN-OFF-ROAD	0.19690	0.1689	1.16578	1.3590
LTV	SIDE-IMPACT	-0.00331	0.2790	-0.01186	0.0001
LTV	FRONTAL(UTS)	0.16440	0.1216	1.35197	1.8278

As in the previous analyses, the coefficients of Table 1 were combined statistically across the four states, resulting in an overall ABS effect on each response type.

The results are displayed in Table 3.

Table 3

ABS Coefficients by Vehicle Type Combined Across FL, MD, MO and PA

RESPONSE	VEHICLE TYPE	BETA	SE
PEDESTRIAN	LTV	-0.02639	0.04104
PEDESTRIAN	PC	-0.14141	0.01706
ROLLOVER	LTV	-0.37390	0.10247
ROLLOVER	PC	-0.08838	0.03937
RUN-OFF-ROAD	LTV	-0.11960	0.05700
RUN-OFF-ROAD	PC	-0.06186	0.01844
SIDE IMPACT	LTV	0.10855	0.06839
SIDE IMPACT	PC	0.14124	0.02349
UTS(FRONTAL)	LTV	-0.08979	0.02632
UTS(FRONTAL)	PC	-0.26697	0.00967

Since 100*(exp(beta)-1) represents the approximate expected percent change in the probability of that positive response, and since beta $\pm$ 1.96*se are the upper and lower 95% confidence bounds for beta, we can compute point estimates and 95% confidence limits for the percent changes in the occurrence of each positive response associated with ABS. An effect is said to be statistically significant if abs(beta/se) >1.96; that is equivalent to its 95% confidence interval lying entirely on one side of zero. A negative value of beta indicates a benefit from ABS since the occurrence of that crash type is expected to decrease, a positive value indicates a disbenefit. Table 4 summarizes the ABS effects. The ABS effects that were found in 1998 without the optional ABS vehicles, are shown for comparison. In 1998, separate analyses were conducted for good and bad surfaces. In order to make comparisons between the present results and the earlier ones, a significant effect for a given vehicle type and response is said to have been found in the earlier work if it was found for either surface condition. For example, the 95% confidence interval for the percentage change in run-off-road crashes for passenger cars on good surfaces was (-17, -9) so a benefit is said to have been found for passengers in run-off-road crashes.

Table 4 summarizes the ABS effects for crashes of all severity levels.

Table 4

ABS EFFECTS COMBINED OVER THE STATES

RESPONSE	VEHICLE	POINT ESTIMATE	UPPER BD	LOWER BD	DIRECTION	PREVIOUS
PEDESTRIAN	LTV	-2.6%	5.6%	-10.1%	NS	NS
PEDESTRIAN	PC	-13.2%	-10.2%	-16.0%	benefit	benefit
ROLLOVER	LTV	-31.2%	-15.9%	-43.7%	benefit	benefit
ROLLOVER	PC	-8.5%	-1.1%	-15.3%	benefit	benefit
RUN-OFF-ROAD	LTV	-11.3%	-0.8%	-20.7%	benefit	benefit
RUN-OFF-ROAD	PC	-6.0%	-2.5%	-9.3%	benefit	benefit
SIDE-IMPACT	LTV	11.5%	27.5%	-2.5%	NS	benefit
SIDE-IMPACT	PC	15.2%	20.6%	10.0%	disbenefit	disbenefit
FRONTAL(UTS)	LTV	-8.6%	-3.7%	-13.2%	benefit	benefit
FRONTAL(UTS)	PC	-23.4%	-22.0%	-24.9%	benefit	benefit

Table 5 summarizes the ABS same information for fatal crashes.

Table 5

ABS EFFECTS IN FATAL CRASHES

RESPONSE	VEHICLE	POINT ESTIMATE	UPPER BD	LOWER BD	DIRECTION	PREVIOUS
PEDESTRIAN	LTV	-22.7%	19.6%	-50.1%	NS	NS
PEDESTRIAN	PC	-0.4%	18.4%	-16.3%	NS	benefit
ROLLOVER	LTV	106.5%	185.9%	49.2%	disbenefit	disbenefit
ROLLOVER	PC	12.3%	52.2%	-17.2%	NS	disbenefit
RUN-OFF-ROAD	LTV	21.8%	69.5%	-12.6%	NS	NS
RUN-OFF-ROAD	PC	-13.4%	4.2%	-28.1%	NS	NS
SIDE-IMPACT	LTV	-0.3%	72.2%	-42.3%	NS	disbenefit
SIDE-IMPACT	PC	32.4%	77.2%	-1.0%	NS	disbenefit
FRONTAL(UTS)	LTV	17.9%	49.6%	-7.1%	NS	NS
FRONTAL(UTS)	PC	-4.9%	11.5%	-19.9%	NS	benefit

Conclusions

The inclusion of the vehicles with optional ABS does not seem to make very much difference in the estimation of the effect of all wheel ABS in crashes of all severities (Table 4). ABS seems to have a beneficial effect in preventing each crash type except for side impacts, where it is appears to be associated with a higher response rate especially for passenger cars. However, it appears to be beneficial in preventing pedestrian crashes, rollovers, run-off-road crashes and frontal crashes with another moving vehicle.

The previous study indicated several disbenefits in fatal crashes. The only statistically significant one remaining is rollovers of LTVs.

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