INSURANCE INSTITUTE FOR HIGHWAY SAFETY
HIGHWAY LOSS DATA INSTITUTE

May 30, 2013

The Honorable David L. Strickland
Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

Dear Administrator Strickland:

The Insurance Institute for Highway Safety (IIHS) and the Highway Loss Data Institute (HLDI) hereby petition the National Highway Traffic Safety Administration (NHTSA) to upgrade the Federal Motor Vehicle Safety Standard (FMVSS) No. 122 Motorcycle brake systems (49 CFR 571.122). The current standard allows manufacturers to install antilock braking systems (ABS) and specifies performance standards specific to ABS. This standard should be strengthened to require ABS on all new motorcycles manufactured for on-highway use in the United States. Research by IIHS and HLDI indicate that ABS reduces the motorcycle fatal crash rate by an estimated 31 percent and the collision insurance claim rate by an estimated 20 percent.

Operating the brakes on motorcycles is more complicated than on passenger vehicles, and locking a wheel during hard braking results in much more dangerous consequences. As such, riders may be reluctant to apply full braking force for fear of locking a wheel, resulting in an otherwise avoidable crash or a more severe one. The Hurt et al. (1981) and MAIDS (Association of European Motorcycle Manufacturers, 2004) in-depth studies of motorcycle crashes had examples of loss of control due to wheel lock and of failure to adequately brake. ABS allows a rider to easily maximize braking force during an emergency without fear of locking a wheel.

Studies conducted on closed test tracks have demonstrated that ABS improves braking performance of both novice and experienced riders (Vavryn and Winkelbauer, 2004) and in a variety of situations (Green, 2006). In the Vavryn and Winkelbauer study, both novice and experienced motorcyclists achieved higher average braking decelerations with an ABS-equipped motorcycle than with a non-ABS motorcycle. The Green study found that stopping distances tended to be shorter for ABS-equipped motorcycles in most test conditions, and typically fewer trials were required to achieve the best result with ABS compared to without. Importantly, Green noted that riders without substantial experience or skill were able to achieve high levels of performance with motorcycles equipped with ABS.

To investigate the crash prevention potential of ABS, a small sample of serious motorcycle crashes identified from insurance liability claims were subjected to crash reconstruction to determine how certain crashes could have been affected by ABS (Gwehenberger et al., 2006). About half of the crashes were deemed to be relevant to ABS, and the majority of those involved another vehicle violating the motorcyclist's right-of-way. It was estimated that between 17 and 38 percent of the crashes deemed to have been ABS-relevant could have been avoided had the motorcycles been equipped with ABS. No results were provided on how ABS might have decreased the severities of the crashes that were deemed inevitable. Two more studies employing similar methods estimated that ABS has the potential to prevent 38 to 50 percent of serious motorcycle crashes (Rizzi et al., 2009; Roll et al., 2009).

1005 N. GLEBE RD., ARLINGTON, VA 22201 TEL. 703/247-1500 FAX 703/247-1678 www.iihs.org

IIHS and HLDI conducted studies on the effectiveness of ABS in reducing real-world motorcycle crash rates (HDLI, 2009; Teoh, 2011) and have since updated them with the most current data (HLDI, 2013; Teoh, 2013). These studies examined optional ABS, so that ABS-equipped motorcycles' crash rates were compared to those of the same motorcycles without ABS. This approach reduced demographic and other variation associated with motorcycle type, manufacturer, and model. Additionally, HLDI was able to control for vehicle make, model, garaging state, and age; rated driver age, gender, and marital status; insurance risk group and deductible; registered vehicle density; and calendar year.

The most recent studies estimated the effect of ABS to be a 31 percent reduction in fatal crash rate per registered motorcycle, a 20 percent reduction in collision claim rate per insured vehicle year, a 28 percent reduction in medical payment claim rate, and a 22 percent reduction in bodily injury liability claim rate; all of these were statistically significant. Results of these studies are similar to those previously published by IIHS/HLDI, indicating consistent evidence of ABS effectiveness. Additionally, HLDI estimated a statistically significant 31 percent reduction in collision claim frequency for motorcycles with ABS and combined braking system (CBS) as a bundled option compared to motorcycles with neither system. This suggests an additional benefit of CBS beyond that of ABS. This part of the analysis was based on a smaller set of motorcycle models, and the ABS+CBS sample in the fatality and registration data was too small to compute a meaningful rate ratio estimate.

In an effort to account for potential confounding factors, NHTSA (2010) conducted a study of motorcycle ABS effectiveness using an alternative approach. This involved defining a group of crashes likely affected by ABS and a comparison group comprised of crash types deemed not relevant to ABS to serve as an alternative measure of exposure. The study found no statistically significant effects of ABS on motorcycle crash risk. However, a drawback to this method is that it is difficult to identify types of crashes for which ABS would not be relevant. Additionally, this method does not necessarily account for selection bias, as behavioral differences between the ABS and non-ABS groups of drivers could result in differing distributions of crash type. Given the uncertainty created by deeming certain classes of crashes to be non-relevant to ABS, these findings do not refute the observed benefits of ABS for motorcycles. IIHS pointed out limitations of this study and submitted the IIHS/HLDI motorcycle ABS research in a comment to NHTSA on August 18, 2010. At that time, IIHS suggested NHTSA begin rulemaking to mandate motorcycle ABS.

Recently the European Commission (2012) mandated ABS for on-highway motorcycles with engine displacement of at least 125 cubic-centimeters beginning in 2016. Although we are not aware of research supporting the exclusion of motorcycles with smaller engines, this mandate still should prevent many crashes.

In summary, research by IIHS and HLDI provides strong and consistent evidence that requiring ABS on motorcycles could greatly reduce the number of motorcycle crashes, both fatal and non-fatal, and this evidence is bolstered by research from others. IIHS and HLDI request that NHTSA begin rulemaking on FMVSS 122 to require that all motorcycles manufactured for on-highway use in the United States be fitted with ABS. Concerns have been raised over the use of ABS in off-highway situations, and none of the studies referenced here addresses the issue. Manufacturers could abate any possible off-highway issues of certain models (e.g., dual-purpose motorcycles) by fitting the ABS system with a disabling switch that defaults to the "on" position when the engine is started. Alternatively, manufacturers could develop ABS systems that automatically detect loose-surface conditions and incorporate that information into ABS triggering algorithms. NHTSA should continue to allow manufacturers to install CBS, but should not delay rulemaking on ABS based on what is not yet known about the effectiveness of CBS.

IIHS and HLDI urge NHTSA to begin such rulemaking as soon as possible to reduce the number of motorcycle crashes, both fatal and non-fatal, by requiring this proven technology.

Sincerely,

Matthew J. Moore
Vice President, HLDI

Eric R. Teoh
Senior Statistician, IIHS

Attachments

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Effects of Antilock Braking Systems on Motorcycle Fatal Crash Rates: An Update

May 2013

Eric R. Teoh
Insurance Institute for Highway Safety

1005 N. Glebe Rd., Arlington, VA 22201 Tel. 703/247-1500 Fax 703/247-1588 www.iihs.org

ABSTRACT

Objective: Antilock braking systems (ABS) prevent wheels from locking during hard braking and may reduce motorcycle drivers' reluctance to apply full braking force. Prior research found that ABS reduced motorcycle fatal crash rates during 2003-08 by 37 percent with 95 percent confidence interval (9 percent, 58 percent). The objective of the current study was to provide an updated examination of the effects of ABS on fatal motorcycle crash rates.

Methods: Motorcycle drivers involved in fatal crashes per 10,000 registered vehicle years during 2003-11 were examined for 13 motorcycle models offering optional ABS. Fatal crash rates for motorcycles with ABS were compared to rates for the same models without ABS.

Results: ABS was associated with a 31 percent reduction in the rate of fatal motorcycle crashes per 10,000 registered vehicle years. The 95 percent confidence interval for this effectiveness estimate was (9 percent, 48 percent). Both the updated estimate and its confidence interval were within the confidence interval of the 2003-08 estimate due largely to the precision afforded by larger sample size.

Conclusions: Further evidence shows that ABS is highly effective in preventing fatal motorcycle crashes.

Keywords: Motorcycle ABS, Fatal motorcycle crashes, Crash avoidance technologies, Antilock brakes, Motorcycle crashes

INTRODUCTION

Improper braking is a major factor in motorcycle crashes. Improper braking, particularly overbraking and resulting loss of control, was identified as a major pre-crash factor in a 1981 in-depth study of the causes of motorcycle crashes (Hurt et al., 1981) and again, 20 years later, in the Motorcycle Accident In-Depth Study (MAIDS; Association of European Motorcycle Manufacturers, 2004). Braked motorcycles lost stability in 43 percent of the crashes studied by Roll et al. (2009).

Operating the brakes on most motorcycles is much more complicated than on four-wheel vehicles. Most motorcycles have separate controls for the front and rear brakes, with the front brake usually controlled by a lever on the right handlebar and the rear brake controlled by a pedal operated by the rider's right foot. During braking, a rider must decide how much force to apply to each control. As with other types of vehicles, much more deceleration can be obtained from braking the front wheel than from braking the rear wheel.

Motorcycles are inherently less stable than four-wheel vehicles and rely on riders' skills to remain upright during demanding maneuvers such as hard braking. Braking too hard and locking a wheel creates an unstable situation. Locking the front wheel is particularly dangerous, with falling down being almost certain. A locked rear wheel is more controllable, but still can lead to loss of control with a concurrent steering input, as in an emergency avoidance maneuver. In such situations, riders concerned about wheel lock may be reluctant to apply full force to the brakes, particularly the front brake, resulting in braking that is not adequate to avoid or mitigate impact. Both the Hurt et al. (1981) and MAIDS (Association of European Motorcycle Manufacturers, 2004) studies had examples of crashes due to either loss of control due to wheel lock or failure to adequately brake.

To address the issue of underbraking (especially of the front wheel), manufacturers have developed braking systems that essentially link the actions of the front and rear brake controls. These systems, referred to collectively as combined braking systems (CBS), apply braking force to both wheels when either control is engaged. The degree to which braking force is applied to the front wheel, for example, when the pedal for the rear brake is depressed varies by system, but the concept is the same. CBS has been shown to reduce stopping distances of experienced riders on closed test tracks (Green,

2006) and would be expected to be beneficial in situations in which a rider underbrakes or does not brake the front wheel. With CBS, however, it is still possible to lock a wheel during hard braking.

Antilock braking systems (ABS) have been adapted and tuned for motorcycles to help riders solve this dilemma. Like ABS systems on other types of vehicles, motorcycle ABS systems monitor wheel speed and reduce brake pressure if imminent wheel lock is detected. Brake pressure is then increased, and the system evaluates and adjusts brake pressure many times per second if necessary. These systems allow riders to apply brakes fully in an emergency without fear of wheel lock. ABS and CBS are not necessarily related; either or both can be implemented on a motorcycle.

ABS has shown strong benefits for motorcyclists. Studies conducted on closed test tracks have demonstrated that ABS improves braking performance of both novice and experienced riders (Vavryn and Winkelbauer, 2004) and in a variety of situations (Green, 2006). In the Vavryn and Winkelbauer study, both novice and experienced motorcyclists achieved higher average braking decelerations with an ABS-equipped motorcycle than with a non-ABS motorcycle. The Green study found that stopping distances tended to be shorter for ABS-equipped motorcycles in most test conditions, and typically fewer trials were required to achieve the best result with ABS compared to without. Importantly, Green noted that riders without substantial experience or skill were able to achieve high levels of performance using motorcycles equipped with ABS.

Other studies evaluated the potential for ABS to prevent real-world crashes. Crash reconstructions for a small sample of serious motorcycle crashes identified from insurance liability claims were used to determine how certain crashes could have been affected by ABS (Gwehenberger et al., 2006). About half of the crashes were deemed to be relevant to ABS, and the majority of those involved another vehicle violating the motorcyclist's right-of-way. It was estimated that between 17 and 38 percent of the crashes deemed to have been ABS-relevant could have been avoided had the motorcycles been equipped with ABS. No results were provided on how ABS might have affected the severities of the crashes that were deemed inevitable. Two more studies employing similar methods estimated that ABS has the potential to prevent 38 to 50 percent of serious motorcycle crashes (Rizzi et al., 2009; Roll et al., 2009).

The effects of ABS on insurance claim rates were evaluated in two studies by the Highway Loss Data Institute (HLDI, 2009, 2013). HLDI studied collision coverage, which pays for damage to one's own vehicle when no one else is at fault; medical payment coverage, which pays medical expenses to the insured rider; and bodily injury liability coverage, which pays medical costs to others when the insured rider is at fault. The most recent results for ABS effectiveness included a 20 percent reduction in collision claim rate per insured vehicle year, a 28 percent reduction in medical payment claim rate, and a 22 percent reduction in bodily injury liability claim rate. All of these estimates were statistically significant and controlled for vehicle make, model, garaging state, and age; rated driver age, gender, and marital status; insurance risk group and deductible; registered vehicle density; and calendar year (HLDI, 2013). These results were similar to those of HLDI (2009). HLDI also compared motorcycles with ABS and CBS as a bundled option with those same models without either technology and found a 31 percent reduction in collision claim rate. This suggests a benefit of CBS beyond that of ABS, but the comparison was based on a relatively small sample of motorcycles.

In another study, HLDI found that ABS was more effective during the first three months of collision insurance policies (HLDI, 2012). New policies represent a number of possible scenarios - for example, a person who is new to motorcycling, an experienced rider who buys a new motorcycle, or a rider who changes insurance company. During the first 90 days of policies, motorcycles with ABS were 30 percent less likely to file a collision claim than the non-ABS versions of the same motorcycles. For policies in effect 91-720 days, ABS motorcycles were 19 percent less likely to file collision claims than the non-ABS versions.

A 2011 study found that ABS reduces motorcycle fatal crash rate per registrations by a statistically significant 37 percent (Teoh, 2011). The study included fatal crashes occurring during 2003-08 and involving motorcycle models with optional ABS. The fatal crash rate for motorcycles with ABS was compared to the rate for the same models without ABS. To examine the possibility of selection bias that would exist if people choosing optional ABS behave differently than those who do not elect to purchase ABS, the study compared the presence of various driver and crash factors among the ABS and non-ABS cohorts. For instance, if people with safer riding habits are more likely to buy ABS, it is plausible that they may have lower rates of speeding and alcohol use, and lower rates of helmet use. No substantial or statistically significant differences were observed.

In an effort to account for potential confounding factors, the National Highway Traffic Safety Administration (NHTSA, 2010) conducted a study of motorcycle ABS effectiveness using an alternative approach. This involved defining a group of crashes likely affected by ABS and a comparison group comprised of crash types deemed not relevant to ABS to serve as an alternative measure of exposure. The study found no statistically significant effects of ABS on motorcycle crash risk. However, as acknowledged by the authors, a drawback to this method is that it is difficult to identify types of crashes for which ABS would not be relevant. Additionally, this method does not necessarily account entirely for selection bias, as behavioral differences between the ABS and non-ABS groups of drivers could result in differing distributions of crash type.

The purpose of the current study was to update Teoh (2011) with the most recent data.

METHODS

Data on fatal motorcycle crashes were extracted from the Fatality Analysis Reporting System (FARS), a national census of fatal crashes on public roads that is maintained by NHTSA. Exposure data consisted of national motorcycle registration records obtained from R. L. Polk and Company. Each record in both databases was indexed by its vehicle identification number (VIN), and the first 10 digits were used to determine make, model, and model year. ABS availability and motorcycle type were determined from a vehicle information database maintained by HLDI. Motorcycles with invalid/missing VINs were excluded.

To be included in the study, a motorcycle model was required to have ABS as an option, and the presence of that option must have been discernible by the presence of an ABS indicator in the VIN or equivalently from the model name (e.g., Honda Gold Wing vs. Honda Gold Wing ABS). This eliminated bias due to comparison of different makes or, especially, styles of motorcycles, the driver death rates of which have been shown to vary widely (Teoh and Campbell, 2010). The final study population (Table 1) included 13 make/model motorcycles, each with both ABS and non-ABS versions. Some motorcycles were excluded due to zero registrations of the ABS versions during the study period or no involvements in fatal crashes for both the ABS and non-ABS versions. For each motorcycle model, model years included in the study were identical for ABS and non-ABS versions.

Among the motorcycles included in Table 1, all of the Hondas and the Suzuki Burgman 650 (both ABS and non-ABS) were equipped with standard CBS; CBS was not available on any of the other motorcycles. Similar to the HLDI (2013) study, an attempt was made to study the effect of ABS and CBS combined relative to the presence of neither. The analysis was repeated for additional motorcycles with ABS and CBS as a bundled option (for these models, the comparison was ABS and CBS versus conventional brakes). However, the sample of such motorcycles was too small to produce a meaningful rate ratio estimate and results of this analysis were not presented.

Data were analyzed for fatal crashes and registrations occurring during 2003-11. Fatal crash rates per 10,000 registered vehicle years for each motorcycle model, both ABS and non-ABS versions, were calculated. If ABS does not affect the risk of fatal motorcycle crashes, then fatal crash rates per registered vehicle years for each motorcycle model should not vary by whether or not it has ABS. Under this assumption, an expected count of drivers involved in fatal crashes was computed for each ABS motorcycle model as the product of the fatal crash rate per registered vehicle year for the non-ABS version and the number of registered vehicle years of the ABS version. A rate ratio estimating the effect of ABS was calculated as the sum of the observed number of drivers in fatal crashes for ABS motorcycles (O) divided by the sum of their expected number of drivers in fatal crashes (E). This is also known as the standardized mortality ratio. It standardizes the exposure distributions of the two study groups to limit possible confounding due to some motorcycles being more likely to have ABS than others. Using formulas derived by Silcocks (1994), a 95 percent confidence interval for the rate ratio was computed as (L, U), where:

$$L = \beta_{0.025}(O, E+1) / [1 - \beta_{0.025}(O, E+1)]$$

$$U = \beta_{0.975}(O+1, E) / [1 - \beta_{0.975}(O+1, E)]$$

where $\beta_p(a,b)$ is the $100 \times p^{th}$ percentile from the beta distribution with parameters a and b.

In addition to the main analysis, information was extracted from FARS describing driver age, speeding behavior, blood alcohol concentration (BAC), and helmet use; number of involved vehicles; and crash location (rural vs. urban) for ABS and non-ABS cohorts. Missing BAC values were accounted for using multiple imputation results available in FARS. Speeding was coded if the motorcycle driver was cited for speeding or if contributing driver factors indicated that the motorcycle was exceeding the posted limit or travelling too fast for conditions. Helmet law type (universal coverage, partial coverage in which only some riders (usually those below a certain age) must wear helmets, and no law) was coded for the state in which a crash occurred and varied over time in states with changes in laws.

RESULTS

Table 2 presents fatal crash involvements, registered vehicle years, and the fatal crash rate per 10,000 registered vehicle years for the study motorcycles during 2003-11. Honda motorcycles, especially the Gold Wing model, dominated the sample, but there was a lower fatal crash rate for the ABS version for all but three of the motorcycle models. Overall, the fatal crash rate per 10,000 registered vehicle years was 3.8 for the ABS motorcycles, compared with 5.2 for the same motorcycles not equipped with ABS.

The rate ratio estimate for ABS versions of study motorcycles relative to non-ABS versions of the same motorcycles was 0.690 with an associated 95 percent confidence interval (0.519, 0.913). The rate ratio estimate corresponds to a statistically significant 31 percent estimated reduction (computed as (RR-1)x100%) in the fatal crash rate per 10,000 registered vehicle years for the ABS versions compared to the non-ABS versions.

Influences on the observed rate ratio of known risk factors for fatal motorcycle crashes were investigated by comparing the distributions of these factors among ABS motorcycles and non-ABS motorcycles included in the study, as summarized in Table 3. The average driver age for non-ABS motorcycles involved in fatal crashes was 53, compared to 54 for ABS motorcycles. Drivers of non-ABS motorcycles were slightly more likely to have been cited for speeding or to have blood alcohol concentrations of 0.08 g/dL or higher. The non-ABS fatal crash involvements also were slightly more likely to occur in states with helmet laws, both universal and partial, and to involve only the motorcycle. However, taken as a whole, these results do not show any substantial difference between the two groups of study motorcycles. None of the differences in risk factors presented in Table 3 was statistically significant at the 0.05 level.

The fleet of study motorcycles was compared to all motorcycles in the United States with optional ABS, including those that were not VIN-discernible, and to the entire U.S. motorcycle fleet in Table 4. Based on the driver death rate variation observed in Teoh and Campbell (2010), motorcycle type was chosen as the basis for comparison among these three groups of motorcycles. Even more so than in Teoh (2011), the motorcycle type distribution of the study motorcycles approximated that of all motorcycles with optional ABS. While ABS generally is starting to be offered on a greater variety of motorcycles, cruisers still lag behind in terms of having an ABS option, compared with the entire U.S. fleet.

DISCUSSION

The results of the current study indicate that ABS is highly effective in reducing motorcyclists' fatal crash rates. The fatal crash rate was 31 percent lower for ABS-equipped motorcycles than for the same models without ABS. Results of this analysis are similar to those of Teoh (2011) and indicate that ABS is proving to be effective as ABS begins to be offered on an increasing number of make/models. The evidence of ABS effectiveness from the current study is bolstered by a similar type of analysis of insurance claims that found statistically significant reductions in claim rates for collision, medical payment, and bodily injury liability coverages while controlling for possibly confounding factors. The results of these studies provide confirmatory evidence of the benefit of ABS expected from engineering principles, test track trials, and crash reconstruction analyses. The robustness of the results reported in the prior and current studies of fatal crashes and the studies of insurance claim rates point to real safety benefits of ABS.

However, this study is not free of limitations. ABS was studied as optional equipment, so the cohort of motorcyclists who choose ABS may differ in some substantive way from those who decline to purchase it. In particular, motorcyclists who choose ABS may be more concerned about safety than those who decline, thus leading to lower fatal crash rates through other safer riding practices. Investigation of known risk factors did not reveal evidence of such a selection bias. However, levels of these factors were not known for riders who were not involved in fatal crashes. Therefore, it was not possible to accurately quantify how such factors influenced the observed reduction in fatal crash rate for ABS motorcycles. It is also possible, however, that riders who choose to invest in ABS ride more miles than those who decline, which would result in an upward bias in the fatal crash rate per registered vehicle year for the ABS cohort relative to the non-ABS cohort. As purported to occur in passenger vehicles (Grant and Smiley, 1993; Winston et al., 2006), motorcyclists may tend to drive ABS-equipped motorcycles more aggressively than non-ABS motorcycles, also resulting in a higher than expected crash rate for the ABS cohort, and thus underestimating the effectiveness of ABS. Without more extensive data, it was not possible to estimate the magnitude or direction of any bias in the estimated rate ratio comparing crash rates for ABS and non-ABS motorcycles. NHTSA (2010) used an alternative approach to deal with some possible sources of bias, but that method relied on defining a sample of crash types unrelated to ABS. Police crash report data lack sufficient detail to reliably determine whether most crash types would be relevant to ABS, so the lack of a statistically significant result in that study does not refute other research.

As in Teoh (2011), the current study included virtually all motorcycles with optional ABS in which the presence of the option could be identified from the VIN. Although this represented several different types of motorcycles, it does not constitute a random sample of all motorcycles in terms of design parameters such as intended use, power, or weight. The effectiveness of ABS may vary by motorcycle type, particularly with respect to vehicle dynamics during hard braking (e.g., the likelihood of lifting the rear wheel or even toppling) and on riders' driving habits. However, there is little reason to believe that ABS would not be beneficial to types of motorcycles that could not be included in these studies. This cannot be evaluated until ABS is available on a broader variety of motorcycles. An alternative, and in some ways stronger, study design would be to compare motorcycle models before and after ABS became standard equipment. This was not possible for models existing during 2003-11, but likely will be an avenue of future research as more manufacturers offer models with standard ABS. BMW made ABS standard equipment on its motorcycle fleet beginning in the 2012 model year.

ABS cannot be expected to prevent or mitigate all crashes, as demonstrated by Gwehenberger et al. (2006) and Rizzi et al. (2009). For example, ABS would not affect the likelihood or severity of a crash involving a motorcycle struck from behind by another vehicle. There are other examples of crashes in which motorcycle ABS would not be relevant, but it is difficult to categorize them by crash type. The small sample of ABS motorcycles and the lack of detailed information on pre-crash events in FARS precluded examination of the effects of ABS on crashes that would or would not likely have been influenced by its presence.

ACKNOWLEDGEMENTS

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Table 1
Study motorcycles, each with ABS and non-ABS versions in these model years

Make/model	Model years
Honda Gold Wing	2001-2010
Honda Interceptor 800	2002-2009
Honda Reflex	2001-2007
Honda Silver Wing	2003-2010
Honda ST1300	2003-2010
Suzuki Bandit 1250	2007-2009
Suzuki Burgman 650	2005-2009
Suzuki SV650	2007-2009
Suzuki V-Strom 650	2007-2009
Triumph Sprint ST	2006-2010
Triumph Thunderbird	2010-2011
Triumph Tiger	2007-2010
Yamaha FJR1300	2004-2005

Table 2
Motorcycle fatal crash involvements and registered vehicle years, 2003-11

	non-ABS versions			ABS versions			
Make/model	Observed fatal crash involvements	Registered vehicle years	Rate per 10,000	Observed fatal crash involvements	Registered vehicle years	Rate per 10,000	Expected fatal crash involvements
Honda Gold Wing	254	503,466	5.0	50	128,521	3.9	64.8
Honda Interceptor 800	29	47,455	6.1	9	13,647	6.6	8.3
Honda Reflex	17	74,506	2.3	3	12,876	2.3	2.9
Honda Silver Wing	25	46,832	5.3	5	8,593	5.8	4.6
Honda ST1300	19	43,449	4.4	8	20,048	4.0	8.8
Suzuki Bandit 1250	4	7,970	5.0	1	2,262	4.4	1.1
Suzuki Burgman 650	22	38,323	5.7	4	10,393	3.8	6.0
Suzuki SV650	33	27,160	12.2	1	1,667	6.0	2.0
Suzuki V-Strom 650	10	21,068	4.7	0	3,965	0.0	1.9
Triumph Sprint ST	5	4,366	11.5	1	3,995	2.5	4.6
Triumph Thunderbird	3	911	32.9	1	639	15.6	2.1
Triumph Tiger	2	4,572	4.4	1	2,737	3.7	1.2
Yamaha FJR1300	18	21,536	8.4	3	21,316	1.4	17.8
Total	441	841,614	5.2	87	230,659	3.8	126.2

Table 3
Driver and crash factors of study motorcycles involved in fatal crashes, 2003-11

	non-ABS versions		ABS versions	
	N	%	N	%
Driver				
Age<30	37	8	4	5
Age 30-39	36	8	5	6
Age 40-49	68	15	20	23
Age 50+	300	68	58	67
speeding	111	25	15	17
BAC 0.08+ g/dL	76	17	11	13
Helmeted	334	76	65	75
Crash				
Single-vehicle	187	42	35	40
Rural location	281	64	57	66
Universal helmet law	180	41	33	38
Partial helmet law	237	54	45	52
No helmet law	24	5	9	10
Total	441		87	

Table 4
Registered vehicle years of 2002 model year and later[a] motorcycles by type, 2003-11

	Motorcycles with optional ABS included in study		All motorcycles with optional ABS		U.S. fleet	
	N	%	N	%	N	%
Cruiser/standard	11,782	1	72,488	3	14,317,340	49
Touring	561,880	57	1,210,026	54	4,720,899	16
Sport-touring	114,710	12	232,652	10	460,360	2
Sport/unclad sport	61,102	6	223,796	10	2,264,533	8
Supersport	0	0	18,777	1	3,332,302	11
Other	206,853	21	463,992	21	4,123,251	14
Total[b]	985,154		2,221,731		29,218,685	

[a]Information on non-study optional ABS motorcycles was not available from HLDI for model year 2001
[b]Does not include off-road motorcycles, all-terrain vehicles (ATVs), or snowmobiles

HIGHWAY LOSS
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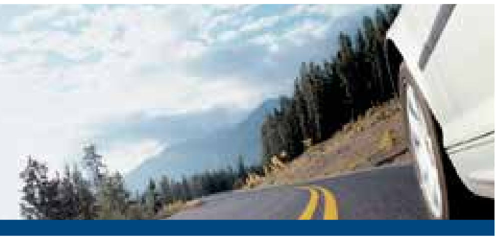


Evaluation of motorcycle antilock braking systems, alone and in conjunction with combined control braking systems

Previous studies have shown that antilock braking systems (ABS) systems reduce insurance claim rates and fatal crash rates for motorcycles. The purpose of this study was to update prior analysis on the relationship between ABS and insurance losses under collision, medical payments, and bodily injury liability coverages and to conduct a similar evaluation of motorcycles equipped with both ABS and combined control braking systems (CCBS). For all of the motorcycles in the study, either ABS or ABS and CCBS were available as optional equipment and the presence of ABS systems could be determined from the VIN. Losses for motorcycles with the systems were compared with losses for those without. The method used in this analysis could not estimate the effect of CCBS alone.

For the motorcycles in the study group used to evaluate the effects of ABS alone, ABS was associated with large reductions in claim rates for all three coverage types studied — 20 percent for collision, 28 percent for medical payment, and 22 percent for bodily injury liability. Due to the limited number of motorcycles in ABS/CCBS study population, analysis of these systems was limited to collision coverage. The reduction in collision claim frequency associated with ABS/CCBS (31 percent) was larger than the reduction for ABS alone.

Introduction

According to the National Highway Traffic Safety Administration (NHTSA) motorcycle registrations more than doubled between 1997 and 2010 (NHTSA, 2012). Analysis by the Insurance Institute for Highway Safety of data from the Fatality Analysis Reporting System shows that, during the same time period, fatalities in motorcycle crashes increased by 110 percent. Motorcyclist deaths began to increase in 1998 and continued to increase and peaked in 2008. Motorcyclist deaths decreased by 16 percent in 2009 compared with 2008 and increased only slightly in 2010 and in 2011. It is not known to what extent the overall decrease from 2008 is related to improvements in highway safety or due to the significant drop in new motorcycle sales from more than 1.1 million in 2008 to only 560,000 in 2010 (MIC, 2011). Compared with automobiles, motorcycles offer much less occupant protection in the event of a crash. Only 20 percent of automobile crashes result in injury or death, whereas 80 percent of motorcycle crashes do (NHTSA, 2005). Therefore, any countermeasure aimed at reducing the likelihood of motorcycle crashes should significantly reduce the risk of injury or death.

In addition to antilock braking systems (ABS), motorcycles increasingly are equipped with systems that integrate the control of the front and rear brakes. In this study, these systems will be referred to as combined control braking systems (CCBS). These systems can apply force from both brakes even if only one brake control is actuated by the rider. There are a variety of implementations. One implementation can be found on the 2013 Yamaha FJR1300. The FJR1300 has eight brake pistons on the front wheel and two on the rear. When a rider actuates the front brake control, six of the front brake pistons activate, while none of the rear activate. When a rider actuates the rear brake control, all of the rear brake pistons activate and two of the front brake pistons activate. All eight front brake pistons are activated only when the rider actuates both brake controls. Honda utilizes a different type of CCBS that electronically distributes brake force over both wheels with either control. The system electronically measures rider input on the brake controls and applies both brakes or only the front or rear.

The purpose of this study was to update prior analysis on the relationship between ABS and insurance losses under collision, medical payments, and bodily injury liability coverages and to conduct a similar evaluation of motorcycles equipped with ABS and CCBS. For all of the motorcycles in the study either ABS alone or ABS and CCBS were available as optional equipment. The presence of the ABS system could be determined from the VIN. Losses for motorcycles with the systems were compared to those without.

Methods

Insurance data

Motorcycle insurance covers damage to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for physical damage versus injuries. Also, different coverages may apply depending on who is at fault. In the present study, collision coverage, medical payment and bodily injury liability was examined. Collision coverage insures against physical damage to a motorcycle sustained in a crash when the rider is at fault. Medical payment coverage (MedPay) covers injuries to insured riders. For motorcycles, bodily injury liability (BI) coverage insures against injuries that at-fault operators cause to other people, including their own passengers.

Rated drivers (riders)

For insurance purposes, a rated driver is assigned to each motorcycle on a policy. The rated driver is the one who typically is considered to represent the greatest loss potential for the insured vehicle. In a household with multiple vehicles and/or drivers, the assignment of drivers to vehicles can vary by insurance company and by state, but typically it reflects the driver most likely to operate the vehicle. Information on the actual driver at the time of a loss is not available in the Highway Loss Data Institute (HLDI) database.

HLDI collects a number of factors about rated drivers. For the present study, data were stratified by rated driver age group (<25, 25-39, 40-64, 65+, or unknown), rated driver gender (male, female, or unknown), and rated driver marital status (married, single, or unknown). Additionally, risk (nonstandard or standard) and deductible range for collision coverage only (0-100, 101-250, 251-500, or 501+) were included.

Motorcycles

For motorcycles to be included in the present study, their vehicle identification numbers (VINs) had to have an ABS indicator. This allowed for very tight control over the study population. Only motorcycles with optional ABS and with loss data for both ABS and non-ABS versions were included. This restriction produced 44 pairs of ABS/non-ABS motorcycles. Furthermore, only pairs with at least one claim for both the ABS version and the non-ABS version were included to make it possible to analyze claim severity. A total of 35 pairs of ABS/non-ABS motorcycles were ultimately included in the study.

The 35 bike pairs were separated into two groups: a group to evaluate the effect of ABS and a group to evaluate the effect of ABS in conjunction with CCBS. The ABS group included 25 pairs, and the ABS/CCBS group included 10 pairs. It should be noted that some of the motorcycles in the ABS study population were also equipped with CCBS. However, in that group both the ABS and non-ABS motorcycles had CCBS. In the ABS/CCBS group the ABS equipped motorcycles had CCBS but the non-ABS motorcycles did not. **Table 1** displays the exposure breakdown for the bikes by ABS and ABS/CCBS status. It should be noted that in the previous HLDI study on motorcycle ABS, five of the ABS equipped motorcycles evaluated had CCBS while the non-ABS motorcycles did not. Consequently, the effect of ABS in that study was confounded with CCBS. The five ABS/CCBS motorcycles comprised approximately 7 percent of the collision exposure in that study.

Total exposure measured in insured vehicle years and the total number of claims in this analysis are shown by insurance coverage type in **Table 2**.

Table 1: Distribution of exposure for antilock and combined control brake systems, collision coverage

Make and series	Exposure	Percent ABS	Percent non-ABS
Aprilia Mana 850	494	20%	80%
Aprilia Scarabeo 500	1,406	49%	51%
Honda Gold Wing	217,874	22%	78%
Honda Interceptor 800	14,806	25%	75%
Honda NT700V	1,300	21%	79%
Honda Reflex	15,070	13%	87%
Honda Silver Wing	18,258	17%	83%
Honda ST1300	22,596	36%	64%
Kawasaki Ninja 1000	88	39%	61%
Kawasaki Ninja 650R	16	29%	71%
Kawasaki Ninja ZX-10R	138	20%	80%
Suzuki Bandit 1250	4,382	23%	77%
Suzuki B-King	1,873	3%	97%
Suzuki Burgman 400	1,075	24%	76%
Suzuki Burgman 650	20,333	27%	73%
Suzuki SV650	11,113	6%	94%
Suzuki V-Strom 650	12,525	23%	77%
Triumph Rocket III	1,773	21%	79%
Triumph Speed Triple	290	33%	67%
Triumph Sprint ST	6,232	39%	61%
Triumph Thunderbird	1,953	50%	50%
Triumph Tiger	6,093	28%	72%
Triumph Tiger 800	910	84%	16%
Victory Cross Country	340	91%	9%
Yamaha FJR1300	18,723	50%	50%
Total	**379,660**	**24%**	**76%**
Make and series	**Exposure**	**Percent ABS/CCBS**	**Percent non-ABS/CCBS**
Honda CBR1000RR	4,091	8%	92%
Honda CBR600RR	8,985	8%	92%
Honda Fury	7,660	2%	98%
Honda Interstate	441	1%	99%
Honda NC700X	122	18%	82%
Honda Shadow Aero 750	99	41%	59%
Honda Stateline	916	5%	95%
Kawasaki Concours 14	14,553	56%	44%
Kawasaki Vulcan 1700 Voyager	3,374	63%	37%
Victory Vision	7,638	15%	85%
Total	**47,878**	**26%**	**74%**

Table 2 : Exposure and claims by coverage type		
	Exposure	Claims
Collison - ABS only		
With ABS	91,823	1,587
Without ABS	287,836	5,899
Total	**379,660**	**7,486**
Collision - ABS/CCBS only		
With ABS/CCBS	12,675	393
Without ABS/CCBS	35,202	1,983
Total	**47,878**	**2,376**
MedPay - ABS only		
With ABS	23,080	238
Without ABS	79,029	1,077
Total	**102,109**	**1,315**
BI-ABS only		
With ABS	84,202	121
Without ABS	266,507	459
Total	**350,709**	**580**

Geographic factors

Geographic characteristics included garaging state and registered vehicle density. Registered vehicle density was defined as the number of registered vehicles per square mile (<100, 100-499, and 500+). State was used in the analysis to control for their potential impacts on losses.

Statistical methods

Data were collected by motorcycle make and series, rated driver age, gender, marital status, vehicle age, vehicle density, risk, deductible range, calendar year and state. Vehicle age was defined as the difference between the calendar year and model year (age -1 was grouped with age 0). Calendar years 2003-12 were used in the analysis for the ABS/non-ABS groups of bikes. Calendar years were limited to 2007-12 for the ABS/CCBS group, as these bikes are newer and not available in the prior calendar years.

Regression analysis was used to quantify the effect of ABS and the combination of ABS and CCBS on motorcycle losses while controlling for other covariates. Claim frequency was modeled using a Poisson distribution, whereas 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. Reference categories for all coverage types for the categorical independent variables were assigned to the values with the highest collision exposure. The reference categories for the ABS analysis were as follows: make/series=Honda Gold Wing, ABS=without ABS, rated driver age range=40-64, vehicle density=100-499 vehicles per square mile, rated driver gender=male, marital status=married, risk=standard, deductible range=$251-$500, state=California, and calendar year=2011. The reference categories for the ABS/CCBS analysis were as follows: make/series=Kawasaki Concours 14, ABS/CCBS=without ABS/CCBS, rated driver age range=40-64, vehicle density=100-499 vehicles per square mile, rated driver gender=male, marital status=married, risk=standard, deductible range=$251-$500, state=California, and calendar year=2011.

Results

Collision coverage analysis was completed to determine the effect of ABS and the combination of ABS and CCBS. Twelve regression models were calculated to produce the results in this study. For the sake of illustration collision frequency results for the ABS group are presented while all other models and the derived results for overall losses appear in a separate Appendix. Tables summarizing the estimated effects of the systems for each coverage type are presented. Summary results of the regression analysis of motorcycle collision claim frequencies for the ABS bikes using the Poisson distribution are listed in Table 3. Results for all independent variables with the exception of gender had p-values less than 0.05, indicating their effects on claim frequencies were statistically significant.

Table 3 : Summary results of linear regression analysis of collision claim frequencies, ABS effect

	Degrees of freedom	Chi-square	P-value
ABS	1	58.94	<0.0001
Vehicle make/series	24	515.14	<0.0001
Vehicle age	1	302.26	<0.0001
Rated driver age	4	177.31	<0.0001
Rated driver gender	2	5.44	0.0659
Rated driver marital status	2	37.15	<0.0001
Risk	1	34.01	<0.0001
Deductible	3	202.49	<0.0001
Vehicle density	2	69.21	<0.0001
State	50	242.78	<0.0001
Calendar year	9	46.37	<0.0001

Detailed results of the regression analysis of the ABS bikes using claim frequency as the dependent variable are listed in Table 4. The table shows the estimates and significance levels for the individual values of the categorical variables. To make results more illustrative, a column was added that contains the exponents of the estimates. The intercept outlines losses for the reference (baseline) categories: The estimate in Table 4 for the ABS effect corresponds to the claim frequency for a Honda Gold Wing without ABS, with vehicle age 0, garaged in a medium vehicle density area in California in 2011, and whose rider was a 40-64-year-old married male classified as standard risk with a policy deductible of $251-$500. The remaining estimates are in the form of multiples, or ratios relative to the reference categories. For example, the estimate corresponding to drivers aged 25-39 in Table 4 equals 0.2638, so younger rated drivers had estimated claim frequencies 30 percent higher than those for 40-64 year old drivers ($e^{0.2638}$=1.3019). Table 4 includes only an abbreviated list of results by state. The states with the five highest and five lowest estimates are listed, along with the comparison state of California. Detailed results for all states and all regressions are available in a separate Appendix.

The estimate corresponding to motorcycle ABS (-0.22) was highly significant (p<0.0001). The estimate corresponded to a 20.1 percent reduction in claim frequencies for motorcycles equipped with ABS. Twenty of the 24 make/series estimates were significant at the p=0.05 level. The reference category for the make/series variable was the Honda Gold Wing. Significant predictions for make/series ranged from 1.2 for the Triumph Tiger to 8.2 for the Kawasaki Ninja 650R. Vehicle age significantly affected collision claim frequency. Claim frequencies were estimated to decrease 12 percent (p<0.0001) for each one-year increase in vehicle age.

Driver age, marital status, risk, deductible and vehicle density significantly predicted motorcycle collision claim frequency for ABS bikes. Compared with losses for rated drivers ages 40-64 (reference category), estimated claim frequencies were significantly higher for all other age groups. Compared with losses for married drivers (reference category), estimated claim frequencies were 23 percent higher (p<0.0001) for rated single drivers. Estimated collision claim frequency for drivers classified as nonstandard risk was 18 percent higher (p<0.0001) than standard risk drivers. Estimated collision claim frequencies decreased as policy deductible increased. Compared with losses for male rated drivers (reference category), estimated claim frequencies were 10 percent lower (p=0.06) for rated female drivers. Motorcycle collision claim frequencies increased with vehicle density. Compared with California (reference category), significant collision claim frequency estimates ranged from 54 percent lower (p=0.015) for Delaware to 15 percent lower (p=0.02) for Michigan. Calendar year, also in **Table 4** has 2011 set as the reference category. Collision claim frequencies for 2009 were significantly different from that of 2011.

Table 4 : Detailed results of linear regression analysis of collision claim frequencies, ABS effect

	Estimate	Exponent estimate	Standard error	Chi-square	P-value
Intercept	-9.4890		0.0646	21601.70	<0.0001
ABS					
With ABS	-0.2244	0.7990	0.0297	56.92	<0.0001
Without ABS	0	1	0		
Make and series					
Aprilia Mana 850	0.9441	2.5704	0.1919	24.21	<0.0001
Aprilia Scarabeo 500	0.6531	1.9215	0.1436	20.70	<0.0001
Honda Interceptor 800	0.6326	1.8826	0.0542	136.44	<0.0001
Honda NT700V	0.3267	1.3864	0.1658	3.89	0.0487
Honda Reflex	0.2419	1.2737	0.0621	15.16	<0.0001
Honda ST1300	0.1979	1.2188	0.0534	13.74	0.0002
Honda Silver Wing	0.5239	1.6886	0.0501	109.31	<0.0001
Kawasaki Ninja 1000	0.8650	2.3751	0.4117	4.41	0.0356
Kawasaki Ninja 650R	2.1024	8.1861	0.4136	25.84	<0.0001
Kawasaki Ninja ZX-10R	1.8303	6.2355	0.1984	85.08	<0.0001
Suzuki B-King	0.8697	2.3863	0.1133	58.90	<0.0001
Suzuki Bandit 1250	0.5566	1.7448	0.0883	39.73	<0.0001
Suzuki Burgman 400	0.7960	2.2167	0.1479	28.99	<0.0001
Suzuki Burgman 650	0.3942	1.4832	0.0478	67.93	<0.0001
Suzuki SV650	0.6900	1.9938	0.0566	148.60	<0.0001
Suzuki V-Strom 650	-0.0722	0.9303	0.0711	1.03	0.3098
Triumph Rocket III	0.6282	1.8742	0.1265	24.65	<0.0001
Triumph Speed Triple	0.6880	1.9897	0.2546	7.30	0.0069
Triumph Sprint ST	0.8092	2.2461	0.0695	135.47	<0.0001
Triumph Thunderbird	0.2227	1.2494	0.1442	2.39	0.1225
Triumph Tiger	0.1910	1.2104	0.0913	4.37	0.0365
Triumph Tiger 800	-0.1346	0.8740	0.2405	0.31	0.5755
Victory Cross Country	0.1957	1.2162	0.3373	0.34	0.5617
Yamaha FJR1300	0.2986	1.3479	0.0588	25.80	<0.0001
Honda Gold Wing	0	1	0		
Vehicle age	-0.1317	0.8766	0.0076	303.50	<0.0001
Rated driver age group					
14-24	1.0275	2.7941	0.0792	168.28	<0.0001
25-39	0.2638	1.3019	0.038	48.15	<0.0001
65+	0.1129	1.1195	0.0344	10.78	0.0010
Unknown	0.2869	1.3322	0.0561	26.10	<0.0001
40-64	0	1	0		

Table 4 : Detailed results of linear regression analysis of collision claim frequencies, ABS effect					
	Estimate	Exponent estimate	Standard error	Chi-square	P-value
Rated driver gender					
Female	-0.1011	0.9039	0.0532	3.61	0.0575
Unknown	-0.0990	0.9057	0.0663	2.23	0.1351
Male	0	1	0		
Rated driver marital status					
Single	0.2088	1.2322	0.0347	36.17	<0.0001
Unknown	0.1509	1.1629	0.0642	5.53	0.0187
Married	0	1	0		
Risk					
Non Standard	0.1667	1.1814	0.0285	34.32	<0.0001
Standard	0	1	0		
Deductible					
0-100	0.3641	1.4392	0.0511	50.70	<0.0001
101-250	0.2245	1.2518	0.0268	70.04	<0.0001
501+	-0.3170	0.7283	0.0416	58.04	<0.0001
251-500	0	1	0		
Registered vehicle density					
0-99	-0.1288	0.8792	0.0305	17.82	<0.0001
500+	0.1450	1.1561	0.0286	25.79	<0.0001
100-499	0	1	0		
State					
Delaware	-0.7742	0.4611	0.3183	5.92	0.0150
Louisiana	0.0018	1.0018	0.0898	0.00	0.9838
Massachusetts	-0.6271	0.5342	0.1156	29.42	<0.0001
Mississippi	-0.1298	0.8783	0.1154	1.26	0.2607
New Hampshire	-0.1021	0.9029	0.1645	0.39	0.5347
North Dakota	-0.6730	0.5102	0.2618	6.61	0.0102
Texas	-0.0206	0.9797	0.0557	0.14	0.7121
Vermont	-0.0979	0.9067	0.2387	0.17	0.6817
West Virginia	-0.5962	0.5509	0.1524	15.31	<0.0001
Wisconsin	-0.6684	0.5126	0.0791	71.46	<0.0001
California	0	1	0		
Calendar year					
2003	-0.3041	0.7378	0.2718	1.25	0.2633
2004	-0.1081	0.8975	0.1324	0.67	0.4142
2005	-0.0729	0.9297	0.0889	0.67	0.4125
2006	-0.0674	0.9349	0.0657	1.05	0.3054
2007	0.0361	1.0368	0.0491	0.54	0.4617
2008	0.0572	1.0589	0.0434	1.74	0.1875
2009	-0.1796	0.8356	0.0432	17.32	<0.0001
2010	-0.0184	0.9818	0.0405	0.21	0.6493
2012	0.0430	1.0439	0.0415	1.07	0.3006
2011	0	1	0		

Table 5 summarizes the collision results for the ABS and ABS/CCBS groups. Claim frequency declined significantly for both groups of bikes, 20.1 percent for the ABS group and 31.3 percent for the ABS/CCBS group (**Figure 1**). **Figure 1** includes the 95 percent confidence bounds for both frequency estimates. The lower bound for the ABS effect overlaps slightly with the upper bound of the ABS/CCBS estimate. To test if these two estimates are statistically different, the arithmetic difference between the two estimates was calculated. Their variances were summed to obtain the variance of the difference. Finally, assuming a normal distribution, a Z-test was conducted for this difference which yielded a p-value of 0.03, meaning that the difference of the two effects is statistically significant. Claim severity also declined for both groups but not significantly (**Figure 2**). Finally, collision overall losses declined significantly for the ABS (20.3 percent) and the ABS/CCBS (34.2 percent) groups (**Figure 3**).

Table 5 : Detailed results of linear regression analysis of collision losses

	Estimate	Effect	Standard error	Chi-square	p-value
ABS only					
Claim frequency	-0.2244	-20.1%	0.0297	56.92	<0.0001
Claim severity	-0.0025	-0.2%	0.0245	0.01	0.9194
Overall losses	-0.2268	-20.3%	0.0385		<0.0001
ABS /CCBS					
Claim frequency	-0.3752	-31.3%	0.0657	32.61	<0.0001
Claim severity	-0.0441	-4.3%	0.0466	0.90	0.3441
Overall losses	-0.4193	-34.2%	0.0805		<0.0001

Figure 1 : Changes in collision claim frequencies for motorcycles with ABS and CCBS

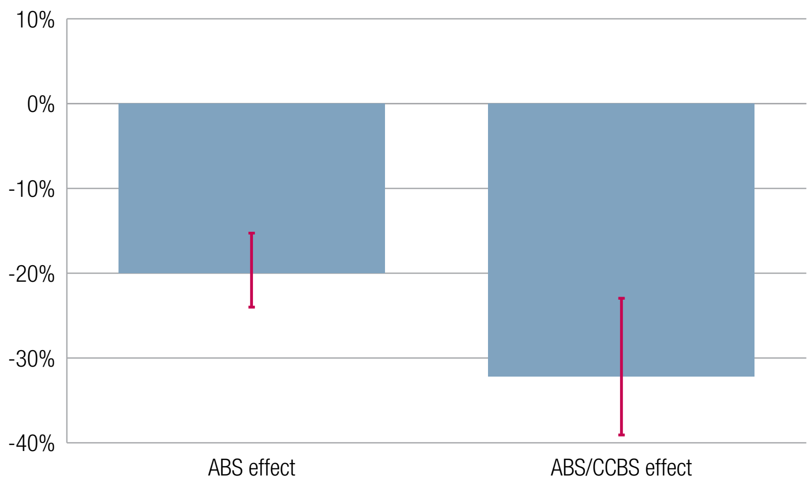


Figure 2 : Changes in collision claim severities for motorcycles with ABS and CCBS

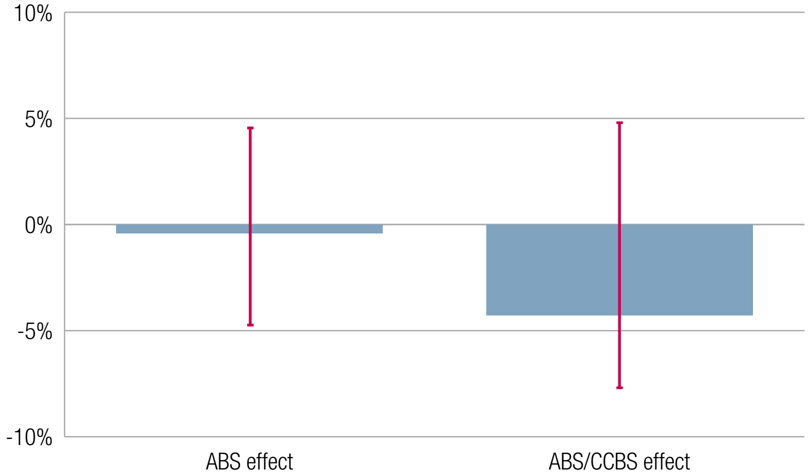


Figure 3 : Changes in collision overall losses for motorcycles with ABS and CCBS

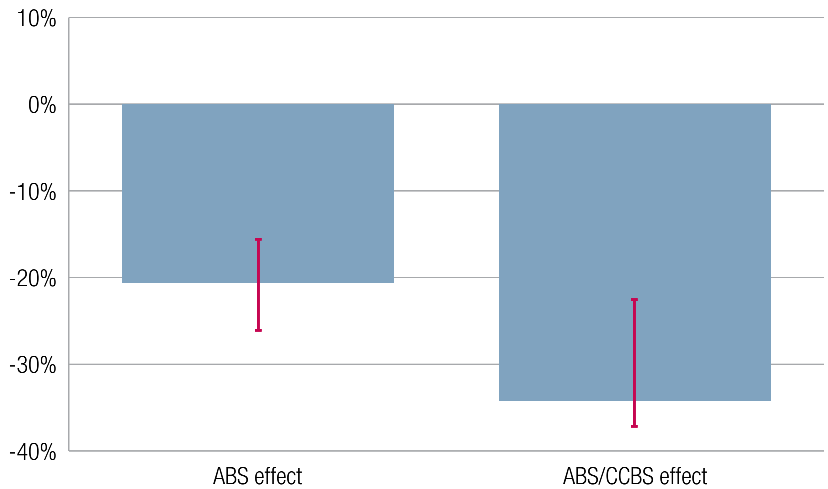


Table 6 summarizes the medical payment results for the ABS only motorcycles. MedPay claim frequencies and severities changed significantly. Frequency declined 28.1 percent and severities increased 24.9 percent. MedPay overall losses declined 10.2 percent but not significantly (**Figure 4**).

Table 6 : Detailed results of linear regression analysis of medical payment losses, ABS effect

	Estimate	Effect	Standard error	Chi-square	p-value
Claim frequency	-0.3298	-28.1%	0.0751	19.30	<0.0001
Claim severity	0.2222	24.9%	0.0788	7.95	0.0048
Overall losses	-0.1076	-10.2%	0.1088		0.3229

Figure 4 : Changes in medical payment losses for motorcycles with ABS

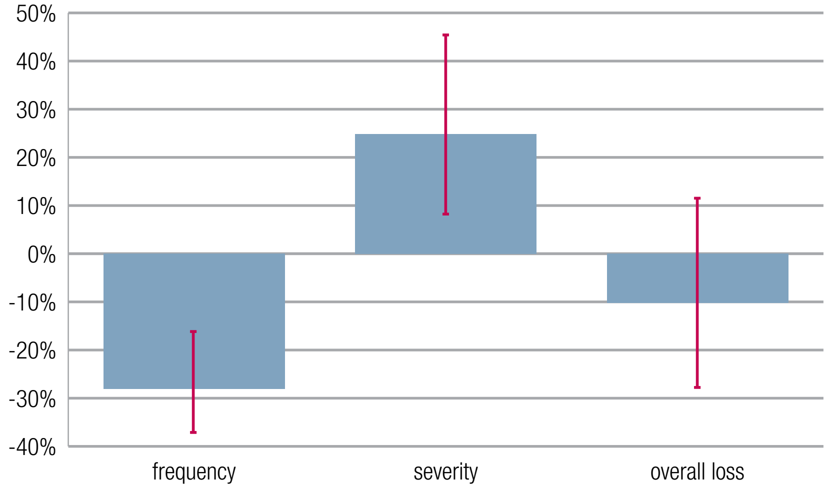
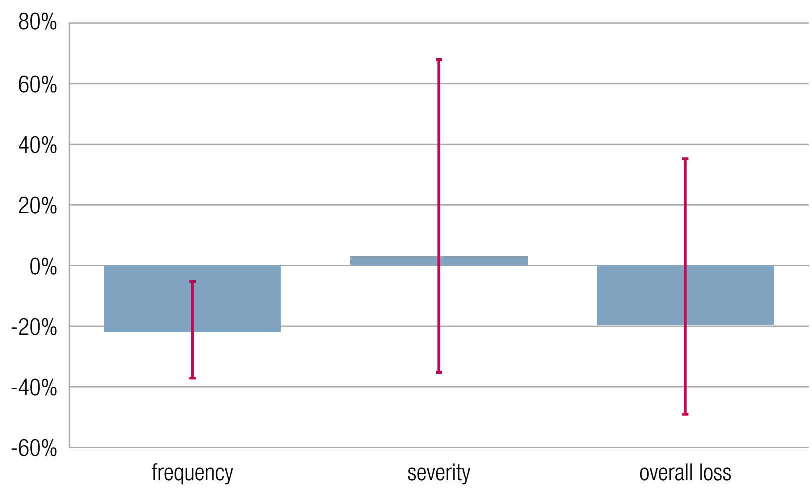


Table 7 summarizes the bodily injury liability results for the ABS only motorcycles. BI claim frequencies declined significantly (22.0 percent) while severities increased a nonsignificant 3.1 percent. BI overall losses declined 19.6 percent but not significantly (**Figure 5**).

Table 7 : Detailed results of linear regression analysis of bodily injury liability losses, ABS effect

	Estimate	Effect	Standard error	Chi-square	p-value
Claim frequency	-0.2487	-22.0%	0.1063	5.48	0.0192
Claim severity	0.0308	3.1%	0.2458	0.02	0.9002
Overall losses	-0.2179	-19.6%	0.2678		0.4157

Figure 5 : Changes in bodily injury liability losses for motorcycles with ABS



Discussion

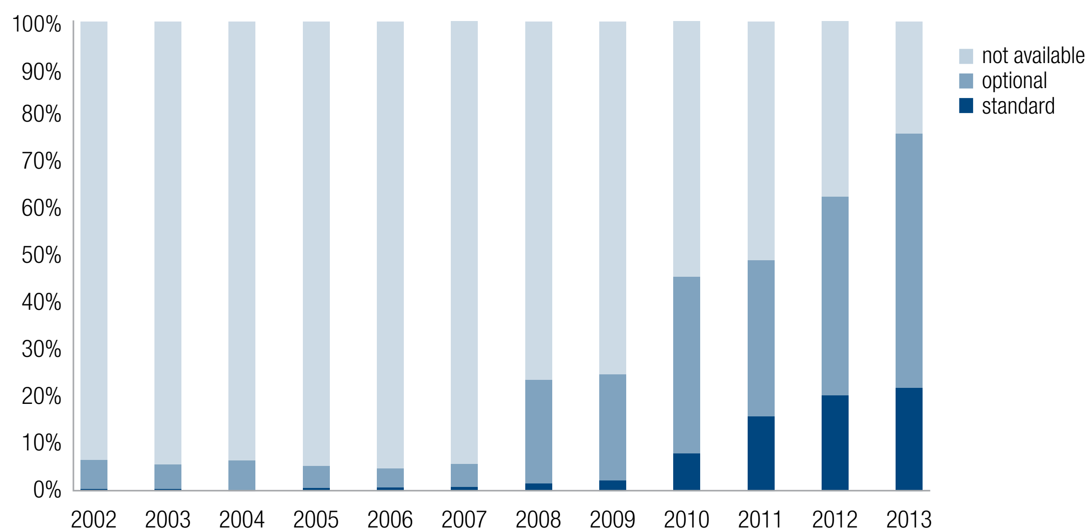
Prior HLDI studies have shown that antilock braking systems (ABS) on motorcycles are effective in reducing collision losses. This study updates the prior study with additional loss experience and new additional motorcycles. This study is the first to look at the effectiveness of ABS in conjunction with combined control brake systems on collision losses. The combined control brake system (CCBS) along with ABS showed larger reductions in collision claim frequency, severity, and overall losses than ABS by itself. The benefits for CCBS are encouraging but the amount of available data is still small. Additional data will further refine this result.

It should be noted that in the previous HLDI study on motorcycle ABS, five of the ABS equipped motorcycles evaluated had CCBS while the non-ABS motorcycles did not. Consequently, the effect of ABS in that study was confounded with CCBS. However, those five motorcycles represented just over 7 percent of the collision exposure in the study so their contribution to the overall findings of the study was relatively small. Collision claim frequencies in that study were reduced by 22 percent. This reduction is much closer to the result for the ABS group (20 percent) than the ABS/CCBS group (31 percent).

Injury coverage losses were also examined. Antilock brakes are associated with significant reductions in Medpay (28.1 percent) and BI claim frequencies (22.0 percent).

Although previous studies have shown the benefit of antilock brakes for motorcycles, ABS is not currently required in the United States. Beginning in 2016 in the European Union, it will be mandatory for motorcycles that have an engine displacement greater than 125 cc to be fit with ABS. Manufacturers have taken the initiative to increase the availability of ABS on new motorcycles in the U.S. over the past few years. More than 90 percent of 2002 bikes did not have ABS available (Figure 6). This is in stark contrast to the 2013 model year, in which more than three-quarters of new bikes either have standard (22 percent) or optional (54 percent) ABS. These are unique motorcycle VIN data and are not exclusive to the study population used in this analysis.

Figure 6: Motorcycle ABS availability by model year



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HIGHWAY LOSS DATA INSTITUTE

1005 N. Glebe Road, Suite 700
Arlington, VA 22201 USA
tel 703/247-1600
fax 703/247-1595
iihs-hldi.org