INSURANCE INSTITUTE
FOR HIGHWAY SAFETY

June 29, 2010

The Honorable Victor Mendez
Administrator
Federal Highway Administration
1200 New Jersey Avenue, SE
Washington, D.C. 20590

Request for Comments; Reclassification of Motorcycles in the Guide to Reporting Highway Statistics; Docket No. FHWA-2010-0010

Dear Administrator Mendez:

The Federal Highway Administration (FHWA) has requested comments on the motorcycle registration data it should request from states. Currently, states report the total number of motorcycles registered but not the vehicle identification numbers (VINs) of registered motorcycles. The Insurance Institute for Highway Safety (IIHS) believes states should provide VIN data to FHWA.

In discussing whether to require states to provide such data, FHWA says, “Discussion with experts in the field indicates that motorcycle attributes contained in the VIN are less standardized than those for auto or truck type vehicles. This implies that VIN data may not be as helpful in classifying motorcycle type vehicles as some may believe.” However, the National Highway Traffic Safety Administration (NHTSA) has set requirements (49 CFR 598) for motor vehicle VINs, including motorcycle VINs. The Highway Loss Data Institute (HLDI), IIHS’s affiliate organization, has created its own VIN decoding software to extract motorcycle attributes such as make, model, and engine size. HLDI also has created a methodology, based on characteristics such as riding position, body style, features, intended use, and driving dynamics, to assign motorcycles to various classes such as scooter, cruiser, and supersport. A description of these classifications is attached.

HLDI’s VIN decoding software and motorcycle classification system are reliable tools for researchers seeking to better analyze and identify rider exposure and crash causality. HLDI can provide FHWA with access to its software or decode the VINs and provide the agency with results. HLDI offers to license the software or provide the service to FHWA free of charge.

In its March 2010 notice, FHWA asked whether having VINs would allow new types of research. Specifically, the agency said it “seeks comments on whether the collection of information contained in the VIN would provide useful or valuable information and, if that information is useful, whether that information could be collected in another way.” In response, IIHS believes the acquisition of VIN information would significantly increase the ability of FHWA and other researchers to look at differences in the public health consequences of different types of motorcycles. Using HLDI’s VIN software, both IIHS and HLDI have been able to study differences in injuries and insurance losses among motorcycle types. For example, IIHS research has shown that supersport motorcycles have a driver fatality rate more than 4 times greater than that of cruiser/standard motorcycles (Teoh and Campbell, 2010). HLDI research shows that insurance losses under collision coverage are nearly 3 times greater for supersport motorcycles than for the average motorcycle (HLDI, 2009). The attached HLDI *Loss Facts* document is the type of report that can be produced only with VIN data.

FHWA also expressed concerns about privacy issues related to VIN data. HLDI’s software requires only the first 10 characters of a VIN to successfully decode information relevant to a motorcycle’s classification and characteristics. Using this partial data effectively would eliminate any privacy concern.

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

IIHS believes that simply requiring states to provide more detailed information on registered motorcycles is an insufficient alternative to requiring VIN data. As new types of 2- and 3-wheel motorcycles are introduced, a categorization system based on even the most detailed definitions will not be flexible enough to cope with the new motorcycle types. VIN data provide all information necessary to properly categorize motorcycles by type and are the simplest and most efficient way to retrieve such information.

By requiring states to provide FHWA with the VINs of all registered motorcycles, the agency would greatly improve its motorcycle registration data to assist in analysis of crash data relating to these vehicles. As IIHS and HLDI research has shown, using motorcycle VIN data is the best way to collect accurate and reliable data for research purposes, and using these data need not compromise the privacy of vehicle owners. For these reasons, IIHS asks FHWA to require states to report to the agency the relevant digits of VINs of registered motorcycles.

Sincerely,

Adrian K. Lund, Ph.D.
President

Attachments

Motorcycle classification and descriptions

Highway Loss Data Institute. 2009. Auto insurance loss facts: collision coverage; Comparison of losses by motorcycle class, 2005-09 models. Arlington, VA.

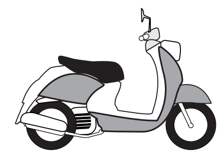
Teoh, E.R. and Campbell, M. 2010. Role of motorcycle type in fatal motorcycle crashes. Arlington, VA: Insurance Institute for Highway Safety.

Motorcycle Classification and Descriptions

Street legal motorcycles are grouped into ten different classes: scooter, cruiser, chopper, touring, dual purpose, standard, sport touring, unclad sport, sport, and super sports. Sidecars can be attached to one or more of the street legal motorcycles and subsequently are exposed to the same hazards inherent in operating motorcycles. Although most motorcycles are designed with the same fundamental components — chassis incorporating two wheels, engine, handle bars, and open riding position — there are design cues and operational differences that distinguish the intended riding purpose and performance expectations.

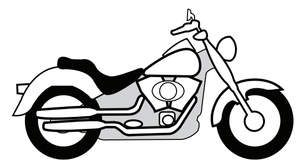
Motorcycles are assigned to classes based on factors such as riding position and ergonomics, body style, features, intended use, and driving dynamics. The following classes are the variations of street legal motorcycles.

Scooter



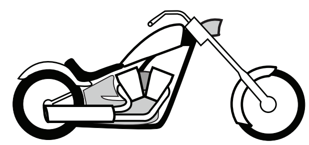
Scooters are characterized by small wheels, automatic transmissions, small engines, and a step-through configuration that allows riders to place both feet on a running board with knees together. However, larger scooters with engine displacements greater than 250 cc are becoming more popular. The Honda Silver Wing, Yamaha Majesty 400, and Suzuki Burgman are examples of the increasing displacements of highway-capable scooters.

Cruiser



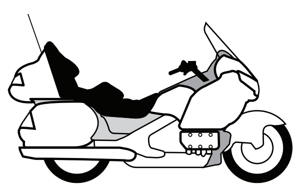
Cruiser motorcycles mimic the style of earlier American motorcycles from the 1930s to the early 1960s, such as those made by Harley-Davidson and Indian. Although cruisers have benefited from advances in technology and metallurgy, the basic design is still very similar to early motorcycles. The riding position places the feet forward of the seat and the hands near shoulder height, the upper body is erect or leaning back slightly. This position allows long-distance comfort but does compromise some degree of control. Cruisers have limited turning ability because of a low-slung design. Cruiser engines produce more torque and less horsepower compared with motorcycles from the sport classes. Cruisers are among the heaviest of motorcycles and can be used with a sidecar.

Chopper



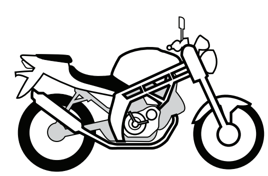
Chopper-style motorcycles are closely related to cruisers. They have a longer wheelbase that results from an extended front fork configuration. The lengthened wheelbase reduces maneuverability. Choppers generally are highly customized and, as a result, more costly. As the term “chopper” implies, the motorcycle is derived by chopping off or removing parts from a typical cruiser with the intent of reducing weight or bulk for the sake of speed. Its reduced maneuverability is exaggerated further by a wide rear tire that assists in acceleration.

Touring



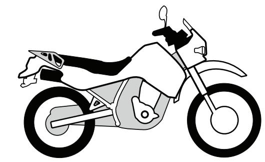
Touring motorcycles are equipped with high-displacement/high-torque engines for carrying a passenger and luggage. The Honda Goldwing which is the best selling motorcycle in this class has a 1,800 cubic centimeter engine. Touring motorcycles are among the longest and heaviest motorcycles. Honda Goldwings can weigh in excess of 800 pounds. Touring motorcycles offer wind protection for the rider, high-capacity fuel tanks, the ability to carry luggage, and an upright riding position that is comfortable for long distances. Although any motorcycle can be equipped and used for touring, touring motorcycles are designed for this purpose. They incorporate technological advances such as antilock brakes and airbags and are more likely to include features such as reverse gear, cruise control, heated hand grips, driver-to-passenger communication systems, navigation, and audio systems.

Dual Purpose



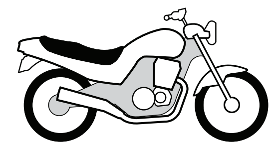
Dual purpose motorcycles are similar to off-road motorcycles. However, they are equipped with road-ready features such as turn signals, brake lights, and horns. They also use four-stroke engines for compliance with emissions requirements. They generally have larger displacement engines than off-road motorcycles, along with a more comfortable riding position.

Standard



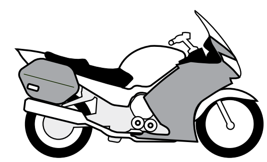
Standard motorcycle designs are basic and generally do not utilize technological advances in chassis and engine design. Many standard motorcycles are generic enough to remain in production for 10 years or more without redesign. Riding positions typically are upright and similar to that of a cruiser, but with foot pegs placed farther rearward. The riding position, coupled with better ground clearance than a cruiser, gives standard motorcycles better handling characteristics. Engine displacements are smaller than those for cruisers.

Sport Touring



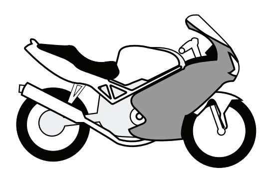
Sport touring motorcycles are similar in design to sport class motorcycles but have some features typically found on touring motorcycles. Sport touring motorcycles typically are derived from sport class frames and share components such as engines and drive trains. Sport tourers normally are equipped with touring features such as saddlebags, high windshields, larger fairings, heated grips, and larger seats—features not found on other sport class motorcycles. Among the other sport class motorcycles, sport tourers tend to have the largest engines, and riding positions are more upright. More than any other sport class motorcycle, sport tourers can accommodate passengers due to larger engines, upright riding positions, and larger seats.

Unclad Sport



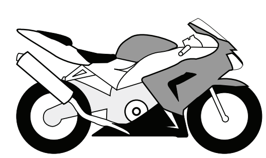
Unclad sport motorcycles are a relatively new market niche, however they are retro in styling. Sometimes referred to as “naked” or “hooligan” motorcycles, unclad sport motorcycles are derivatives of sport/super sport motorcycles. They do not have full body panels or fairing coverings typically found on sport/super sport motorcycles. Compared with sport and super sport motorcycles, unclad sport motorcycles generally have lower horsepower. The riding position places the feet under the seat and the hands below shoulder height. The rider’s knees are bent and the upper body has a slight forward lean, giving unclad sport motorcycles a riding position that is more comfortable than the sport class. The reduced horsepower and riding position make them more user friendly and suitable for everyday riding. Some motorcycles in this class serve as beginner motorcycles, whereas others are as powerful and agile as some sport and super sport motorcycles and are targeted at premium customers (e.g., Ducati and Aprilia).

Sport



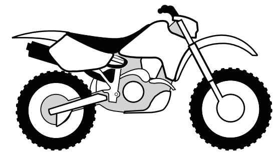
Sport class motorcycles are light and powerful. Their power-to-weight ratios are second only to the super sport class. They benefit from advances in design and technology intended for racing; however they are not considered racing specification machines. The riding position places the feet under the seat and the hands below shoulder height. The rider’s knees are bent, and the upper body has a forward lean. This riding position improves control when cornering and accelerating. All sport motorcycles have extensive body paneling and fairing covers to provide wind protection and assist in aerodynamics. Sport motorcycles can be equipped with side bags or a rear trunk to provide limited touring ability, but they do not have the features and amenities typically found in the touring class. Sport motorcycles have a wide range of engine displacements. The riding position and lower power-to-weight ratios make sport class motorcycles more suitable for street use rather than super sport motorcycles. Sport motorcycles are capable of high speeds, but they do not offer the acceleration, stability, and handling of racing-specification machines.

Super Sport



Super sport motorcycles are consumer versions of the motorcycles used by factory racing teams and use racing specifications as benchmarks in design. Their range of engine displacements is limited to meet racing requirements of the class. The power-to-weight ratios of super sport motorcycles are higher than any other mass produced motor vehicle. As racing specification machines, measures are taken to reduce weight and increase power, thus making these motorcycles quick in acceleration, nimble in handling, and capable of high speeds. The riding position is suitable for racing. The riding position places the feet under the seat and the hands below shoulder height. The rider’s knees are bent and the upper body has a forward lean. There also is less space between the seat and feet than for sport motorcycles to provide better rider/racer control. Super sport motorcycles have extensive body paneling and fairing coverings, but generally only offer good wind protection when the rider is in a crouched riding position.

Off-Road Motorcycle



Off-road motorcycles generally are light weight with small displacement engines. The suspension travel is longer than a typical motorcycle, with higher ground clearance. Their construction is rugged, simple, and without bodywork and fairings. Tires typically are knobby for tractability because off-road motorcycles are designed to be ridden through rough and muddy terrain. Many off-road motorcycles are produced strictly for recreational or competitive use and are not street legal. Generally, they are equipped with two-stroke engines.

AUTO INSURANCE
loss facts

HIGHWAY LOSS DATA INSTITUTE

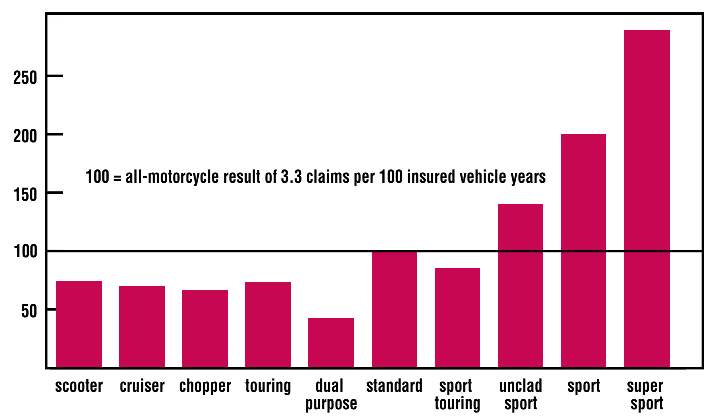
COLLISION COVERAGE

COMPARISON OF LOSSES BY MOTORCYLE CLASS, 2005-09 MODELS

Collision coverage insures against physical damage sustained in crashes to insured people's own vehicles. The damage may occur from striking another vehicle or an object such as a tree or pole. The information in this fact sheet is based on collision coverage results for 2005-09 model motorcycles insured under private motorcycle policies.

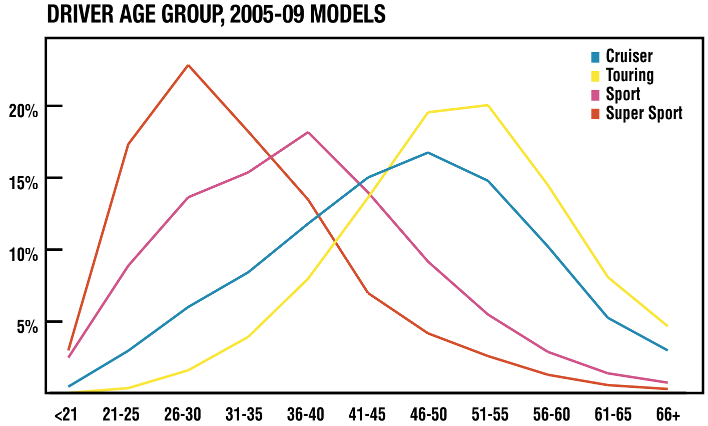
Two main factors determine collision losses. One is how often claims are filed (claim frequency). The other is how big the claim payments are, depending on the amount of severity and damage (claim severity). These two factors combine to indicate overall insurance losses or average loss payments per insured vehicle year. For motorcycles, overall losses are mostly driven by claim frequency.

RELATIVE MOTORCYCLE COLLISION CLAIM FREQUENCY BY CLASS, 2005-09 MODELS



Supersport motorcycles have the highest relative claim frequency. Frequencies range from 42 for dual purpose motorcycles to 289 for supersport.

MOTORCYCLE COLLISION EXPOSURE DISTRIBUTION BY CLASS AND RATED DRIVER AGE GROUP, 2005-09 MODELS



Losses for sport and supersport motorcycles are driven by a disproportionately young ridership. For the supersport class, collision exposure is highest for rated drivers 26-30 years old. In contrast, collision exposure for the touring class is highest for rated driver age groups 46-50 and 51-55.

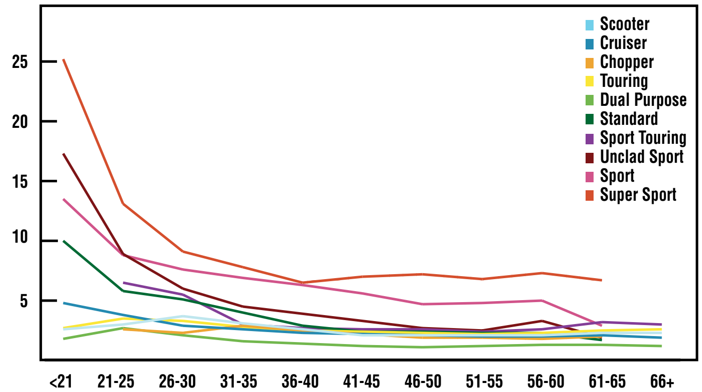
JULY 2010. The Highway Loss Data Institute is a nonprofit organization closely affiliated with the Insurance Institute for Highway Safety, which is wholly supported by auto insurers. HLDI gathers, processes, and publishes data on insurance loss variations among vehicles.

1005 North Glebe Road, Arlington, VA 22201 703-247-1600 www.iihs.org

AUTO INSURANCE
loss facts

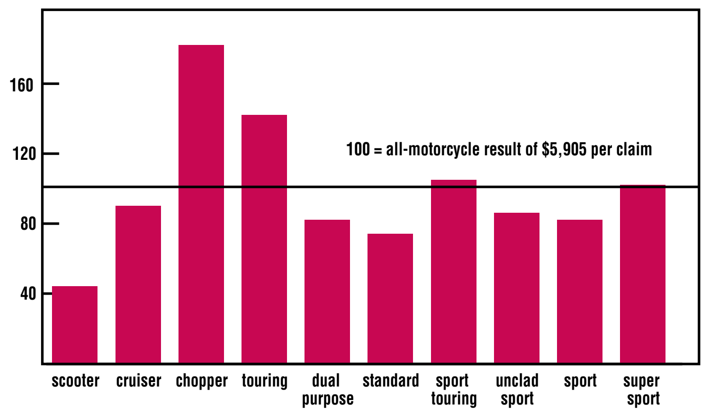
HIGHWAY LOSS DATA INSTITUTE

MOTORCYCLE COLLISION CLAIM FREQUENCIES BY CLASS AND RATED DRIVER AGE GROUP, 2005-09 MODELS



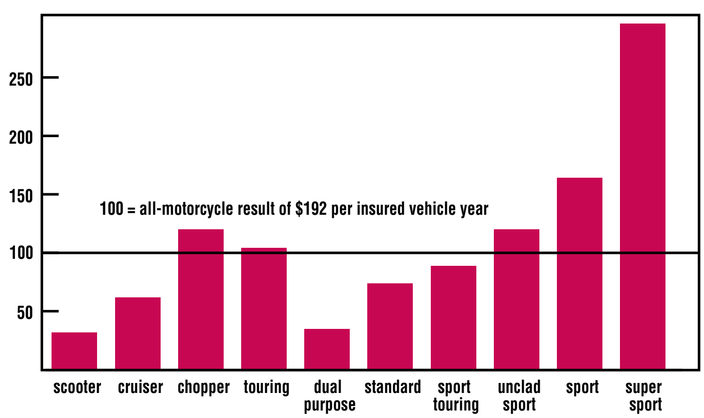
Regardless of age, claim frequencies are higher for the supersport class than all other classes across all age groups.

RELATIVE MOTORCYCLE COLLISION CLAIM SEVERITY BY CLASS, 2005-09 MODELS



Chopper class motorcycles have the highest relative claim severity. Severities range from 44 for scooters to 182 for choppers.

RELATIVE MOTORCYCLE COLLISION OVERALL LOSSES BY CLASS, 2005-09 MODELS



Supersport motorcycles have the highest relative overall losses. Losses range from 32 for scooters to 296 for supersports.

Role of Motorcycle Type in Fatal Motorcycle Crashes

Eric R. Teoh
Marvin Campbell

March 2010

INSURANCE INSTITUTE FOR HIGHWAY SAFETY
1005 NORTH GLEBE ROAD ARLINGTON, VA 22201
PHONE 703/247-1500 FAX 703/247-1678
www.iihs.org

Abstract

Introduction: Motorcycles vary in design and performance capability, and motorcyclists may select certain motorcycle types based on driving preferences. Conversely, motorcycle performance capability may influence the likelihood of risky driving behaviors such as speeding. Both mechanisms may affect fatal crash risk when examined by motorcycle type. Although it was not possible to estimate the effect of each mechanism, the current study analyzed fatal crash data for evidence of motorcycle type differences in risky driving behaviors and risk of driver death.

Methods: Street legal motorcycles were classified into 10 types based on design characteristics and then further grouped as cruiser/standard, touring, sport touring, sport/unclad sport, supersport, and all others. For each motorcycle type, driver death rates per 10,000 registered vehicle years and the prevalence of fatal crash characteristics such as speeding were analyzed. Differences among motorcycle types concerning the effect of engine displacement were examined using Poisson regression.

Results: Overall, driver death rates for supersport motorcycles were four times as high as those for cruiser/standard motorcycles. Fatally injured supersport drivers were most likely to have been speeding and most likely to have worn helmets, but least likely to have been impaired by alcohol compared with drivers of other motorcycle types. The patterns in driver factors held after accounting for the effects of age and gender. Increased engine displacement was associated with higher driver death rates for each motorcycle type.

Conclusion: Strong effects of motorcycle type were observed on driver death rates and on the likelihood of risky driving behaviors such as speeding and alcohol impairment. Although the current study could not completely disentangle the effects of motorcycle type and rider characteristics such as age on driver death rates, the effects of both motorcycle type and rider age on the likelihood of risky driving behaviors were observed among fatally injured motorcycle drivers.

Keywords: Motorcycles; Driver death rates; Vehicle power; Risky driving behavior

1. Introduction

Motorcyclist crash deaths have more than doubled, from a low of 2,056 in 1997 to 5,091 in 2008, the highest number ever recorded since the National Highway Traffic Safety Administration (NHTSA) began compiling fatal crash data in 1975 (IIHS 2009a). Many factors contribute to motorcyclist fatalities including speeding, risky maneuvers, alcohol use, nonuse of helmets, and risky behaviors among other road users. Crashes involving a vehicle other than a motorcycle accounted for slightly more than half of motorcyclist deaths in 2008 (IIHS 2009a).

Motorcycles vary dramatically in design, particularly with respect to size, weight, and performance capability (peak acceleration, maximum lean angle), and riders may select certain types of motorcycles based partly on their driving practices. Riders prone to higher risk driving behavior may choose more powerful and performance-oriented motorcycles. Motorcycle performance capability also may influence the likelihood that drivers will speed or engage in other risky maneuvers. Drivers may be more likely to speed on motorcycles with high-horsepower engines compared with less powerful ones. A similar pattern exists for automobiles. A study by the Highway Loss Data Institute (HLDI, 2007) found that collision insurance claims occurred more frequently and involved more expensive damage as vehicle power increased. Engine power, as measured by peak horsepower output, tends to be correlated with engine displacement. However, high-performance motorcycles tend to have smaller engines designed to produce high horsepower (IIHS, 2009a), so caution must be exercised in investigating safety effects of engine displacement.

A 1985 study conducted in California found that the registration-based injury crash rate for “racing design” motorcycles was approximately four times the rate for touring motorcycles (Kraus et al., 1988). Motorcycle designs have evolved greatly since the early 1980s, and the passenger vehicle fleet has changed substantially. There are many more motorcycles on the road, and traffic congestion has increased on many roadways. Speed limits in many states also have increased. Fewer US states have universal motorcycle helmet laws (IIHS, 2009b), which have been shown to reduce fatal crash rates among motorcyclists (Houston and Richardson, 2008). A recent HLDI (2009) study showed that insurance collision claims occurred more frequently for supersport motorcycles than for other types of motorcycles. However, these claims were not as costly, on average, as claims for other types of motorcycles such as touring motorcycles.

The goal of the current study was to investigate the role of motorcycle type in the fatal crash experience of motorcyclists. Driver death rates per registered vehicle year were examined by motorcycle type and calendar year. Also evaluated were the driver, vehicle, and environment factors indicative of risk-taking behavior.

2. Methods

Motorcycles were grouped into 12 types based on a classification system developed by HLDI: cruiser, standard, touring, sport touring, sport, unclad sport, supersport, chopper, dual purpose, scooter, all-terrain vehicle (ATV), and off-road. The classifications consider design characteristics such as intended use, riding position, engine power, passenger comfort, and cost. Descriptions of the motorcycle types are listed in Appendix A. Unclad sport and sport motorcycles were combined for analyses because their designs only differ primarily by the presence of plastic engine covers, or fairings. Cruiser and standard motorcycles were combined because of similar designs. Sport touring and sport motorcycles are similar in structure and design but were kept separate due to substantial differences in target markets and intended use.

Motorcycle registration data were obtained from R.L. Polk & Company for calendar years 2000 and 2003-08, all of the years for which data were available. Data on fatally injured motorcyclists for the same set of years were extracted from the Fatality Analysis Reporting System (FARS), a census of fatal crashes on public roads maintained by NHTSA. Data included motorcycle driver age and gender, blood alcohol concentration (BAC), license status, helmet use, and contributing crash factors such as speeding; motorcycle vehicle identification numbers (VINs); and crash conditions such as state, time of day, and number of involved vehicles. In both datasets, motorcycle VINs were decoded to identify make, model, and model year. Motorcycle type and engine displacement were subsequently obtained from a motorcycle features database maintained by HLDI.

The rate of driver deaths per 10,000 registered vehicle years was computed for each motorcycle type during the study years. Driver deaths, as opposed to drivers involved in fatal crashes, were studied because different types of motorcycles may be more or less likely than others to carry passengers, thus affecting the likelihood that a given crash is fatal. During the study years, not all states required registration of off-road vehicles, namely ATVs and off-road motorcycles, or dirt bikes. As a result, and because these vehicles were not designed for public road use, registered vehicle counts were not appropriate measures of exposure for driver deaths occurring on public roads. For these reasons, ATVs and dirt bikes were excluded from all analyses. To obtain counts of motorcycles of unknown type (those for which VINs were not decodable or missing) excluding ATVs and dirt bikes, the number of unknowns for each calendar year was reduced by the proportion of off-road vehicles in the VIN-decodable sample for that year. Analogous adjustments were conducted for driver deaths and for registration counts. These adjustments were intended to derive totals representing only street legal motorcycles. Rate ratios and confidence intervals, calculated with a Poisson regression model estimating only the effect of motorcycle type, were used to quantify differences in driver death rates by motorcycle type.

Driver death rates by motorcycle type were further tabulated by driver age and the presence of FARS variables indicating speeding, driver error, alcohol impairment (BAC $\geq$ 0.08 g/dL), helmet use, license status (properly licensed to operate a motorcycle vs. improper license type or unlicensed), type of crash (single vehicle), and time of crash (9 p.m. to 6 a.m.). Driver factors were based on police assessments of behaviors such as speeding, improper lane change, driving the wrong direction, or failure to yield. Multiple imputation results/methods were used to account for drivers with missing BACs (Subramanian, 2002).

Logistic regression was used to examine the role of driver factors in fatal motorcycle crashes by modeling the prevalence of each factor among fatally injured motorcycle drivers while controlling for motorcycle type, driver age and gender, and calendar year. Speeding, alcohol use, and other factors were not rare (not less than 10 percent), so the odds ratios were not accurate approximations of prevalence ratios. Prevalence ratios for all of these variables were estimated from the odds ratios using the method of Zhang and Yu (1998). Because the regression model that imputes BACs includes driver age as a covariate, the models in the present study also were fit without age. Results for the other covariates did not differ substantially, indicating their effects were not confounded by age. Furthermore, a model was fit including only drivers with observed BACs. Results did not differ substantially from those of the model including imputed BAC values, suggesting the estimate of the age effect was reliable.

Engines within each motorcycle type tend to be similarly designed, so engine displacement was a reasonable surrogate for horsepower rating within each motorcycle type. For example, supersport motorcycles with 1,000 cubic centimeter (cc) engines tend to produce higher horsepower than supersport motorcycles with 600 cc engines. A similar trend would be expected among touring motorcycles. However, a 1,000 cc supersport motorcycle typically has a higher horsepower rating than a 1,000 cc touring motorcycle. To test the effect of increased horsepower, Poisson regression was used to model the effect of increasing engine displacement within each motorcycle type on the rate of driver deaths per 10,000 registered vehicle years. The model also controlled for the effects of motorcycle type and calendar year to ensure they did not confound the engine displacement effect for each motorcycle type. Because displacement was modeled as a continuous variable (measured in cc), the motorcycle type terms measured the effect of motorcycle type for hypothetical motorcycles with zero displacement engines. These effects are not meaningful alone and were not presented. Rate ratios were computed for each motorcycle type and scaled to represent the effect of a 100 cc increase in engine displacement.

3. Results

3.1. Driver deaths, registrations, and death rates

Motorcycle driver deaths overall increased during the study years (Table 1). However, driver deaths for sport touring, sport/unclad sport, and supersport motorcycles decreased in 2008 compared with 2007. Registrations increased annually among all motorcycle types during the study years, including in

2008 (Table 2). The proportion of registered motorcycles that could not be classified (because of missing or invalid VINs) was approximately 27 percent annually for 2003-08 and 36 percent for 2000. There was no evidence that any motorcycle type was disproportionately underrepresented in the registration data.

Table 3 lists driver death rates per 10,000 registered vehicle years by motorcycle type and calendar year. The largest variation in death rates was due not to changes over time but to motorcycle type. For all study years combined, the driver death rate was 337 percent higher for supersport motorcycles than for cruiser/standard motorcycles (22.3 vs. 5.1 deaths per 10,000 registered vehicle years). Sport touring motorcycles had the lowest driver death rate of 4.3, or 15 percent lower than that for cruiser/standard motorcycles. All pairwise differences in driver death rates by motorcycle type were statistically significant at the 0.05 level.

3.2. Vehicle, driver, and crash characteristics

The average age of fatally injured motorcycle drivers varied substantially by motorcycle type. Drivers of supersport motorcycles were the youngest, with an average age of 27 in 2000 and 2003-08, and touring motorcycle drivers were the oldest, at 51. Fatally injured drivers of touring and sport touring motorcycles were similar in age, at 49, and drivers of sport/unclad sport and supersport motorcycles were more similar in age, at 32. The average age of fatally injured drivers of cruiser/standard motorcycles during the study years was 45.

Table 4 lists the prevalence of crash and driver characteristics for all the study years combined disaggregated by motorcycle type. Among fatally injured motorcyclists, speeding was most common for drivers of supersport and sport/unclad sport motorcycles. More than half of these drivers were speeding at the time of the crash, compared with less than a third for cruiser/standard and touring motorcycles. Driver error, which includes speeding, also was most common (77 percent) for supersport motorcycles. Drivers of sport touring motorcycles were least likely to have been impaired by alcohol and were most likely to have worn helmets. Fatally injured drivers of supersport motorcycles had a lower prevalence of alcohol impairment and higher prevalence of helmet use compared with drivers of cruiser/standard and touring motorcycles. Supersport drivers also were most likely not to be properly licensed.

Risky driving behaviors such as speeding may be more common among younger drivers than older ones, suggesting many of the differences in driver death rates and risky behaviors by motorcycle type could be due to riders of different ages tending to ride different types of motorcycles. In particular, 68 percent of fatally injured supersport drivers were younger than 30, compared with only 12 percent of cruiser/standard drivers and 2 percent of touring drivers. Appendix B lists driver and crash factors disaggregated by age group and motorcycle type. Although an age effect within each motorcycle type was evident, the effect of motorcycle type persisted within each age group. For example, 61 percent of fatally injured supersport drivers younger than 30 were speeding. This is higher than for supersport drivers in their 40s (55 percent). However, only 35 percent of fatally injured cruiser/standard drivers younger than 30 were speeding, compared with 28 percent of cruiser/standard drivers in their 40s.

Table 5 summarizes results of the logistic regression models estimating the prevalence of driver and crash factors among fatally injured motorcycle drivers associated with motorcycle type, driver age and gender, and calendar year. After controlling for motorcycle type and time trends, increasing driver age was associated with statistically significant reductions in the prevalences of speeding, driver error, alcohol impairment, improper licensure, and nighttime crash, and with a higher likelihood of helmet use. The same trends were observed for female riders compared with male riders. Controlling for driver age and gender and calendar year did not change the directions of motorcycle type effects on the prevalences of these factors (Table 4). For instance, fatally injured supersport drivers were more than twice as likely as cruiser/standard drivers to have been speeding (60 vs. 27 percent). Accounting for differences in driver age and gender and calendar year reduced this figure to 1.86, still a strong and statistically significant effect of motorcycle type.

For all motorcycle types except sport touring (no effect), a 100 cc increase in engine displacement was associated with increases in driver death rates (Table 6). The increase was only 3 percent for supersport motorcycles and ranged from 7 to 9 percent for cruiser/standard, touring, and sport/unclad sport motorcycles.

4. Discussion

Large variations in driver death rates (per 10,000 registered vehicle years) were observed when examined by motorcycle type and by fatal crash circumstances that indicate risky driving behaviors. Driver death rates for supersport motorcycles were more than four times as high as those for cruiser/standard motorcycles. After accounting for the effects of driver age and gender, fatally injured supersport drivers were about twice as likely to have been speeding and about half as likely to have been impaired by alcohol compared with cruiser/standard drivers. Helmet use among fatally injured motorcycle drivers was highest for sport touring motorcycles (82 percent) and lowest for cruiser/standard and touring motorcycles (both 49 percent). Results of the analyses generally were consistent with the hypothesis that risky driving behavior is associated with driver death rates, and that much of the variation can be explained by motorcycle type. However, variation in driver death rates by motorcycle type could not be directly attributed to observed variation in risky driving behaviors because data on the prevalence of these behaviors in the riding population (drivers not killed in crashes and drivers that did not crash) is not available, and their relative contributions to overall driver death rates have not yet been well established.

Relative driver death rates (per registered vehicle year) may overestimate or underestimate the relative risk of one type of motorcycle if it is driven, on average, substantially more miles than another. In the current study, the driver death rate for supersport motorcycles was about 4.4 times that of cruiser/standard motorcycles. If supersport motorcycles were driven, on average, 4.4 times as many miles per year as cruiser/standard motorcycles, then the driver death risks, per mile driven, would be equal. Although such a dramatic difference seems unlikely, data on average annual mileage by motorcycle type based on the current study's classification scheme are not available. However, the Motorcycle Industry Council's (2004) survey of motorcyclists in 2003 indicated average annual mileage was 2,934 for sport motorcycles, 3,238 for cruisers, and 4,714 for touring motorcycles. These data suggest the current study may underestimate driver death risk per mile driven for supersport or sport/unclad sport motorcycles compared with other types of motorcycles. Conversely, driver death risk for touring motorcycles may be overestimated.

Risky driving behaviors associated with driver age may account for some differences in driver death rates by motorcycle type. However, it was not possible to evaluate the effect of driver age on death rates because of the lack of appropriate exposure data. Owner age was not available in the registration data used for this study. Data from the Motorcycle Industry Council's (2004) survey indicated the median age of owners of sport motorcycles was 32, compared with 43 for cruisers and 50 for touring motorcycles. Although this suggests a strong age effect, analyses on the prevalence of risky driving behaviors such as speeding and alcohol use demonstrated clear effects of both motorcycle type and driver age. It was not possible to quantify the relative contribution of each without more extensive exposure data.

Acknowledgements

The authors acknowledge Anne McCartt and Adrian Lund of IIHS for providing comments that improved the writing of this manuscript. This work was supported by the Insurance Institute for Highway Safety.

References

Highway Loss Data Institute. (2007). *Insurance special report A-74: Horsepower and insurance losses*. Arlington, VA.

Highway Loss Data Institute. (2009). *Insurance motorcycle collision report MR-09: 2005-09 model years*. Arlington, VA.

Houston, D. J. & Richardson, Jr., L. E. (2008). Motorcycle fatality rates and mandatory helmet-use laws. *Accident Analysis and Prevention*, 40, 200-208.

Insurance Institute for Highway Safety. 2009a. *Fatality facts, 2008: motorcycles*. Arlington, VA. Available: http://www.iihs.org/research/fatality_facts_2008/motorcycles.html Accessed: September 11, 2009.

Insurance Institute for Highway Safety. 2009b. *Helmet use laws*. Arlington, VA. Available: http://www.iihs.org/laws/HelmetUseOverview.aspx. Accessed: September 21, 2009.

Kraus, J. F., Arzemanian, S., Anderson, C. L., Harrington, S., & Zador, P. (1988). Motorcycle design and crash injuries in California, 1985. *Bulletin of the New York Academy of Medicine,* 64, 788-803.

Motorcycle Industry Council. (2004). *2003 Motorcycle/ATV owner survey summary report*. Irvine, CA.

Subramanian, R. (2002). *Transitioning to multiple imputation – A new method to estimate missing blood alcohol concentration (BAC) values in FARS*. Report no. DOT HS 809-403. Washington, DC: National Highway Traffic Safety Administration.

Zhang, J. & Yu, K.F. (1998). What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *Journal of the American Medical Association*, 280, 1690-1691.

Table 1
Motorcycle driver deaths by motorcycle type and calendar year

	2000	2003	2004	2005	2006	2007	2008	All years
Cruiser/Standard	903	1,197	1,242	1,520	1,546	1,677	1,692	9,777
Touring	250	394	440	514	551	590	651	3,390
Sport touring	15	21	22	22	26	37	28	171
Sport/Unclad sport	267	378	427	441	440	509	467	2,929
Supersport	553	822	914	1,075	1,258	1,371	1,342	7,335
Other*	30	42	54	83	88	96	129	522
Unknown**	529	438	410	419	423	390	391	3,001
Total *	2,582	3,349	3,583	4,135	4,382	4,734	4,758	27,524

*Excludes off-road vehicles (ATVs and dirt bikes).
**Reduced by the proportion of off-road vehicles among vehicles with decoded VIN

Table 2
Motorcycle registrations by motorcycle type and calendar year

	2000	2003	2004	2005	2006	2007	2008	All years
Cruiser/Standard	1,762,486	2,350,163	2,555,318	2,796,601	3,048,441	3,201,996	3,432,618	19,147,623
Touring	491,581	663,423	729,452	815,199	909,861	981,137	1,070,804	5,661,457
Sport touring	24,315	41,287	48,930	58,532	66,292	72,875	84,160	396,391
Sport/Unclad sport	230,557	302,720	325,298	360,414	398,698	424,779	474,240	2,516,706
Supersport	257,194	376,290	416,564	473,830	539,699	584,514	643,034	3,291,845
Other*	267,427	327,556	377,142	433,507	518,816	588,846	694,202	3,207,496
Unknown**	1,304,361	1,016,125	1,184,456	1,179,536	1,160,687	1,167,067	1,269,049	8,281,281
Total*	4,337,921	5,077,564	5,637,160	6,117,619	6,642,494	7,021,214	7,668,107	34,833,972

*Excludes off-road vehicles (ATVs and dirt bikes).
**Reduced by the proportion of off-road vehicles among vehicles with decoded VIN

Table 3
Motorcycle driver deaths per 10,000 registered vehicle years by motorcycle type and calendar year

	2000	2003	2004	2005	2006	2007	2008	All years	Rate ratio (95% confidence interval)
Cruiser/Standard	5.1	5.1	4.9	5.4	5.1	5.2	4.9	5.1	1.00 (-,-)
Touring	5.1	5.9	6.0	6.3	6.1	6.0	6.1	6.0	1.17 (1.15, 1.20)
Sport touring	6.2	5.1	4.5	3.8	3.9	5.1	3.3	4.3	0.85 (0.78, 0.91)
Sport/Unclad sport	11.6	12.5	13.1	12.2	11.0	12.0	9.8	11.6	2.28 (2.23, 2.33)
Supersport	21.5	21.8	21.9	22.7	23.3	23.5	20.9	22.3	4.37 (4.31, 4.44)
Total*	6.0	6.6	6.4	6.8	6.8	6.8	6.2	7.9	

*Total includes other/unknown motorcycle types, and excludes off-road vehicles (ATVs and dirt bikes).

Table 4
Prevalence (percent) of driver and crash factors of fatally injured motorcycle drivers by motorcycle type, 2000, 2003-08

	Speeding	Driver error	BAC 0.08+ g/dL	Helmeted	No motorcycle license	Younger than 30	Single-vehicle crash	9 p.m. to 6 a.m. crash
Cruiser/Standard	27	56	36	49	18	12	44	27
Touring	23	52	28	49	10	2	48	22
Sport touring	37	58	10	82	8	4	42	12
Sport/Unclad sport	53	72	23	68	31	47	42	28
Supersport	60	77	21	70	35	68	43	32
Total*	39	63	29	56	25	31	44	28

*Total includes other/unknown motorcycle types, but excludes off-road vehicles (ATVs and dirt bikes).

Table 5
Relative prevalence of driver and crash characteristics from logistic regression models, 2000, 2003-08

	Speeding	Driver error	BAC 0.08+ g/dL	Helmeted	No motorcycle license	Single-vehicle crash	9 p.m. to 6 a.m. crash
Touring vs. cruiser/standard	0.90*	0.95*	0.82*	0.96*	0.65*	1.08*	0.90*
Sport touring vs. cruiser/standard	1.45*	1.05	0.30*	1.67*	0.47*	0.94	0.49*
Sport/unclad sport vs. cruiser/standard	1.70*	1.22*	0.53*	1.49*	1.24*	0.95*	0.77*
Supersport vs. cruiser/standard	1.86*	1.28*	0.44*	1.56*	1.25*	0.98	0.80*
10 year increase in driver age	0.88*	0.95*	0.88*	1.07*	0.75*	1.01	0.80*
Female vs. male	0.67*	0.97	0.51*	1.20*	0.66*	1.00	0.57*
Calendar year (1 year increase)	1.00	0.98*	1.01	1.01*	1.02*	1.00	1.00

*Statistically different than 1.00 at the 0.05 level.

Table 6
Driver death rate ratios and 95-percent confidence intervals by motorcycle type from Poisson regression controlling for motorcycle type and calendar year

	effect of a 100cc increase in engine displacement
Cruiser/Standard	1.07 (1.06, 1.08)
Touring	1.08 (1.06, 1.10)
Sport touring	1.00 (0.88, 1.15)
Sport/Unclad sport	1.09 (1.07, 1.10)
Supersport	1.03 (1.02, 1.05)
Calendar year (1 year increase)	0.99 (0.99, 1.00)

Appendix A – Types of motorcycles, Highway Loss Data Institute

Scooter

Scooters are characterized by small wheels, automatic transmissions, small engines (often below 50cc), and a step-through configuration that allows riders to place both feet on a running board.

Cruiser

Cruisers mimic the style of earlier American motorcycles from the 1930s to the early 1960s, such as those made by Harley-Davidson and Indian. The riding position places the feet forward of the seat and the hands near shoulder height, with the upper body erect or leaning back slightly. This position allows long-distance comfort but does compromise some degree of control. Cruiser engines tend to produce more torque and less horsepower than motorcycles in the sport classes. Cruisers are among the heaviest of motorcycles.

Chopper

Chopper-style motorcycles are closely related to cruisers. They have a longer wheelbase that results from an extended front fork configuration. The lengthened wheelbase reduces maneuverability. Choppers generally are highly customized and, as a result, more costly. In addition to the effect of an extended front fork, their reduced maneuverability is exaggerated further by a wide rear tire that assists in acceleration.

Touring

Touring motorcycles are equipped with high-displacement/high-torque engines and are designed for carrying a passenger and luggage. Touring motorcycles are among the longest and heaviest motorcycles. Touring motorcycles offer wind protection for the rider, high-capacity fuel tanks, the ability to carry luggage, and an upright riding position that is comfortable for long distances.

Dual Purpose

Dual purpose motorcycles are similar to off-road motorcycles. However, they are equipped with road-ready features such as turn signals, brake lights, and horns. They also use four-stroke engines for compliance with emissions requirements. They generally have larger displacement engines than off-road motorcycles, as well as a more comfortable riding position.

Standard

Standard motorcycle designs are basic and generally do not utilize technological advances in chassis and engine design. Riding positions typically are upright and similar to that of a cruiser, but with foot pegs placed farther rearward. Engine displacements are usually smaller than those of cruisers.

Sport Touring

Sport touring motorcycles are similar in design to sport class motorcycles but have some features typically found on touring motorcycles. Sport touring motorcycles typically are derived from sport class frames and share components such as engines and drive trains. Sport touring motorcycles normally are equipped with touring features such as saddlebags, high windshields, larger fairings, heated grips, and larger seats. Among the other sport class motorcycles, sport touring bikes tend to have the largest engines and riding positions that are more upright.

Unclad Sport

Unclad sport motorcycles are derivatives of sport/supersport motorcycles. They do not have full body panels or fairing coverings typically found on sport/supersport motorcycles. Compared with sport and supersport motorcycles, unclad sport motorcycles generally have lower horsepower. The riding position places the feet under the seat and the hands below shoulder height.

Sport

Sport class motorcycles are light and powerful. Their power-to-weight ratios are second only to the supersport class. They benefit from advances in design and technology intended for racing; however they are not considered racing specification machines. The riding position places the feet under the seat and the hands below shoulder height. The rider's knees are bent, and the upper body has a forward lean. This riding position improves control when cornering and accelerating. All sport motorcycles have extensive body paneling and fairing covers to provide wind protection and assist in aerodynamics. Sport motorcycles have a wide range of engine displacements. Sport motorcycles are capable of high speeds, but they do not generally offer the acceleration and handling of racing-specification machines.

Supersport

Supersport motorcycles are consumer versions of the motorcycles used by factory racing teams and use racing specifications as benchmarks in design. Their range of engine displacements is limited to meet racing requirements of the class. The power-to-weight ratios of supersport motorcycles are higher than any other mass produced motor vehicle. The riding position is suitable for racing and places the feet under the seat and the hands below shoulder height. The rider's knees are bent and the upper body has a forward lean. There also is less space between the seat and feet than for sport motorcycles to provide better rider/racer control. Supersport motorcycles have extensive body paneling and fairing coverings, but generally only offer good wind protection when the rider is in a crouched riding position.

Off-Road Motorcycle

Off-road motorcycles generally are light weight with small displacement engines. The suspension travel is longer than a typical motorcycle, with higher ground clearance. Their construction is rugged, simple, and without bodywork and fairings. Tires typically are knobby for tractability because off-road motorcycles are designed to be ridden through rough and muddy terrain. Many off-road motorcycles are produced strictly for recreational or competitive use and are not street legal. Generally, they are equipped with two-stroke engines.

All-Terrain Vehicle

All-terrain vehicles (ATVs) are designed with four wheels and may not generally be operated on public roads. Engine displacements tend to be low, but some engines share the same advanced designs as street legal motorcycles. ATVs generally accommodate one rider and are operated with the use of motorcycle-like controls including handle bars.

Appendix B
Prevalence (percent) of driver and crash factors of fatally injured motorcycle drivers by motorcycle type and age group, 2000, 2003-08

	Speeding				Driver error			
	<30	30-39	40-49	50+	<30	30-39	40-49	50+
Cruiser/Standard	35	34	28	20	62	61	57	51
Touring	28	31	24	20	57	57	52	50
Sport touring	57	47	40	31	100	60	60	52
Sport/Unclad sport	54	55	50	39	74	73	69	64
Supersport	61	58	55	48	78	74	73	63
Total *	54	45	31	21	74	67	58	51
	BAC 0.08+ g/dL				Helmeted			
	<30	30-39	40-49	50+	<30	30-39	40-49	50+
Cruiser/Standard	32	46	42	24	42	44	47	56
Touring	28	49	36	19	38	39	47	53
Sport touring	26	18	12	5	57	77	84	86
Sport/Unclad sport	18	28	30	18	65	67	74	83
Supersport	19	24	30	10	70	70	72	76
Total *	21	36	39	22	62	55	50	56
	Unlicensed				Single-vehicle crash			
	<30	30-39	40-49	50+	<30	30-39	40-49	50+
Cruiser/Standard	31	23	18	11	41	46	46	43
Touring	23	20	12	6	49	48	48	49
Sport touring	0	10	8	7	57	23	40	49
Sport/Unclad sport	37	30	23	10	40	44	40	49
Supersport	36	33	24	20	43	43	49	41
Total *	37	29	19	10	42	45	46	45
	9 p.m. to 6 a.m. crash							
	<30	30-39	40-49	50+				
Cruiser/Standard	35	37	29	17				
Touring	23	40	28	15				
Sport touring	43	13	12	10				
Sport/Unclad sport	30	30	23	18				
Supersport	33	31	27	12				
Total *	33	34	28	16				

*Total includes other/unknown motorcycle types, and excludes off-road vehicles (ATVs and dirt bikes).