Effectiveness of Motorcycle Training and Motorcyclists' Risk-Taking Behavior

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2 authors:

Peter Tarmo Savolainen
Wayne State University

Fred L. Mannering
University of South Florida

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Peter Savolainen and Fred Mannering

Persistent increases in motorcycle fatalities and injuries in recent years have heightened safety awareness and have focused attention on the role that motorcyclist training and education can play in reducing accident rates. In this study a 2005 sample of Indiana motorcyclists was used to estimate statistical models of the effectiveness of existing training programs in reducing accident probabilities. Statistical models relating to motorcyclist speed choice and helmet usage behavior were also estimated. The findings showed that those individuals who took beginning rider training courses were more likely to be involved in an accident than those who did not and that those who took the beginning course more than once were much more likely to be involved in an accident. Although explanations for these findings can range from the use of ineffective course material to changes in risk perception as a result of taking the course, another explanation is that riders who take the course are inherently less skilled than those who do not. The findings underscore the need for a careful and comprehensive study of rider skills and risk perceptions to maximize the effectiveness of motorcycle training courses.

Nationwide increases in motorcycle fatalities and injuries have underscored the need to improve motorcycle safety. To be sure, operating a motorcycle is a far more complex process than operating an automobile, and many riders do not have a complete appreciation of the complexities of motorcycle operation until they are involved in an accident. From the notion of countersteering to front and rear brake force application, traction control and power application, and the alertness and concentration required to negotiate traffic patterns dominated by cars, motorcycling presents formidable skill challenges to riders of all ages.

Formal motorcycle rider education and training have been viewed as critical to mastering the demanding skills necessary to operate and control a motorcycle. Many have believed that the unique handling characteristics of the motorcycle and the rider's vulnerability to perceptual, aerodynamic, and roadway disturbances require innate abilities and the acquisition of a high level of skill—most effectively obtained through formal training. However, surprisingly few evaluations have been undertaken to determine the effectiveness of motorcycle rider education and training, despite the importance ascribed to such programs (*1*). Of these, early studies on the effectiveness of rider training programs produced encouraging results, with formally trained riders being found to have a lower risk of collision than riders not so trained, although later, methodological shortcomings have brought the results of many of the early studies into question. Small sample sizes and a lack of control for important factors, such as rider training and exposure, were among the various problems identified with these studies by Collins (*2*) and Satten (*3*).

By contrast, the better-designed studies generally produced disappointing results, often finding that formally trained riders were not at lower risk of a collision than riders who did not receive the instruction. In addition, several evaluations actually found that formally trained riders had higher accident rates (per number of miles ridden) than those who were informally trained (*1*).

However, the criticisms of previous studies on the effectiveness of motorcycle training courses have been numerous, including the lack of consideration of variables that go beyond violation and accident statistics (*4*), the lack of control for exposure (the number of miles ridden) (*2, 3*), a lack of complete consideration of the dissimilarity between individuals who seek motorcycle training and those who do not (*5–9*), and a lack of consideration of possible risk compensation as trained riders acquire new skills that may enable them to ride faster instead of safer (*10*).

The last two points deserve some elaboration. Numerous studies have shown that motorcycle training courses do not attract a random sample of motorcyclists in terms of a demographic comparison. Because individuals who take the course are self-selected, they are a nonrandom group of motorcyclists and may be more or less likely to be involved in an accident than the general motorcyclist population. This concept can be a potentially fatal flaw if it is overlooked in training course evaluation. For example, if course participants are more likely to be accident prone than the general population of motorcyclists, the fact that there were no statistically significant differences in after-course accident involvement for riders who took the course in comparison with that for riders who did not take the course is a testament to the success of the course. Conversely, if the motorcycle training courses attract riders who are less likely to be accident prone, a finding that the course graduates are less likely to be involved in an accident may not be sufficient for determination of the effectiveness of the course. Possible self-selectivity must be considered in assessing the effectiveness of training courses.

The second point is potential offsetting behavior. The idea is that training courses provide riders with a new skill set. If after training they maintain the same riding intensity (speed selection, vehicle following behavior, etc.) as that before training, the improved skill set will presumably result in a lower probability of an accident. However, offset theory suggests that riders will use some of the skill set to increase their riding intensity because they can now ride faster and assume the same level of risk that they had before taking the training course [see the work of Winston et al. (*10*)].

The intent of this study is to provide some additional evidence on the effectiveness of motorcycle training courses by accounting for as many of the factors that are known or suspected to affect training

P. Savolainen, Wayne State University, 5451 Cass Avenue, Room 302, Detroit, MI 48202. F. Mannering, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN 47907. Corresponding author: F. Mannering, flm@purdue.edu.

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course effectiveness within the limitations of a motorcyclist survey approach. Within this context, a 2005 sample of Indiana motorcyclists was used, and their accident histories and the effect that the Motorcycle Safety Foundation's basic and experienced rider courses have on it were studied. Some additional insight into motorcyclists' behavior and the effect that training courses may have is provided by studying motorcyclists' propensity to report riding above 90 mph on public roads in the past year and their propensity to wear helmets. The findings provide additional information for the ongoing debate on the effectiveness of motorcycle training courses.

METHODOLOGY

To gain some insight into the effectiveness of motorcycle training courses and the behavior of individuals taking and not taking the course, three statistical models were developed: (*a*) a model of the annual probability that the rider will be involved in one or more accidents; (*b*) a model of the probability that the rider has ridden above 90 mph on public roads at least once in the past year; and (*c*) a model of the probability that the rider uses a helmet always, sometimes, or never while riding. All three of these models involve discrete outcomes; two have binary outcomes (having an accident or not and riding above 90 mph or not) and one has three outcomes (always, sometimes, or never wearing a helmet). In all of these cases, a binary or multinomial logit formulation is an appropriate modeling methodology. To arrive at this formulation, a linear function of covariates that determine the likelihood that motorcyclist n will have discrete outcome i (i.e., having an accident, or H_{in}) is defined as

$$H_{in} = \boldsymbol{\beta}_i \boldsymbol{X}_n + \epsilon_{in} \tag{1}$$

where

- $\boldsymbol{X}_n$ = vector of measurable characteristics that determine outcome i (e.g., rider age, rider gender, and risk-taking behavior),
- $\boldsymbol{\beta}_i$ = vector of estimable coefficients, and
- ϵ_{in} = error term that accounts for unobserved factors influencing resulting outcomes.

McFadden (*11*) has shown that if ϵ_{in} is assumed to be generalized-extreme-value distributed, the standard multinomial logit model results in

$$P_n(i) = \frac{\exp[\boldsymbol{\beta}_i \boldsymbol{X}_n]}{\sum_I \exp[\boldsymbol{\beta}_I \boldsymbol{X}_n]} \tag{2}$$

where $P_n(i)$ is the probability that motorcyclist n has discrete outcome i and I is the set of possible outcomes. This model is estimable by standard maximum likelihood methods (*12*).

To assess the effect of the vector of estimated coefficients ($\boldsymbol{\beta}_i$), elasticities that measure the magnitude of the impact of specific variables on the outcome probabilities were calculated. The elasticity (E) was computed for each motorcyclist n (the n subscript is omitted) as

$$E_{x_{ki}}^{P(i)} = \frac{\partial P(i)}{\partial x_{ki}} \times \frac{x_{ki}}{P(i)} \tag{3}$$

where $P(i)$ is the probability of discrete outcome i, and x_{ki} is the value of variable k for outcome i. With Equation 2, Equation 3 gives

$$E_{x_{ki}}^{P(i)} = [1 - P(i)]\beta_{ki} x_{ki} \tag{4}$$

where β_{ki} is the estimated coefficient associated with variable x_{ki}. Elasticity values can be roughly interpreted as the percent effect that a 1% change in x_{ki} has on the discrete outcome probability, $P(i)$.

Elasticities are not applicable to indicator variables (those variables taking values of 0 or 1). In these cases, a pseudoelasticity, in terms of percent impact, can be calculated as

$$E_{x_{ki}}^{P(i)} = \left[\frac{\exp[\Delta(\boldsymbol{\beta}_i \boldsymbol{X}_i)] \sum_{\forall I} \exp(\beta_{kI} x_{kI})}{\exp[\Delta(\boldsymbol{\beta}_i \boldsymbol{X}_i)] \sum_{\forall I_a} \exp(\beta_{kI} x_{kI}) + \sum_{\forall I \neq I_a} \exp(\beta_{kI} x_{kI})} - 1\right] \times 100 \tag{5}$$

where I_a is the set of alternate discrete outcomes with x_k in the function determining the outcome, and I is the set of all possible discrete outcomes. The pseudoelasticity of a variable with respect to a discrete outcome represents the percent change in the probability of outcome i when the variable is changed from 0 to 1. Thus, a pseudoelasticity of 35% for a variable means that when the value of the variable in the subset of observations where x_k is equal to 0 is changed from 0 to 1, the probabilities of the outcome for these observations increased, on average, by 35%. See the work of Washington et al. for a complete discussion of elasticities in the context of statistical and econometric models (*12*).

DATA

The Indiana motorcyclist survey described here was designed to obtain a more complete picture of motorcycle safety within Indiana. The survey was developed and distributed to motorcyclists throughout Indiana in an effort to gain insight into characteristics of the riding population. The survey builds on previous work by Mannering and Grodsky (*13*), which examined motorcyclists' perceived likelihood of being involved in an accident through a survey distributed in *Rider* magazine. The survey for the present study collected demographic, vehicle, and riding characteristics for each motorcyclist. The main objectives of the survey were to determine what types are riders were most prone to be involved in an accident and to evaluate the effectiveness of existing rider training programs.

The survey was distributed to more than 8,000 riders in November 2005. The Indiana Chapter of the American Bikers Aimed Toward Education (ABATE) supplied documentation for each motorcyclist who has gone through the state training program, pass or fail, dating back to 2000. Surveys were mailed to 4,000 riders in this group, and 558 responded. The response rates were expected to be lower for this group because some address information was believed to be outdated. Consequently, additional surveys were distributed through the November ABATE newsletter, which resulted in an additional 181 responses.

An additional 4,000 surveys were mailed to a control group. The control group was created by using the Indiana Bureau of Motor Vehicles database of all Indiana residents who own a motorcycle or who have a motorcycle permit or endorsement, and 588 responses were received.

Unfortunately, detailed socioeconomic and riding data are not available for the general population of motorcyclists in Indiana. Thus, it is not clear how the data would compare with the data for the overall motorcyclist population. In addition, the response rate was about 15%, which could also introduce some variance between the sample and the overall Indiana motorcyclist population. These points should be kept in mind when the subsequent analysis is evaluated, although it should be pointed out that the statistical models that are used produce unbiased results, even when the samples are not representative of the overall population [see the work of Washington et al. (*12*), pp. 278–280].

Table 1 presents the response percentages, averages, and standard deviations of the sample data. The average age of the respondents was nearly 48 years, with 16% female, making the sample a bit older (nationally, the average age of riders is about 42 years) and with more females (nationally, about 10% of riders are female) than a random national sample. The following are some other interesting elements of the sample: (*a*) 26% report that they ride more than 5,000 mi/year, (*b*) 89% rate their riding skills as good or very good, (*c*) 67% percent report that they ride motorcycles with above 1,000-cc engine displacement, (*d*) only 56% report that they always or usually wearing a helmet, (*e*) 20% reported that they rode above 90 mph on public roads in the past year, (*f*) 22% report that they ride within 2 h of drinking, (*g*) 12% report that they have been involved in an accident in the past 5 years, and (*h*) 59% report that they had at least one near miss in the past 12 months.

Comparison of the variables between ABATE and non-ABATE riders found no statistically significant differences, with the exception of helmet usage (ABATE members were less likely to always wear a helmet). Comparison of trained riders (those who completed the Motorcycle Safety Foundation's basic rider course) with untrained riders found that many characteristics of the two groups were quite similar, including age (average ages of 44.8 years for the trained group and 46.6 years for the untrained group), motorcycle type, exposure, riding behavior, and accident involvement. However, there were some notable differences among the following variables: gender, use of protective equipment, self-rated riding ability, riding experience, and license status. Ninety-five percent of the untrained riders in the sample were male, whereas 76% of the trained riders were male. The rate of helmet usage was found to be higher among the trained riders,

TABLE 1 Sample Summary Statistics

Variable	Values
Average age in years (standard deviation in parentheses)	47.83 (11.57)
Percent male/female	84/16
Percent with primary mode of travel: car/pickup/SUV/van/motorcycle/other	27/35/19/5/12/2
Percent who currently ride	97
Miles ridden in typical year: <501/501–1,000/1,001–5,000/5,001–10,000/>10,000	8/15/51/20/6
Year started riding: 1950s/1960s/1970s/1980s/1990s/2000s	5/15/24/11/11/34
Self-rated riding ability: very good/good/fair/poor/very poor	29/59/11/1/0
Type of motorcycle typically ridden: sport bike/cruiser/touring/other	15/46/27/12
Engine displacement of motorcycle ridden most often (cc): <500/500–999/1,000–1,499/1,500+	5/28/52/15
Motorcycles currently owned: 0/1/2/3/4/Over 4	4/65/22/5/1/3
Percent who are ABATE members	46
Completed the Motorcycle Safety Foundation's basic rider course (percent)	60
Completed the Motorcycle Safety Foundation's basic rider course more than once (percent)	6
Year last completed the Motorcycle Safety Foundation basic rider course (percent): before 2000/2000/2001/2002/2003/2004/2005	20/9/8/14/19/22/8
Completed the Motorcycle Safety Foundation's experienced rider course (percent)	12
Year last completed the Motorcycle Safety Foundation experienced rider course (percent): before 2000/2000/2001/2002/2003/2004/2005	12/6/12/13/15/30/12
Most useful component of Motorcycle Safety Foundation courses (percent): braking skills/counter steering/riding strategies/other	24/18/49/9
Reasons for not taking a training course (percent): cost/time/no need/other	4/34/47/15
Percent currently licensed/endorsed/neither	94/4/2
Year permit/endorsement received (percent): <1980/80–84/85–89/90–94/95–99/2000+	17/9/6/7/10/51
Frequency of helmet usage (percent): always/usually/sometimes/rarely/never	40/16/21/14/9
Percent wearing helmet meeting Department of Transportation standards	99
Reasons for not wearing (percent): discomfort/reduced awareness/no need/forgot/other	36/28/16/2/18
Frequency of wearing other protection (percent): always/usually/sometimes/rarely/never	35/33/25/4/2
Percent typically wearing reflective clothing/equipment	34
Typical travel speed on roads with 55 mph speed limits (percent): <55/56–60/61–65/66–70/>70	17/52/22/7/2
Maximum travel speed in past year in mph (percent): <70/70–79/80–89/90–99/100+	30/31/19/8/12
Percent drinking within 2 h of riding	22
Reasons for riding after drinking (percent): felt capable/short distance/no alternative	75/22/3
Percent with a motorcycle accident in past 5 years	13
Percent with at least one near-miss in the past 3 months	34
Percent with at least one near-miss in the past 12 months	59

with 44% of the trained riders and 34% of the untrained group of riders always wearing their helmets and only 5% of trained riders and 14% of untrained riders never wearing their helmets. The trained group was found to be more experienced than the untrained group, with averages of 21.3 and 17.5 years of experience, respectively; generally the distribution of riding experience was close between the two groups. Untrained riders were more likely to rate their own riding ability as very good (39% versus 23% for the trained riders). Finally, 4.2% of the respondents in the untrained group but only 0.5% of the respondents in the trained group had neither a motorcycle permit nor an endorsement.

ACCIDENT INVOLVEMENT MODEL

Information on rider accidents in the past 5 years was available for model estimation. Therefore, each rider could generate as many as five observations for model estimation, because the likelihood of annual accident involvement was considered. For those riders who indicated that they took the Motorcycle Safety Foundation's basic rider course in one of the past 5 years, the accident data for the year that they took the course were eliminated from the database (they would thus generate 4 years instead of 5 years of accident data). This ensures that in each year considered a rider has unambiguously taken or not taken the course. Also, to test for the possibility that error term correlation among the multiple observations generated by each rider is not affecting the estimation results, fixed and random effects logit models were estimated [see the work of Washington et al. (*12*)]. It was found that the error term correlation did not significantly influence the coefficient estimates and that a standard logit model (which assumes error term independence) was statistically justified.

The maximum likelihood estimation results are presented in Table 2, which shows that a wide variety of variables were found to be statistically significant (the *t*-statistics exceeded 1.6). To understand the effects of these variables on the annual probability that riders are involved in an accident, the corresponding elasticities are presented in Table 3. These reported elasticities are averaged over the population (each rider generates an elasticity in each year).

Turning first to rider behavior variables, it was found that riders who report that they never wear a helmet are an average of 63% more likely to be involved in an accident per year. This may be capturing the risk-taking behavior of this group of riders. Those riders who typically ride sport bikes were found to be 54% more likely to be involved in an accident, and this may be a proxy variable for overall risk-taking behavior.

As shown in Table 3, the next set of variables relates to exposure, with those riding 500 to 1,000 mi/year being 64% less likely to be involved in an accident and those riding more than 10,000 mi/year being 102% more likely to be involved in an accident. These exposure categories are relative to the less than 500-mi/year and 1,000- to 10,000-mi/year categories. It seems that riding 500 to 1,000 mi/year generates the least accident risk because this may be sufficient mileage to sharpen riding skills (relative to the skills for motorcyclists who ride less than 500 mi/year, which has a neutral impact on accident risk, given the other variables in the model) but not sufficiently high for the increased exposure to take effect.

Riders who report that they rode over 100 mph on public roads in the last year (12% of the riders in the sample reported doing this) were, on average, 161% more likely to be involved in an accident. In this case, the 100-mph threshold provided the most statistically significant results. As one might expect, excessive speed appears to be a good indicator of risk-seeking behavior. Also, those citing short distance as a reason for drinking and riding were 108% more likely to be involved in an accident. This again appears to be an indicator of taking greater risks.

With regard to socioeconomic and experience variables, individuals with 2 to 4 years of riding experience were 58% less likely to be involved in an accident and those with 5 or more years experience were 51% less likely to be involved in an accident. Although statistically there is little difference between these two experience categories, the implication is that riders with less than 2 years of experience are significantly more likely to be involved in an accident than riders with 2 or more years of experience. This is because the coefficient for riders with less than 2 years of experience is implicitly set to zero and that having more than 2 years experience

TABLE 2 Annual Accident Propensity Binary Logit Model

Variable	Coefficient Estimate	*t*-Ratio
Constant	−3.651	−11.51
Rider behavior variables		
Never wear a helmet	0.498	1.64
Typically ride sport bike	0.444	1.86
Typically ride 500–1,000 mi per year	−1.032	−2.42
Typically ride over 10,000 mi per year	0.724	2.56
Have ridden over 100 mph in past 12 months	0.984	4.54
Cited short distance as reason for drinking and riding	0.753	2.57
Socioeconomic and experience variables		
2–4 years of riding experience	−0.877	−2.45
5+ years of riding experience	−0.732	−2.47
Rider younger than 35 years of age	0.473	1.91
Rider course variables		
Completed basic rider course once	0.373	1.84
Completed basic rider course multiple times	1.059	4.29
Cited no need for taking basic rider course	−0.734	−2.29
Number of observations	4,880	
Log likelihood at zero	−559.48	
Log likelihood at convergence	−508.75	

NOTE: All coefficients are defined for the accident outcome.

TABLE 3 Elasticities Regarding Probability of Annual Accident Involvement

Variable	Elasticity (%)
Rider behavior variables	
Never wear a helmet	63
Typically ride sport bike	54
Typically ride 500–1,000 mi per year	−64
Typically ride over 10,000 mi per year	102
Have ridden over 100 mph in past 12 months	161
Cited short distance as reason for drinking and riding	108
Socioeconomic and experience variables	
2–4 years of riding experience	−58
5+ years of riding experience	−51
Rider under 35 years of age	59
Rider course variables	
Completed Basic Rider Course once	44
Completed Basic Rider Course multiple times	180
Cited no need for taking Basic Rider Course	−51

has a negative effect on accident likelihoods. Alternatively, the 2+ years of experience could have implicitly been set to zero and the coefficient for less than 2 years of experience could have been estimated, which then would have been positive, indicating a greater accident risk. See the work of Washington et al. for additional information on the interpretation of coefficients (*12*).

The key socioeconomic finding was that riders younger than 35 years of age were 59% more likely to be involved in an accident (with all other factors held constant). Interestingly, in this model, the difference between young male and female motorcyclists was not significant. This differs from the findings from some previous work, such as that of Chesham et al., who found that young male motorcyclists are at a higher risk of accident involvement than other motorcyclists (*14*). In general, young males as a group have been found to behave more riskily than females and have also been found to have worse hazard perception (*15, 16*).

The Motorcycle Safety Foundation's basic rider course was found to be significant with three variables in the accident model. For the first variable, those who completed the basic rider course were found to be 44% more likely to be involved in an accident. This may reflect the ineffectiveness of the course, the fact that the course is attracting an inherently less skilled set of riders, or that the postcourse skill set is being used to ride more aggressively (the safety compensation argument raised earlier). Commenting on the effectiveness of the material taught in the basic rider course is beyond the scope of this paper. In terms of the course attracting inherently less skilled riders, a wide range of variables were controlled for in the model, but it is possible that unobservable variables that are not correlated with those included in the model still influenced the model estimates. In terms of safety compensation negating the benefits of the course (and, in fact, making riders more dangerous), access to data detailed enough to thoroughly explore this matter, as has been done for automobile safety features (*10*), were, unfortunately, not available. Thus, the true underlying reasons for this finding are open to interpretation. However, it is noteworthy that other recent studies have found riders who have taken the basic rider course to be statistically distinguishable. For example, Savolainen and Mannering found that riders taking the basic rider course more than 2 years before the time of an accident were 171% more likely to be fatally injured (*17*).

The second course-related finding was that those who completed the basic rider course multiple times were an additional 180% more likely to be involved in an accident. This finding may reflect the fact that people who take the course repeatedly are trying to improve an inherently diminished skill set (or one that changes over time) that affects their accident likelihoods. Thus, this variable may be capturing one's inherent ability to master or the need to refresh the relatively complex physical and mental skills necessary to operate a motorcycle. Interestingly, there was no significant age difference between people who took the basic rider course once and those who took it multiple times (both groups were roughly 45 years of age). However, those who took the course multiple times had, on average, almost 12 more years of experience. It appears that more experienced riders—perhaps those noting a decline in their skills or those having had recent experiences with near misses—are more likely to take the basic riding course repeatedly.

People who cited no need for taking the basic rider course were 51% less likely to be involved in an accident (the average age of these riders was 24.4 years, and 85% of these riders had 5 or more years of experience). This seems to provide some evidence supporting the fact that the people taking the beginner course may be inherently less skilled riders. It is also interesting that 12% of the sample took the Motorcycle Safety Foundation's experienced rider course (the sequel to the basic rider course), but this did not have a statistically significant effect, positive or negative, on accident probabilities.

As a final point, it is noteworthy that ABATE members had a slightly higher accident rate than non-ABATE members (0.159 accidents over the 5-year period for ABATE members versus 0.105 accidents for non-ABATE members). There was little difference between genders: males averaged 0.129 accidents over the study period and females averaged 0.136 accidents.

OTHER MODELS

Two additional models were estimated to gather some insight into other aspects of motorcyclists' behavior and the possible effects of motorcycle training: a model of the probability of riding above 90 mph on public roads at least once in the past year and a model of the probability of using a helmet always, sometimes, or never while riding.

Riding over 90 mph at least once in the past year is a measure of risk taking, and 20% of the riders in the sample admitted to doing this (other speeds were also considered, for example, 80 mph; but it was found that the 90-mph speed provided the best statistical fit and identification of speeding riders). Estimation results of the binary logit model for determination of the probability that a rider will exceed 90 mph are presented in Table 4, with the corresponding elasticities presented in Table 5. Factors that were found to increase the likelihood of exceeding 90 mph on public roads in the last year were having a motorcycle as a primary mode of travel, riding a sport bike, riding 5,000 mi/year or more, reporting to have drank alcohol within 2 h of riding, involvement in an accident or near miss in the past year, and becoming a licensed motorcyclist at age 40 years or older. Factors reducing the probability of riding 90 mph or above included usually wearing reflective clothing or equipment, riding a bike with an engine displacement of less than 900 cc, increasing rider age, and being female. Note that the variables becoming licensed over 40 (which increased the likelihood of exceeding 90 mph) and increasing rider age (which decreased the likelihood of exceeding 90 mph) may interact for

TABLE 4 Maximum Speed (more than 90 mph) Binary Logit Model

Variable	Coefficient Estimates	*t*-Ratio
Constant	–0.176	–0.37
Rider behavior variables		
Motorcycle is primary mode of travel	0.444	2.11
Usually wear helmet	0.412	2.58
Usually wear reflective clothing/equipment	–0.434	–2.47
Typically ride a sport bike	1.080	5.46
Typically ride engine displacement 500 cc or less	–0.989	–2.31
Typically ride engine displacement 900 cc or less	–0.419	–2.09
Typically ride 5,000–10,000 mi per year	0.936	4.96
Typically ride over 10,000 mi per year	1.470	5.17
Drank alcohol within 2 h of riding in past year	0.646	3.75
Involved in accident/near-miss in past year	0.325	2.11
Socioeconomic variables		
Rider age in years	–0.048	–6.14
Female rider	–1.106	–3.98
Obtained license at age 40 or later	0.409	1.98
Number of observations		1,333
Log likelihood at zero		–923.97
Log likelihood at convergence		–554.71

NOTE: Coefficients are defined for riding more than 90 mph on public roads in the past 12 months.

TABLE 5 Elasticities Regarding Probability of Riding More Than 90 mph on Public Roads in Past Year

Variable	Elasticity (%)
Rider behavior variables	
Motorcycle is primary mode of travel	42
Usually wear helmet	39
Usually wear reflective clothing/equipment	–30
Typically ride a sport bike	128
Typically ride engine displacement 500 cc or less	–57
Typically ride engine displacement 900 cc or less	–29
Typically ride 5,000–10,000 mi per year	106
Typically ride 10,000 mi per year	189
Drank alcohol within 2 h of riding in past year	66
Involved in accident/near-miss in past year	30
Socioeconomic variables	
Rider age in years[a]	–1.82
Female rider	–61
Obtained license at age 40 or later	38

[a]This is a continuous variable and elasticities are not reported in percent. See Equation 4 and its accompanying discussion.

some riders, producing a more complex age–licensing interaction. Interestingly, no rider course variables were significant in this model.

Estimation results of the model of the probability of using a helmet always, sometimes, or never while riding are presented in Table 6, with the corresponding elasticities presented in Table 7. The rider course variables that were found to influence helmet usage significantly included being an ABATE member and completing the basic rider course (which were associated with a 31% increase in the probability of always wearing a helmet) and citing no need to take a Basic Rider Course, which was associated with an 18% lower probability of always wearing a helmet. Some other interesting findings are as follows: (*a*) riders who reported that their motorcycle was their primary mode of travel had a 69% higher probability of never wearing a helmet, (*b*) those who reported riding over 100 mph in the last year had a 28% higher probability of always wearing a helmet, (*c*) ABATE members had a 32% lower probability of always wearing a helmet, (*d*) female riders had a 22% lower probability of always wearing a helmet, and (*e*) those who rated themselves as very good riders had a 53% higher probability of never wearing a helmet. The results show that ABATE members who completed the basic rider course had a 31% higher likelihood of always wearing a helmet and that all ABATE members (whether they completed the rider course or not) had a 32% lower probability of always wearing a helmet. This implies that ABATE members who complete the basic rider course have roughly the same probability of always wearing a helmet as the general population (since the 31% increase nearly cancels the 32% decrease) but that ABATE members who have not taken the basic rider course have a 32% lower probability of always wearing a helmet.

SUMMARY AND CONCLUSIONS

By using a sample of Indiana motorcyclists, three models were estimated to gain some insight into the effectiveness of motorcycle training courses and factors that influence some key elements of

TABLE 6 Multinomial Logit Model Estimation Results

Variable	Coefficient Estimate	*t*-Ratio
Constant (A)	–1.074	–2.66
Constant (S)	–0.911	–2.16
Rider behavior variables		
Motorcycle is primary mode of travel (N)	0.707	3.50
Never wear protective equipment (N)	1.064	3.80
Drank alcohol within 2 h of riding in past year (A)	–1.234	–6.84
Drank alcohol within 2 h of riding in past year (S)	–0.694	–3.56
Always wear protective equipment (S)	–1.220	–7.47
Always wear protective equipment (N)	–0.640	–3.46
Typically wear reflective clothing/equipment (N)	–0.755	–4.34
Typical travel speed over 70 mph on 55 mph roads (N)	–1.439	–2.27
Typical travel speed less than 60 mph on 55 mph roads (N)	–0.330	–2.08
Typically ride engine displacement less than 700 cc (A)	0.568	3.05
Typically ride engine displacement over 1,200 cc (A)	–0.619	–4.22
Involved in near-miss in past 3 months of riding (N)	0.205	3.74
Rode over 100 mph in last year (A)	0.618	2.95
Socioeconomic, experience and opinion variables		
Rider age in years (A)	0.026	3.32
Rider age in years (N)	–0.022	–2.79
Female rider (A)	–0.534	–2.90
Rider is ABATE member (A)	–1.091	–4.09
Years of riding experience (A)	–0.012	–2.27
Number of bikes owned (N)	–0.287	–3.19
Self-rated as excellent rider (N)	0.553	3.52
Rider course variables		
Rider is ABATE member and completed Basic Rider Course (A)	0.618	2.26
Rider cited no need for taking Basic Rider Course (A)	–0.434	–2.49
Number of observations		1,308
Log likelihood at zero		–1,436.77
Log likelihood at convergence		–1,109.62

NOTE: Coefficients are defined for (A) always wear a helmet, (S) sometimes wear a helmet, and (N) never wear a helmet.

TABLE 7 Elasticities of Helmet Usage

Variable	Always	Sometimes	Never
Rider behavior variables			
Motorcycle is primary mode of travel	—	—	69%
Never wear protective equipment	—	—	115%
Drank alcohol within 2 h of riding in past year	–35%	12%	—
Always wear protective equipment	—	–53%	–17%
Typically wear reflective clothing/equipment	—	—	–45%
Typical travel speed over 70 mph on 55 mph roads	—	—	–70%
Typical travel speed less than 60 mph on 55 mph roads	—	—	–22%
Typically ride engine displacement less than 700 cc	26%	—	—
Typically ride engine displacement over 1,200 cc	–23%	—	—
Involved in near-miss in past 3 months of riding	—	—	17%
Rode over 100 mph in last year	28%	—	—
Socioeconomic, experience and opinion variables			
Rider age in years[a]	0.53	—	–0.82
Female rider	–22%	—	—
Rider is ABATE member	–32%	—	—
Years of riding experience	–12%	—	—
Number of bikes owned	—	—	–19%
Self-rated as very good rider	—	—	53%
Rider course variables			
Rider is ABATE member and completed basic rider course	31%	—	—
Rider cited no need for taking basic rider course	–18%	—	—

[a]This is a continuous variable and elasticities are not reported in percent. See Equation 4 and its accompanying discussion.

motorcyclists' behavior. In addition to the model estimation results, which showed that a wide variety of factors influence motorcyclist speed and helmet usage, the findings show that individuals who take the Motorcycle Safety Foundation's basic rider course are more likely to be involved in an accident than those motorcyclists who do not. Although there are many possible reasons for this, including a possibly ineffective course content and changes in motorcyclist risk perception as a result of taking the course, the fact that such courses may attract inherently less capable riders is a real possibility. There is some indirect evidence for this in the accident likelihood model, such as the finding that those who take the course multiple times are much more likely to be involved in an accident. With current data, it is not impossible to isolate the elements that may be good indicators of riders' inherent motorcycling skill set and how this might best be improved. To move forward with effective motorcycle training, skill measurement methods must be developed and research must be undertaken to understand how these skills can be improved, with full consideration given to possible risk compensation and the fact that course users may be a sample of inherently less skilled riders.

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