Effectiveness of Motorcycle Training and Licensing

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Motorcycle crash fatalities in the United States have been increasing since 1997, when the total number of fatalities reached a record low. Motorcycle training programs were enacted before this rise, and many studies have aimed to show their effectiveness. The objective of this study is to review and synthesize the results of existing research on the effectiveness of motorcycle education courses and different licensing procedures. The effectiveness of programs is examined through the effect training has on accident rates, violation rates, and personal protective equipment use found through past research. Research to date has not consistently supported the notion that training is either effective or ineffective. Some studies have demonstrated that accident and traffic violation rates are lower for trained riders than for untrained riders, whereas others have demonstrated that they are higher for trained riders. Training increases the use of personal protective equipment among motorcyclists. Motorcycle licensing procedures have been shown to have different effects on accident rates. Lower accident rates have been observed in areas with stricter regulations for obtaining a license. The studies vary greatly in both the methods used for comparison and the rigor of their evaluation methodology. No standards for evaluation exist. The findings of these previous studies may be more a reflection of the methods used to evaluate motorcycle training than the effectiveness of training itself.

Motorcycle crash fatalities in the United States have been increasing since 1997, when the total number of fatalities reached a record low (*1*). Motorcycle training programs were put in place long before this rise, but motorcycle training has taken on renewed prominence as a method to improve motorcycle safety by producing safer, more skilled motorcycle riders. Training may be popular with policy makers, however, because of what Mayhew (*2*) refers to as "strong face validity." However, Mayhew found that there is little evidence that driver training is effective at improving safety. Motorcycle and car driving skills are of course very different. The question is how effective motorcycle training programs are at improving rider safety.

The training courses developed by the Motorcycle Safety Foundation (MSF) are the most frequently used curricula in the United States (*3*). The two novice courses taught are the Motorcycle RiderCourse: Rider and Street Skills (MRC:RSS) and the Basic RiderCourse (BRC). The BRC is a more recent program that some states have adapted as their main curriculum, though many still use the MRC:RSS (*4*). Both courses involve training in a classroom and on a motorcycle. The classroom training incorporates information about how to safely operate the motorcycle on the road. Moreover, classroom training focuses on safety measures that motorcyclists can take to protect themselves and become more conspicuous to other drivers. The skills training includes the basic skills needed to safely operate a motorcycle, such as shifting, braking, and swerving. These are considered some of the more difficult maneuvers and are not easily mastered. The MSF courses are all taught by certified RiderCoaches, who undergo extensive training to become prepared to teach the courses (*5*).

Another novice course frequently offered is Harley-Davidson's Rider's Edge New Rider, which is based on the courses developed by the MSF. The course is offered at Harley-Davidson dealers and, upon its completion, the graduate is awarded a card stating that he has passed the MSF RiderCourse. This course also incorporates both knowledge and skill training (*6*). Moreover, some states, such as Oregon and Maine, have developed their own curriculum for training motorcyclists. These courses are generally based on the same curriculum as the MSF courses but are modified as the states see fit (*7*). The Motorcycle Training Program (MTP) in Canada offered in 1980, which was studied by Jonah et al., consisted of classroom, off-street, and on-street training (*8*).

Licensing is intertwined with rider education. Licensing procedures often encourage motorcyclists to seek formal training. Motorcycle training is mandatory for licensing in 19 states. In 16 states, training is only mandatory for riders through a certain age (either 18 or 21), and in three states training is required for new riders at any age (*9*). Different licensing procedures may also have an effect on motorcyclist safety. Graduated driver licensing for car drivers has been widely studied and accepted as an effective method of improving driver safety in cars. Much less is known about whether a graduated licensing system would be as effective for motorcyclists.

OBJECTIVE

This literature review aims to look at the effectiveness of motorcycle education courses, especially among the various training programs. The effectiveness of programs is examined through the effect that training had on accident rates, violation rates, and personal protective equipment use found through past research. Moreover, this study aims to review different motorcycle licensure systems and their effectiveness.

METHODS

The methods, findings, and conclusions of seven independent studies were compared to evaluate the effectiveness of motorcycle training. The studies examined several different outcome events that may be

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affected through training. These include the effect of training on accident rates, violation rates, and personal protective equipment use. Studies were selected that compared trained and untrained riders on the basis of accidents or violations. The Engineering Village search engine was used to search the Compendex, Ei Backfile, Inspec, Inspec Archive, and National Technical Information Service (NTIS) databases. Transportation Research Information Service (TRIS), Science Direct, and Medline were also used to search for relevant articles. Keywords included motorcycl*, training, effectiv*, and accident. A critical comparison was made between the findings of the different studies. Moreover, two other studies were examined to review the effects of different motorcycle licensing programs. The studies were analyzed in terms of the reported effects of different licensing systems on accident rates.

RESULTS

Effectiveness of Training Programs

The effectiveness of motorcycle training classes has been evaluated by several different studies. An overview of the studies is given in Table 1. No standard methods for evaluation exist. The studies vary greatly in the comparisons that are made and the effects that are examined. These previous studies usually used small sample groups, opening the possibility that the data do not accurately represent the population (*16*). Haworth et al. found that the evaluation of training courses is typically based on the number of accidents occurring in years following the training rather than on the curriculum itself (*16*).

Effect of Rider Training on Accidents

All the studies evaluated accident counts or accident rates as a metric of effectiveness of motorcycle training (Table 2). It should be noted that accident rates are a common, but not necessarily ideal, measure of training effectiveness. Accidents are infrequent and may have many causes besides training or rider skill. Nonetheless, several studies have shown that training produces a decline in accident rates. Billheimer analyzed California accident trends to see the effects of the introduction of a safety program in 1987 (*10*). The California Motorcyclist Safety Program (CMSP) was mandatory for all those under the age of 18 seeking a motorcycle license at the time of its introduction, though this age was increased to 21 in 1991. In the 9 years following the introduction of the program, the number of fatal motorcycle accidents dropped 69% (*10*). However, Billheimer suggests that several other factors besides the introduction of a mandatory training program may have influenced this decline. He notes that a mandatory helmet law was introduced in 1992. Also, the number of motorcycles sold during this time period declined (*10*). Also, U.S. motorcycle fatalities were declining nationally during the time period of this study (*1*). Therefore, the decrease cannot be solely attributed to the introduction of the CMSP.

Billheimer also completed a matched-pair study to examine the effects of motorcycle training by the CMSP. Trained and untrained riders were paired on the basis of age, sex, and riding experience to make a more accurate comparison between the two groups. It was found that there were fewer accidents per kilometer for trained riders with little experience before training as opposed to their untrained counterparts. Accident rates were calculated on the basis of distance traveled as reported by riders in the survey. However, both 1 and 2 years after the training period, no significant difference was found in accident rates between trained and untrained riders. Moreover, no significant difference in accident rates was seen between the trained riders with prior experience and their untrained equivalents (*10*). Billheimer concluded that those who had little to no experience before taking the course benefited most from it (*10*).

The British Columbia Safety Council's motorcycle safety training program was evaluated by McDavid et al. through a matched-pair

TABLE 1 Overview of Studies on Training Effectiveness

Author	Year	Course Evaluated	Method of Collection	Sample Size[a]	Method of Normalization	Metric of Effectiveness
Billheimer, J. W. (*10*)	1998	California Motorcyclist Safety Program (CMSP)[b]	Accident trends, interviews	T: 1,139 U: 1,139	Rider-reported miles ridden	Accidents Violations
Davis, C. F. (*11*)	1997	Connecticut Rider Education Program (CONREP)	Accident reports	T:9,320 U:41,680	Rider population	Accidents Accident severity Accident responsibility
Jonah, B. A. (*8*) Dawson, N. E. Bragg, B. W. E.	1982	Motorcycle Training Program (MTP)	Telephone interviews, driving records	T: 811 U: 1,080	Rider-reported miles ridden	Accidents Traffic violations
McDavid, J. C. (*12*) Lohrmann, B. A. Lohrmann, G.	1989	British Columbia's motorcycle safety program	Driving records	T: 139 U: 139	N/A	Motorcycle accidents Motor vehicle accidents
Mortimer, R. G. (*13*)	1984	MRC:RSS	Survey	T: 213 U: 303	Rider-reported miles ridden	Moving violation Accidents Cost of damage to motorcycle
Mortimer, R. G. (*14*)	1988	MRC:RSS	Survey	T: 913 U: 500	Rider population, rider-reported miles ridden	Protective equipment usage Accidents Violations Cost of damage and injury
Savolainen, P. T. (*15*) Mannering, F. L.	2007	BRC	Survey	1,327	N/A	Accident involvement

[a]T = trained, U = untrained.
[b]In California, training was mandatory for people under age 18 from 1988 to 1991. In 1991, training became mandatory for anyone who sought a motorcycle license and was under the age of 21.

TABLE 2 Findings of Studies Examining Effect of Rider Training on Accident Rates

Author	Year	Method of Control	Findings
Billheimer, J. W. (*10*)	1999	Matched-pair	Fewer accidents per kilometer 6 mo. after training for trained riders with <805 km of prior experience Similar number of accidents per kilometer 6 mo. after training for trained riders with >805 km of prior experience No difference in number of accidents per kilometer 1 and 2 years after training
Davis, C. F. (*11*)	1997	N/A	Fewer accidents per operator for CONREP graduates Accidents involving CONREP graduates were not as severe Accident responsibility was equally distributed between graduates and nongraduates.
Jonah, B. A. (*8*) Dawson, N. E. Bragg, B. W. E.	1982	Statistical	Fewer reported accidents by MTP graduates No effect on accidents seen between MTP and informally trained groups when controlled for sex, age, time licensed, distance traveled, education, and drinking
McDavid, J. C. (*12*) Lohrmann, B. A. Lohrmann, G.	1989	Matched-pair	Trained riders had fewer motor vehicle accidents. Trained riders tended to be in fewer and less severe motorcycle accidents.
Mortimer, R. G. (*13*)	1984	Statistical	Accidents per mile for those trained was not lower after age and years licensed had been controlled for.
Mortimer, R. G. (*14*)	1988	Statistical	Those trained did not have fewer accidents per mile.
Savolainen, P. T. (*15*) Mannering, F. L.	2007	Statistical	Increased number of accidents for those who were trained Increased number of accidents for those who were trained more than once

study (*12*). With an entirely male sample, they paired trained and untrained riders on the basis of age, month licensed, and number of automobile accidents involved in before licensing. All data were gathered from police-reported accidents, and fault was not considered in the analysis. According to McDavid et al., a statistical analysis that takes into account different factors, as was done in many other studies, is not accurate enough because of the variability in driving behavior between the people in the two groups. Pairing based on number of accidents before attaining a motorcycle license controls for this variable (*12*). The untrained group was found to have 32% more motor vehicle accidents than the trained group and 64% more motorcycle accidents during the first 5 years after licensing. Though the higher percentage of motor vehicle accidents was found to be statistically significant, the difference in percentage of motorcycle accidents was not. The number of accidents both in motor vehicles and in motorcycles decreased as the number of years ridden increased. Moreover, the accidents that trained riders were involved in were less severe. From these findings it appears that training produces desirable outcomes; however, because of the small sample size, no definite conclusions could be drawn (*12*).

The Connecticut Rider Education Program (CONREP) was evaluated by Davis (*11*), and he found that the number of accidents per rider was significantly lower for those who completed CONREP. The accident records for Connecticut were examined and the operators of the motorcycles involved in crashes were cross-referenced with a list of people who had completed CONREP. The accident rates of CONREP graduates and those who did not receive training were 0.0042 and 0.0196, respectively (*11*). It was also found that the accidents involving those who had completed CONREP were significantly less severe than those involving nongraduates. However, it was not concluded that graduates were responsible for fewer accidents than nongraduates (*11*).

Some studies have shown that existing training courses may not be effective or may even have negative effects. An evaluation by Jonah et al. of the MTP, a course offered throughout Canada, demonstrated that after controlling for confounding factors such as age, sex, time licensed, education, distance traveled, and alcohol use, there was no difference in accident rates between trained and untrained riders (*8*). Through a study conducted in Indiana, Savolainen and Mannering found that those who completed the BRC were 44% more likely to be involved in an accident (*15*). Moreover, those who took the course more than once were 180% more likely to be involved in an accident than untrained riders (*15*). Savolainen and Mannering offered several different possible explanations for this observation. First, the course may give riders the feeling of improved skill, increasing risk-taking behaviors because they are operating at the same perceived risk level. Alternatively, the course may be attracting a group of riders who are less skilled. Thus, the course may not be the cause of more people being in accidents; it is the inherent skill level of the people themselves. The last possibility is that the course itself may be ineffective (*15*).

Mortimer reviewed the effectiveness of the MRC:RSS in 1984 and found that 22.1% of those surveyed who had taken the motorcycle rider course reported being in a motorcycle accident during the 12 months before the study, whereas 16.2% of the untrained survey group reported being in an accident (*13*). The participants who were trained had taken the MRC:RSS less than 3 years before the survey and remained active motorcyclists. The control group was composed of people who were active motorcycle riders in the year before the survey. When the accident rates are calculated with distance ridden as reported by the riders in the survey, the accident rate for those who completed the training course was more than twice as great as the rate for the control group. For the trained group the rate was 103.5 accidents per million miles as opposed to 43.8 accidents per million miles for the control group (*13*). Moreover, for those who held a license for less than 2 years, there was no significant difference in accidents between the trained and untrained groups. This finding is significant because it is anticipated that the training will affect drivers most within the first 2 years of their receiving a license (*13*). Four years later, Mortimer repeated the same experiment with more than twice the sample size. The accident rates per million miles ridden for trained and untrained riders were 86.7 and 37.7, respectively (*14*). Though the rates for each group were less than those found in 1984, the trained riders still maintained a higher accident rate than untrained riders. After the rates were controlled for both age and number of years licensed, the trained group still had a higher accident rate than the untrained group. Last, it was again found that within the first 2 years of holding a license those who were trained did not have lower accident rates than those who were untrained (*14*).

TABLE 3 Findings of Studies Examining Effect of Rider Training on Violation Rates

Author	Year	Method of Control	Findings
Billheimer, J. W. (*10*)	1998	Matched-pair	Lower violations per kilometer 6 mo after training for trained riders with <805 km of prior experience Higher violations per kilometer 6 mo after training for trained riders with >805 km of prior experience
Jonah, B. A. (*8*) Dawson, N. E. Bragg, B. W. E.	1982	Statistical	Lower traffic violations seen among MTP graduates
Mortimer, R. G. (*13*)	1984	Statistical	No difference in violations per mile between trained and untrained riders
Mortimer, R. G. (*14*)	1988	Statistical	No difference in frequency of violations No difference in violations per mile

Effect of Rider Training on Violation Rates

Another means of evaluating the effectiveness of training programs is comparing the rates of traffic violations between trained and untrained motorcyclists. Violations are more frequent than accidents and can provide further insight into driving behaviors. It is expected that there would be lower violation rates among trained riders because they should have a better understanding of, as well as more respect for, the laws of the road (*8*). However, as with accident rates, the reported effect of training on traffic violation rates also varies across several studies (Table 3).

Billheimer states that those who were novice riders and completed the CMSP "tended" to have lower violation rates than their untrained counterparts, though the differences were not found to be statistically significant (*10*). After controlling for factors that may cause variability in driving attitudes, Jonah et al. found that those who completed the MTP were also less likely to be involved in traffic violations (*8*). In contrast, Mortimer found, in both of his studies, that there was no statistically significant difference between violation rates of trained and untrained riders (*13, 14*). Moreover, Billheimer found that more experienced riders—those with more than 805 km of riding experience—tended to have higher violation rates, which may be an indicator that some experienced riders are more willing to take risks. This conclusion was not, however, found to be statistically significant (*10*).

Effect of Rider Training on Personal Protection Equipment Use

Riders who received training were found to be more likely to use personal protective equipment while riding (Table 4). Mortimer observed that those who received training wore protective equipment while riding more often than those who did not. However, Mortimer also noted that riders who received training were more likely to wear their seatbelt while driving a car (*13, 14*). Thus, this observation may be a reflection of the nature of those who seek training (*13*). In a study completed in Indiana, Savolainen and Mannering found that only 5% of those who received training never wore their helmet as opposed to the 14% of untrained riders who did not wear a helmet (*15*). It should be noted that over 55% of the people included in this study were members of the American Bikers Aimed Towards Education (ABATE) of Indiana (*15*). The ABATE organization opposes mandatory helmet laws (*17*), but it is unknown whether those individual members who were surveyed share this position.

Limitations of Studies

Comparison of the findings of the studies is not straightforward because the methodology, outcome metric, and even the curricula vary from study to study. There is no standard method for evaluating training effectiveness. The limitations of the methodologies used in the studies reviewed earlier are examined next.

Differences in Curricula According to Haworth et al., one common flaw in studying the effectiveness of motorcycle training has been the failure to directly examine the teaching methods used. Instead, many studies focus on the outcome events that may be influenced by training, such as accident and injury rates (*16*). These studies do not take into account the inherent differences in curricula, training sites, and instructors (*18*).

Forty-seven states offer government-sponsored motorcycle training programs (*4*). Most states offer one of the two MSF courses, either the MRC:RSS or the BRC. Some states offer a curriculum that is unique to the state; however, it is generally based on the

TABLE 4 Findings of Studies Examining Effect of Rider Training on Use of Personal Protective Equipment

Author	Year	Method of Control	Findings
Mortimer, R. G. (*13*)	1984	Statistical	Trained riders used personal protective equipment more. Trained riders used seatbelt more often in a motor vehicle than untrained riders.
Mortimer, R. G. (*14*)	1988	Statistical	Trained riders used personal protective equipment more. Trained riders used seatbelt more often in a motor vehicle than untrained riders.
Savolainen, P. T. (*15*) Mannering, F. L.	2007	Statistical	Trained riders used helmets more frequently, though it should be noted that about 55% of those surveyed were ABATE members.

same curriculum as the MSF courses (*7*). Baldi et al. evaluated the government-sponsored training programs in each state on the basis of three main categories: administration, education, and licensing. Each category contained subcategories upon which each state's program was evaluated, and states were scored on the basis of these criteria. The categories and effective practices were based on suggestions made in the National Agenda for Motorcycle Safety (NAMS). The administration and licensing categories evaluated the organization of the course and integration of licensing into the course. The education category assessed the quality of the course itself. This category was broken down into subcategories of sound curricula, effective training and delivery, outreach and information efforts, incentives for training, regular program assessments and quality control, and instructor education and teaching (*18*). There was a range of scores, and this variance represents differences in the effectiveness of each state's program. The same curricula, when presented at different training sites, can differ in effectiveness.

Bias of Self-Selection Most motorcycle training programs are not mandatory. The set of riders who choose to take motorcycle training may not be representative of the entire population of riders. Several studies (*8, 11, 13, 14*) have concluded that riders who choose training tend to be more conscious of safety than those who do not seek formal training. Mortimer questioned participants about how frequently they use a seat belt while operating a motor vehicle. In both studies, the percentage of trained riders who reported consistent use of a seat belt was higher than both the percentage of untrained riders and the average percentage of people in the state who expressed consistent use of a seat belt (*13, 14*). The effects of this bias should be in favor of the training program. Since those enrolled in the course are more conscious of safety, there should be lower accident rates among the trained group (*8*).

It is also possible that those who seek training are inherently not as good at motorcycling as those who do not seek training (*15*). Also, Savolainen and Mannering noted that those who expressed no need to take a training course were 51% less likely to be involved in an accident (*15*). Seeking training may then be a result of a lesser skill level, favoring the notion that those who are trained are more likely to be involved in an accident.

One method used in an attempt to eliminate this bias is matching trained and untrained riders on the basis of significant similarities such as age, sex, and years riding or licensed (*10, 12*). McDavid et al. also paired riders on the basis of the number of accidents they were involved in before receiving a motorcycle license (*12*). It was assumed that having a similar driving record implied a similar level of safety while driving. The notion is that this approach should equalize the levels of risk taking and safety consciousness of riders in the experimental and control groups. The matched-pair approach suffers from two drawbacks. First, the method makes the assumption that the researcher knows a priori what factors to control for. Other factors, for example, years of education, weekly alcohol consumption, or vision acuity, may or may not be more important. Second, because subjects are picked manually by the researcher rather than through random selection, these choices are subject to the unintentional prejudices of the researcher.

Nonrepresentative Samples Many of the studies acquired information through surveys and interviews. Not all riders will take the time to complete a survey or participate in an interview. These studies rely on that subgroup of riders who self-select to participate. This selection is evident in the response rates reported in the studies. Mortimer mailed surveys to people who completed the BRC to compile his experimental group and interviewed riders at motorcycle stores to compile the control group (*13, 14*). The study was conducted in both 1984 and 1988 and the response rates for the surveys were 59.2% and 56%, respectively (*13, 14*). The response rate for the control group was over 90% in both studies.

Jonah et al. conducted telephone interviews to gather data for both the trained and untrained groups and the response rates were 57% and 71%, respectively (*8*). Savolainen and Mannering mailed surveys to members of ABATE of Indiana and a control group. The response rate for ABATE members was 14%, with 181 additional surveys gathered from the ABATE of Indiana newsletter. It is thought that the low response rate was due to mailings to outdated addresses. The response rate for the control group, however, was 14.7% (*15*). These are just a sample of some of the response rates from the surveys. Because a large fraction of those surveyed did not respond, there is potentially a nonresponse bias in the results of these studies. The nonrespondents may be a different group with different riding and accident experiences than the respondent group.

Licensure

Licensing is interconnected with rider education; motorcycle licensing procedures often encourage motorcyclists to seek formal training. Many aspects of licensing are facilitated through the completion of a motorcycle training course. Some states waive testing procedures for those who have completed an approved course (*4*). As demonstrated earlier, this incentive motivates people to seek training.

Even though a motorcycle license is required in all 50 states and the District of Columbia (*19*) as well as in New Zealand, Australia, and other countries (*16, 20*), motorcyclists without a motorcycle endorsement account for a large portion of those who are involved in motorcycle accidents. In Maryland, 17% of motorcycle owners do not possess a motorcycle license; however, 27% of motorcyclists involved in accidents were unlicensed (*21*). In a study conducted in southern California in the 1970s, Hurt et al. found that unlicensed motorcyclists accounted for 25% of the riders but 50% of all motorcycle crashes (*22*). In 2005, 8% of New South Wales riders involved in accidents were not licensed to ride a motorcycle, though they were involved in 32% of fatal accidents (*23*). Licensing procedures vary among the different states as well as among different countries. Most states in the United States do not have a graduated licensing system for motorcycle riders; however, this system is more widely used in other countries such as New Zealand and Australia.

Licensing Systems

Each state has different requirements to obtain a motorcycle license. In 2004, 46 states and the District of Columbia required operators to hold a permit before they could acquire a motorcycle license. However, restrictions placed on permits vary by state. According to McGwin, Jr., et al., the three restrictions most frequently placed on permit holders among the states are no passengers or night riding and no using the motorcycle without a helmet (*19*). Fifteen states have a graduated licensing system similar to those currently in place for automobile drivers. Tiered motorcycle licensing programs are in place in nine states (*24*). Tiered licensing places restrictions on motorcycle operation based on engine displacement (*3*).

The procedure to obtain a motorcycle license in Victoria, Australia, has three steps. First, a learner permit is held for at least 3 months. Then a skills test is taken to obtain a restricted license, which is held for a year. The restricted license can be upgraded to an unrestricted license without any further testing. Restrictions on the learner's permit and the restricted license include a maximum engine size of 260 cubic centimeters and a zero BAC level. In order to obtain a restricted license, the seeker must complete a licensing training course (*16*). The motorcycle licensing process is similar in New South Wales, Australia. However, as of 1990, training was required before both the learner's license and the provisional license are received, where the provisional license is the equivalent of the restricted license in Victoria. The duration of holding each license is slightly different, requiring the learner's permit to be held for 3 months and the provisional license to be held for 1 year (*23*). A similar graduated system was enacted in New Zealand in 1987 (*20*).

Effect of Different Licensing Systems on Accident Rates

Accident rates and the licensing system in place in a locality are correlated (Table 5). In the United States, McGwin, Jr., et al. (*19*) found that states requiring a training course for licensing tended to have lower fatality rates based on the estimated vehicle miles traveled (VMT). Moreover, the number of fatal accidents per miles traveled was significantly lower in states where a system with a restricted permit was implemented as opposed to states with an unrestricted permit. Also, states that (*a*) require a skills test to attain a permit, (*b*) mandate a longer duration of time between receiving a permit and obtaining a license, or (*c*) place three or more restrictions on permit holders have a lower motorcyclist fatality rate than other states when the number of accidents per miles traveled is compared (*19*).

It should be noted that the VMT estimated by FHWA for motorcycles may be underestimated. In North Carolina, it was found that the VMT as reported by FHWA differed from the VMT reported by the state starting in 1998 and increased in the following years (*25*). Also, a telephone survey was completed to verify the estimated VMT, and the reported VMT was more than two times greater than the estimated VMT (*25*). The underestimated VMT would make the accident rates calculated with these data artificially high. However, the rates for other types of vehicles, such as automobiles, are more accurate. The inaccuracy in the estimated VMT proves a problem when motorcycle accident rates are compared with accident rates for other motor vehicles. It is anticipated that the inaccuracy should not greatly affect a comparison between accident rates of trained and untrained motorcyclists in the same area and time frame since they are both calculated with the same data.

The effects of the New Zealand graduated licensing system on the accident rates were studied to determine the impact of the system. Data from 1978 to 1994 were examined in the study. It was found that the number of riders between the ages of 15 and 19 who were involved in a crash decreased between 1984 and 1993. Moreover, there was an observed 22% decrease in hospitalizations for people in this age group after the graduated licensing system was enacted. As anticipated, accidents and hospitalizations decreased the most for the 15- to 19-year-old age group as compared with the groups 20 to 24 years old and 25 years old and above. However, during this same period, there was also a decline in the number of people aged 15 to 19 years old who owned motorcycles (*20*), making this study inconclusive.

DISCUSSION OF RESULTS

The divided support for motorcycle training between the studies may seem surprising. Like drivers' education, there is a common assumption that training should produce safer riders. However, in a review of driver education, Mayhew found no clear evidence that such education is effective (*2*). The DeKalb study, published in 1983, is the largest and most thorough review of driver education (*2*). The study demonstrated that the effects of such training were minor and not lasting (*26*, *2*). Though driver education and motorcycle training cannot be directly compared, many of the studies reviewed here have also questioned the value of motorcyclist training. Previous research has addressed several of the assumptions regarding the effectiveness of such training.

One common assumption is that trained motorcyclists have fewer accidents. A review of the literature shows that there is no consensus for the validity of this assumption. McDavid et al. found that trained riders tended to have fewer and less severe motorcycle accidents (*12*). Davis found that motorcyclists with training had fewer accidents per person than untrained riders (*11*). Billheimer demonstrated that in the first 6 months following training, riders with little experience before training tended to have fewer accidents than untrained riders with a similar amount of experience. However, after this time period,

TABLE 5 Findings of Studies Examining Effect of Licensing on Accident Rates

Author	Year	Location	Licensing System	Metric of Effectiveness	Findings
McGwin, Jr., G. (*19*) Whatley, J. Metzger, J. Valent, F. Barbone, F. Rue III, L. W.	2004	United States	Various	Mortality rate based on VMT	When comparing miles ridden, lower mortality rate in states that Required a skill test to obtain a permit, Placed three or more restrictions on the permit, and Required a longer permit holding period When comparing number of riders, lower mortality rate in states that required training for licensure
Reeder, A. I. (*20*) Alsop, J. C. Langley, J. D. Wagenaar, A. C.	1999	New Zealand	Graduated	Hospitalization due to motorcycle accidents	22% decrease for 15- to 19-year-old hospitalizations Decrease in the number of licensed 15- to 19-year olds General trends before implementation of GDLS were down, and no great effect seen by the start of the GDLS.

GDLS = graduated driver licensing system.

there was little difference in the accident rates (*10*). For riders with more experience before completing training, no significant differences were observed in accident rates at any time (*10*). After statistically controlling for factors that may influence accidents, Jonah et al. found there to be no difference in accident rates between trained and untrained riders (*8*). Mortimer came to the same conclusion in both his studies (*13, 14*). Savolainen and Mannering reported that trained riders had an increased accident rate (*15*). On the basis of the current findings, the assumption that training decreases accident involvement cannot be wholly accepted as true.

Another common assumption about motorcycle training is that there will be a decrease in traffic violation rates. Again, the literature provides a mixed review on the validity of this assumption. McDavid et al. demonstrated that trained riders had fewer violations (*12*). Likewise, Billheimer found that those with little experience before training tended to have lower violation rates. However, he also found that those with greater prior experience exhibited higher violation rates (*10*). Similarly, Mortimer found no difference in violation rates between trained and untrained riders (*13, 14*).

An increased use of personal protective equipment is another supposition made about training. Both of the Mortimer studies concluded that trained riders used personal protective equipment more often than untrained riders (*13, 14*). Savolainen and Mannering also found that trained riders used helmets more frequently (*15*). Thus, the literature supports this benefit of training.

Last, a common assumption about licensing is that graduated licensing systems are effective in reducing accidents and their severity. In the United States, many states do not have graduated licensing for motorcyclists. However, McGwin, Jr., et al. found that there were fewer motorcyclist fatalities in states with longer permit-holding periods (*19*). This finding supports the notion that those who are allotted more time to practice before receiving an unrestricted license, as is the case with a graduated licensing system, are less likely to be involved in a severe accident. A study conducted by Reeder et al. on the effectiveness of a graduated licensing system in New Zealand was inconclusive (*20*).

LIMITATIONS OF STUDIES

The evaluation of training and licensing effectiveness is not a straightforward exercise. Many of the studies examined in this review had shortcomings. Following is a summary of the limitations of the studies reviewed here and recommendations for improvements for future effectiveness studies:

- Random samples versus biased samples. Ideally, studies should be conducted on the basis of random sampling. Only in this manner can a sample be assured to capture all the variation in the motorcycling population. Riders who choose to respond to a survey may not be representative of the population of all riders. They may respond, for example, because they are motivated by having suffered an accident. Equally suspect are samples of convenience in which a group of riders is selected for survey not because the sample is representative of all riders but because it is convenient to survey. A sample of convenience would include riders surveyed because they are in a class or because their names are on an organization's readily obtainable mailing list. Riders who voluntarily choose training may have self-selected to be in the class for reasons ranging from being less skilled to simply being more safety-conscious than the general population of motorcycle riders.
- Surveys versus interviews. Surveys with low response rates are subject to nonresponse bias. Nonrespondents may have had very different riding experiences than respondents. A much improved method of collecting personal data would be through on-site interviews, because the response rate would be much higher.
- Researcher bias. A matched-pair sample is questionable because pairing people assumes that the researcher knows what factors essentially make them equal enough to be directly compared. The factors chosen to match the riders are subject to the conscious and unconscious biases of the individual researcher. One possible way of eliminating a sample bias would be to include all possible subjects and look at the sample over a period of time, including time both before and after training.
- Outcome metrics. The ideal study would consider another means of evaluation than accidents. Accidents are relatively rare and may not be based on the skill of the rider. The use of violation counts or rates, although still not representative of the entire skill set of the motorcyclist, would provide more insight into motorcycle trends since there are more violations than accidents. Also, the denominator for rates needs to be carefully chosen and computed. As discussed earlier, current VMT data are faulty, making rates artificially high, so a different measure for comparison should be chosen.
- All training courses are not equivalent. Not all training is equal because not all trainers and training sites are equally proficient in teaching the material of the course.

An ideal study would use a random sample, base conclusions on factors other than accident rates, and choose an appropriate method for calculating rates. These ideal conditions would be challenging to attain but would lead to a more conclusive assessment of training and licensing effectiveness.

CONCLUSION

Research to date has not consistently supported the notion that training is either effective or ineffective. No standard methods for evaluation exist, and studies vary greatly in the comparisons that are made and the effects of training that are investigated. Many studies have evaluated the effectiveness of training programs through a comparison of the accident rates between trained and untrained riders. Some studies have demonstrated that motorcycle training is effective (*7, 10–12, 18,*), whereas other studies have demonstrated that it is ineffective (*8, 13–15*). However, not all training offered is equal; different curricula and different motivators for receiving training exist. Motorcycle education has proved to be effective in increasing the usage of personal protective equipment. Trained riders were found to use personal protective equipment more often than untrained riders (*13, 15*).

Licensing systems were also found to have an effect on motorcycle accidents. Licensing systems, which increase the amount of supervised practice time motorcyclists must complete before receiving an unrestricted license, were shown to result in lower accident rates.

The conclusions of this review are based on a limited number of studies. A great variability exists between different studies because of the methods used and consequences of training that are examined. One of the major findings of this review is that many of the studies suffered from methodological shortcomings that cast varying degrees of doubt on their findings. A number of limitations in these previous studies were identified, and elements that should be incorporated into future effectiveness studies were recommended. The results of these previ-

ous studies may be more a reflection of the methods used to evaluate motorcycle training than the effectiveness of training itself.

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