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New Jersey Motorcycle Fatality Rates

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Submitted by

Yusuf Mehta, Ph.D., P.E.
Associate Professor
Department of Civil and Environmental Engineering
Rowan University

Hampton C. Gabler, Ph.D.
Allison Daniello
Kimberly Swanseen
Department of Mechanical Engineering
Virginia Tech

NJDOT Research Project Manager
Edward Stephen Kondrath

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16. Abstract

Motorcycle crashes have been increasing in recent years, more than doubling since 1991. In 2007 there were 84 fatal motorcycle crashes in New Jersey. This report describes the methods and findings of an investigation of motorcycle crashes in New Jersey. An additional analysis of guardrail collisions is reported since these crashes have demonstrated to be more severe for motorcyclists than passengers of other vehicles. Lastly, this report provides specific recommendations for reducing the number and severity of motorcycle crashes in New Jersey.

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Table of Contents

List of Figures

List of Tables

1. Introduction and Background

Motorcyclists are vulnerable users of the road since motorcycles do not provide the same protection as cars or other vehicles. Moreover, motorcyclists are less conspicuous on the road, making them harder to see for car and truck drivers. The number of motorcycle fatalities has increased in recent years, and has doubled since 1991 [1], as shown in Figure 1. In 2007, there were 84 motorcyclist fatalities in New Jersey.

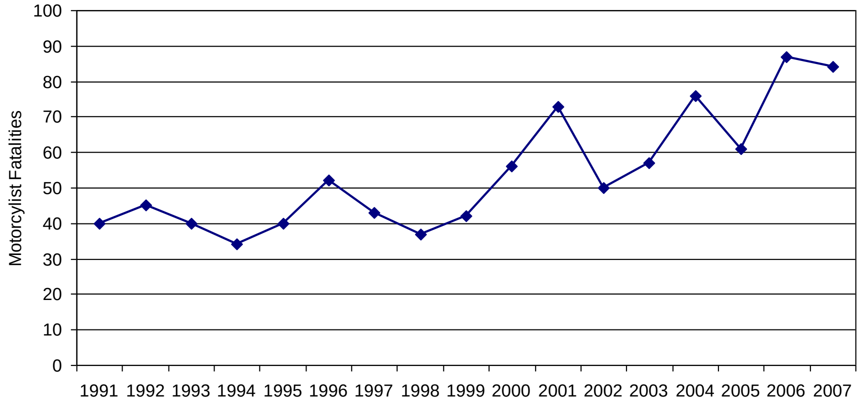

Figure 1. Annual Motorcycle Fatalities in New Jersey (1991-2007)

Motorcycle crashes are caused by a combination of different factors, including motorcyclist behavior and experience, other driver behavior, and the road environment. The behavior of the motorcyclist has an influence on the outcome of motorcycle crashes. In 2006, 12% of motorcyclists fatally injured in motorcycle crashes in New Jersey were either wearing an unapproved helmet or not wearing a helmet at all. Drinking and riding also has a large influence on motorcycle crashes; 31% of fatal crashes in New Jersey in 2006 involved an intoxicated motorcyclist. The experience of a motorcyclist influences the avoidance or causation of crashes. With experience comes skills such as negotiating a curve, swerving, and avoidance maneuvers.

Aside from the behavior of the motorcyclist, the behaviors of car and truck drivers have a large influence on motorcycle crashes. Frequently, other drivers report not having seen the motorcyclist before a crash. Other drivers also might not consider limitations that motorcyclists have due to the instability of the motorcycle and drive around motorcycles as they would around other road users. However, special precautions should be taken while driving around motorcycles.

The design of the road also plays an important role in the severity of motorcycle crashes. Roadside collisions are frequently much more severe for motorcyclists than for users of other vehicles; motorcycles provide significantly less protection for a motorcycle than other vehicles. Nationally, there are more fatal motorcycle-guardrail collisions than fatal car-guardrail collisions [2]. Roadways are not typically designed with the special needs of motorcyclists in mind, as design factors that provide more safety to users of other vehicles may be more hazardous to motorcyclists.

2. Literature Review of Rider Training Effectiveness

Summary

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 paper 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 usage 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 untrained riders, while others demonstrated that they are higher for trained riders. Training increases the use of personal protective equipment amongst 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 varied 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 rather the effectiveness of training itself.

Introduction

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 policymakers however because of what Mayhew [3] 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. This chapter reviews previous studies on the effectiveness of motorcycle training programs at improving rider safety.

The training courses developed by the Motorcycle Safety Foundation (MSF) are the most frequently used curricula in the United States [4]. 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 [5]. 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 [6].

Another novice course frequently offered is Harley-Davidson's *Rider's Edge* New Rider course, which is based on the courses developed by the MSF. The course is offered at Harley-Davidson dealers and, upon completion of the course, the graduate is awarded a card stating they have passed the MSF RiderCourse. This course also incorporates both knowledge and skill training [7]. 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 [8]. The Motorcycle Training Program in Canada offered in 1980, which was studied by Jonah et al., consisted of classroom, off-street, and on-street training [9].

Licensing is intertwined with rider education. Licensing procedures often encourage motorcyclists to seek formal training. Motorcycle training is mandatory for licensing in nineteen 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 [10]. 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 amongst the various training programs. The effectiveness of programs is examined through the effect that training had on accident rates, violation rates, and the personal protective equipment usage 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 affected through training. These include the effect of training on accident rates, violation rates, and personal protective equipment usage. Studies were selected that compared trained and untrained riders based on accidents or violations. Engineering Village search engine was used to search the Compendex, Ei Backfile, Inspec, Inspec Archive, and NTIS databases. 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 different licensing systems had 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 have usually used small sample groups, opening the possibility that the data does not accurately represent the population [11]. 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 [11].

Table 1. Overview of Studies on Training Effectiveness

Author(s)	Year	Course Evaluated	Method of Collection	Sample Size[1]	Method of Normal-ization	Metric of Effectiveness
Billheimer, J. H.	1999	California Motorcyclist Safety Program (CMSP)[2]	Accident Trends, Interviews	T: 1139 U: 1139	Rider-reported miles ridden	*Accidents *Violations
Davis, C.F.	1997	Connecticut Rider Education Program (CONREP)	Accident Reports	T:9320 U:41680	Rider Population	*Accidents *Accident Severity *Accident Responsibility
Jonah, B. A. Dawson, N. E. Bragg, B. W. E.	1982	Motorcycle Training Program (MTP)	Telephone Interviews, Driving Records	T: 811 U: 1080	Rider-reported miles ridden	* Accidents * Traffic violations
McDavid, J. C. 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.	1984	MRC:RSS	Survey	T: 213 U: 303	Rider-reported miles ridden	* Moving violation * Accidents * Cost of damage to motorcycle
Mortimer, R. G.	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. Mannering, F.	2007	BRC	Survey	1327	N/A	* Accident involvement

[1]T = Trained, U = Untrained
[2]In California, training was mandatory for people under age 18 from 1988-1991. In 1991, training became mandatory for anyone seeking their motorcycle license and was under the age of 21.

Effect of Rider Training on Accidents

All of 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 [12]. The California Motorcyclist Safety Program (CMSP) was mandatory for all people under the age of eighteen seeking a motorcycle license at the time of its introduction, though this age was increased to twenty-one in 1991. In the nine years following the introduction of the program, the number of fatal motorcycle accidents dropped 69% [12]. However, Billheimer suggests 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 [12]. 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 based on age, sex, and riding experience to make a more accurate comparison between the two groups. It was found that there were fewer accidents per kilometers for trained riders with little experience before training as opposed to their untrained counterparts. Accident rates were calculated based on distance traveled as reported by riders in the survey. However, both one and two years after the training period, there was no significant difference 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 [12]. Billheimer concluded that those who had little to no experience prior to taking the course benefited most from it [12].

The British Columbia Safety Council’s motorcycle safety training program was evaluated by McDavid, Lohrmann, and Lohrmann through a matched-pair study [13]. Using an entirely male sample, they paired trained and untrained riders based on age, month licensed, and number of automobile accidents involved in before licensing. All data was gathered from police reported accidents and fault was not considered in the analysis. According to McDavid et al., a statistical analysis which takes into account different factors, as done in many other studies, is not accurate enough due to 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 [13]. The untrained group was found to have 32% more motor vehicle accidents than the trained group and 64% more motorcycle accidents during the first five 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 on motor vehicles and 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, due to the small sample size, no definite conclusions could be drawn [13].

The Connecticut Rider Education Program (CONREP) was evaluated by Davis, and he found that the number of accidents per rider were significantly lower for those who completed CONREP [14]. 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 [14]. It was also found that the accidents involving people who completed CONREP were significantly less severe than those involving non-graduates. However, it was not concluded that graduates were responsible for fewer accidents than non-graduates [14].

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 Motorcycle Training Program, a course offered throughout Canada, demonstrated that, after controlling for confounding factors such as age, sex, time licensed, education, distance traveled, and alcohol usage, there was no difference in accident rates between trained and untrained riders [9]. 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 and found that 22.1% of those surveyed who had taken the motorcycle rider course reported being in a motorcycle accident during the twelve months prior to the study, whereas 16.2% of the untrained survey group reported being in an accident [16]. The participants who were trained had taken the MRC:RSS less than three years prior to the survey and remained active motorcyclists. The control group was composed of people who were active motorcycle riders in the year prior to the survey. When the accident rates are calculated using 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 [16]. Moreover, for those who held a license for less than two years, there was no significant difference in accidents between the trained and untrained groups. This is significant because it is anticipated that the training will affect drivers most within the first two years of receiving a license [16]. 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 [17]. 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. Lastly, it was again found that within the first two years of holding a license those who were trained did not have lower accident rates than those who were untrained [17].

Table 2. Findings of Studies Examining the Effect of Training on Accident Rates

Author(s)	Year	Method of Control	Findings
Billheimer, J. H.	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 accident per kilometer 1 and 2 years after training
Davis, C.F.	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 non-graduates
Jonah, B. A. Dawson, N. E. Bragg, B. W. E.	1982	Statistical	* Fewer reported accidents by MTP graduates * No effect on accidents seen between MTP and IT groups when controlled for sex, age, time licensed, distance traveled, education, and drinking
McDavid, J. C. 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.	1984	Statistical	* Accidents per mile for trained were not lower after age and years licensed had been controlled for
Mortimer, R. G.	1988	Statistical	* Trained did not have fewer accidents per mile
Savolainen, P. Mannering, F.	2007	Statistical	* Increased number of accidents for those who were trained * Increased number of accidents for those who were trained more than once

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 [9]. However, as with accident rates, the reported effects 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 [12]. After controlling for factors that may cause variability in driving attitudes, Jonah et al. found that those who completed the Motorcycle Training Program were also less likely to be involved in traffic violations [9]. In contrast, Mortimer found, in both of his studies, that there was no statistically significant difference between violation rates of trained and untrained riders [16], [17]. 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 [12].

Table 3. Findings of Studies Examining the Effect of Training on Violation Rates

Author(s)	Year	Method of Control	Findings
Billheimer, J. H.	1999	Matched-pair	* Lower violations per kilometer 6 mo. after training for trained riders with <805 km of prior experience * Higher violations per mile 6 mo. after training for trained riders with >805 km of prior experience
Jonah, B. A. Dawson, N. E. Bragg, B. W. E.	1982	Statistical	* Lower traffic violations seen amongst MTP graduates
Mortimer, R. G.	1984	Statistical	* No difference in violations per mile between trained and untrained riders
Mortimer, R. G.	1988	Statistical	* No difference in frequency of violations * No difference in violations per mile

Effect of Rider Training on Personal Protection Equipment Usage

Riders who received training were found to be more likely to use personal protective equipment while riding (Table 4). Mortimer observed that people 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 [16], [17]. Thus, this observation may be a reflection of the nature of those who seek training [16]. 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 ABATE of Indiana [15]. The ABATE organization opposes mandatory helmet laws [18], but it is unknown whether those individual members who were surveyed share this position.

Table 4. Findings of Studies Examining the Effect of Training on Usage of Personal Protective Equipment

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

Limitations of Studies

Comparison of the findings of the studies is not straightforward as the methodology, outcome metric, and even the curricula vary from study to study. There is no standard method for evaluating training effectiveness. The following section examines the limitations of the methodologies used in the studies reviewed above.

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 [11]. These studies do not take into account the inherent differences in curricula, training sites, and instructors [19].

Forty-seven states offer government-sponsored motorcycle training programs [5]. 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 same basic curriculum as the MSF courses [8]. Baldi et al. evaluated the government sponsored training programs in each state based on three main categories: administration, education, and licensing. Each category contained subcategories upon which each state's program was evaluated, and states were scored based on 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 [19]. The scores of the states ranged and this variance represent variations 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 [9], [14], [16], [17] 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 seatbelt while operating a motor vehicle. In both studies, the percentage of trained riders that 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 that expressed consistent use of a seat belt [16], [17]. 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 amongst the trained group [9].

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 based on significant similarities such as age, sex, and years riding or licensed [12], [13]. McDavid et al. also paired riders based on the number of accidents they were involved in before receiving a motorcycle license [13]. 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.

Non-representative 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 [16], [17]. The study was conducted in both 1984 and 1988 and the response rates for the surveys were 59.2% and 56% respectively [16], [17]. 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 [9]. Savolainen and Mannering mailed surveys to members of the American Bikers Aimed Towards Education (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 anticipated that the low response rate is 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 non-response bias in the results of these studies. The non-respondents may be a very different group with very different riding and accident experiences than the respondent group.

Licensure

Licensing is intertwined 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 [5]. As demonstrated above, this incentive motivates people to seek training.

Even though a motorcycle license is required in all 50 states and the District of Columbia [20] as well as in New Zealand, Australia, and other countries [11], [21], motorcyclists without a motorcycle endorsement account for a large portion of people 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 [22]. In a study conducted in southern California in the 1970's, Hurt et al found that unlicensed motorcyclists accounted for 25% of the riders but 50% of all motorcycle crashes [23]. 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 [24]. Licensing procedures vary between the different states as well as amongst different countries. Most states in the United States do not have a graduated licensing system established for motorcycle riders; however, this 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 require operators to hold a permit before they can 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 amongst the states are no passengers or night riding and a helmet must be in use at all times [20]. 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 [25]. Tiered licensing places operating restrictions on motorcycle operation based upon engine displacement [4].

The procedure to obtain a motorcycle license in Victoria, Australia has three steps. First, a learner permit is held for at least three 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 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 [11]. The motorcycle licensing process is similar in New South Wales, Australia. However, as of 1990, training is required before receiving both the learner's license and the provisional license, 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 three months and the provisional license to be held for one year [24]. A similar graduated system was enacted in New Zealand in 1987 [21].

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 found that states requiring a training course for licensing tended to have lower fatality rates based on the estimated VMT. Moreover, the number of fatal accidents per miles travelled 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 require a skills test to attain a permit, mandate a longer duration of time between receiving a permit and obtaining a license, or place three or more restrictions on permit holders have a lower motorcyclist fatality rate than other states when comparing the number of accidents per miles traveled [20].

It should be noted that the VMT estimated by the Federal Highway Administration (FHWA) for motorcycles may be underestimated. In North Carolina, it was found that the VMT as reported by the FHWA differed from the VMT reported by the state starting in 1998 and increasing in the following years [26]. 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 [26]. The underestimated VMT would make the accident rates calculated using 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 comparing motorcycle accident rates to 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 using the same data.

The effects of the New Zealand graduated licensing system 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 age of 15 and 19 who were involved in a crash decreased between 1984 and 1993. Moreover, there was an observed 22% decrease in hospitalization 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 to the 20-24 year old and the 25 year old and above groups. However, during this same period, there was also a decline in the number of people aged 15-19 years old who owned motorcycles [21], making this study inconclusive.

Table 5. Findings of Studies Examining the Effect of Licensing on Accident Rates

Author(s)	Year	Location	Licensing System	Metric of Effective-ness	Findings
McGwin, Jr., G. 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 * Required a longer permit holding period When comparing number of riders, lower mortality rate in states that * Required training for licensure
Reeder, A.I. Alsop, J.C. Langley, J.D. Wagenaar, A.C.	1999	New Zealand	Graduated	Hospitalization due to motorcycle accidents	* 22% decrease for 15-19 year old hospitalizations * Decrease in the number of licensed 15-19 year olds * General trends before implementation of GDLS were down and no great effect seen by the start of the GDLS

Discussion

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 driver education is effective [3]. The “DeKalb” study, published in 1983, is the largest and most thorough review of driver education [3]. The study demonstrated that the effects of driver education were minor and not lasting [27] cited in [3]. Though driver education and motorcycle training cannot be directly compared, many of the studies reviewed in this paper have also questioned the value of motorcyclist training.

Previous research has addressed several of the assumptions regarding motorcycle training effectiveness. 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 [13]. Davis found that motorcyclists with training had fewer accidents per person than untrained riders [14]. Billheimer demonstrated that, in the first six 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, there was little difference in the accident rates [12]. For riders with more experience before completing training, no significant differences were observed in accident rates at any time [12]. 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 [9]. Likewise, Mortimer came to the same conclusion in both his studies [16], [17]. Savolainen and Mannering reported that trained riders had an increased accident rate [15]. Based on the current findings, the assumption that training decreases accident involvement cannot be wholly accepted as true.

Another common assumption about motorcycle training is 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 [13]. Likewise, Billheimer found that those with little experience prior to training tended to have lower violation rates. However, he also found that those with greater prior experience exhibited higher violation rates [12]. Similarly, Mortimer found no difference in violation rates between trained and untrained riders [16], [17].

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 [16], [17]. Savolainen and Mannering also found that trained riders used helmets more frequently [15]. Thus, the literature supports this benefit of training.

Lastly, 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 [20]. This suggests 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 [21].

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:

- <u>Random Samples vs. Biased Samples</u>. Ideally, studies should be conducted based upon 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 consciousness than the general population of motorcycle riders.

- Surveys vs. Interviews. Surveys with low response rates are suspect to non-response bias. Non-respondents 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 match-pair sample is questionable because pairing people assumes that the researcher knows what factors essentially make people “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 other than accidents. Accidents are relatively rare, and may not be based on the skill of the rider. The use of violations counts or rates, while 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 above, current VMT data is faulty, making rates artificially high, so a different measure for comparison should be chosen.

- All Training Courses are not Equivalent. Lastly, 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 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 [8], [12]-[14], [19], while other studies have demonstrated that it is ineffective [9], [15]-[17]. However, not all training offered is equal; different curricula and different motivators for receiving training exist. Motorcycle education has proven to be effective in increasing the usage of personal protective equipment. Trained riders were found to make use of personal protective equipment more often than untrained riders [15], [16].

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 paper are based upon the review of a limited number of studies. There exists a great variability between different studies due to 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 which cast varying degrees of doubt on their findings. This paper has identified a number of limitations in these previous studies, and recommended elements which should be incorporated into future effectiveness studies. The results of these previous studies may be more a reflection of the methods used to evaluate motorcycle training rather than the effectiveness of training itself.

3. Literature Review of Motorcycle Barrier Crashes

Introduction

Motorcyclist fatalities can occur from a variety of accidents. In 2005, motorcyclists comprised 42% of fatalities due to guardrail collisions, whereas only 3% of vehicles on the roads are motorcycles in the United States [2]. More motorcyclists were killed in guardrail collisions than passengers of any other vehicle in 2005 [2]. Guardrails are designed to retain cars and other large vehicles such as vans and trucks. However, motorcycles also share the road. Motorcyclists are usually thrown from their motorcycle in the event of a collision, leaving them at the mercy of the surrounding environment, including roadside barriers, as they come to a stop. Barriers have been very effective in saving the lives of occupants of cars and trucks. Guardrails cannot simply be removed to protect motorcyclists. Therefore, improvements need to be made in several areas in order to keep motorcyclists as well as car occupants safe.

The injuries sustained in a motorcyclist-guardrail collision are dependent on the design of the barrier [29]. Steel guardrails are designed to absorb the energy from an impact through deformation. With less energy present, the chances of the colliding object being redirected into oncoming traffic is significantly reduced. However, they are designed to retain large vehicles such as cars and trucks. The posts supporting the W-beam of the guardrail are one of the most serious dangers to motorcyclists. They generally have narrow faces and sharp edges, causing the force to be highly concentrated on the motorcyclist as he/she collides with it. These posts are unforgiving to the tumbling cyclists [28].

Research has been conducted in Europe and Australia to reduce the number and severity of injuries and fatalities incurred from collisions with roadside barriers. Several different modifications to roadside barriers have been designed to reduce the severity of the injuries inflicted on colliding motorcyclists. Some of these redesigns have been installed in Europe and Australia based on these findings in order to make the roads more motorcycle friendly. However, to date little has been done to address the issue in the United States.

Injury Countermeasures

Shielding motorcyclists from the posts of the guardrail is an effective way to reduce the severity of injuries and the fatality rate since posts are the most hazardous component. The I-beam shaped post is the most commonly used post; however, it also contains the most edges and narrow faces. Different modifications to guardrails have been designed in order to ensure they are motorcycle friendly. One modification that can be made is the addition of a lower W-beam. This additional beam prevents a motorcyclist from moving under the barrier as he/she comes to a halt, preventing him/her from colliding with the harsh edges of the posts. Several other methods of protecting motorcyclists from the I-beam posts have also been developed. SEC-Envel developed a metal shield that is attached below the W-beam and serves the same purpose as the addition of an extra W-beam (Figure 2). However, it is constructed from a flat piece of ductile metal, so it absorbs more energy upon impact than does the additional W-beam. It has been in use in France since 1997 and approximately 500 kilometers were installed across France by the year 2000 [30].

Figure 2. Metal shield developed by SEC-Envel. The flexible metal covers the hazardous posts and prevents motorcyclists from colliding with them [30][30] (left) and [31] (right).

The Plastrail by Sodilor is another guardrail modifier made in France (Figure 3). Constructed from plastic, it is designed to enlarge the surface area around the post, therefore reducing the concentration of the energy transfer upon impact. The Mototub by Sodirel (Figure 4) is similar to the Plastrail; however, it is fabricated from 70% recycled material instead [30].

Figure 3. The Plastrail by Solidor. This plastic covering provides protection to motorcyclists by covering the posts of the guardrail [31].

Figure 4. The Mototub by Sodirel. The Mototub is made from 70% recycled material and prevents motorcyclists from hitting the posts of the guardrail [30].

Impact attenuators are another means of protecting motorcyclists from posts. These surround the posts and create a larger surface area to collide with as well as protect the motorcyclists from the harsh faces of the posts (Figure 5). They can be made from a variety of different synthetic materials [32]. Testing on neopolene impact attenuators has shown that they have significantly reduced the severity of injuries incurred upon collision, though they are most effective in collisions occurring between 50 and 60 km/h [28]. Also, other testing was done with cadavers to determine the difference in severity of the injuries incurred when impact attenuators were in use as opposed to unprotected I-beam posts. It was also found that the injuries were significantly less severe when the impact attenuators were used [32].

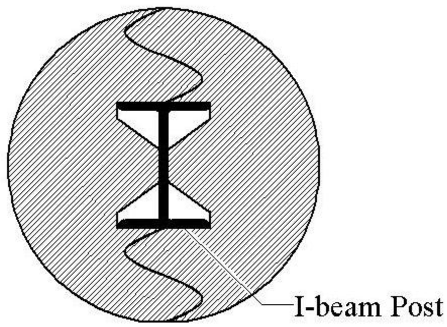

Figure 5. Sample Impact Attenuator. Impact attenuators surround posts, creating a larger surface area for impact as well as protecting motorcyclists from the sharp edges of posts (Adapted from FEMA, 2000).

The shape of the post itself can also be altered in order to reduce the severity of an injury caused upon collision. Posts that are more rounded and have fewer exposed sharp edges have been designed to replace the I-beam posts. The sigma-post has a cross-section shaped like the capital Greek letter sigma (Σ), thus having less exposed sharp edges and a more rounded shape (Figure 6). These features do not allow for the energy to concentrate in areas as highly as it concentrates in a collision with the I-beam post. Posts with other cross sections shaped like the letters “C” and “Z” (Figure 6) have also been used to reduce the severity of injuries [32].

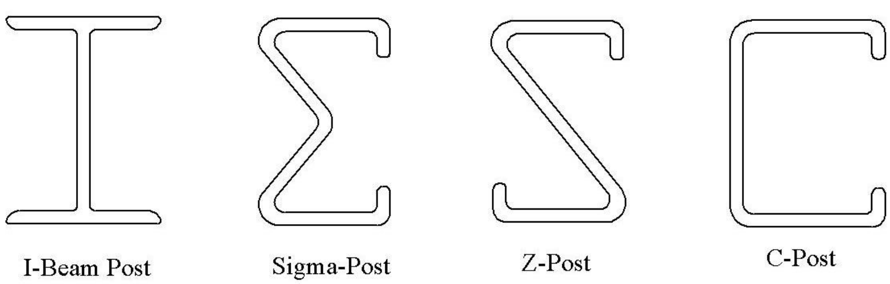

Figure 6. Various Post Designs. The I-beam post is the most commonly used post; however, it also poses the greatest threat to motorcycles. The Σ -, Z-, and C- posts have a more rounded shape and less harsh edges, making them safer for motorcyclists (Adapted from [30]).

Cost and Feasibility

Both motorcyclists and passengers of other vehicles are protected through these modifications; however, it is not economically beneficial to modify all guardrails to be motorcycle friendly. A cost analysis of replacing systems in Germany was done and it was found the cost of updating the current systems was too high as compared with the costs of accidents. However, it was also found that if ten percent of guardrails were made motorcycle friendly, the additional safety measures would be cost effective [28]. Thus, areas that pose the most danger, also known as black spots, need to be targeted for barrier improvement. Tight and non-constant curves are potential black spots due to the difficulty of maneuvering a motorcycle around them [30]. In addition, areas where accidents have already occurred may be considered black spots and are candidates for improved barrier systems. In Germany, several stretches of roadway seen to be hazardous were equipped with improved barrier systems after a study was done on their effectiveness. “According to the police accident reports available for these sections, the accidents that occurred reportedly would have been much more severe or even fatal had the guardrails at the scenes not been fitted with W-beams or crash absorbers” [28]. Though these modifications are proven to be effective, other actions must be taken in conjunction with them because they are too expensive to implement on every guardrail.

International Motorcycle Initiatives

Initiatives have been taken across Europe in order to make roads safer for motorcyclists. More frequently now roads are being upgraded to better accommodate motorcyclists. A stretch of highway RV 32 in Norway was opened on May 7, 2008 that had been modified to incorporate safety measures for motorcyclists that are usually overlooked in road design [33]. Moreover, France has allocated over five million euros a year for the improvement of crash barriers around hazardous curves and the fitting of motorcycle friendly devices in black spots. The Provincial Council of Utrecht in the Netherlands decided to only install motorcycle friendly barriers when new barriers are erected [34]. These are just some examples of recent measures taken to protect motorcyclists; programs have been put in place in other European Countries such as Germany, Portugal and the United Kingdom to ease the severity of motorcycle accidents.

Regulations

Several studies and research have been completed showing the increased severity that guardrails can add to a motorcycle collision. As of 2005, throughout Europe no regulations on crash barrier design and testing were set to consider the implications on motorcyclists [34]. Moreover, based on an analysis of the methods used, motorcyclists have not been considered in the international standard testing methods of roadside barriers [32]. In 2005 Spain pioneered the development of a barrier-motorcyclist crash test which takes the first step toward such an international standard [36]. In June, 2008, a resolution was passed in Europe to modify safety barrier regulations so as to incorporate safety features to protect motorcyclists [37]. As demonstrated above, roadside barriers pose a serious threat to motorcyclists, causing significant numbers of injuries and fatal accidents to occur. Regulations governing both barrier and road design would make the roads safer by reducing the total number of fatal guardrail collisions involving motorcyclists.

Conclusion

Motorcyclist fatalities can occur from a variety of accidents. In the United States in 2005, motorcyclists comprised 42% of fatalities due to guardrail collisions, whereas only 3% of vehicles on the roads were motorcycles [2]. More motorcyclists were killed in guardrail collisions than passengers of any other vehicle type in 2005 [2]. Guardrails are designed to retain cars and other large vehicles such as vans and trucks. However, motorcycles also share the road with these vehicles. Motorcyclists are usually thrown from their motorcycle in the event of a collision, leaving them at the mercy of the surrounding environment, including roadside barriers, as they come to a stop. Guardrails have been very effective in saving the lives of occupants of cars and trucks, and cannot simply be removed to protect motorcyclists. However, the literature describes improvements can be made in several areas in order to keep motorcyclists, as well as car occupants, safe in guardrail collisions.

Several modifications to guardrails have been proposed in order to make them more motorcycle friendly. The posts of guardrails are generally viewed as the most hazardous component [28]. The small faces concentrate the force and a collision with one usually results in a much more severe injury than a collision with a smoother surface. One modification that can be made to prevent motorcyclists from colliding with these posts is the addition of a supplementary covering beneath the W-beam, which would inhibit the motorcyclist from sliding under the guardrail. Also, impact attenuators could be added around the posts. These cover the post and provide a larger, smoother surface area for a motorcyclist to collide with. Lastly, the shape of the post itself could be modified to reduce the amount of small faces exposed.

Modifying all barriers would not be economically efficient [28]. Thus, the literature recommends that areas that pose the most threat to motorcyclists should be targeted for modification. Several European countries have begun to make modifications to guardrails. Moreover, a regulation is being developed in Europe that incorporates motorcyclist safety in guardrail designs. Developing regulations incorporating motorcycle safety would ensure that motorcyclists are not excessively injured in the event of a guardrail collision. Several different options exist to reduce the representation of motorcyclists in fatal guardrail collisions.

4. Survey of Motorcyclists, RiderCoaches, and Motorcycle Dealerships in New Jersey

Introduction

Motorcycle accidents are increasing at an alarming rate within in New Jersey, doubling within the past decade. In 2007, 84 fatalities were the result of motorcycle crashes. There is little understanding of why motorcycle rates have risen at a substantial amount.

There are many factors that influence crashes, including rider behavior, rider attitude, level of training, and experience. One method of determining the factors which influence motorcycle safety is to poll motorcycle users directly. To gain a better understanding of these aspects, a survey was administered to motorcyclists in New Jersey. Instructors of rider training courses and motorcycle dealers were also surveyed to supplement the data obtained through the rider survey.

Objectives

The goal of this survey chapter is to determine characteristics of motorcyclists in New Jersey as well as their opinions on safety and testing and training processes.

Research Approach

Three surveys were developed and distributed, each of which addressed a different group of motorcycle enthusiasts. The surveys were distributed to the respective groups via the mailing cards and the Internet. The survey was first distributed in May 2008, and remained available for a year. The final data presented in this report were collected on July 15, 2009.

Development of the Survey

Three surveys were developed to determine the opinions of motorcycle riders, RiderCoaches, and motorcycle dealerships. Each survey addressed the topics of safety, licensing, and training. These surveys were developed by the research team in close collaboration with our project panel members from the New Jersey Motor Vehicle Commission (NJMVC). The objective and details of each survey are described below and sample surveys are included in Appendices A-C.

- Survey for Registered Motorcyclists. The first survey was aimed to provide an overview of registered motorcyclists in New Jersey. The survey covered six main areas: motorcyclist characteristics, safety practices, licensing, training, crash data, and perceived hazards on the road. The survey included 31 questions, with equal portions of the survey allocated for each topic. Lastly, a comment box was included to gain further insight from motorcyclists.

- Survey for MSF RiderCoaches (Course Instructors). Training instructors for safety courses have unique insights into novice rider perceptions and attitudes on safety. This survey focused on instructors' experience, both as a rider and an instructor, and opinions on testing and course difficulty levels. This survey consisted of 12 questions and a comment area.

- Survey for Motorcycle Dealerships. This survey focused on motorcycle dealerships' licensing requirements for purchase, perceptions of testing and training processes, and endorsement of personal protective equipment. It consisted of 17 questions as well as an area for additional comments.

Distribution of the Survey

In order to minimize costs and maximize efficiency, the surveys were designed to be online. These online surveys reduced the amount of paper consumed, as well as facilitated in tabulating the results. The survey was available at www.rowan.edu/mvc, and responses were stored on a secure website. Printed versions of the survey were also available upon request. Printed responses to the survey were entered manually by the team into the database. No personal information was collected with the survey responses in either form.

Riders were notified of the survey through a card distributed with the motorcycle registration renewal forms from the NJMVC. The instructor and dealer cards were mailed directly to these individuals. A sample card is shown in Figure 7.


WE NEED YOUR HELP!

On behalf of the New Jersey Motor Vehicle Commission, and the New Jersey Department of Transportation, we are requesting your help for a very important project. Your responses to our 5 minute survey will provide valuable information for motorcyclists in New Jersey. To respond, visit

www.rowan.edu/mvc

and enter the code found on the reverse of this card.
This code does not link any personal information,
it simply lets us know that you have responded.

Would you rather have a printed version?
Simply fill out this form and mail it back to:

Motorcycle Research Team
ATTN: Yusuf Mehta
Rowan Hall
201 Mullica Hill Road
Glassboro, NJ 08028

Name: ____
Address: ____
City: ____
State: ____ Zip: ____

Rowan University

Figure 7. Survey Response Card

Each card had a unique identification code (UID) on the back that served multiple purposes. This UID was a required input to complete a survey and lead participants to the appropriate survey. The first character of the UID was either an "R" for the rider survey, "I" for the instructor survey, or "D" for the dealer survey. The second 2 characters in the UID were the state code ("NJ"). Second, the UID prevented multiple responses from a single participant; two surveys cannot be completed under the same UID number. As requested by the sponsor, the last 5 digits of the UID were random and did not link any personal information to the survey or the mailing information. This ensured privacy for participants of the survey.

The cards were produced in association with Rowan University's publications department. The Rowan Web Services department produced the online survey. After review by the sponsor of the project, the cards were printed by Rowan University, and mailed by NJMVC.

Incorporating the survey cards in the motorcycle registration renewal mailers sent out by the state also reduced incurred costs for envelopes and postage. The online response system also eliminated the need for return postage which would be very costly. If the return postage were required to be paid by the potential respondents, the response rate would have been significantly less. Therefore, the system devised increased the efficiency and response as well as reduced costs to both researchers and the State of New Jersey.

Results

The survey cards were distributed to approximately 40,000 people. The survey was distributed beginning in May, 2008. The overall response rate to all the surveys was 7.3%. Table 6 shows the distribution of response rates per survey type. Typical survey response rates are around 1-2% [38]. Although the response was better than a typical survey, it must be noted that the perceptions and trends of the respondents may not necessarily represent the entire population of interest. Surveys with a large non-response fraction may be biased.

Table 6. Distribution of Survey Responses

Survey Type	Responses	Estimated Distribution	Response Percent
Rider	2,858	40,000	7.1%
Instructor	71	200	35.5%
Dealer	18	200	9.0%
Total	2,947	40,400	7.3%

Rider Survey

The response rate of riders to the survey was 7.1%. The demographics of the respondents are shown in Table 7. 82.4% of the rider responses were from motorcyclists over the age of 40. Also, 44% of respondents had more than 20 years of experience riding a motorcycle.

Field	Value	Percentage of Responses
Sex		
Male	2,600	91.0%
Female	258	9.0%
Age		
18-25	53	1.9%
26-29	87	3.0%
30-39	362	12.7%
40-49	837	29.3%
50-59	965	33.8%
60-69	490	17.1%
70+	64	2.2%
Riding Experience		
Less than 2 years	204	7.1%
2 - 5 years	439	15.4%
5 - 10 years	456	16.0%
10 - 20 years	493	17.2%
More than 20 years	1,266	44.3%

Table 7. Demographics of Rider Respondents

Riders were asked what type of motorcycle they ride and their main motive for riding. The most common motorcycle type was a cruiser (Figure 8). Also, in the multiple response regarding reasons for riding, the most popular response was riding for recreational purposes (Figure 9).

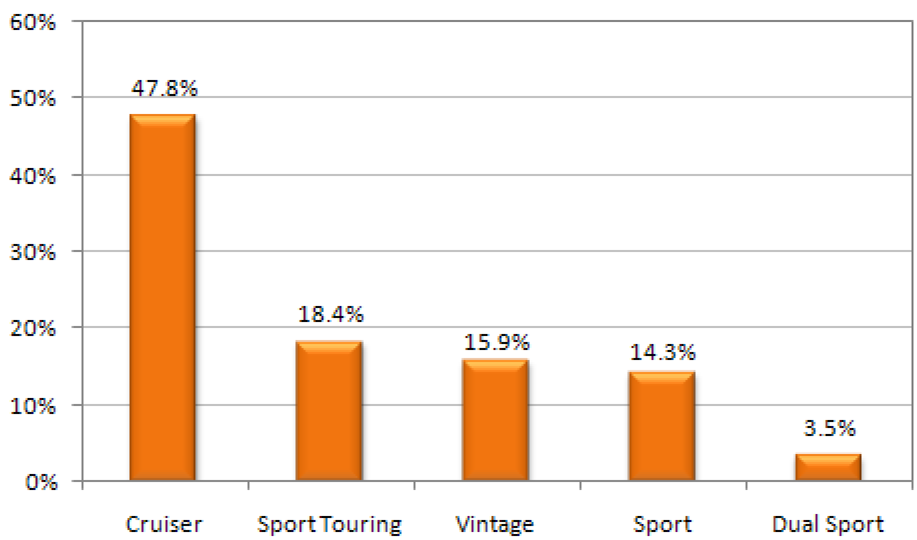

Figure 8. Riders' motorcycle type

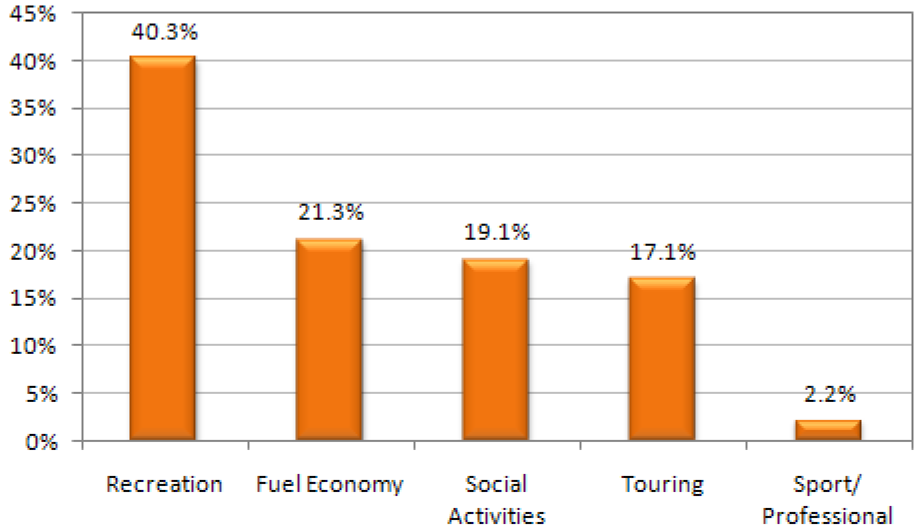

Figure 9. Reasons for riding a motorcycle

Safety Practices

Several questions in the survey addressed riders' safety concerns. The first group of questions regarded helmet usage and motivations for wearing a helmet. The majority of riders surveyed primarily wore a full face/ flip-up helmet (Figure 10). Also, 91% indicated that they wear a helmet every time they ride, though this number drops to 62% if there was no mandatory helmet law (Figure 11). Moreover, 87% of respondents indicated that one reason they wore a helmet was for safety purposes. Therefore, the New Jersey helmet law is effective in promoting helmet usage amongst motorcyclists.

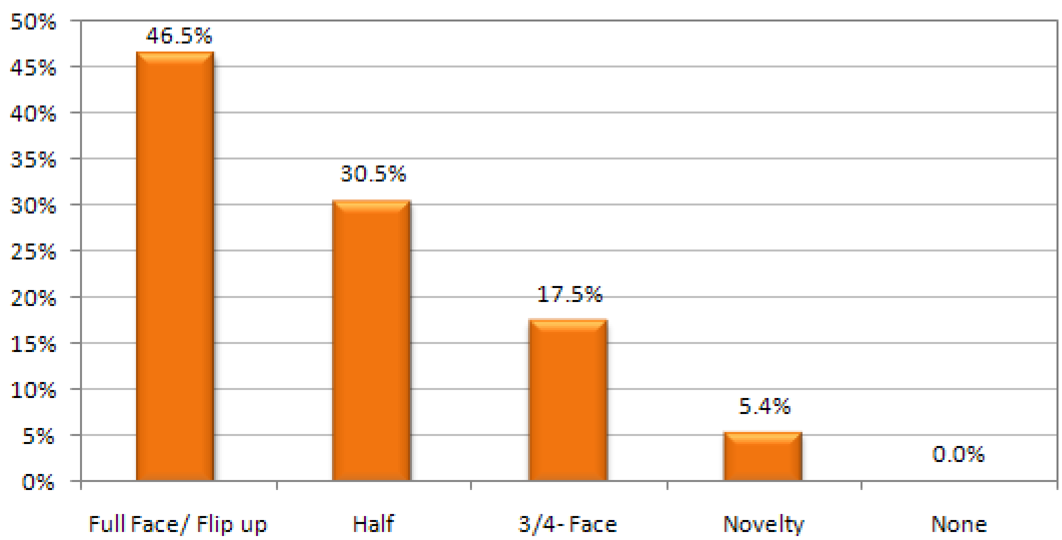

Figure 10. Type of helmet used by surveyed riders

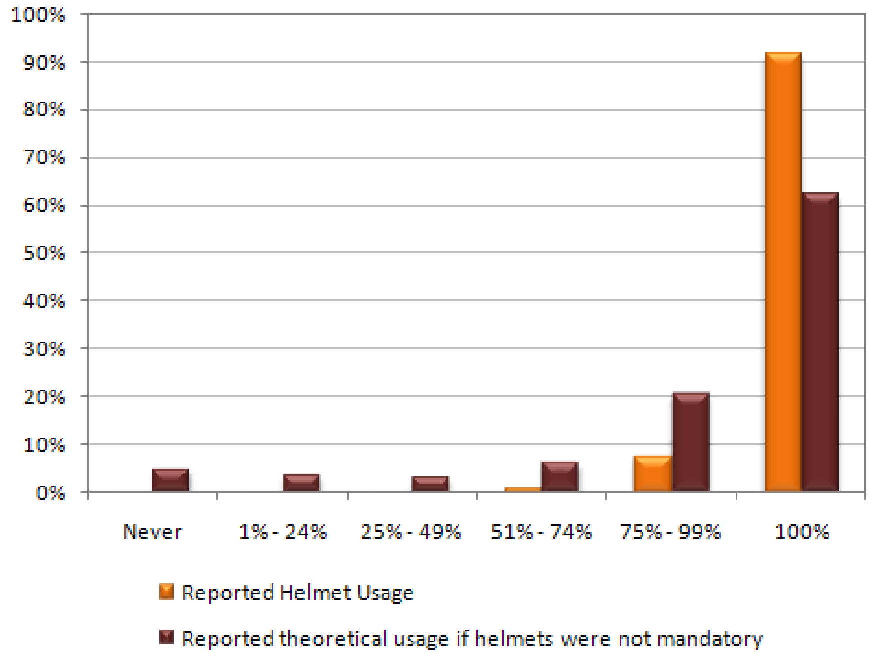

Figure 11. Actual and theoretical helmet usage

Participants were also surveyed about other personal protective equipment they typically wore while riding, aside from a helmet. The most common types of protective equipment used were gloves and boots. Participants who received formal training tended to use personal protective equipment more frequently. Ninety-seven percent of participants trained used at least one other piece of safety equipment, whereas 93% of participants not trained used at least one other piece of safety equipment. Moreover, 65% of trained participants used 3 or more pieces of personal protective equipment, as compared to 45% of untrained participants (Figure 12).

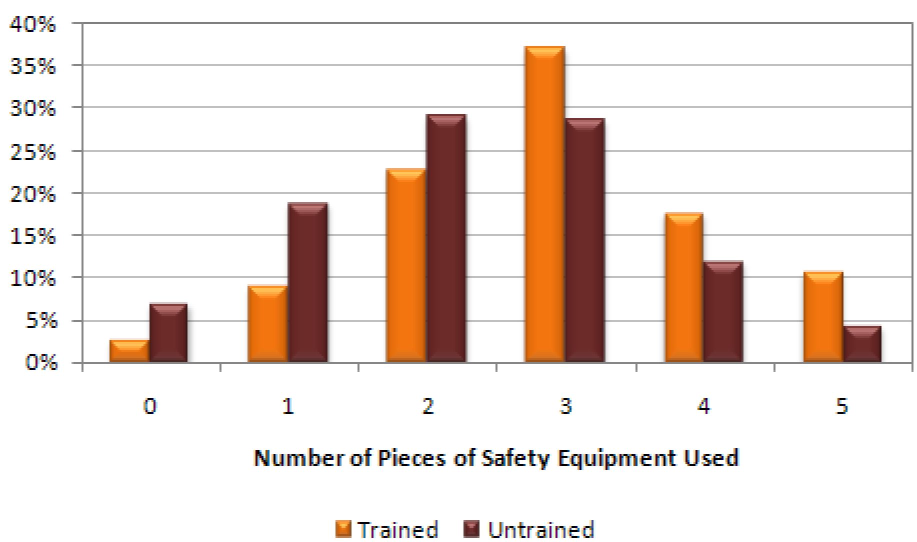

Figure 12. Safety equipment usage amongst riders surveyed

Training and Licensing

The majority of respondents obtained their motorcycle licensing by taking the Motor Vehicle Commission Test (Figure 13). 99.5% of participants held a valid New Jersey drivers license, and 97.7% held a valid motorcycle endorsement.

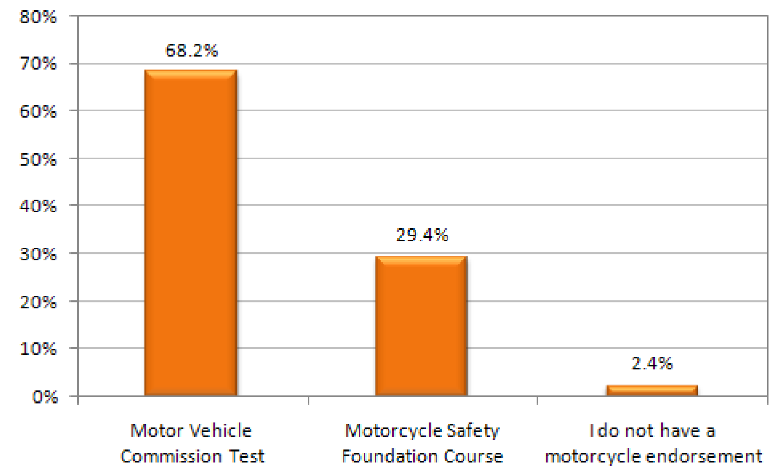

Figure 13. Method of obtaining motorcycle endorsement

The majority of participants (51%) completed either testing or training on their own motorcycle. However, 7.3% of participants also indicated they used a rented scooter to complete the test (Figure 14).

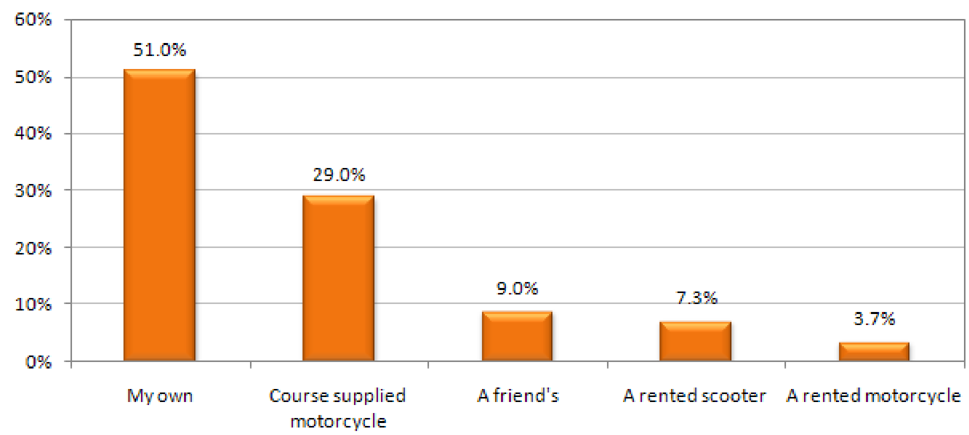

Figure 14. Motorcycle used by participants to complete test/course

Lastly, most people used a motorcycle with an engine displacement between 101 cubic centimeters (cc) and 500cc during the test or course (Figure 15). These are relatively small motorcycles. An additional 7.4% of people completed the test or course on a motorcycle less than 100cc, which may correspond to the percentage of the respondents who used a rented scooter.

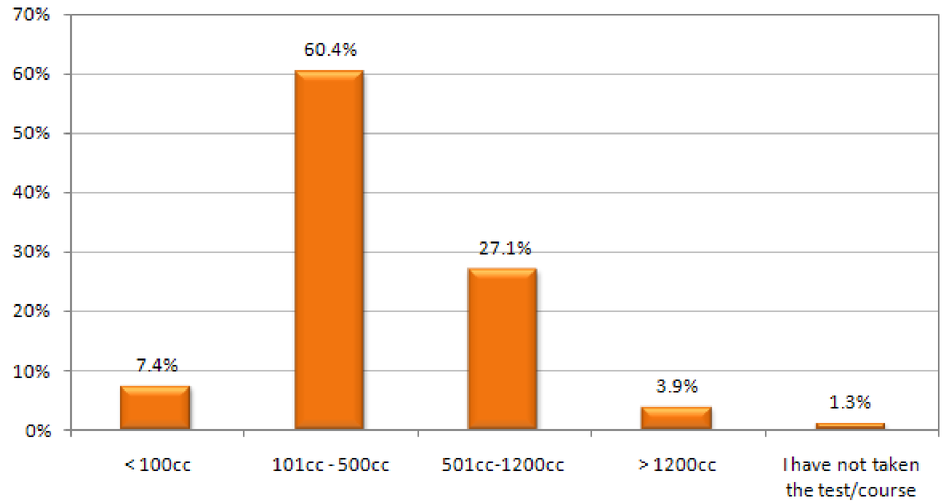

Figure 15. Engine displacement of motorcycle respondants used for the test/course

Slightly less than half of the respondents (44.6%) indicated they completed a motorcycle training course. Of those who completed the course, 82% felt it was highly effective (Figure 16). Also, 62% felt the course covered enough information without giving too much information (Figure 17).

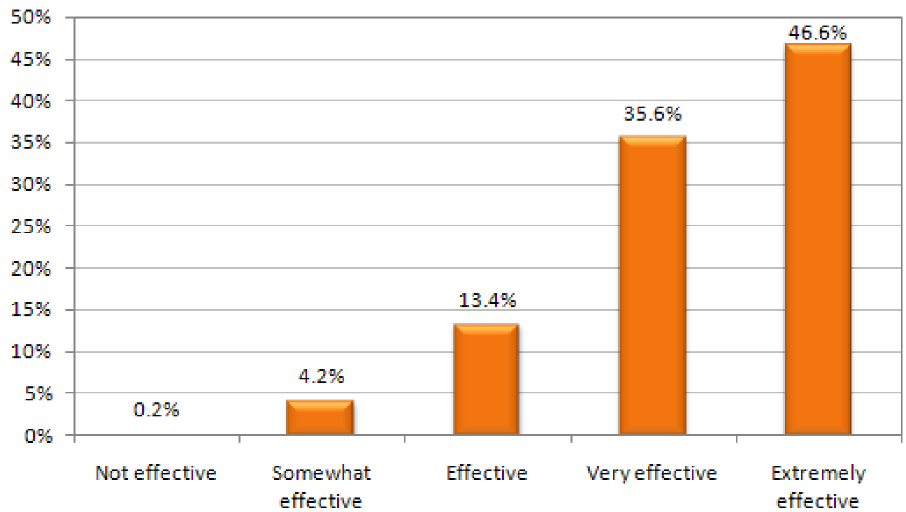

Figure 16. Respondents' perception on effectiveness of safety course

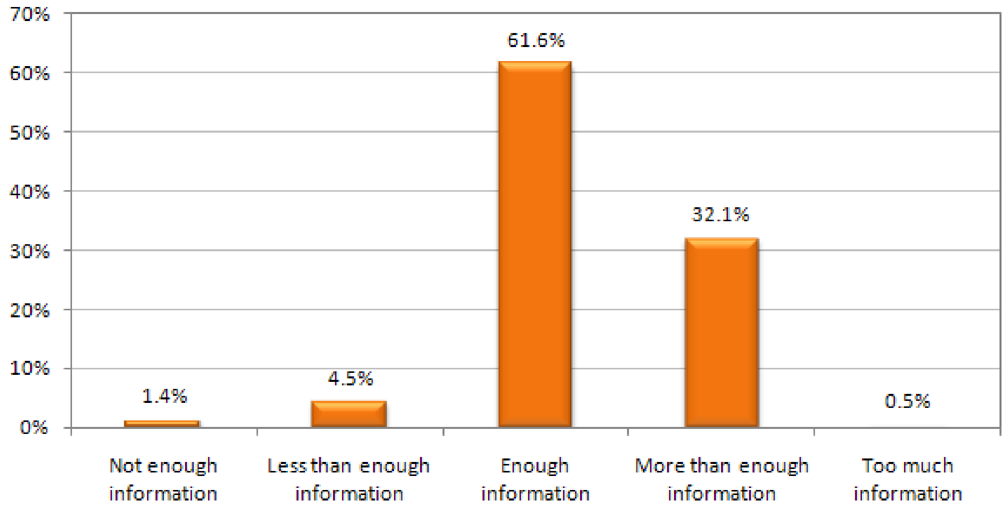

Figure 17. Respondents' perceptions on material presented in safety course

<u>Crash Involvement</u>

Respondents were asked about circumstances of crashes they had been involved in while riding their motorcycle. About one-third (33.1%) of respondents were involved in a crash. The majority of the crashes were multi-vehicle crashes, with the fault being placed on the other driver by respondents (Figure 18).

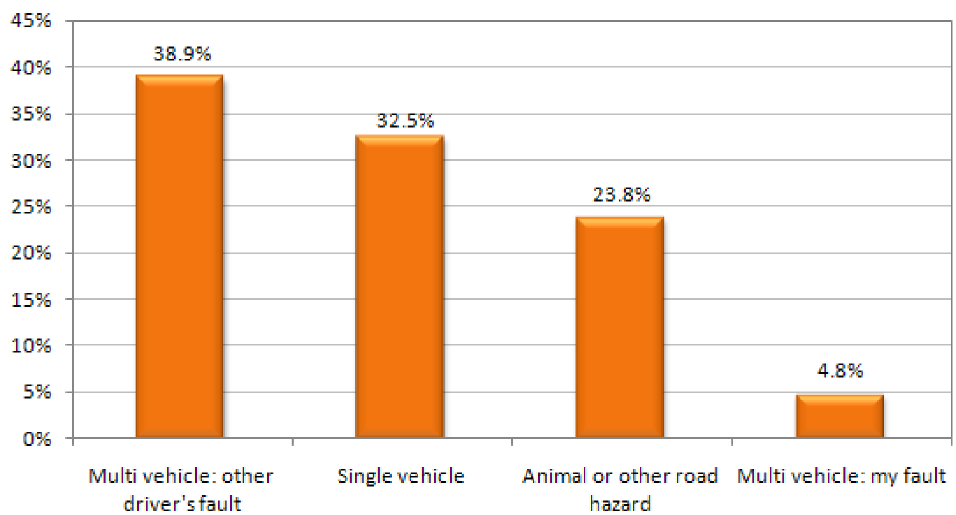

Figure 18. Circumstances of respondents' crashes

Approximately half of respondents (53.2%) indicated that they reported the crashes in which they were involved, and 54% reported that they did not require medical attention after the crash. Also, 88% of respondents indicated they were using at least one additional piece of safety equipment at the time of the crash.

Perceived hazards

Riders were asked what situations they felt posed hazards to motorcyclist. The majority of people felt intersections were the most dangerous areas for riders when compared to highways, residential roads, rural roads, and parking lots (Figure 19).

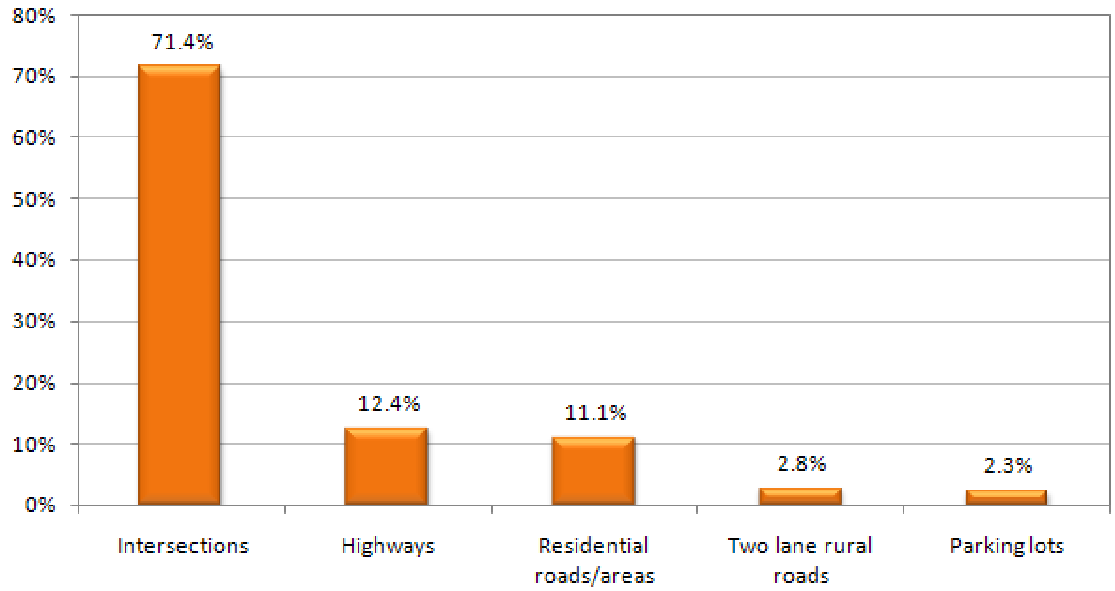

Figure 19. Perceived hazardous roadway areas

Instructor survey

Seventy-one RiderCoaches responded to the survey, resulting in a response rate of 35.5%. Table 8 gives the demographics of the instructors who responded.

Table 8. Demographics of Instructor Respondents

Field	Value	Percentage of Responses
Sex		
Male	59	83.1%
Female	12	16.9%
Age (Years Old)		
26-29	2	2.8%
30-39	7	9.9%
40-49	19	26.8%
50-59	32	45.1%
60-69	11	15.5%

Table 8 (continued).

Field	Value	Percentage of Responses
Riding Experience		
5 - 10 years	13	18.3%
10 - 20 years	24	33.8%
More than 20 years	34	47.9%
Training Experience		
Less than 2 years	9	12.7%
2 - 5 years	24	33.8%
5 - 10 years	18	25.4%
10 - 20 years	19	26.8%
More than 20 years	1	1.4%

The majority of instructors rated the Basic Rider Course (BRC) as having a moderate level of difficulty for new riders (Figure 20).

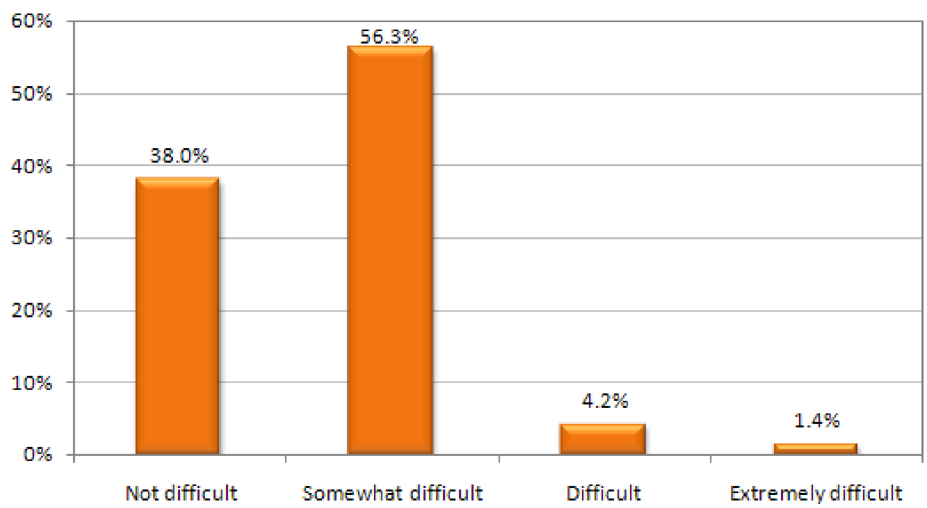

Figure 20. Instructors' perceived difficulty of Basic Rider Course

Half the instructors surveyed felt the written test covered enough information. However, only 36% felt the road test covered an adequate amount of information (Figure 21).

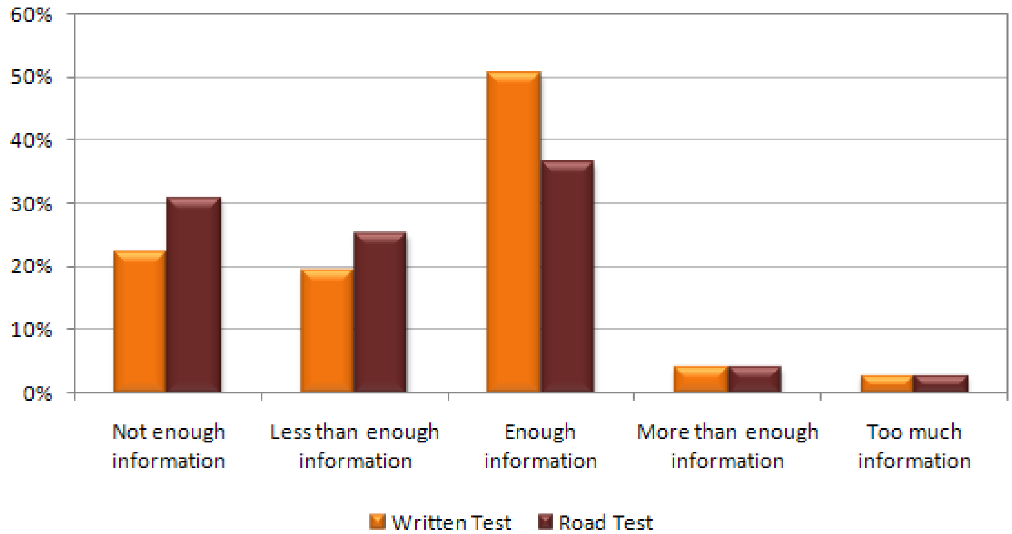

Figure 21. Instructors' perceived coverage of information for motorcycle written and road tests

Instructors were also surveyed about the Experienced Rider Course (ERC), questioning the difficulty and enrollment levels. Most instructors felt the course did not cover enough information (Figure 22). Moreover, 83% felt more people would enroll in the course if more incentives for taking the course were offered.

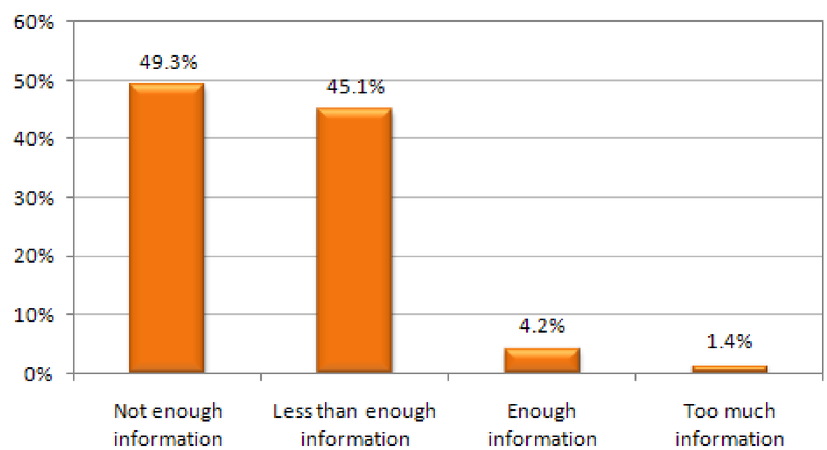

Figure 22. Instructors' perceived coverage of material in ERC

Dealership Survey

The response rate of dealerships was 9.0%, with 18 dealerships responding to the survey. Five dealerships exclusively sold on-road motorcycles and one sells only off-road motorcycles. The remaining 12 dealerships sold both on- and off-road motorcycles.

The majority of dealerships that responded did not require that purchasers have a motorcycle endorsement prior to buying a motorcycle. However, most dealerships required the buyer to have an endorsement if he/she were riding the motorcycle from the dealership (Figure 23).

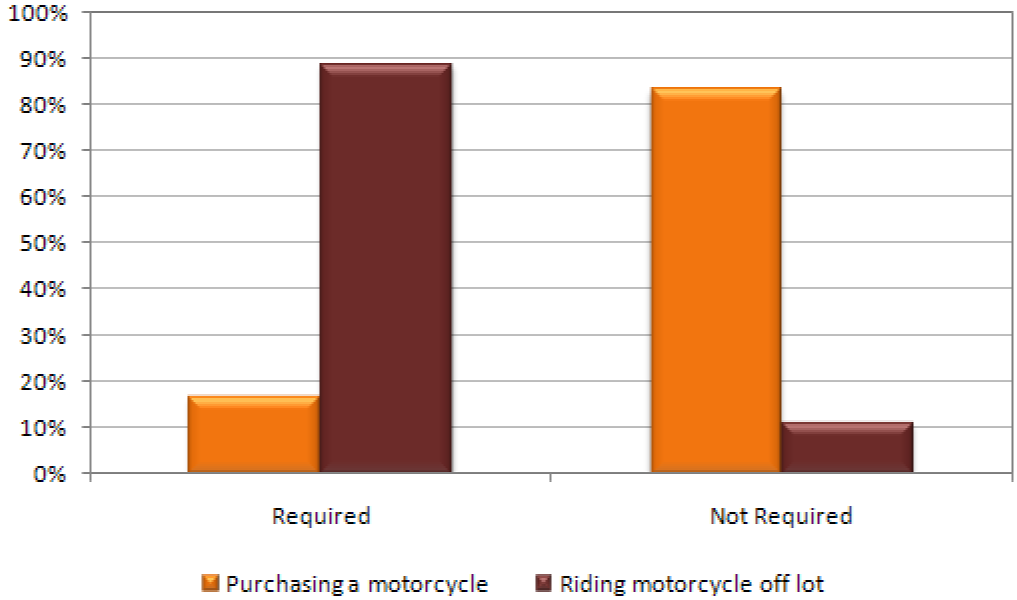

Figure 23. Dealership endorsement requirements

All the dealerships surveyed encouraged new riders to take a safety training course and knew the courses available in their area. 72% of dealerships felt the safety training course was extremely effective.

The majority of dealerships encouraged riders to use personal protective equipment. Gloves were encouraged by 94% of the dealerships surveyed, and boots were encouraged by 89% of dealerships. Based on the survey data, riders are exposed to good safety measures by dealerships.

Discussion

The riding population surveyed is supportive of training efforts, and those who completed the course generally felt it to be effective. As discussed previously in this report, training tends to increase the use of personal protective equipment amongst riders. The survey displayed these results, with 65% of the trained respondents using 3 or more pieces of safety equipment, as compared to 45% of the untrained respondents.

RiderCoaches and riders who completed the training course indicated that the course covered an adequate amount of information, without covering too much information. However, RiderCoaches also indicated that they felt the road test did not cover enough information.

Recommendations for Further Study

Though almost 3,000 responses were collected from riders, there still remains a large portion of the population of non-respondents. Therefore, the results of this survey may not reflect the opinions of the motorcycling population in New Jersey. Similarly, there were only 18 responses from dealerships. RiderCoaches had the highest response rate, though, due to a small population, there were still few responses.

During the analysis of the data, there were several loopholes found in the survey, which prevented a multivariate analysis of the results. For instance, riders were surveyed about crash experience and training experience; however, the survey did not ask whether the crash occurred before or after training. Therefore, no correlations could be drawn between training and likelihood of a crash. Similarly, correlations between motorcycle type and crash events could not be drawn because the survey did not ask for the motorcycle type at time of the crash.

If the survey were repeated, these loopholes could be avoided by narrowing its scope. The survey was designed to be brief, to encourage people to complete it. However, questions were asked about a vast range of topics. With a narrower focus, more detailed questions can be asked about each topic, such as training in relation to any crash events, and the survey will still remain brief.

5. Evaluation of Training and Licensing Procedures in New Jersey

Summary

This chapter examines the current testing and training practices within the state of New Jersey. The aspects of the endorsement process focused on in this section include the lack of motorcycle engine displacement limitations, appropriate testing and training vehicle speeds, and other testing conditions. This chapter combines survey results with data from FARS and NJCRASH to show the limitations of the current training and testing procedures in New Jersey.

Introduction

Many factors of motorcycle ridership have been explored based on the results of the analyzed resources. Some of these factors lead to motorcycle fatalities. The main factor of concern is the process of obtaining a motorcycle endorsement. The aspects of the endorsement process that need to be scrutinized include the lack of motorcycle engine displacement limitations, appropriate testing and training vehicle speeds, as well as other testing/training conditions which do not appropriately simulate actual roadway characteristics.

Currently in New Jersey there are two methods to obtain a motorcycle endorsement. The first method involves taking the NJMVC motorcycle test. This is broken into two parts, the written test and road test. The written test is designed to test general knowledge about motorcycles and vehicle safety. The road portion of the test evaluates a rider's ability to operate a motorcycle at low speeds. The second method for obtaining a license is by taking an approved basic motorcycle training course. This course is designed to give riders the skills necessary to safely operate a motorcycle on the roadways. There are currently 9 approved sites across New Jersey. The course had been offered by the state in two locations, free of charge, until 2009. As of April 16, 2009, the NJMVC website stated that courses were no longer available through the state [39].

Motorcycle Engine Displacement

From the survey data respondents suggested that the current processes of testing and training are inadequate. Currently there are no restrictions on the size of motorcycle used to perform the testing and training. As a result motorcyclists tend to take the test and/or train on a motorcycle smaller than what they plan to use on the road. This makes the endorsement process easier for the rider, but does not accurately test the rider's ability to operate a larger motorcycle on the road. One rider reported that he purchased a 1500cc cruiser from a dealership. As part of the motorcycle purchase the dealership lent him a 50cc scooter on which he took and passed the road test. This rider's ability to properly operate his motorcycle was not appropriately tested. Likewise, the provided motorcycles for the basic MSF course are typically smaller than 500cc. Figure 24 shows the distribution of motorcycle displacement sizes used to obtain a motorcycle endorsement, via testing or training. These data are compared to the engine displacement of motorcycles involved in fatal crashes from FARS 1998-2007.

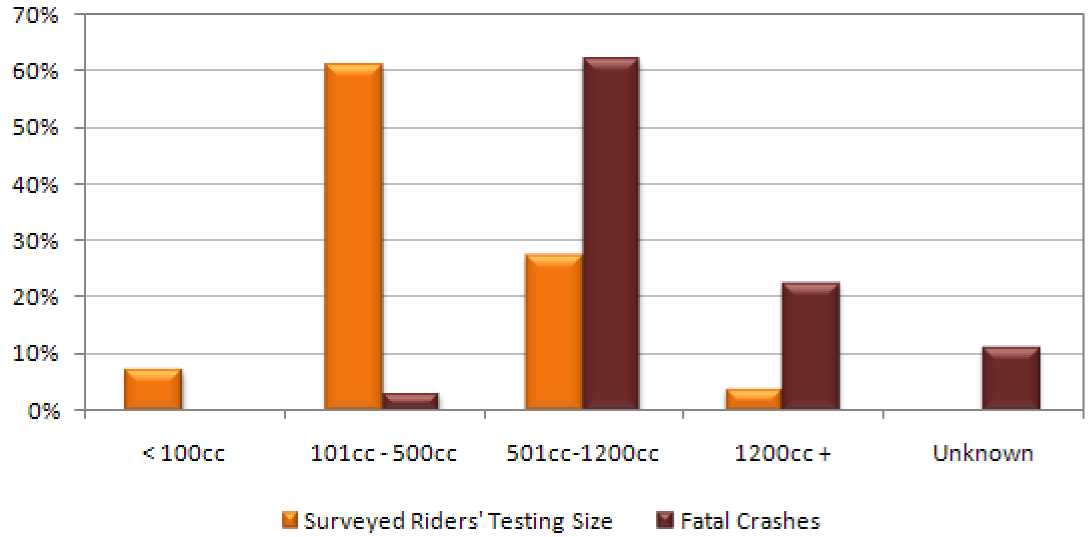

Figure 24. Motorcycle Engine Displacement Distribution for Testing/Training and Fatalities

According to the riders surveyed, approximately 70% of testing and training occurs on motorcycles with displacement smaller than 500cc. According to the FARS reports (1998-2007), 85% of motorcycle related fatalities in New Jersey involved motorcycles over 500cc.

Scooters also pose a large issue for testing and training. Scooters are small and lightweight, vastly different from a large 1200cc motorcycle. They are easier to control and maneuver. Many motorcyclists use scooters to complete their road test for these reasons with the intensions of riding a significantly larger motorcycle, as previously related. The use of scooters for testing should be reevaluated due to the differences between them and motorcycles that are typically ridden.

Testing and Training Vehicle Speeds

Another factor that leads to motorcyclist fatalities is the testing and training vehicle speeds. The NJMVC road test and the MSF basic course are both performed in enclosed areas. The requirements to obtain the endorsement consists of 4 various tasks, all of which are performed while traversing at low speeds. During the test/training riders are not exposed to higher roadway speeds. During the road test and the basic MSF course riders are not required to exceed 15 mph. The testing and training at low speeds accurately test a rider's ability to operate a motorcycle at low speeds, but the rider's higher speed skills remain unevaluated. The NJCRASH database was analyzed in order to confirm the importance of testing and training at higher speeds. Figure 25 shows the results of this analysis.

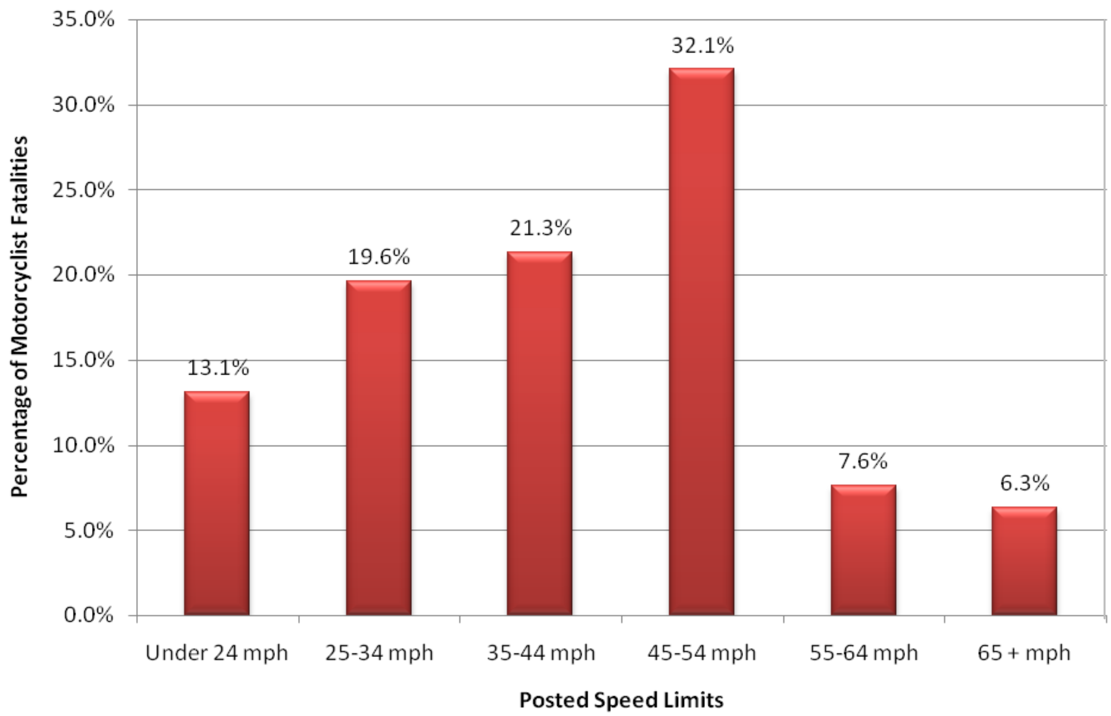

Figure 25. Posted Speed Limit Distribution for Fatal Motorcycle Accidents (NJCRASH)

The basic rider course and the road test do not require motorcyclists to go above 35 mph, yet according to the NJCRASH data, 67% of fatalities occur at posted speeds greater than 35 mph. It is assumed that these fatalities occurred while the vehicle traversing at, or above the posted speed. There are two other factors that may affect the fatality results in relation to speed. First, higher speeds will increase the chance of fatality. Second, the majority of motorcycle travel time may be performed on roads with posted limit of 45-54 mph. These factors confirm the importance of testing and training at typical roadway operation speeds.

Recommendations

Based on the survey data and various crash data sources we conclude that the current process of motorcycle endorsement procurement in the state of New Jersey could be greatly improved. The NJMVC written/road test and the MSF basic rider course do not adequately test a rider's ability to operate a motorcycle on the roadway. There are methods that may be put into practice in order to better evaluate a rider's competence. These methods focus on the two major aspects of testing and training previously discussed.

1. *Institute Graduated Licensing for Motorcyclists*

Tiered or graduated licensing is one way to limit riders from using motorcycles that exceed the rider's skills and abilities. Tiered licensing is common in Europe and other foreign countries and has even been instituted in 9 states in the United States, including Maryland and Pennsylvania [25][40]. These licensing systems are based on various rider aspects including age and riding experience. The individuals who are in the restricted category are limited on the type of motorcycle they operate. This motorcycle limitation may be based on weight, power, type, and engine displacement of the motorcycle.

Analysis of crash data shows that tiered licensing in the state of New Jersey should be based on the rider's experience. Riders who are younger than 30 years old are responsible for approximately 40% of motorcycle fatalities. This is higher than any other age range; however the majority of the fatalities involve people over 30. Figure 26 shows the age distribution for various crash data as comprised from the NJCRASH database. Because of the distributed age ranges, a tiered licensing system should be based on experience and not age.

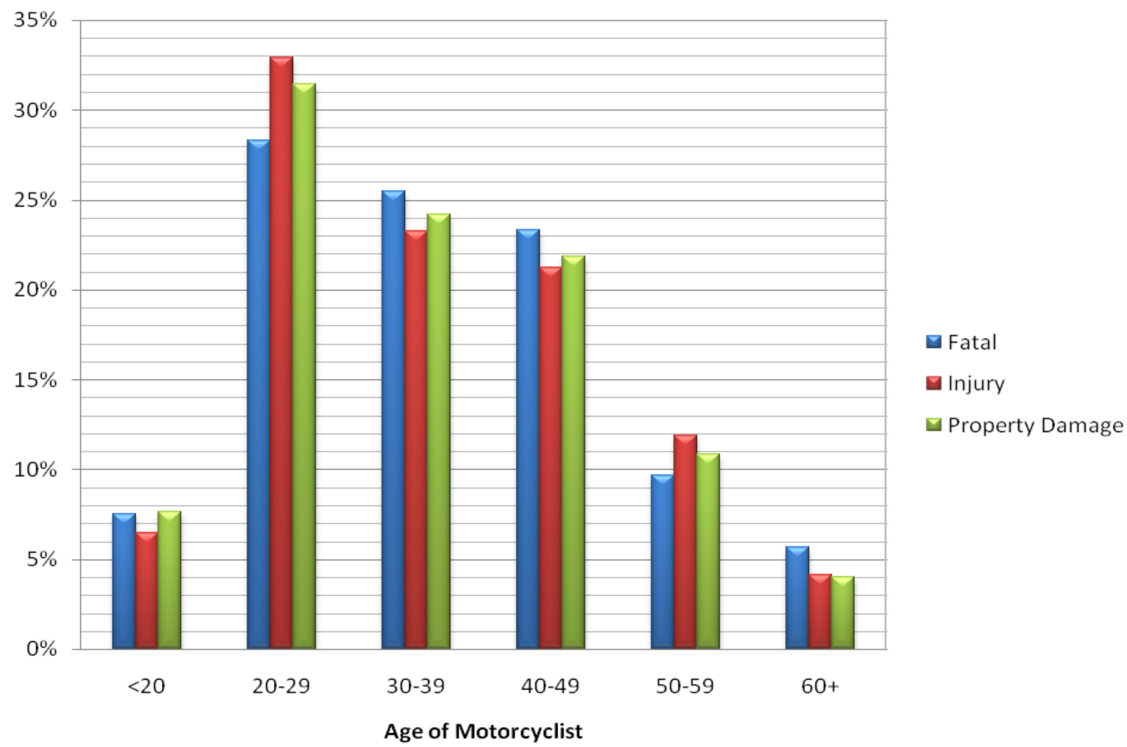

Figure 26. Motorcyle Crash Age Distribution

2. *Institute Test Staging*

Another method of tiered licensing is by test staging. This would not be based on age or experience, but rather on the ability a rider has to complete testing procedures. One method of accomplishing test staging is by limiting the motorcycle used by the rider based on the size of motorcycle used to perform the test and or training. For example, performing the test on a 500cc motorcycle would qualify the rider to operate a 500cc and lower motorcycle on the road. Only after the rider completes the test on a larger motorcycle would he/she qualify to operate a larger motorcycle on the road. This is another way to limit the size of motorcycle based on experience and skill. In Europe, a new directive is under development to require riders to complete the testing on motorcycles of three different engine displacements [40].

3. *Ban the Use of Scooters to Take the Test*

Common testing methods involve sharp maneuvers in a small testing area. These types of maneuvers are more difficult to complete on larger motorcycles. Motorcyclists will often rent a small scooter with an automatic transmission to complete the test. Many locations offer scooter rentals, advertising that they will allow a rider to become familiar with it and practice the maneuvers on the test before escorting him/her to the testing center [40]. Therefore, taking the test on a scooter does not evaluate the skills that a motorcyclist would need to safely operate a motorcycle on the street. Banning the use of scooters would make the testing conditions more realistic as riders would be forced to use a motorcycle that is more similar to those typically ridden on the streets.

4. *Adopt More Realistic Testing and Training Vehicle Speeds and Conditions*

Accurate testing and training environments should mimic actual roadway conditions as much as possible. This includes the requirement to operate the vehicle at a wider range of velocities, in a wider range of situations. Currently the process of obtaining a motorcycle endorsement includes a rider's ability to make turns, weave in and out of cones, and come to a stop, all while traveling at slow velocities [41], and passing a very basic knowledge test. Also 95% of the surveys instructors think the training is less than difficult. In order to better train motorcyclists for roadway operation, the current process of testing and training should be reevaluated and possibly altered. Possible alterations include on/off ramps, intersections, lane changes, increased accident avoidance, increased speeds and other common rider situations. The testing and training would become more challenging, and as a result will have a higher failing rate; however, the testing and training process would better evaluate the rider's skills.

By enhancing the current testing and training procedures through implementation of the previously mentioned suggestions, the fatality rates within the state of New Jersey, and elsewhere can be decreased.

6. Analysis of Fatal Motorcycle Crash Statistics

Introduction

The number of fatal motorcycle crashes in the United States has been rising since 1998. In 1998, there were 2,211 fatal motorcycle crashes throughout the country. However, in 2007 this figure rose to 5,001, more than double the number of fatal crashes 10 years previously (Figure 27). Data collected in the Fatality Analysis Reporting System (FARS) from 1998-2007 was analyzed to determine recent trends in fatal crashes. Moreover, characteristics of riders and their motorcycles were analyzed to see if there are common characteristics between the riders and motorcycles involved in fatal crashes. Lastly, conditions under which crashes occurred were analyzed to determine if there were certain conditions that may contribute to a fatal crash.

Objectives

Characteristics of crashes were categorized into three main areas: riders, motorcycles, and environment. Through an analysis of the Fatality Analysis Reporting System (FARS), the trends in these three main categories were analyzed.

Questions sought to be answered in this study include:

- Who is involved in fatal crashes?
- What types of motorcycles are involved in fatal crashes?
- Under what conditions are fatal crashes occurring?

Lastly, this study seeks to compare national trends to trends in New Jersey by comparing characteristics determined through the aforementioned categories.

Methods

The FARS data from 1998 to 2007 were used to complete an analysis of fatal motorcycle crash trends in the United States. Data was extracted from FARS using the SAS 9.2 software. Three main data sets were compiled from the FARS data to complete the analysis. The first data set contained records for each person fatally injured in a motorcycle crash. This was established by combining the data sets available from FARS. Approximately 13% of those involved in a fatal crash were not fatally injured. These people were not included in the analyses. The data were used to describe the characteristics of people involved. The second data set contained one record for each motorcycle involved. These records retained information about the driver and all the passengers on the motorcycle (i.e., gender, injury, etc.). This data set was used mostly for determining the characteristics of the drivers and motorcycles involved in fatal crashes. The last data set contained one record for each crash. This data set was used to tabulate information about crash conditions since conditions of one collision were not repeated if two motorcycles were involved in the same crash.

Results

The number of fatal motorcycle crashes has been rising in recent years. There were a total of 35,307 fatal crashes in the United States between 1998 and 2007. The number of crashes per year more than doubled over the decade (Figure 27).

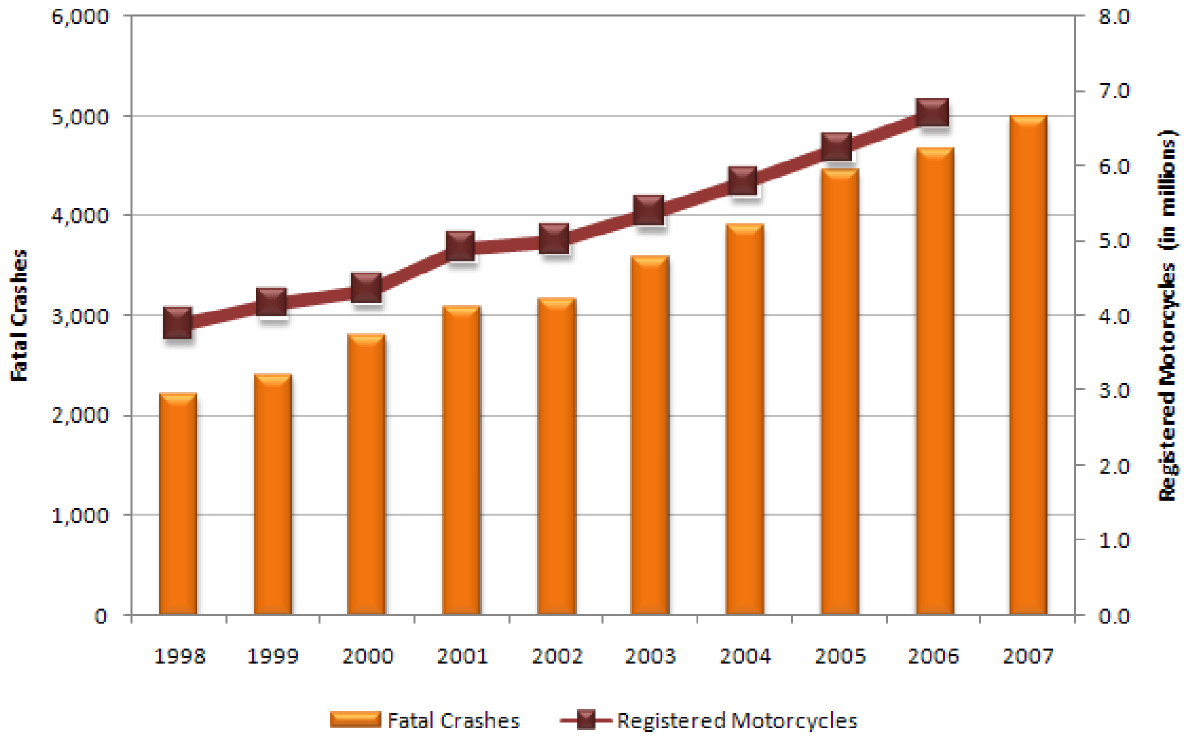

Figure 27. Total Number of Fatal Motorcycle Crashes by Year in the United States (FARS 1998-2007 and Traffic Safety Facts, 2007 [43])

The number of fatal crashes in New Jersey also generally increased over the time period from 1998-2007 (Figure 28). However, unlike the United States, there was a 31% decrease in accidents between the years 2001 and 2002, when the trend started rising again. There were a total of 606 fatal motorcycle crashes in New Jersey between 1998 and 2007.

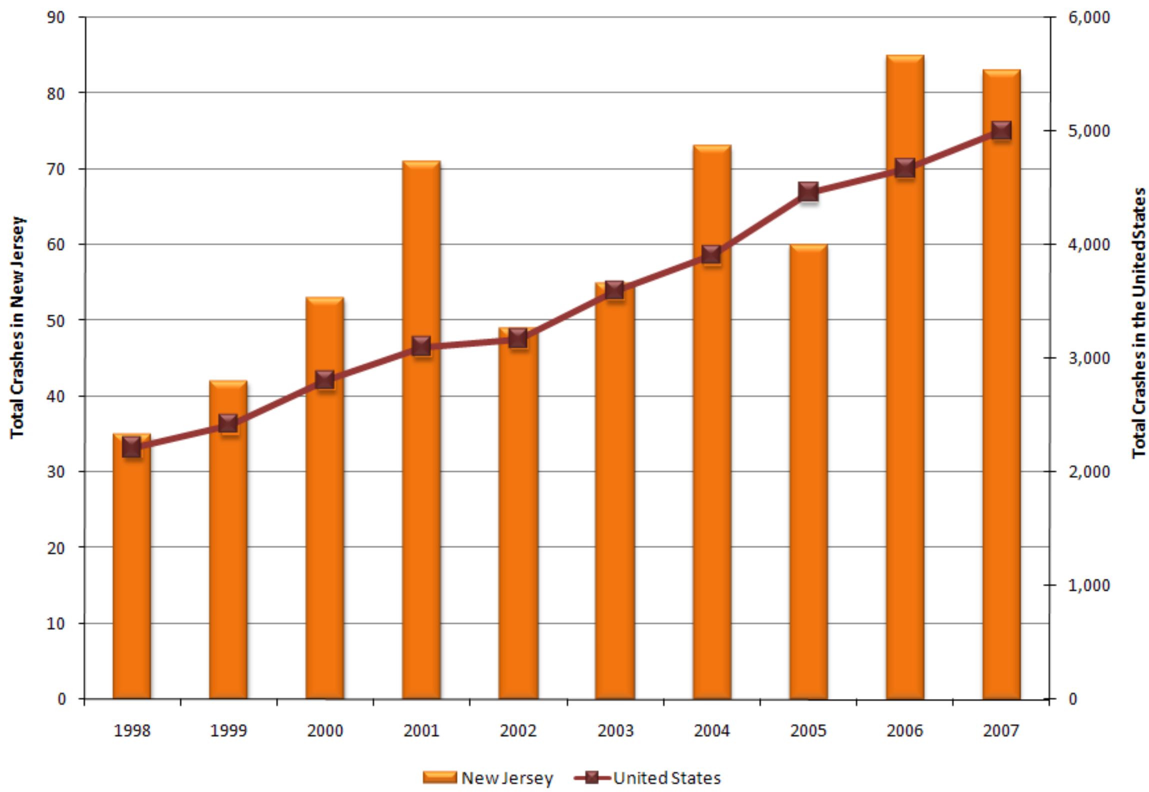

Figure 28. Number of Fatal Crashes in New Jersey and the United States

There were a total of 57,305 vehicles involved in fatal motorcycle crashes in the United States, 36,793 (64%) of which were motorcycles. The distribution of single and multi-vehicle crashes per year is shown in Figure 29. These data were collected by using the "Vehicle Forms Submitted" field. Those crashes with only one vehicle form were tabulated as single-vehicle crashes, and those with more than one vehicle form were tabulated as multi-vehicle crashes. As shown in Figure 30, 45.6% of the fatal motorcycle crashes from 1998-2007 in the United States were single vehicle crashes. Therefore, motorcycle crashes cannot simply be blamed on "the other car," as in approximately half of the crashes there was no "other car." Involvement of other vehicles cannot be ignored however as multi-vehicle crashes accounted for 57% of fatal motorcycle crashes in New Jersey. This emphasizes the need of car and truck drivers to maintain better awareness of motorcyclists on the highway.

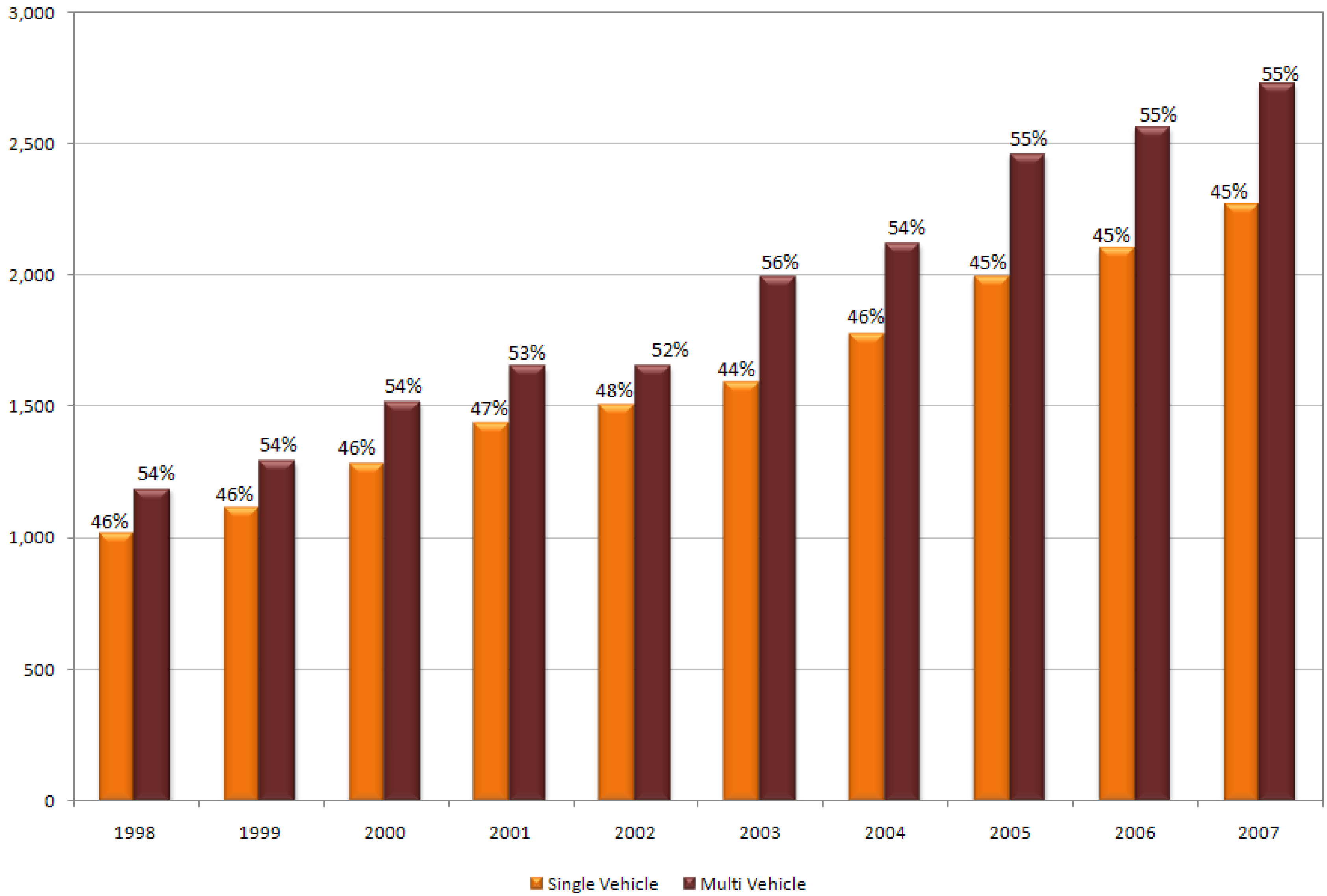

Figure 29. Single and Multi Vehicle Crashes by Year in the United States

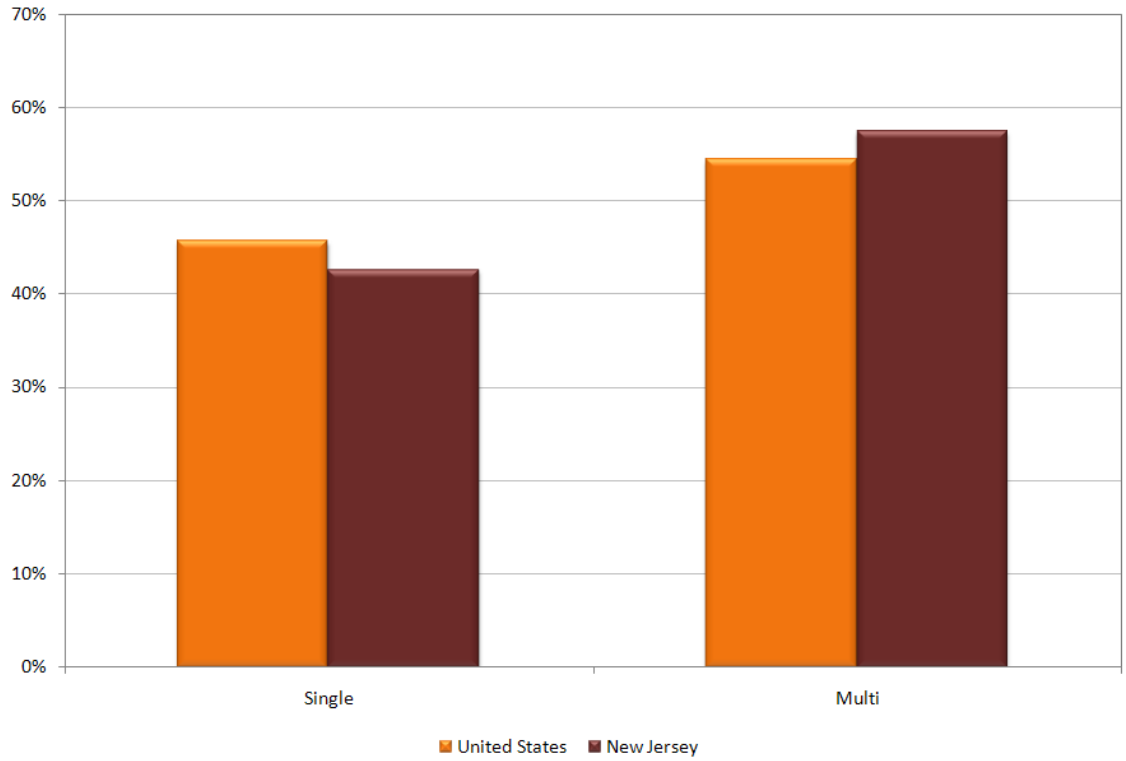

Figure 30. Single and Multi Vehicle Crashes: United States v. New Jersey (1998-2007)

Demographics of Riders

The first research objective in this study was to determine the characteristics of people involved in fatal motorcycle crashes. Two different demographics were considered to answer this question: gender and age. Furthermore, FARS was examined to determine if motorcyclists were riding while intoxicated and on a valid license. During the specified time period, 41,823 people were on a motorcycle and involved in a fatal motorcycle crash in the United States. Approximately 13% of this population (5,400 people) were not fatally injured, and were excluded from the analysis.

A total of 672 riders and passengers were involved in fatal motorcycle crashes in New Jersey over the time frame. 623 of these riders were fatally injured in the crash (93%). The remaining 49 people (7%) survived the crash and were excluded from the analysis. A higher percentage of males was killed in fatal crashes in New Jersey (94.1%) than in the United States (90.5%), as shown in Figure 31. Moreover, the people fatally injured in New Jersey tended to be slightly younger. Though the highest percentage of people were 31-50 years old, as seen nationally, there was a higher percentage of people aged 21-30 years old in New Jersey (Figure 32).

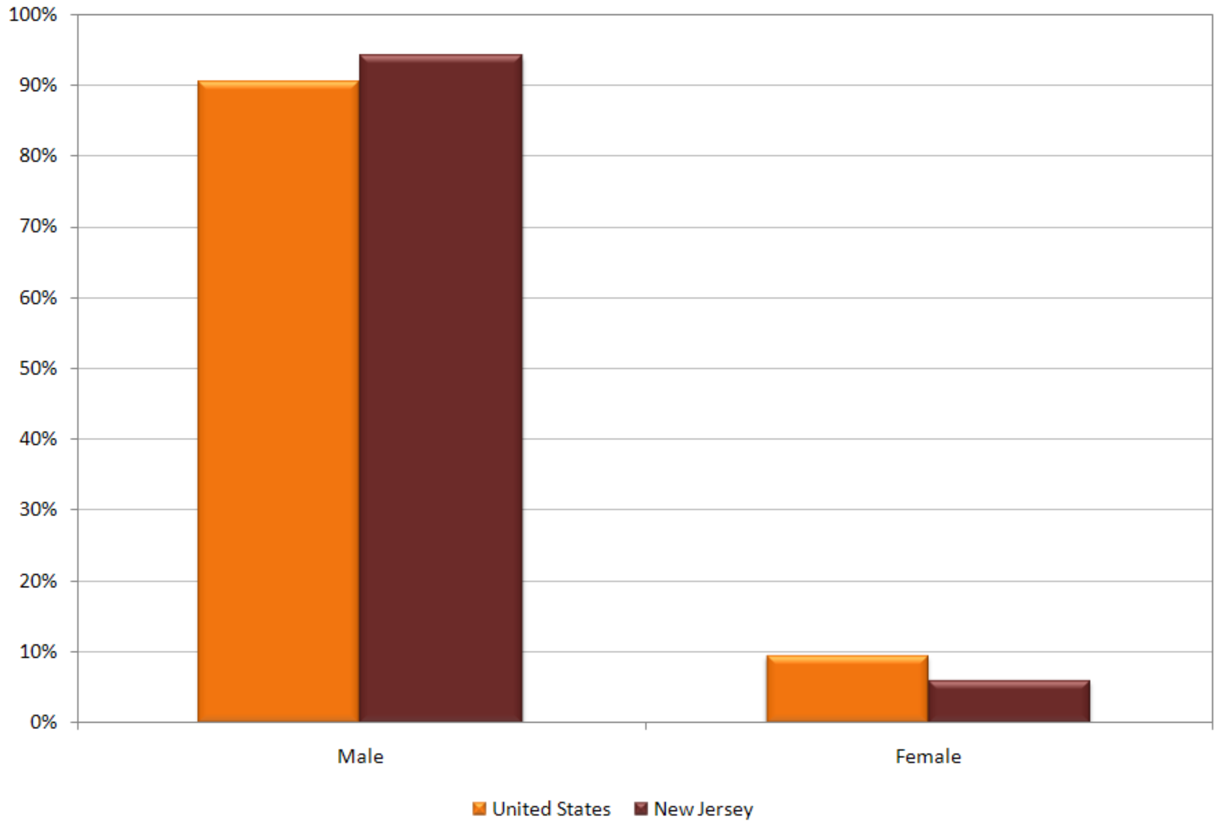

Figure 31. Gender Distribution of People Fatally Injured in a Motorcycle Crash: United States v. New Jersey (1998-2007)

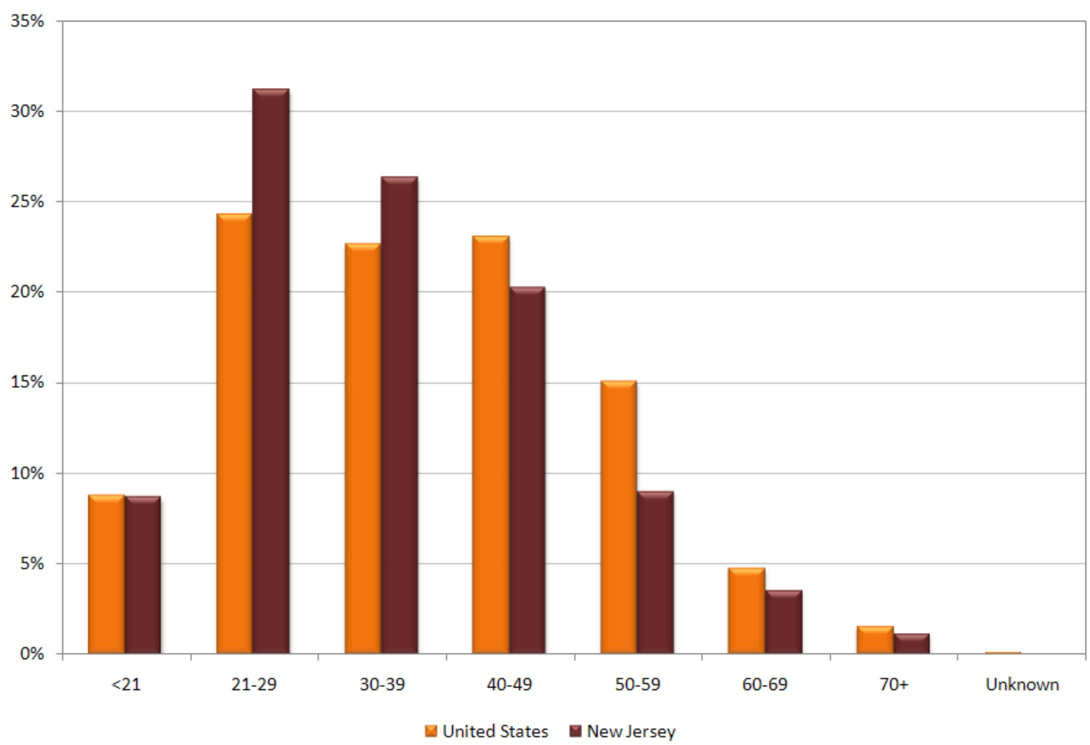

Figure 32. Age Distribution of People Fatally Injured in a Motorcycle Crash: United States v. New Jersey (1998-2007)

There were 36,793 motorcycle drivers involved in fatal crashes in the United States over the specified time period. In our sample, only 30.6% of these drivers were intoxicated at the time of the crash (Figure 33). A tabulation of the field “Driver Drinking” provided the desired data. This is in contrast to the *Basic RiderCourse* Rider Handbook, which claims that almost half of the riders killed were intoxicated [43]. As shown in Figure 33, New Jersey also had approximately the same percentage of alcohol involvement in the fatal crashes.

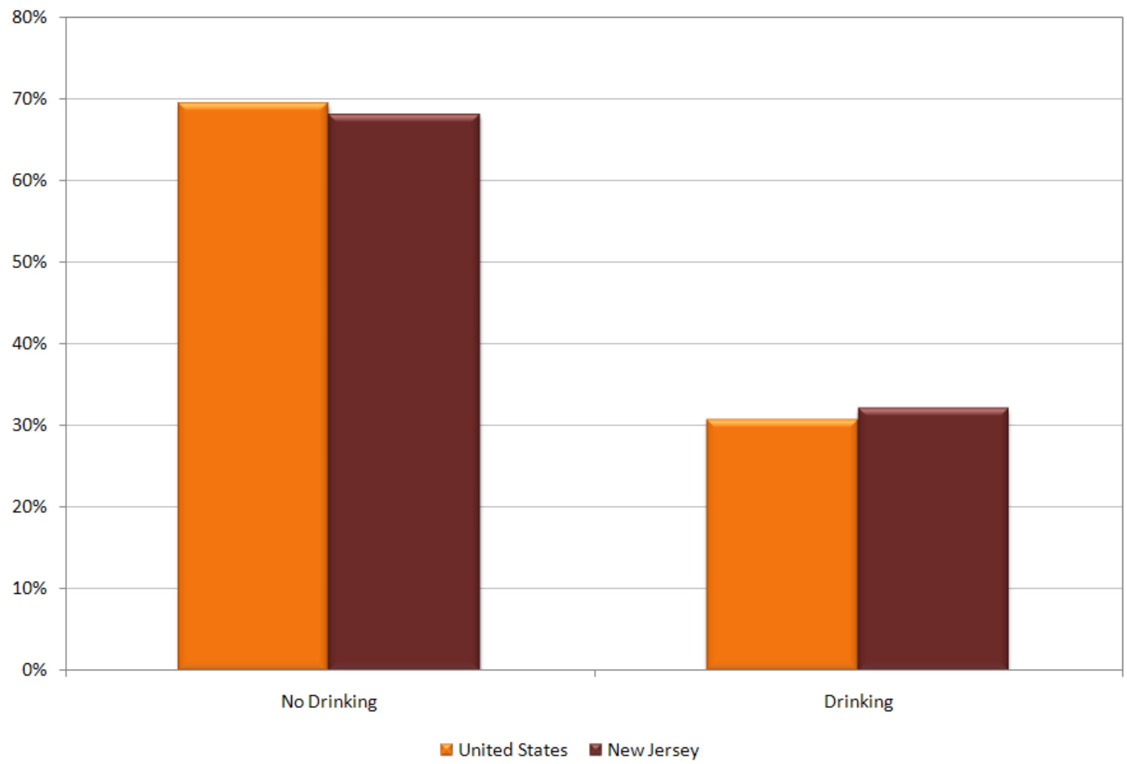

Figure 33. Drinking Status of Motorcyclists Involved in Fatal Crashes: United States v. New Jersey (1998-2007)

In past studies, it was found that unlicensed riders were overrepresented in fatal motorcycle crashes. In Maryland, 17% of motorcycle owners do not possess a license; however, 27% of motorcyclists involved in accidents were unlicensed [2]. In 2005, 8% of New South Wales riders involved in accidents were unlicensed, though they were involved in 32% of fatal accidents [24]. The license status of all drivers involved in fatal crashes was tabulated using the field “Driver License Type Compliance.” All drivers recorded as having a valid license or not required to have a license were considered “Valid.” However, 22.6% of motorcyclists involved in a fatal crashes both in the United States and in New Jersey from 1998-2007 did not hold a valid license at the time of the crash, and an additional 3.2% of motorcyclists were not licensed (Figure 34).

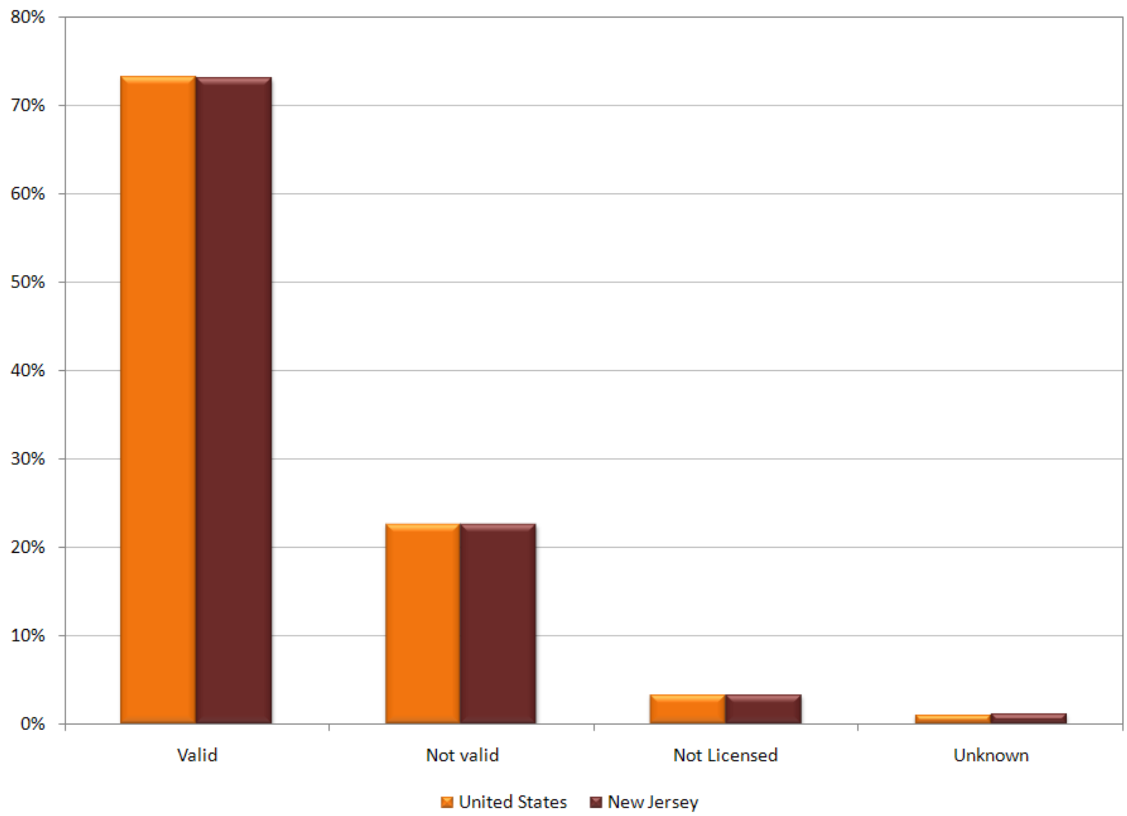

Figure 34. Driver's License Status for Motorcyclists in Fatal Collisions: Untied States v. New Jersey (1998-2007)

Motorcycle Characteristics

The second objective of the study was to determine common characteristics amongst the motorcycles involved in fatal crashes. The motorcycles that people were riding during fatal collisions were also analyzed to see if there was a commonality amongst the make and the engine size. There were 36,793 motorcycles involved in fatal crashes in the United States during the decade analyzed, 616 of which were involved in a crash in New Jersey.

The FARS field "Vehicle Make" was used to gather data about the make of the motorcycles, and the field "CC Displacement" was used to determine the engine size of the motorcycles involved. Harley-Davidson was the most common motorcycle make involved in a fatal crash (Figure 35) in the United States, accounting for 31.3% of all motorcycles. The makes of the motorcycles involved in crashes in New Jersey also followed a similar trend as in the United States (Figure 35). However, there were approximately the same percentage of Harley-Davidson, Honda, and Suzuki motorcycles (ranging from 24.0% to 21.3% respectively) involved in fatal crashes in New Jersey. Nationally, the percentage of these decreased respectively at a much greater rate. Lastly, there were higher percentages of Suzuki and Kawasaki motorcycles involved in crashes in New Jersey as compared to the United States (21.3% to 15.9% for Suzuki and 16.6% to 11.3% for Kawasaki).

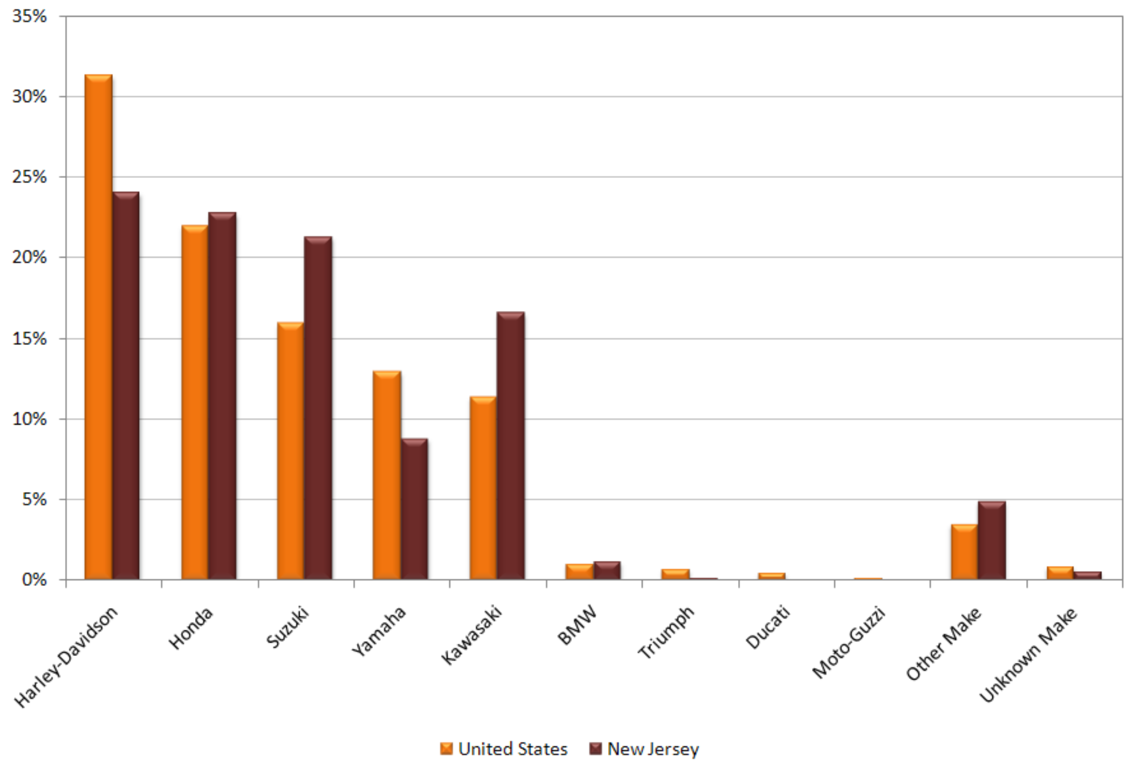

Figure 35. Distribution of Motorcycle Makes in Fatal Crashes: United States v. New Jersey (1998-2007)

In the United States 59.9% of motorcycles had an engine size of 750 cubic centimeters or larger, and 30.0% of all motorcycles were larger than 1250 cc (Figure 36). The engine size of the motorcycles involved in fatal crashes in New Jersey follows a similar trend as the engine size of those involved nationally (Figure 36); 59.3% of motorcycles involved in fatal crashes in New Jersey had an engine with a displacement of 750 cc or greater.

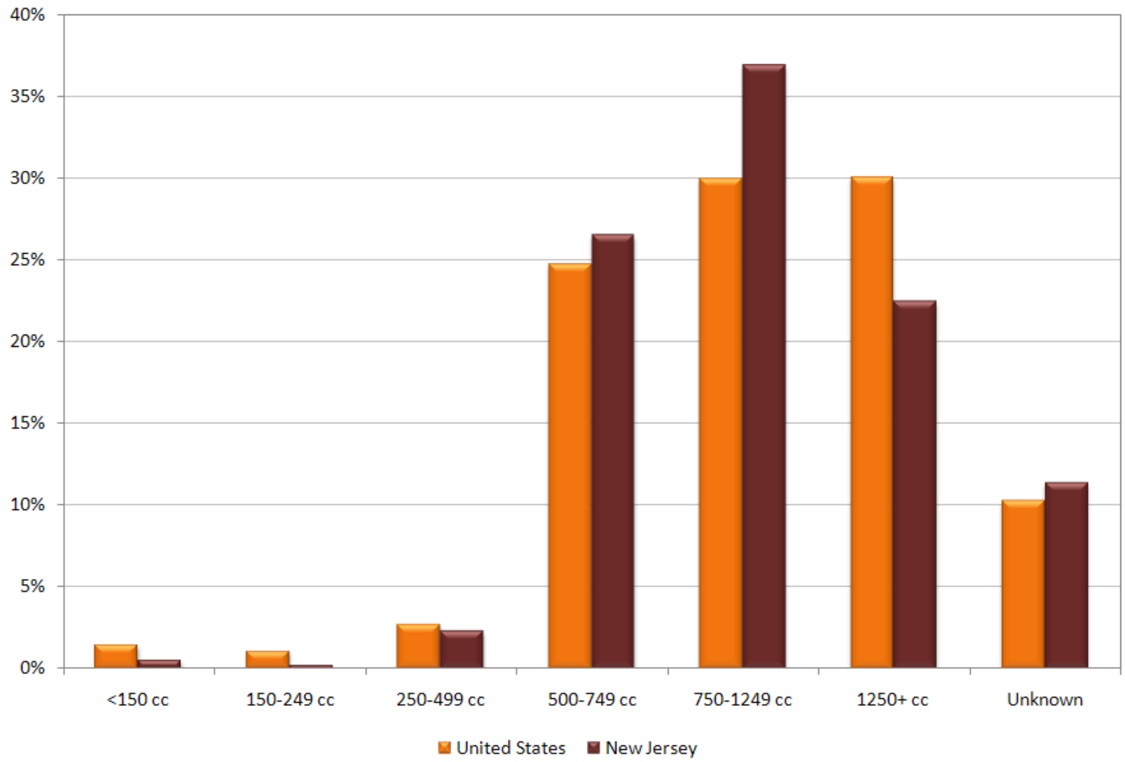

Figure 36. Distribution of Engine Size of Motorcycles in Fatal Crashes: United States v. New Jersey (1998-2007)

Crash Conditions

There were a total of 35,307 fatal crashes that occurred from 1998-2007 in the United States, 606 of which were in New Jersey. The conditions under which crashes have occurred were analyzed. First, the timing of fatal motorcycle crashes was examined by looking at the time of the year and the time of the day when the most crashes occur. The environmental conditions of weather and lighting were also considered.

The “Month” field was used to tabulate how many accidents occurred in each month. The months were then separated into their respective seasons. June, July, and August were combined to form the summer category. Fall was comprised of September, October, and November. Likewise, December, January, and February were incorporated in winter. Most fatal crashes (38.8% in the United States and 44.6% in New Jersey) occurred during the summer (Figure 37). Moreover, 64% of the crashes in the country and 67% of the crashes in New Jersey occurred in either the spring or summer.

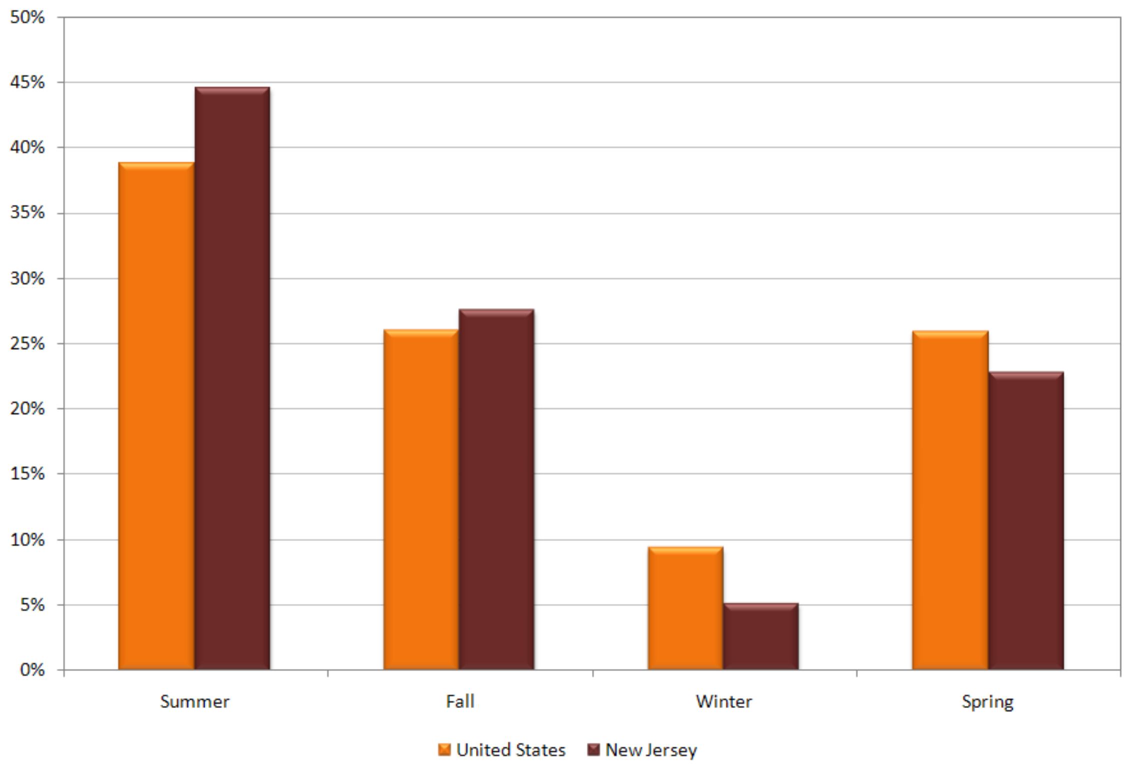

Figure 37. Distribution of Fatal Motorcycle Crashes by Season: United States v. New Jersey (1998-2007)

Next, the time of day was tabulated using the “Hour” field. The highest percentage of crashes (7.9% in the United States and 8.8% in New Jersey) occurred between 5:00 and 5:59 pm, around rush hour and at the end of the regular work day (Figure 38). Some data for the United States were excluded from the figure for consistency, i.e., if the time of some crashes was either unknown (0.87%) or coded as occurring during the 24th hour (0.07%). This was done in order to gain a better representation of the data. There were no invalid data for the crashes in New Jersey.

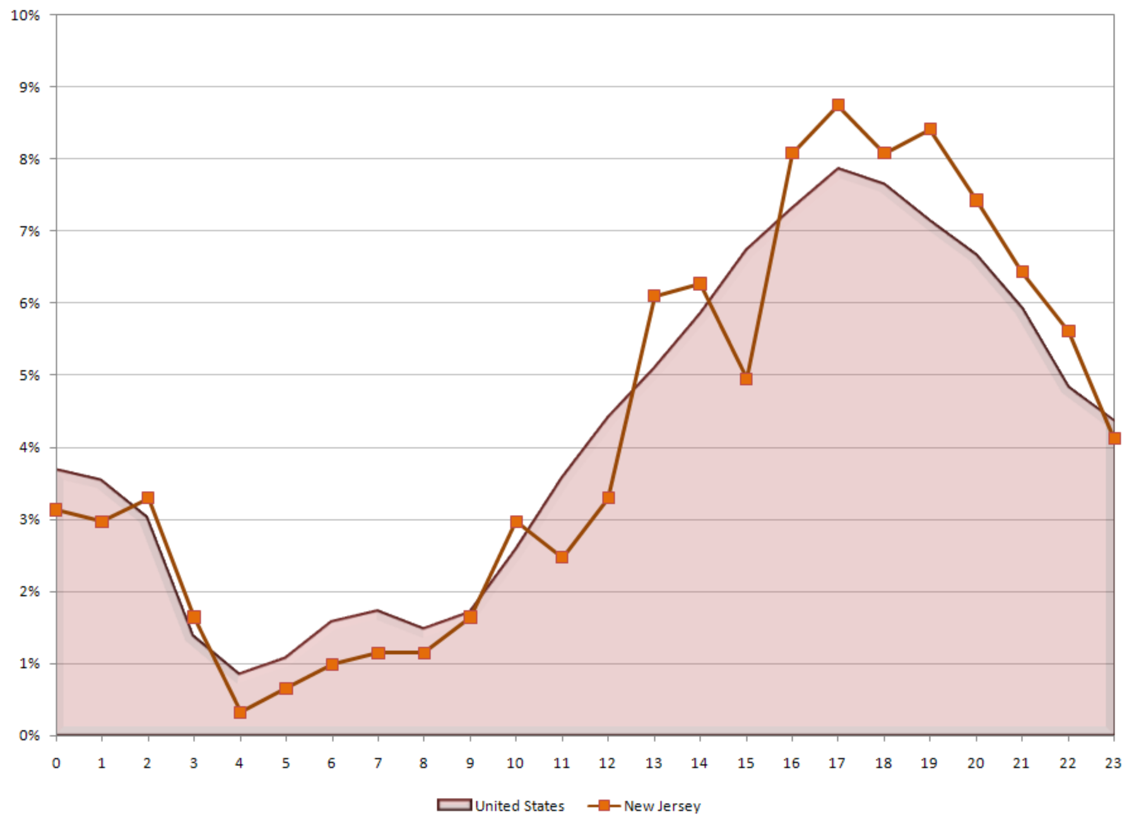

Figure 38. Distribution of Fatal Crashes by Time of Day:United States v. New Jersey (1998-2007)

Almost all (96.7% in the United States and 98.1% in New Jersey) of the crashes occurred during normal weather conditions (Figure 39), which is a reflection of motorcycling being a fair weather activity. Moreover, 57% of crashes occurred in daylight (Figure 40). An additional 18.0% occurred on a lighted road when it was dark in the United States. This figure was higher in New Jersey; 28.2% of crashes occurred on lighted roads in the dark.

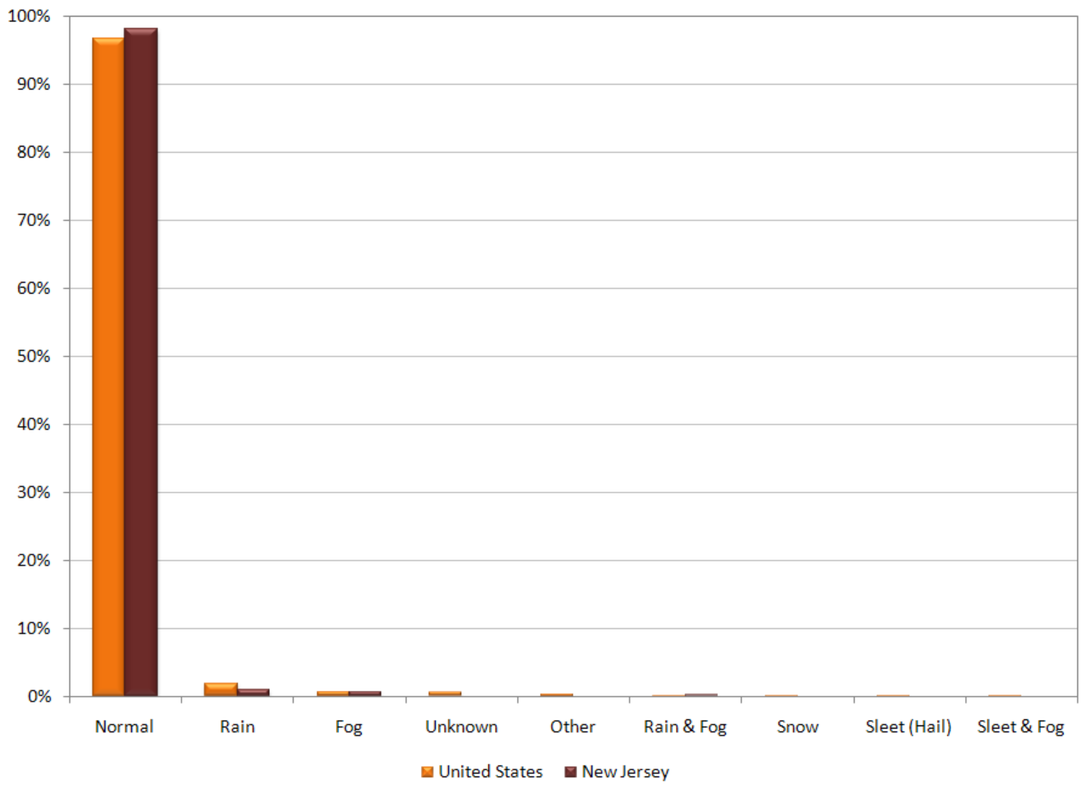

Figure 39. Distribution of Fatal Crashes by Weather Conditions: United States v. New Jersey (1998-2007)

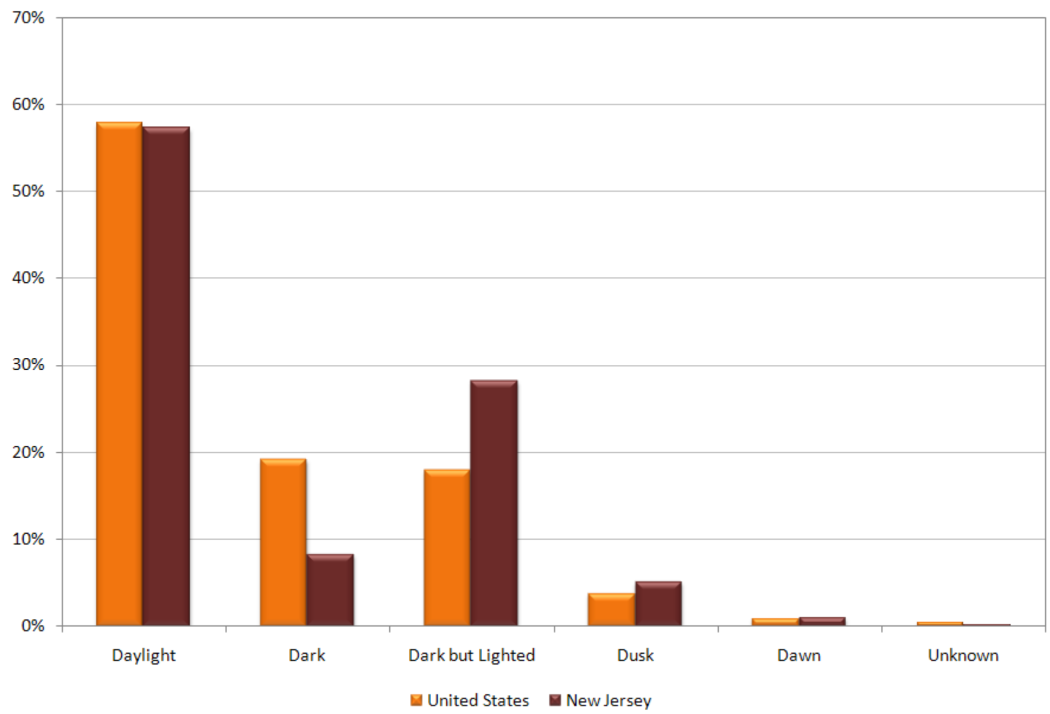

Figure 40. Distribution of Fatal Motorcycle Crashes by Lighting Conditions: United States v. New Jersey (1998-2007)

Discussion

The number of fatal motorcycle crashes has been increasing since 1998. More than half of these crashes involved more than one vehicle. The overwhelming majority (90% nationally and 94% state-wide) of people fatally injured were males. Moreover, most of the people fatally injured were aged 31-50 (46%), and more than two-thirds were not intoxicated at the time of the crash. A higher percentage of people fatally injured in New Jersey were aged 22-30 (31% as compared to 23% nationally). Almost three-quarters (73%) of the drivers involved in fatal crashes either had a valid license or were not required to hold a license at the time of the crash.

Most motorcyclists were riding a Harley-Davidson motorcycle at the time of the crash. Harley Davidson motorcycles accounted for 31% of all motorcycles on which the driver and/or passenger was fatally injured during a crash in the United States and 24% in New Jersey. However, in New Jersey there was approximately the same number of Harley-Davidson, Honda, and Suzuki motorcycles involved in fatal crashes. Moreover, motorcycles with an engine size of 750 cubic centimeters or larger accounted for approximately 60% of motorcycles in fatal crashes.

Weather conditions were normal during almost all of the fatal collisions. Only 2.5% of crashes in the United States and 1.9% of crashes in New Jersey occurred during inclement weather, and 0.5% of weather conditions at the time of the crash remained unknown. Thus, weather was not one of the main contributors to fatal motorcycle crashes. The highest percentage of motorcycle crashes occurred during the summer and the spring. These statistics are most likely a reflection of motorcycling being a fair weather activity. Motorcyclists are susceptible to hypothermia due to the wind chill factor that occurs from riding [43]. Moreover, approximately 57% of the crashes occurred during the daylight. Of those that occurred at night, 48% occurred in a lighted area in the United States and 77% occurred in a lighted area in New Jersey. The highest percentage of crashes occurred between 5:00 and 5:59 pm. The number of fatal crashes gradually rose from 5:00 am until 5:00 pm, when the number of fatal crashes peaked. A smaller peak was also observed at 7:00 am, though afterwards the number of fatal crashes did not decrease as drastically and continued to rise after 9:00 am.

Fatal crashes in New Jersey did not rise as steadily as those in the United States. However, this may be observed due to a smaller data set and slighter variations having a greater impact on the trend. A higher percentage of males were killed in fatal crashes in New Jersey than in the United States. However, as seen nationally, the majority of people fatally injured in New Jersey were aged 31-50 (44% in New Jersey).

Conclusions

The conclusions of this analysis of fatal motorcycle crashes in the United States and New Jersey are as follows:

1. Nearly half of all fatal crashes in New Jersey were single vehicle crashes. Thus, fatal motorcycle crashes cannot be blamed exclusively on car drivers, as half the crashes did not involve another vehicle.
2. Over half of all fatalities in New Jersey included another vehicle. Hence, there is a need for improved diver awareness of motorcycles and improved conspicuity of motorcycles.
3. Males aged 31-50 are most likely to be fatally injured in motorcycle crash. Moreover, drivers of motorcycles who were fatally injured, or whose passenger was fatally injured, were most likely to hold a valid license and not be intoxicated at the time of the crash.
4. Motorcycles involved in crashes were most likely to be Harley-Davidson motorcycles and have an engine size of 750 cubic centimeters or larger.
5. Motorcycling is a fair weather mode of transportation. Most fatal crashes occurred during fair weather conditions and during the daylight. The highest percentage of crashes occurred during the summer.
6. The characteristics of fatal motorcycle crashes in New Jersey were consistent with national motorcycle crash characteristics.

7. Field Inspection of Motorcycle-Roadside Crash Sites

Abstract

One factor associated with the frequency and severity of motorcycle collisions with roadside objects may be the design and maintenance of the road. Two methods of analysis were used to investigate the influence of the road geometry and design of roadside environment on motorcycle collisions. Satellite imagery was used to develop an overview of different collision sites. Site visits for 118 motorcycle-roadside object crashes at 110 different sites were conducted to record details about each site, including types of guardrails and distance of the object struck from the road.

Introduction

Motorcyclists are overrepresented in guardrail collisions. Motorcycles comprise only 2% of vehicles on the roads, but account for 42% of all guardrail collisions [2]. Motorcyclists are more vulnerable on the road than other vehicle passengers due to the instability of their vehicle as well as greater exposure to the outside environment. There are various causes of motorcycle crashes, including the design and maintenance of the road. Roadside environments were further investigated to determine characteristics that may lead to a higher risk for motorcyclists running off the road.

Potential design factors include road curvature, superelevation, barrier type, and barrier offset distance from the travel lane. Road surface factors of interest include the presence of rumble strips, potholes, cracking, painted areas, and gaps between the road surface and bridge decks.

Objective

The first objective of this component is to describe the methods used to develop a database with detailed information about roadside object motorcycle collision sites. Using this method, 110 individual motorcycle crash sites were investigated. This component also presents the findings from the investigations of these sites.

Methods

The cases used in this study were extracted from the New Jersey Crash Records Database (NJCRASH) for calendar years 2005-2008. NJCRASH is a complete collection of police accident reports which are available in electronic form. Of particular value to this project, most crashes have been geocoded with the latitude / longitude coordinates of the crash site. The geocoded locations of motorcycle-roadside object collisions were investigated using two methods: a satellite image analysis and an individual site inspection. For this pilot study, a subset of these cases was investigated to determine the feasibility of our approach. Motorcycle collisions with guardrails, concrete barriers, poles, and trees were investigated. Sites where motorcycles only overturned were not investigated due to time constraints. However, including these sites would introduce a control group into the investigations.

Satellite Imagery Analysis

The imagery analysis gave a first look at the different guardrail collision sites. Using the latitude and longitude data recorded in the NJCRASH database, sites were located on satellite images using Google Earth Pro. A screenshot was taken of each collision site and incorporated with data tables that displayed information about the accident based on the coded NJCRASH Data. The tables incorporated data about the time and date of the crash, location, information on the rider and motorcycle, and sequence of events to give an overall description of each accident.

The radius of curvature was also investigated through the satellite imagery analysis. Collisions that occur on any size curve are listed simply as ‘curve’ in the NJCRASH database. NJCRASH does not describe the radius of the curve. However, it is important to know the radius of a curve: curves with smaller radii may be more dangerous for riders [30]. Thus, comparing the radii of curves on which collisions occurred may help in determining the geographic locations where accidents are occurring.

Google Earth Pro was used to measure the radii of curves where collisions occurred. The circle tool used to draw a circle on the image. The tool measures the radius of the circle, which can be adjusted by dragging the endpoint of the radius on the map. The center of the circle can also be adjusted by dragging the center to a new location. Using these two operations, the circle was fit as best as possible to the curve Figure 41. The median of the road was used as guidance in determining the curvature of the circle, and, when possible, the circle was fit to the median. On roads where there was no median, the lines on the road were used as reference if they were visible in the satellite imagery.

Figure 41. Example radius of curvature measurement from Google Earth Pro. This collision occurred in Mercer County on Route 640. The radius of curvature is 200 feet.

Once the circle was fit to the curve, the radius of the circle was recorded to the nearest foot. The Google Earth Pro tool records the radius to the nearest hundredth of a foot; however, the rounding was made in order to compensate for human error in fitting the circle to the curve.

Site Survey Data Collection

Though satellite imagery provided an introduction to the area where a crash occurred, the imagery is not of a high enough resolution to determine smaller characteristics of the road, such as variations in the surface and the type of guardrail surrounding the road. Motorcycles are more vulnerable to these variations as they are significantly less stable than other motor vehicles. Data currently available through NJCRASH does not include detailed information about the roadside objects, such as the distance of a struck object from the road or the condition of the object.

Site visits were conducted to methodically document the characteristics of the roadway, roadside, and barrier at each crash site (Figure 42). A data collection form was developed specifically for this project, and used to ensure the same data were gathered at every site. It allowed investigators to select specific characteristics from a list of options, with the option of adding characteristics that were not included. Additionally, this format allowed for simpler analysis of data than a sheet without any options because there are a finite amount of responses to each question. A sample data collection form is included in Appendix A.

Figure 42. Motorcycle-pole collision site.

The data collection sheet focused on two main areas: the characteristics of the roadway/roadside and the characteristics of the fixed object. Table 9 lists the data elements collected about the roadway and roadside. The main data elements included roadway characteristics, road surface conditions, and shoulder/median characteristics and conditions. Several roadway dimensions were also recorded including lane width and grade. Photographs were taken in order to compare the road conditions and surrounding environments around each crash site. The data collection sheet also contained a check list of photographs to be taken to ensure that common features can be compared.

Table 9. Roadway Data Elements Collected

Data Element	Characteristics
Roadway Characteristics	Surface
	Surface Change
	Lighting
	Alignment
	Profile
	Curb
	Number of Lanes
	Speed Limit
	Obstructions of view
	Proximity to other road/ramp
	Warning Signage
Road Surface and Surrounding Conditions	Painted Surface
	Potholes
	Patches
	Notable Cracks
	Reflectors
	Contaminants
Shoulder and Median Characteristics	Presence
	Surface
	Division
	Potholes, Patches and Notable Cracks
	Contaminants
Roadway Dimensions	Average Lane Width
	Curb Height
	Grade (direction of travel)
	Superelevation
	Grade around Curve (if applicable)

Characteristics about the roadway were also inspected to see if there were common aspects of the road that could potentially be a cause of an accident. It was noted if there were any potholes, patches, or cracks in the road, as a motorcycle can lose stability from riding over one of these defects. Any abrupt changes in the elevation were noted as these are also hazardous to motorcyclists. However, one limitation of our study was that the inspections occurred many months after, and sometimes 2 to 3 years, after the crash. These roadway characteristics may have changed from the time of the crash. Several design aspects of the road were also examined. First, it was noted if there was a rumble strip in the shoulder as the high surface variation may cause a rider to lose control.

The second focus of the data collection was on the fixed object. Sites with motorcycle collisions into guardrails, concrete barriers, poles, and trees were examined through the site surveys. Table 10 gives the data elements and dimensions collected for fixed object. Several different characteristics describing the guardrail were observed through site visits. First, the type of rail was recorded since this is the main component of the guardrail. Moreover, the height of the rail from the ground was measured. In the event of a collision a motorcyclist can fall from his/her motorcycle and slide under the guardrail, potentially colliding with the post. Second, the type of post was recorded. As described earlier in this report, posts can be one of the greatest hazards to motorcyclists as they have narrow faces and edges which concentrate the force. Lastly, it was noted if any additional safety measures, such as an additional W-beam or metal guard, were used on the guardrail at the collision site. Characteristics of other roadside objects were incorporated such as type of concrete barrier, pole type, and distinguishing features.

Table 10. Fixed Objects Data Elements Collected

Fixed Object	Characteristics
Guardrail	Possible Purpose
	Post Type
	Rail Type
	Block
	Terminal Type (if applicable)
	Damage to Rail/Post
	Dimensions
	Height to bottom of rail
	Distance from Edge of Pavement
	Edge of Pavement to End of Lane
	Distance Between Posts
Concrete Barrier	Type
	Dimensions
	Height of Barrier
	Width at Top
	Distance to Edge of Pavement
	Edge of Pavement to End of Lane
	Length of Each Section
Pole/Tree	*Pole*
	Material
	Pole Type
	Base Location Material
	Location
	Breakaway / Device (if applicable)
	Dimensions
	Circumference at 3' from ground
	Height of Concrete Base (if applicable)
	Distance to Edge of Pavement
	Edge of Pavement to End of Lane

As listed in Table 10, measurements of the shoulder width, slope, and distance between the object and end of the pavement were taken at each site. A diagram was included in the survey sheet to clarify the required measurements for each object. Figure 43 shows the diagram included for guardrail collisions. Similar diagrams were included for concrete barrier and pole/tree collisions. The distance of the object from the road may have an effect on the severity of a collision; if the object is further away from the flow of traffic, the motorcyclist will have more time to slow down before colliding with it.

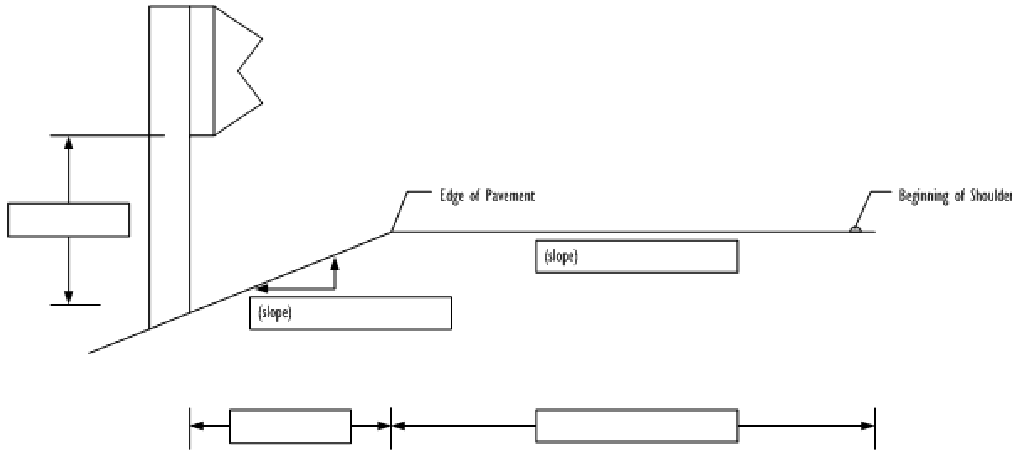

Figure 43. Guardrail and Road Environment Measurements. This figure was included in the site survey sheets to gather data about the distance of the object from the road and the slope of the road**.**

Police reports for each site visited were obtained from the New Jersey Department of Transportation before most site visits. The police reports contained more information about the occurrences of the accident, sometimes including a diagram. This additional information facilitated finding the site and exact location of the collision, as many sites had multiple poles, trees, or lengths of guardrails.

Results

To date, a database of 118 collisions which have occurred at 110 crash sites has been developed. Approximately 120 people were involved in these crashes. Table 2 presents the composition of the resulting dataset. This includes 53 guardrail collision sites, 21 pole collision sites, 23 tree collision sites, and 21 concrete barrier collision sites. The majority of the collisions (113) occurred in either 2007 or 2008.

Table 11. Composition of Data Set of Motorcycle-Roadside Object Collisions (NJCRASH 2005-2008)

Variable	Number of Cases
All	118
Year of Crash	
2005	1
2006	4
2007	66
2008	47
Object Struck	
Guardrail	53
Concrete Barrier	21
Pole	21
Tree	23

Table 11 (continued).

Variable	Number of Cases
Injury Severity	
Fatality	16
Incapacitating Injury	18
Moderate Injury	50
Complaint of Pain	22
Property Damage Only	0
Missing from Report	12

There were several sites that were too hazardous for investigators to completely examine due to dangerous traffic conditions. For these cases, a partial inspection was completed. Several drive-by site inspections were done to gather as much information about the area as possible without exiting the vehicle. Table 12 shows the distribution of complete and partial inspections completed for each collision type.

Table 12. Distribution of complete and drive-by site inspections

	Inspection Type		
Crash Type	**Complete**	**Drive By**	**Total**
Guardrail	36	17	53
Concrete Barrier	11	10	21
Tree	17	6	23
Pole	21	0	21

Example Case

On Route 579 in Bethlehem Township in Hunterdon County, a crash location was investigated where there were 7 motorcycle-guardrail collisions from 2006-2008. The posted speed limit on the road is 35 mph, with a reduction to 10 mph around the curve. The road took a sharp turn left, and disappeared from vision due to the downgrade of the road (Figure 44). There were two driveways ending at the curve.

Figure 44. Route 579, Bethlehem Township, Hunterdon County. Seven motorcycle-guardrail collisions occurred at this site from 2007 to 2008.

There were at least 5 areas of damage along the W-beam guardrail, suggesting other vehicle crashes had occurred on the same curve (Figure 45). Some of the steel strong posts were also bent and damaged.

Figure 45. Damage to guardrail. There is notable damage to the rail and the posts in multiple areas.

The distance of the guardrail from the edge of the lane gradually narrows as the road curves left. The guardrail-road offset distance was measured in three places to be 7.4, 5.0, and 4.0 feet from the edge of the lane. Along the curve, the guardrail was located only 0.75 feet from the edge of the pavement. The guardrail is in place to protect vehicles from the wooded slope behind it. The road slopes 11° in the direction of the road. The road angled 23° toward the center of the curve.

During the site visit, a street cleaner was seen at the site, implying that the site is well kept. There was little debris noticed on the side of the road as well. There were no potholes, patches, or large cracks in the asphalt surface of the road. However, the road was rough and uneven (Figure 46), which may be more hazardous for motorcycles than other vehicles.

Figure 46. Road Surface. The surface of the road was noted to be rough and uneven.

The geometry of the site was analyzed using Google Earth Pro. The radius of curvature of the site was measured to be 49 feet (Figure 47). This is a very narrow curve as none of the other sites investigated using the satellite imagery were found to have a radius under 100 feet.

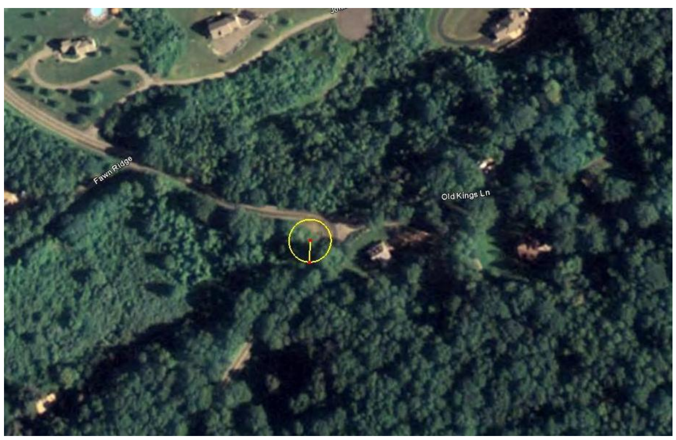

Figure 47. Radius measurement of example site. The radius of the curve was measure to be 49 feet.

Site Survey Data Collection Results

There were 118 motorcycle crash sites visited including both roadside (74%) and median crashes (25%). The roadway condition of each of the sites was examined as explained in the methodology section. Overall, 93% of the sites were free of potholes and 78% did not have any notable patches in the road. Lastly, there were no notable cracks in the road surface at 70% of the crash sites.

Overall, 32 of the 79 (41%) sites with a shoulder were noted to have contaminants such as gravel or dirt in the shoulder. Though the condition of the site may have changed since the crash, these contaminants may have caused motorcyclists to lose control of their motorcycles. Keeping roadsides clean may increase the chance of the motorcyclist regaining control of his/her motorcycles and reduce the number of crashes.

Measurements were taken to determine the distance of the fixed object from the lane edge. Of the sites where measurements could be taken or accurately estimated, the majority of sites (40) had roadside objects placed less than 5 feet from the edge of the lane, as shown in Figure 48.

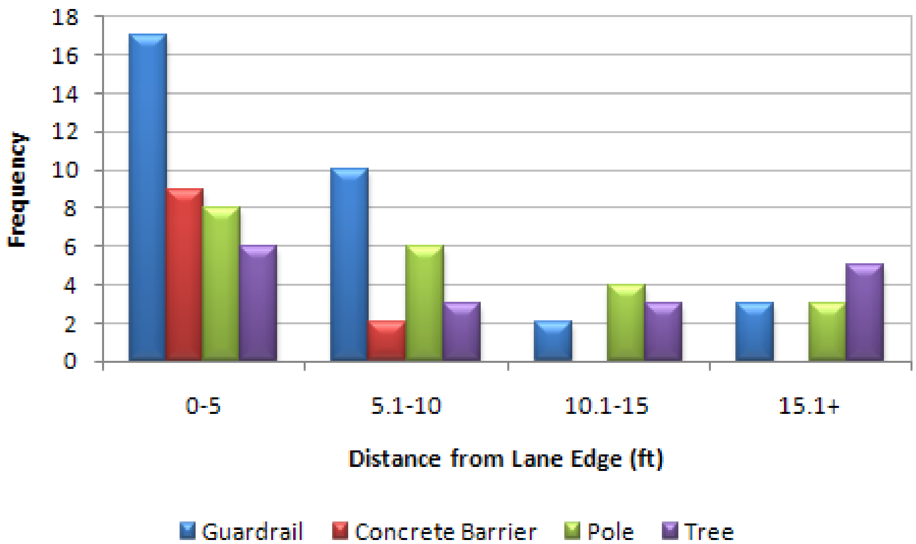

Figure 48. Distance of object from end of lane by object type.

Figure 49 shows a breakdown of the distance of the object from the road by the injury severity for all types of collisions. The majority of fatal and incapacitating crashes occurred when the object was between 5 and 10 feet from the edge of the lane. However, there were also fewer of these sites visited due to the relative occurrence of these collisions. The majority of the moderate injury and complaint of pain collisions occurred when the object was less than 5 feet from the edge of the lane.

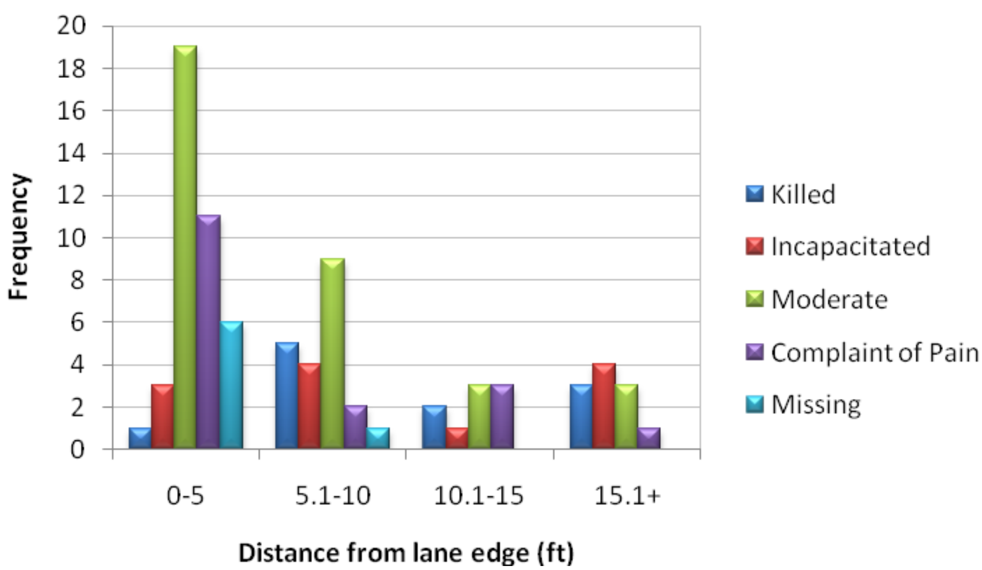

Figure 49. Object distance by injury severity for all objects struck.

Sixty-nine percent of the collisions occurred on curves, the majority of which were on left curves (Figure 50). Curves were most frequent in guardrail collisions; 72% of the guardrail collisions examined occurred on curves. Less than half of the collisions (43%) with concrete barriers occurred on curves. This may be a reflection of where concrete barriers are most frequently used.

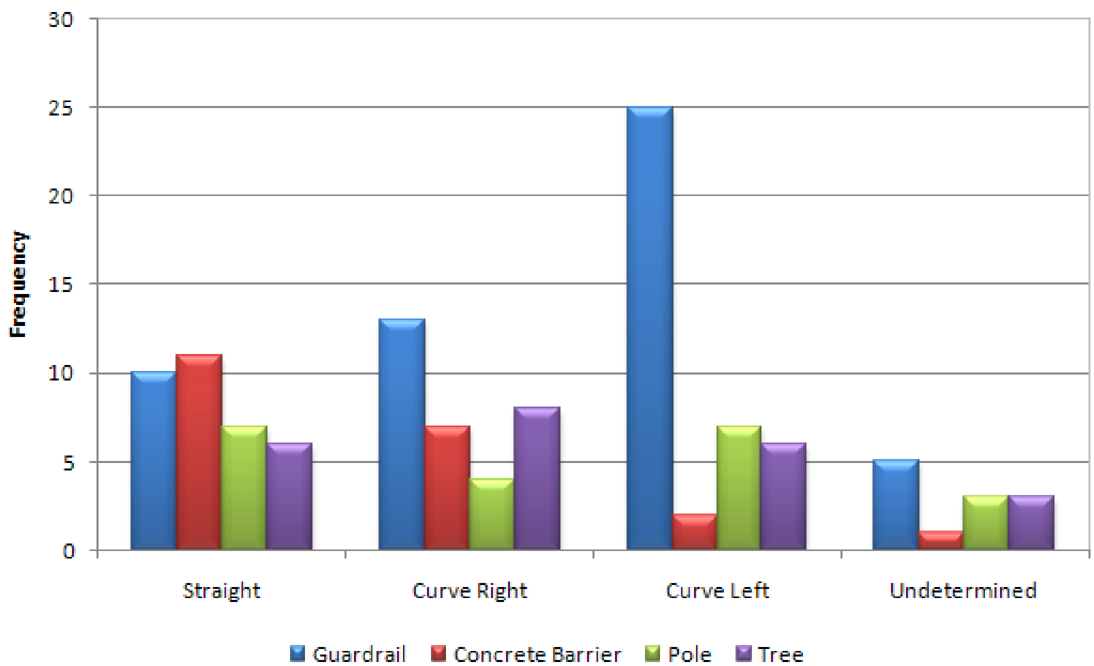

Figure 50. Roadway alignment at crash sites visited by collision type.

The risk of severe injury was computed as a function of the distance from the lane edge (1) for the sites visited. Figure 51 shows the distribution of the crash risk for all objects struck.

$$Risk = \frac{Fatal\ and\ Incapacitating\ Crashes}{Total\ Crashes\ at\ Distance\ Range} \tag{1}$$

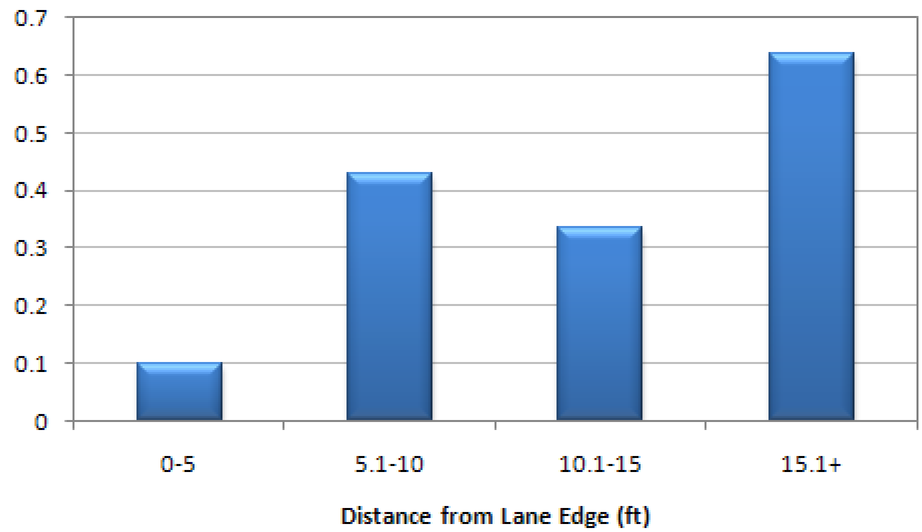

Figure 51. Risk of severe injury from fixed object as a function of distance from the lane edge

Of the 72 sites investigated where the crash occurred on a curve, 61% (44) had warning signage notifying road users of the upcoming curve. In fatal crashes on curves, 67% had warning signage present, whereas only 57% of curves where injury crashes occurred had signage. Negotiating a curve and quick changes in direction are more difficult on a motorcycle as compared to other vehicles due to their instability. Providing additional signage at curves would give motorcyclists more time to reduce their speed and properly negotiate the curve instead of having to react to the curve as they reach it. Also, additional signage on curves recommending a safe speed for motorcyclists would reduce the chance of a motorcyclist, especially one unfamiliar with the road, negotiating the curve at an unsafe speed.

Many of the collisions occurred on exit and/or entrance ramps. Overall, 21 crashes examined (18%) were either on or in the proximity of an entrance or exit ramp. Based on the police reports, it was noted in a few crashes that the motorcyclist failed to turn. Also, 19 crashes were noted to occur either in or near an intersection, and an additional 11 occurred near one or multiple driveways.

The grade of the road was noted at the sites. The majority of the crashes occurred on a level road. Figure 52 gives the percentage of each collision type that occurred in each grade category. Overall, 71% of crash sites examined had a level surface and 28% occurred on a grade.

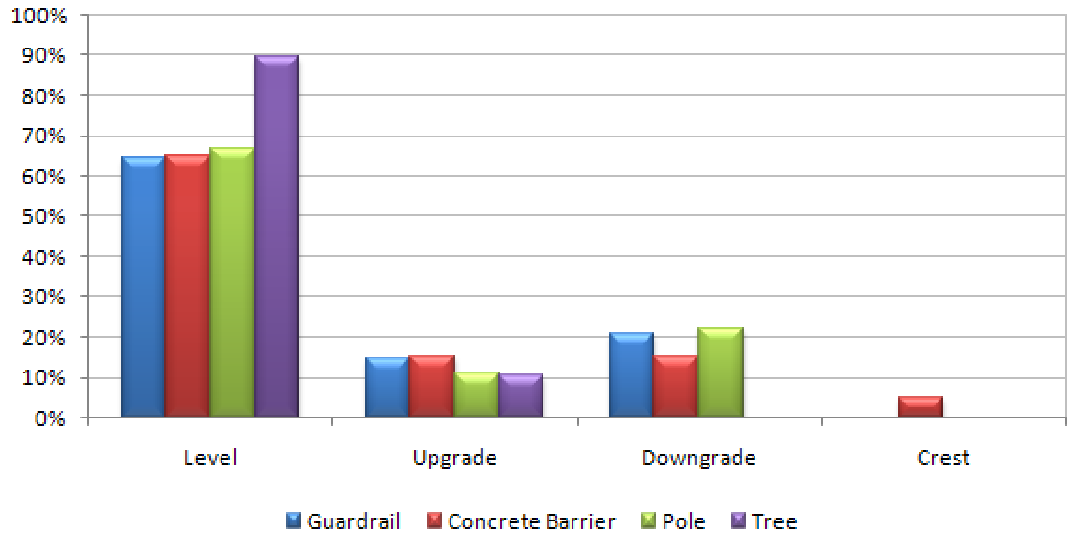

Figure 52. Grade of road at crash sites by collision type.

Lastly, the surface roughness of the roads at 42 of the crash sites was investigated. Data were only available for state roads. According to the *Report to the Governor and the Legislature on New Jersey's Roadway Pavement Program* for the 2007 fiscal year, a road with an international roughness index (IRI) between 95 and 120 in/mi is considered a fair road and an IRI between 120 and 170 is considered a mediocre road [45]. The average IRI for the crash sites analyzed was 157.69 in/mi, with values ranging from 0.0 to 643.89 in/mi. A distribution of roughness based on the scale set in the aforementioned report [45] is given in Table 13.

Table 13. Distribution of Surface Roughness at Crash Sites

Rating	IRI Range (in/mi)		Number of Crash Sites
	Minimum	Maximum	
Good	0	95	9
Fair	95	120	8
Mediocre	120	170	10
Deficient	170		14

One notable crash site visited is the intersection of Miller Avenue and Route 35 in Hazlet Township, Monmouth County. At this location, the surface roughness of Route 35 is 643.89 in/mi. According to the police accident report, the rider was moving forward from the light on Route 35 and lost control of the motorcycle, resulting in a collision with the concrete barrier. As shown in Figure 53, the road has big ruts, especially visible in the crosswalk line, which may have contributed to the crash.

Figure 53. Surface roughness at intersection of Route 35 and Miller Avenue in Hazlet Township, Monmouth County

<u>Guardrail Crash Site Results</u>

The sites of 53 motorcycle-guardrail collisions were investigated, totaling 48 different sites due to multiple collisions occurring at two sites. The guardrails all had w-beam rails with steel strong posts (37), steel weak posts (2), wood posts (3), or a combination of steel and wood posts (3). Data were not recorded for 3 as hazardous road conditions prevented investigators from conducting a complete inspection. Overall, 82% of the fatal and incapacitating collisions (14 of 17) and 76% of less severe crashes (32 of 42) occurred with a strong post. This may be a reflection of the standard types of guardrails used in New Jersey.

The blockouts used varied between steel (15), wood (4), recycled plastic (11), and none (2). Three sites included a guardrail with a combination of different types of blockouts. Data were not recorded at 13 sites. The average height from the bottom of the rail to the ground was 1.41 feet. The standard distance between the bottom of the w-beam to the ground is 1.29 feet. The results from the distribution of guardrail types are most likely due to the standards for guardrails in New Jersey.

Almost three-quarters (72%) of the guardrail collisions examined occurred on curves, as shown in Figure 54. This is a higher percentage of crashes compared to tree and pole collisions, as 52% of pole crashes and 61% of tree crashes occurred on curves. Moreover, nearly half of the guardrail collisions (47%) occurred on a left hand curve. As discussed in Chapter 3, curves are known to be more hazardous to motorcyclists due to the difficulty of maneuvering a motorcycle. The presence of warning signage was noted at 25 of the 32 sites where guardrail collisions occurred on curves. At these sites, 72% were marked with warning signage around the curve. A speed reduction sign around the curve was noted at 6 sites, half of which included a speed reduction of 25 mph.

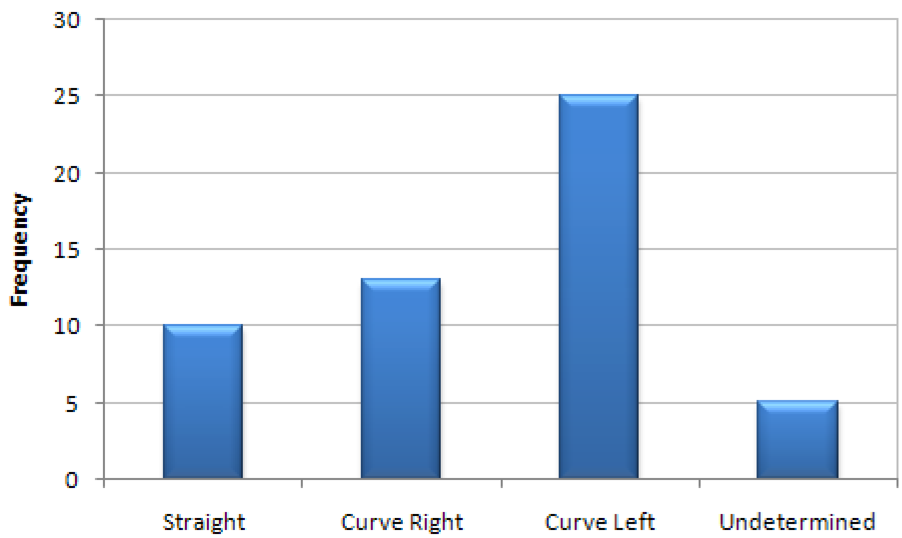

Figure 54. Roadway alignment of guardrail collisions.

<u>Satellite Imagery Analysis.</u> A separate analysis for 139 guardrail collision sites in New Jersey from 2005-2007 was conducted. The main component of each site investigated through the use of Google Earth was the radius of curvature at each site. Fifty-eight (42%) of the collisions investigated occurred on curves, 41 of which (34%) occurred on a curve with a radius of curvature of less than 1000 feet.

The distribution of the crashes across New Jersey was also found after each crash was analyzed (Figure 55). Most motorcycle-guardrail collisions were in northern New Jersey.

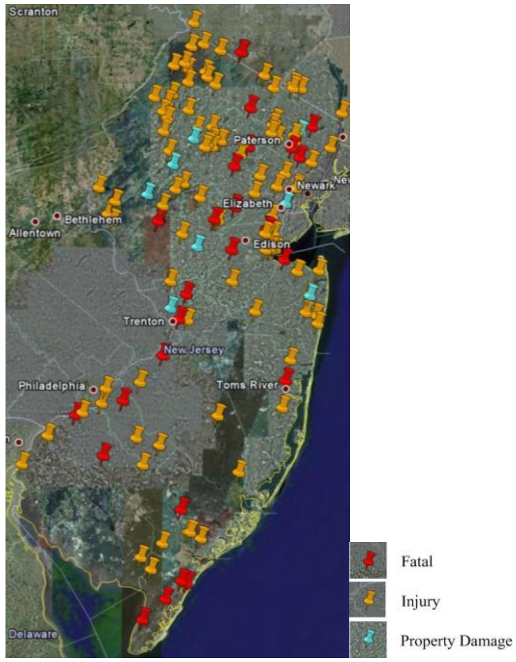

Figure 55. Distribution of motorcycle-guardrail collisions in New Jersey (2005-2007).

<u>Concrete Barrier Crash Site Results</u>

Twenty-one concrete barrier collision sites were investigated, 20 of which included collisions with New Jersey shaped barriers. The other collision occurred with a concrete retaining wall on an over pass. At over half the sites (11 of 21), the alignment of the road was straight. This differs from the other types of collisions examined; 24% of crash sites with guardrails, poles, or trees had a straight road alignment. This may be a reflection of the roadway types where concrete barriers are typically used.

<u>Pole and Tree Crash Site Results</u>

There were a total of 21 pole crash sites visited for this investigation. The pole sights were all recorded to have wood poles, the majority of which were embedded in soil. None of the poles examined were breakaway poles. The diameters of 9 poles investigated were measured. The average diameter was 0.94 feet, with a standard deviation of 0.15 feet. The pole location for 8 poles was recorded. The diameter of the tree was only measured at two sites to be 1.5 feet and 0.5 feet. Data were not recorded for the other sites. Of the poles investigated, 5 were located on the right side of the road and 3 were located on the left side. The roadside is given in relation to the direction the motorcyclist was travelling at the time of the crash.

Discussion

Two methods of evaluating motorcycle collisions with roadside objects were used to develop an enhanced database about the roads on which these crashes are occurring. Using satellite imagery from Google Earth, the radius of curvature at collision sites was obtained. It was seen that approximately 1/3 of crashes occurred on roads with a radius of curvature of less than 1000 feet. However, these data are limited by the precision of the user to fit a curve to the road.

Motorcycle collision sites were also analyzed through site surveys. One hundred ten sites have been visited to date. One challenge was the occasional unavailability of latitude and longitude data from the NJCRASH database. Most of the recent crashes (2007-2008) were geocoded with these coordinates; however, there were some crashes that were neither geocoded nor included an exact location. In some cases, positioning coordinates appeared to be inaccurate. In several cases, the investigators' judgment was used to deduce the location of the crash.

A second challenge has been to obtain safe access to the sites for physical measurements. Many of the collisions occurred on main roads with higher speed limits. These roads sometimes have no place for investigators to safely stop for the inspection. For sites that were too dangerous to investigate thoroughly, a drive-by investigation was completed. This allowed for general information to be gathered about each site, though no measurements could be taken.

A third challenge was the need to promptly visit a crash site after the incident. We investigated several sites years after the incident with the hope that characteristics, e.g. barrier type or road curvature, would be unlikely to have changed. Some characteristics however, e.g. defects in the roadway surface or barrier damage, may have been repaired prior to our site inspections. To account for this possibility, our protocol required that the investigator note any indications of repair, e.g. new barriers or poles.

Conclusions

This chapter has presented the design and development of a novel database containing detailed road design and maintenance information about motorcycle collision sites with roadside objects. This database extends the traditional databases of police-reported crash reports with engineering data such as guardrail type and distance of object struck from the road. Thus far, 110 sites have been investigated, supplemented with an analysis of satellite imagery and police accident reports. This database will provide researchers with more information to determine what environmental aspects are characteristic of motorcycle crashes.

Overall, the roadways tended to be free from defects such as potholes, cracks, or patches. However, at many of the sites contaminants such as sand or gravel were noted to be either in the roadway or in the shoulder. Keeping roads free from debris like this may reduce the number of crashes since this debris may be leading to motorcyclists losing control of the motorcycle. The objects struck tended to be within 5 feet of the lane edge. Providing additional space between objects and roadsides may give motorcyclists more time to regain control before colliding with a fixed object.

The majority of the crashes investigated occurred on curves. Approximately 60% of the curves were marked with warning signage. Providing additional signage on curves may reduce the number of motorcycle crashes by providing motorcyclists with more time to reduce their speed and prepare for the curve.

Moreover, almost three-quarters of the guardrail collisions investigated occurred on curves. Since there are a high percentage of motorcycle-guardrail collisions occurring on curves, they are ideal locations to provide protective measures to guardrails, such as those described in Chapter 3, or additional signage for motorcyclists. Also, there were several locations investigated where multiple crashes occurred. These are also candidates for guardrail modifications or additional signage since they have proven to be hazardous to motorcyclists. For example, the curve on Route 579 in Bethlehem Township (described in the Sample Site Survey) would be a prime location to modify the barrier since multiple crashes occurred in the same location within a year.

8. Analysis of High-Risk Crash Sites

Introduction

Certain road conditions can dramatically affect a motorcycles performance. Therefore it is important to understand what exactly can cause a motorcycle to crash. One way to do this is to identify particularly dangerous areas of roadway.

Using motorcycle crash records and sorting them by roadway, milepost and direction of travel we will be able to determine areas where motorcycle accidents are more likely to occur and be more severe. These hotspots can then be investigated further to determine what makes them dangerous to motorcyclists.

Objective

This chapter uses New Jersey motorcycle crash data for the years of 2006-2008 to determine high risk locations for collisions involving motorcycles. This analysis, which is commonly performed for passenger vehicles, is now being applied to motorcycles to determine possible locations where further investigations should take place.

Methodology

This section describes the methods used to collect, sort and analyze the New Jersey motorcycle crash data. Also discussed is the scoring metric used to determine the severity of the hot-spot locations.

Data Collection

The information used in this study came from the New Jersey Department of Transportation's crash records for the years 2006-2008. Crashes that involved one or more motorcycles were extracted and a filter was performed to remove miscoded vehicles and multiple motorcycle entries. This filter resulted in 5516 motorcycle crash entries. The milepost data for each site was also rounded to the nearest whole mile in order to establish a length for each hot spot location.

These 5516 entries were then sorted according to their SRI (standard route identifier), rounded milepost and direction of travel. A search was then performed to isolate mileposts where three or more motorcycles were involved in a collision on the same road and going the same direction. Of the 5516 initial crash sites, 210 locations had three or more motorcycles involved in one or more crashes at the site.

This 210 site dataset, which included 780 motorcycle riders, could now be analyzed for crash site severity.

Determining Crash risk

Four methods were used to determine the crash risks of individual sites. These are:

1. Frequency of motorcycle involvement in a collision
2. Frequency of motorcycle occupant involvement in a collision
3. Number of seriously injured persons involved in a motorcycle crash
4. 5-4-3-2-1-1 ranking based on KABCO scale

Crash Frequency

To determine crash frequency, the number of motorcycles that crashed at each roadway milepost location, were added. After this dataset was sorted for number of motorcycles involved, it was also sorted by number of riders involved, and number of riders which were killed or incapacitated.

5-4-3-2-1-1 Risk Metric

Table 14 shows the breakdown of the 5-4-3-2-1-1 risk metric used to determine crash risk based on severity of crash injuries.

Table 14. KABCO 5-4-3-2-1-1 Risk Metric

KABCO code	Injury Severity	Score
K	Killed	5
A	Incapacitated	4
B	Moderate Injury	3
C	Complaint of Pain	2
O	Property Damage Only/ Rider Uninjured	1
	Injury Severity Unknown	1

This metric was used because it assigns values to all injury severities, ranking the most severe, a fatality, as a 5 and the least severe non-injury or property damage only as a 1. Therefore more severe injuries are weighted higher in the overall scoring of a crash location. However, it should be noted that one fatality (at rank 5) is not necessarily equal in severity to 5 collisions without injury (ranked at 1).

The scores for each site were then summed and the sites were sorted with the highest score being first, and most severe.

Use of Google Earth and NJ Straight Line Diagrams

After the hot-spots were identified, a few of the more severe locations were investigated using Google Earth Pro and the New Jersey straight line diagrams. Using Google Earth we were able to get aerial and in some cases street views of the crash locations in question. These were used to verify the police reported information and also to provide a rough idea of the road conditions at the crash locations.

The straight line diagrams were used to obtain more detailed information about the number of lanes and pavement widths of the roadway. These can also provide important information about conditions that could be hazardous to motorcyclists.

Results and Discussion

The following tables show the results from the motorcycle data analysis. The top 25 sites which were deemed most severe are shown in this report.

Frequency tables

Table 15 shows the results of the data sort by number of motorcycles involved in a crash at a certain location. Note that the mile post range was determined initially by rounding the milepost data. Southbound NJ 23 between mileposts 18-18.18 has the most motorcycles, 7, involved in a crash. It can be seen that northbound I-95 between milepost 53.65 and 54.1 also had 7 motorcycles involved in a crash and southbound at the same milepost had 6 motorcycle collisions. I-95 and the Garden State Parkway are represented most often for number of multi-motorcycle crash locations, 3 each out of the top 25.

This table also shows the breakdown of road type and roadway orientation. Out of the top 25 sites, 12 were located on roads classified as State Highways. 29 out of the 136 motorcycle collisions occurred at intersections and 11 occurred on a ramp. 101 of these crashes took place on a straight road while 35 took place on a curve.

Forty-nine of the crashes that are listed in this table were single vehicle crashes. It is interesting to note that in 2 out of the 3 top 25 cases where all of the accidents in a hot-spot occurred on a curve, all of the crashes were single vehicle crashes. These two locations are NJ 23 southbound between 18-18.18 and I-95 northbound between 53.65 and 54.1. These two sites had 7 single vehicle motorcycle crashes each and all of which occurred on a curve.

Table 15. Motorcycle Crash Hot Spots by Number of Motorcycles involved

Crash Location	Mile Post Range	County Name	Dir. of Travel	Num. of Motorcycles	Num. of Riders	Roadway Type	At an intersection	On a ramp	Straight	Curve	Single Veh. Crash	Multi Veh. Crash
NJ 23	18-18.18	Passaic	North	7	8	State Highway	3	0	0	7	7	0
I-78	54.1-54.4	Union	West	7	7	Interstate	0	0	6	1	5	2
I-78	56.5-57.44	Essex	East	7	7	Interstate	0	3	5	2	3	4
I-95	53.65-54.1	Union	North	7	7	State/Interstate Authority	0	0	0	7	7	0
NJ 47	40.56-40.96	Cumberland	North	6	7	State Highway	5	0	6	0	0	6
I-95	54.1	Union	South	6	7	State/Interstate Authority	0	1	0	6	2	4
NJ 3	4.89-5	Passaic	East	6	6	State Highway	0	1	5	1	2	4
NJ 23	48.6-49.3	Sussex	South	6	6	State Highway	0	0	2	4	4	2
NJ 27	27.95-28.35	Union	South	6	6	State Highway	2	0	6	0	1	5
GSP	80.7-81.4	Ocean	South	6	6	State/Interstate Authority	0	0	6	0	1	5
GSP	150.7-151.4	Essex	South	6	6	State/Interstate Authority	0	0	6	0	1	5
NJ 37	10.03-10.37	Ocean	West	5	7	State Highway	2	0	5	0	0	5
NJ 37	6.55-6.69	Ocean	West	5	6	State Highway	0	0	5	0	2	3
Rt 503	5.81-6.38	Bergen	South	5	6	County	3	0	5	0	0	5
Rt. 530	8.76-8.84	Burlington	West	5	6	County	4	0	5	0	0	5
NJ 42	6.6-7	Camden/ Gloucester	North	5	5	State Highway	0	2	4	1	1	4
I-95	75.55-76.15	Bergen	South	5	5	State/Interstate Authority	0	0	4	1	5	0
US 130	30.58-30.62	Camden	North	5	5	State Highway	0	0	3	2	3	2
GSP	145.5-146.4	Essex	North	5	5	State/Interstate Authority	0	0	5	0	0	5
I-676	3.5-3.6	Camden	North	5	5	Interstate	0	2	3	2	1	4
Essex County 602	.79-1.29	Essex	East	5	5	County	4	0	5	0	0	5
Cape May County 603	4.53-5.39	Cape May	North	4	6	County	2	0	4	0	1	3
US 1	37.5-37.97	Middlesex	South	4	5	State Highway	0	0	4	0	2	2
US 1	43.5-44.3	Union	North	4	5	State Highway	2	0	3	1	1	3
Us 9	129.75-129.77	Middlesex	North	4	5	State Highway	2	2	4	0	0	4

Table 16 sorts the same data, however this time the collisions are ranked according to the number of motorcycle riders involved in the collision. The location with the most motorcycles involved in a collision also corresponds to the most riders involved; however this trend is not always true.

Table 16. Motorcycle Crash Hot Spots by Number of Riders Involved

Crash Location	Mile Post Range	County Name	Direction of Travel	Number of Motorcycles	Number of Riders
NJ 23	18-18.18	Passaic	North	7	8
I-78	54.1-54.4	Union	West	7	7
I-78	56.5-57.44	Essex	East	7	7
I-95	53.65-54.1	Union	North	7	7
NJ 47	40.56-40.96	Cumberland	North	6	7
I-95	54.1	Union	South	6	7
NJ 37	10.03-10.37	Ocean	West	5	7
NJ 3	4.89-5	Passaic	East	6	6
NJ 23	48.6-49.3	Sussex	South	6	6
NJ 27	27.95-28.35	Union	South	6	6
GSP	80.7-81.4	Ocean	South	6	6
GSP	150.7-151.4	Essex	South	6	6
NJ 37	6.55-6.69	Ocean	West	5	6
Rt 503	5.81-6.38	Bergen	South	5	6
Rt. 530	8.76-8.84	Burlington	West	5	6
Cape May County 603	4.53-5.39	Cape May	North	4	6
NJ 42	6.6-7	Camden/Gloucester	North	5	5
I-95	75.55-76.15	Bergen	South	5	5
US 130	30.58-30.62	Camden	North	5	5
GSP	145.5-146.4	Essex	North	5	5
I-676	3.5-3.6	Camden	North	5	5
Essex County 602	.79-1.29	Essex	East	5	5
US 1	37.5-37.97	Middlesex	South	4	5
US 1	43.5-44.3	Union	North	4	5
Us 9	129.75-129.77	Middlesex	North	4	5

Table 17 breaks the motorcycle crash data down by injured person. The number of severely injured persons, people who were killed or incapacitated, was counted and the sites were ranked according to this sum. It can be seen that one of the worst sites (K+A=3) was also the location with the most motorcycle crashes and riders, NJ 23 northbound between milepost 18 and 18.18.

A second dangerous location on NJ 23 occurred between mileposts 24.1-24.2 southbound. This site also had a (K+A) score of 3 with 1 fatality and 2 incapacitated riders.

Table 17. Motorcycle Crash Hot Spots by Number of Severe injuries

Crash Location	Mile Post Range	Dir. of Travel	Num. Riders Killed	Num. Riders Incapacitated	Num. Riders W/ Moderate Injury	Num. Riders W/ Complaint of Pain	Num. Riders W/ No injury	Num. Riders unknown Injury	Num. of Motorcycles	Num. of Riders	Severely Inj. Riders (K+A)
NJ 23	18-18.18	North	1	2	5	0	0	0	7	8	3
NJ 23	24.1-24.2	South	1	2	1	0	0	0	3	4	3
Rt. 528	22.44	North	0	3	1	0	0	1	3	5	3
NJ 23	48.6-49.3	South	2	0	0	2	2	0	6	6	2
NJ 35	43.1-43.46	North	1	1	2	0	0	0	4	4	2
I-80	34.6-35.4	East	1	1	2	0	0	0	4	4	2
NJ 94	33.5-33.7	North	1	1	1	0	0	0	3	3	2
NJ 94	45.29-45.44	South	1	1	1	0	0	0	3	3	2
NJ 47	15.8-15.98	South	1	1	0	1	0	0	3	3	2
US 30	9.63-9.83	East	0	2	2	0	1	0	4	5	2
NJ 35	42.75-43.45	South	0	2	1	0	0	0	3	3	2
NJ 440	18.58-19.35	North	0	2	0	1	1	0	4	4	2
NJ 35	56.62-57.43	North	0	2	0	1	0	0	3	3	2
Camden County 689	1.66-2.41	South	0	2	0	1	0	0	3	3	2
I-80	53.7-54.1	West	1	0	2	1	0	0	4	4	1
GSP	118.9-118.9	North	1	0	2	0	1	0	4	4	1
NJ 47	.92-1.38	North	1	0	2	0	0	0	3	3	1
Rt. 540	40.1	West	1	0	2	0	0	0	3	3	1
Rt. 548	6.2-6.35	West	1	0	2	0	0	0	3	3	1
Rt. 563	29.74	North	1	0	2	0	0	0	3	3	1
Ocean Ave	1.14-1.41	South	1	0	0	3	0	0	3	4	1
NJ 23	52-52.36	South	1	0	1	1	0	0	3	3	1
US 9	84.61-85.25	North	1	0	1	0	1	0	3	3	1
Rt 527	48.95-49.05	South	1	0	0	2	0	0	3	3	1
AC 646	4.94-5.18	West	1	0	1	0	1	0	3	3	1

5-4-3-2-1-1 Risk Metric

Table 18 shows the results of the 5-4-3-2-1-1 Risk Metric method of scoring crash location severity. Between mileposts 18 and 18.18 on NJ 23 north, was again identified as the most dangerous with a score of 28. At this site, there were 8 injuries including 1 fatality, 2 incapacitated riders and 5 moderately injured riders.

I-95 northbound between 53.65- 54.1 is the second most dangerous location with a score of 20. This site is important because I-95 southbound, at close to the same milepost, had a score of 15 which is also significant in the scoring table. At this site, 11 riders were injured when you include both north and south.

When combining both directions of travel, I-78 between mileposts 54.1 and 57.44 becomes a point of interest. The east and west directions of this location contain a total of 14 motorcycle crashes and 14 passengers. Both directions also have a significant 5-4-3-2-1-1 score of 18 in the west direction and 15 in the east.

It is interesting to note that out of the top 25 sites according to the 5-4-3-2-1-1 risk metric, 11 of the hot spot locations had all of their riders injured during the crash.

Table 18. 5-4-3-2-1-1 KABCO-Scored Motorcycle Crashes

Crash Location	Mile Post Range	Dir. of Travel	Num. of Motorcycles	Num. of Riders	Num. Riders Killed	Num. Riders Incapacitated	Num. Riders W/ Moderate Injury	Num. Riders W/ Complaint of Pain	Num. Riders W/ No injury	Num. Riders unknown Injury	5-4-3-2-1-1-Score
NJ 23	18-18.18	North	7	8	1	2	5	0	0	0	28
I-95	53.65-54.1	North	7	7	0	1	5	0	1	0	20
I-78	54.1-54.4	West	7	7	0	0	4	3	0	0	18
NJ 47	40.56-40.96	North	6	7	0	0	4	2	1	0	17
NJ 23	48.6-49.3	South	6	6	2	0	0	2	2	0	16
NJ 23	24.1-24.2	South	3	4	1	2	1	0	0	0	16
Rt. 528	22.44	North	3	5	0	3	1	0	0	1	16
US 1	37.5-37.97	South	4	5	0	1	4	0	0	0	16
GSP	80.7-81.4	South	6	6	0	1	3	1	1	0	16
NJ 35	43.1-43.46	North	4	4	1	1	2	0	0	0	15
I-80	34.6-35.4	East	4	4	1	1	2	0	0	0	15
US 30	9.63-9.83	East	4	5	0	2	2	0	1	0	15
NJ 37	6.55-6.69	West	5	6	0	1	3	0	2	0	15
NJ 3	4.89-5	East	6	6	0	0	3	3	0	0	15
NJ 37	10.03-10.37	West	5	7	0	0	3	2	2	0	15
I-78	56.5-57.44	East	7	7	0	0	3	2	2	0	15
I-95	54.1	South	6	7	0	0	3	2	2	0	15
GSP	150.7-151.4	South	6	6	0	0	3	2	1	0	14
I-80	53.7-54.1	West	4	4	1	0	2	1	0	0	13
US 9	132.85-133.36	North	4	5	0	0	4	0	1	0	13
US 22	55.6-55.88	West	4	5	0	0	4	0	1	0	13
NJ 42	6.6-7	North	5	5	0	0	4	0	1	0	13
NJ 94	41.56-42.2	North	4	5	0	0	3	2	0	0	13
GSP	145.5-146.4	North	5	5	0	0	4	0	1	0	13

Google Earth Analysis of Important Sites

To get a better idea of the road conditions for each location, latitude and longitude measurements were used to obtain a satellite image of NJ 23 around mile 18, I-95 around milepost 54 and I-78 between miles 54 and 57.

<u>NJ 23</u>

Figure 56. NJ 23 Northbound Between MP 18-18.18

This hotspot location on NJ 23 occurred starting at the exit of one curve and around another. The radius of the curve is 466ft and it is a two lane highway. There are a few roadway entrances and according to the New Jersey straight line diagrams, the road shoulder in this location is approximately 2ft and the pavement width is 24ft.

I-95

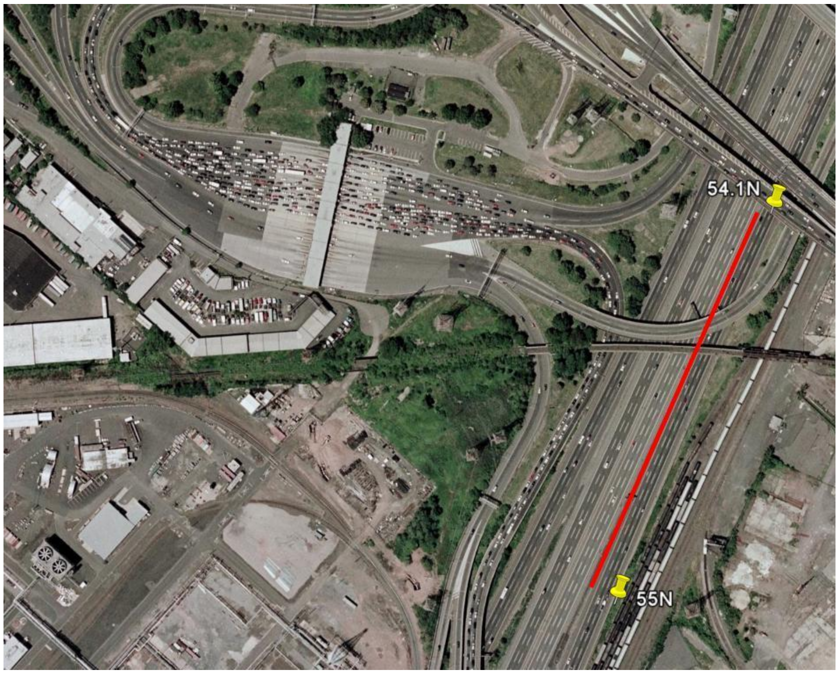

Figure 57. I-95 Northbound from 55-54.1 and Southbound 54.1

The stretch of I-95 where this hotspot location occurs is near Newark Airport, and is relatively straight. It consists of 2 northbound directions and 2 southbound directions. Although only one accident that occurs here is coded as being on a ramp, it is our opinion that all 13 of the accidents occurred on the north and south bound ramps at this location. This is because the all of the crashes were coded as occurring on curved sections of road. I-95 is not curved in this section, but the ramps are curved. Also, most of the cases, 9 out of the 13, had a reported speed limit below that of the interstate (ranging from 0-35mph with only 4 reporting 55mph).


Figure 58. Street view of an entrance ramp to I-95 South around MP 54

The ramps on this section of road are curved, and are expected to be congested because of the toll plaza and the proximity to the Newark airport. This location might be hazardous because of these two factors as well as the drastic speed change required around these curves.

I-78

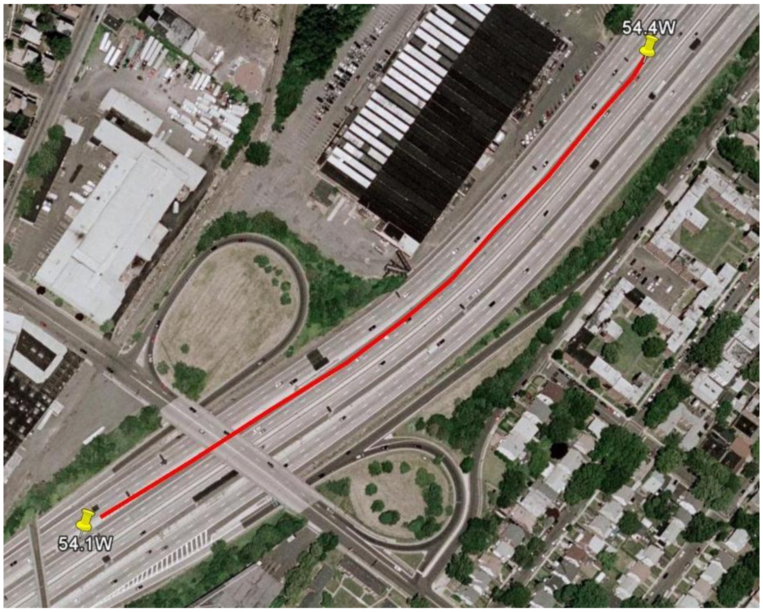

Figure 59. I-78 Westbound 54.4-54.1

Figure 60. I-78 Eastbound 56.5-57.4

Although we originally combined I-78 East and West, after looking at Google imagery, the two locations on I-78 occur on two distinct sections of road which are actually separated completely by a curve. Both hotspots occur on slightly curved portions of interstate.

At the first location, I-78 W between 54.4 and 54.1, there are 2 westbound roads, local and express. The express has 2 lanes of traffic and is 24ft wide and the local has 3 lanes of traffic and is 36ft wide. Both the express and local roads have substantial right shoulders, 12ft, and minimal left shoulders 3ft and 2ft respectively.

At the second location, I-78E 56.5-57.44, there are 2 eastbound roads, express and local. Again the express is 24ft wide with 2 lanes of traffic and the local is 36ft wide with 3 lanes of traffic, however, the local reduces to 2 lanes of travel right before milepost 57.4. Both again have a substantial right had shoulder of 12ft and a minimal left hand should of 2-3ft. All of this information is again taken from the NJ straight line diagrams.

Limitations

There are a few limitations to this study. When collecting the data for this study, some crash locations had to be dismissed because they did not include SRI or milepost. Without this information the crash location could not be determined or utilized. Direction of travel was also not included in some of the records, so, even if the SRI and mileposts matched another site, the crash location without direction of travel could not be used.

Another major limitation is the accuracy of the police reporting. There are some instances where more than one crash occurred at the same milepost, before rounding, but the road in one case was coded as straight while in another it was coded as curved. It is impossible to determine what is the inaccuracy with this site, the milepost at which it was coded or the roadway orientation. Another example of reporting inaccuracy occurred in the I-95 hotspots discussed earlier, it is our opinion that all 13 of the crashes at these locations occurred on a ramp while only one of the collisions was reported as such. There also seem to be large discrepancies with the reported speed limits with some hotspots ranging from 0mph to 55mph.

This study classified a hot-spot by rounding the mile post to the nearest whole mile, which might not tell the whole story. There are some locations, like the crash location discussed in Chapter 8 on US 579, where there were 7 crashes on one curve and this site is considered as 2 hot-spots instead of one. This is because the 7 crash locations were reported under slightly different mileposts. Therefore some hot-spots, which might not seem significant at a certain milepost, may actually be severe if the mileposts were rounded to the tenth of a mile, or truncated.

Conclusions and Recommendations

This chapter presents the top 25 sites of the motorcycle crashes in NJ using several metrics of severity. These sites should be considered candidates for remediation. The following are 4 particularly aggressive sites

1. NJ 23 northbound between mileposts 18-18.18 is the most dangerous site according to all metrics used. This location had a 5-4-3-2-1-1 score of 28 and involved 7 motorcycles and 8 riders.

2. I-95 around milepost 54 was considered a hot-spot in both the northbound and southbound directions. This milepost included a total of 13 motorcycles and 14 riders.

3. I-78 east and west, between mileposts 54.1 and 57.44, should be looked at as two separate hotspots however both are considered severe on their own. Each involves 7 motorcycles and 7 riders.

4. Rt. 579, between mileposts 36.23 and 37, as discussed in Chapter 8, should be viewed as one hotspot instead of two. This location involved 7 crashes and 7 riders. As one location it would have a KABCO 5-4-3-2-1-1 score of 20 however it involves no severely injured persons.

5. The use of Google Earth and the NJ straight line diagrams are an excellent tool for investigating the crash hot-spots. It can verify the police report accuracy and provide preliminary information about road curvature, number of lanes and pavement width. In locations where the street view is present actual road conditions can be assessed.

9. Recommendations

After an investigation of motorcycle crashes in New Jersey, the following recommendations are made to reduce the number and severity of motorcycle crashes in New Jersey.

Recommendation 1: Revise the Testing and Training Process

There are currently two ways to obtain a motorcycle license in New Jersey. A motorcyclist can obtain a permit and hold it for a minimum of 20 days, then complete the road test. The license can also be obtained without taking the road test by completing and passing a training course at an approved site. These processes do not accurately represent the conditions to which motorcyclists are most often exposed. Testing and training typically occurs at slow speeds, rarely exceeding 15 mph. Additionally, smaller motorcycles (with engine displacements less than 500 cc), which are easier to control, are most often used for testing and training, even when motorcyclists intend to ride significantly larger motorcycles. The research group recommends a tiered licensing system based on the engine displacement of the motorcycle and the rider's ability to operate it under normal conditions to replace the current system.

- Limitation on Engine Size. Motorcyclists should be required to complete the testing process on a motorcycle that accurately resembles the motorcycle they will most often be operating. Completing the road test on a smaller motorcycle (less than 500 cc) would allow a motorcyclist to operate any motorcycle less than 500 cc. In particular, the use of scooters to take the test should be banned. A motorcyclist would be allowed to operate a larger motorcycle only after completing the test on a larger motorcycle.

- Ban the Use of Scooters to Complete the Test. Many motorcyclists rent scooters to take the road test since they are easily maneuverable in small areas. However, motorcyclists intend to ride much larger motorcycles. Banning scooters for the road test would make current testing more realistic.

- Accurate Testing Speeds. Currently, both the testing and training processes occur at slow speeds (typically less than 15 mph). Testing at higher speeds would allow for a more accurate representation of how a motorcyclist would perform under typical driving conditions. This component of testing may be added into the second stage of the tiered licensing.

These changes would more accurately test a rider's ability to operate his/her motorcycle on the street. By increasing the difficulty of the test, the failure rate will most likely be higher, complemented by a decreased number of motorcycle fatalities in New Jersey.

Recommendation 2: Increased Motorcycle Awareness by Car and Truck Drivers

Over half of motorcycle fatalities in New Jersey involve a collision with another vehicle. Motorcycles are vastly different from other vehicles on the road. They are significantly less stable, provide less protection to users, and cannot always brake as quickly as cars. Moreover, the operation of a motorcycle is much more complicated than the operation of a car. Due to these limitations, car and truck drivers need to pay specific attention to motorcyclists on the road. The difficulty of seeing motorcycles in traffic and the limitations of motorcycles should be presented to car and truck drivers during training courses. Many car and truck drivers reported not seeing the motorcycle before colliding with it. Encouraging drivers, especially beginner drivers, to specifically be aware of motorcyclists will reduce the number and severity of motorcycle crashes.

Recommendation 3: Recertification Training for Motorcyclists

A particular concern in motorcycle safety are riders who receive their motorcycle licenses at an early age, stop riding for many years, and then begin riding again 10 or 20 years after last being on a motorcycle. Older riders with rusty skills may be at a higher risk of a crash than seasoned riders who have been riding continuously. New Jersey should consider implementing a "recertification" course or a "recertification" test once every 10 years to ensure that a rider maintains his/her skills.

Recommendation 4: Advanced Training for Motorcyclists

Many riders take the Basic RiderCourse (BRC) which introduces motorcyclists to safe riding practices. The training should not stop here however. The Experienced RiderCourse (ERC) reinforces and builds upon these concepts; giving motorcyclists supervised riding practice in more realistic situations and at higher speeds. Riders should be encouraged to take the ERC to improve safe riding practices under a controlled environment.

Recommendation 5: Modify the roadside on select roads to reduce injury risk for motorcyclists

The majority of motorcycle crash sites with guardrails, poles, and trees examined were curved roads. Moreover, 72% of guardrail collisions examined occurred on curves. Providing additional protection for motorcyclists from guardrails, such as the addition of a rail below the W beam that shields motorcyclists from the posts, on curves may reduce the severity of accidents on curves, as discussed in Chapter 3. This would have an even higher benefit if sites where multiple accidents have already occurred were improved to provide additional protection, such as Route 579 in Hunterdon County (see Chapter 7 page 62).

Recommendation 6: 6. Fully investigate and remediate roadways hazardous for motorcyclists

NJDOT should identify and publish the 10 highest risk motorcycle crash locations. This should be conducted as part of a regular program to assess state roadways for motorcycle safety. NJDOT should initiate a program to reduce the number of crashes at these high risk sites using enforcement, infrastructure improvements, and better signage. As an example, this research program has identified NJ 23 northbound around milepost 18 and I-95 north and south bound around milepost 54 are hazardous for motorcyclists based upon the multiple crashes occurring at these locations.

Recommendation 7: Provide additional warning signage for motorcyclists

NJDOT should place additional warning signage for motorcyclists at the high risk locations identified in this and in follow-on studies on motorcycle roadway crash assessment. Through an analysis of areas where multiple accidents occurred, several locations were identified to be of a high risk to motorcyclists. Areas such as these are prime locations for adding additional signage to warn motorcyclists of specific hazards in the area.

Warning signage is often seen at curves, notifying road users of the curve and a safe speed for negotiating it. Since motorcycles handle differently than other vehicles, providing additional signage with safe speeds for motorcycles to travel around curves.

Recommendation 8: Maintain roadways with “deficient” road surfaces

33% of crash sites visited with available surface roughness data were labeled as “deficient” roads based on standards in the *Report to the Governor and the Legislature on New Jersey’s Roadway Pavement Program*. Roads with an IRI of greater than 170 in/mi are classified as deficient.

One crash site noted for improvement is visited is the intersection of Miller Avenue and Route 35 in Hazlet Township, Monmouth County. At this location, the surface roughness of Route 35 is 643.89 in/mi.

Recommendation 9: Maintain roads to be free from debris

Many of the sites visited had sand and gravel either in the shoulder or in the road. Keeping roads free from such debris is especially important for motorcycle safety because the debris reduces the traction and may cause the motorcyclist to lose control of his/her motorcycle.

Recommendation 10: Follow-on research needs

This study has identified several areas which may influence motorcycle safety, but which will require further research before implementation or assessment. We recommend that the items below be considered in future evaluations of motorcycle safety:

- Review of Military Motorcycle Training Effectiveness. The U.S. military has enacted aggressive training programs to reduce motorcycle crashes and deaths. We recommend that follow-on research be conducted to determine the effectiveness of these training programs. Specifically, this follow-on task would determine whether riders who have had the military motorcycle training had any differences in riding history than civilians who self-selected to be trained.
- Stricter licensing tests. The follow-on research should develop specific recommendations for what would be an enhanced motorcycle rider test course that includes skills to be tested and pass/fail criteria. The task should also assess the likely reaction of prospective motorcyclists to a stricter licensing test.

10. Summary

The Problem

Motorcycle fatalities have been increasing at a rate greater than the rate of motorcycle ownership. Nationwide, motorcyclist fatalities have more than doubled in the past decade. There are several influencing factors that may lead to a motorcycle crash. The behavior of the road users, both motorcyclists and other drivers, has an influence on the severity and frequency of crashes. Also, the roadway and the surrounding environment may have more of an influence in motorcycle crashes than other vehicle crashes. This investigation looks at these different components of crashes to determine methods to reduce motorcycle crashes in New Jersey.

Licensing Practices

Through an analysis of crash reports, many motorcyclists have reported losing control of their motorcycle, resulting in a crash. Moreover, motorcycles with a larger engine displacement are typically more difficult to control than smaller motorcycles. The survey developed questioned motorcyclists as to what size motorcycle they had used for obtaining their license. It was seen that most motorcyclists had used a small motorcycle (less than 500cc) for obtaining a license. However, the 87% of fatal crashes in New Jersey from 2001-2007 have occurred on motorcycles with an engine displacement greater than 500cc. Licensing practices can be modified to ensure that people riding larger motorcycles can control and properly operate them.

Rider and Driver Behavior

There are several defensive actions that motorcyclists can take to reduce the risk and severity of crashes. First, wearing equipment such as a motorcycling boots, gloves, and jacket provides additional protection to a motorcyclist in the event of a crash. Motorcycle training courses have proven effective in increasing the usage of personal protective equipment amongst motorcyclists who have taken the course.

Through an analysis of police accident reports, it was seen that operators of other vehicles on the road frequently reported not seeing the motorcyclist. Increasing the awareness of the additional hazards motorcyclists face on the roads may lead to an increased attention level for operators of other vehicles.

Motorcycle-Barrier Crashes

Motorcycle collisions with barriers, especially guardrails, have been shown to be more severe than other vehicle collisions with barriers. This project investigated methods that could be used to reduce the severity of these crashes. Motorcycles provide less protection to motorcyclists than other vehicles provide to their passengers. Therefore, the motorcyclist is left to the mercy of the surrounding environment in the event of a collision. Therefore, roadway design may have an influence on the severity of crashes.

In-depth crash site investigations were completed to determine environmental characteristics of crash sites. In addition to guardrail crashes, single vehicle motorcycle collisions with concrete barriers, poles, and trees were also investigated. It was seen that 68% of the crash sites investigated were on curves. Multiple crashes had occurred within 2 years on 5 of the curves investigated. Moreover, 72% of the motorcycle-guardrail collisions investigated occurred on a curve.

Providing additional protective measures into roadway design for motorcyclists on some curves, especially those where multiple crashes have occurred, may reduce the number and severity of crashes in these areas.

Roadway Environment

Several aspects of the roadway environment have demonstrated to be particularly hazardous for motorcyclists. Several locations have been identified to have multiple crashes, making these ideal locations for further investigation and roadway improvement. Milepost 18 on NJ 23 north had the most motorcycle crashes and number of riders involved in New Jersey and was the most dangerous location according to the 5-4-3-2-1-1 KABCO risk metric. The entrance and exit ramps around milepost 54 on I-95 north and south is another location which would be ideal for further investigation, with 13 total crashes occurring at this location. Through site investigations, other locations were identified with multiple crashes. These were not always included in the same hot spot location though they occurred on the same expanse of roadway. Analyzing and modifying roadways with multiple crashes would be cost efficient since these locations have already proven to be hazardous. Modifications, including additional signage or protective measures for motorcyclists, will reduce the number and severity of crashes in these locations.

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Appendix A. Rider Survey

Rowan University

NJMVC Motorcycle Survey

1) What year were you born?

2) What is your sex?

- Male
- Female

3) What type of motorcycle do you ride?

- Cruiser
- Sport Touring
- Sport
- Dual Sport
- Standard

4) What reason(s) do you ride? (Please check all that apply)

- Recreation
- Fuel Economy
- Touring
- Social Activities
- Sport/Professional

5) How many years have you been actively riding?

- Less than 2 years
- 2 years to 5 years
- 5 years to 10 years
- 10 years to 20 years
- More than 20 years

6) How often do you wear a helmet?

- ○ Never
- ○ More than 0% but less than 25%
- ○ More than 25% but less than 50%
- ○ More than 50% but less than 75%
- ○ More than 75% but less than 100%
- ○ 100%

7) If there was no helmet law, what percentage of the time would you wear your helmet?

- ○ Never
- ○ More than 0% but less than 25%
- ○ More than 25% but less than 50%
- ○ More than 50% but less than 75%
- ○ More than 75% but less than 100%
- ○ 100%

8) Why do you wear a helmet? (Please check all that apply)

- ☐ I don't
- ☐ It's the law
- ☐ Safety
- ☐ My friends wear helmets

9) What kind of helmet is your PRIMARY helmet?

- ○ Half
- ○ 3/4- Face
- ○ Full Face/Flip-up
- ○ Novelty
- ○ None

10) Do you wear any other protective gear, on a regular basis? (Please check all that apply)

- ☐ Gloves
- ☐ Protective Pants (Not Jeans)
- ☐ Boots
- ☐ Protective Jacket
- ☐ Joint/Spine protectors
- ☐ None

11) Have you ever consumed alcohol before riding your motorcycle?

- Yes, less than two drinks
- Yes, more than two, but less than four
- Yes, 4 or more drinks
- No

12) Do you have a valid NJ drivers license?

- Yes
- No

13) Do you have a valid Motorcycle endorsement?

- Yes
- No

14) How did you obtain your Motorcycle endorsement?

- Motor Vehicle Commission Road Test
- Motorcycle Safety Foundation Course
- I do not have a motorcycle endorsement

15) What motorcycle did you use to take the test/course?

- My own
- A friend's
- A rented motorcycle
- A rented scooter
- Course supplied motorcycle
- I have not taken the test/course

16) What was the engine displacement of the bike you used for the test / course?

- Less than 100cc
- 101cc - 500cc
- 501cc - 1200cc
- Over 1200cc
- I have not taken the test/course

17) If you took the NJMVC motorcycle test, do you think it accurately tested your ability to operate a motorcycle properly?

- Yes
- No
- I didn't take the NJMVC motorcycle test

18) Have you ever taken the Motorcycle Safety Foundation course?

- Yes
- No

If you answered **YES** to question 18, please answer the following questions. If not, please skip to question 21.

19) Please rate the courses overall effectiveness based on skills learned:

- Not effective
- Somewhat effective
- Effective
- Very effective
- Extremely effective

20) Do you feel the course covered enough information?

- Not enough information
- Less than enough inform
- Enough information
- More than enough information
- Too much information

21) Please rate your interest in taking a motorcycle safety course:

- Not interested
- Somewhat interested
- Interested
- Very interested
- Extremely interested
- Did not know it was offered

22) What factors kept you from taking one? (Please select all that apply)

☐ It is too expensive

☐ I don't have the time for one

☐ I am not interested

☐ I don't think it will be helpful

☐ I don't know where they are

☐ I didn't know they existed

☐ Not convenient to my location

☐ Already took the course

23) Have you ever been involved in an accident with your motorcycle?

○ Yes

○ No

If you answered **YES** to question 23, please answer the following questions, if not please skip to question 29.

24) What were the circumstances?

○ Single vehicle

○ Multiple vehicle my fault

○ Multiple vehicle other driver's fault

○ Animal or othe road hazard

25) Where did the accident occur?

○ An intersection

○ Highway

○ Two lane rural road

○ Parking lot

○ Residential road/area

○ Off road

26) When you got into your accident, what protective gear were you wearing? (Please check all that apply)

- ☐ Gloves
- ☐ Protective Pants (Not Jeans)
- ☐ Boots
- ☐ Protective Jacket
- ☐ Joint/Spine protectors
- ☐ None

27) Was medical attention required?

- ○ Yes, overnight hospitalization
- ○ Yes, but no overnight hospitalization
- ○ No

28) Did you feel the severity of the accident required reporting it to law enforcement?

- ○ Yes
- ○ No

29) What types of situations do you feel are most dangerous to a motorcyclist?

- ○ Intersections
- ○ Highways
- ○ Two lane rural roads
- ○ Parking lots
- ○ Residential roads/areas

30) What do you feel is the most likely cause of motorcycle accidents?

- ○ Inattentive or distracted car and truck drivers
- ○ Wildlife/Animals
- ○ Stunts/Excessive Speed
- ○ Inexperienced drivers
- ○ Curves

31) Do you feel that the conditions of roadway surfaces ever compromises your safety as a rider?

- ○ Yes
- ○ No

32) Do you have any additional comments that you feel will help to reduce motorcycle fatalities? (limit 200 words)

Appendix B. Instructor Survey

Rowan University

NJMVC Motorcycle Survey

What year were you born? [ ]

What is your sex?

- ○ Male
- ○ Female

How many years have you been actively **riding?**

- ○ Less than 2 years
- ○ 2 to 5 years
- ○ 5 years to 10 years
- ○ 10 years to 20 years
- ○ More than 20 years

How many years have you been actively **training?**

- ○ Less than 2 years
- ○ 2 to 5 years
- ○ 5 years to 10 years
- ○ 10 years to 20 years
- ○ More than 20 years

How did you obtain your Motorcycle endorsement?

- ○ Motor Vehicle Commission Test
- ○ Motorcycle Safety Foundation Course
- ○ No endorsement

In your opinion, how difficult is the basic rider course for the average rider?

- Not difficult
- Somewhat difficult
- Difficult
- Very difficult
- Extremely difficult

Do you feel the MVC written test covers enough information?

- Not enough information
- Less than enough information
- Enough information
- More than enough information
- Too much information

Do you feel the MVC road test covers enough information?

- Not enough information
- Less than enough information
- Enough information
- More than enough information
- Too much information

Do you feel there are enough locations offering the course?

- Yes
- No

In the U.S. there are no restrictions on which bike a person can ride, regardless of their experience and skill. What do you believe should be done to keep riders from riding bikes beyond their skill level? (Please check all that apply)

- ☐ Nothing, it is part of our freedom.
- ☐ Riders should be required to take more courses based on the size of their bike.
- ☐ Riders should have to ride for a certain amount of time riding before being allowed to ride a larger bike.
- ☐ There should be a certification system for different types of motorcycles.

In your opinion, how difficult is the experienced rider course for the average rider?

- ○ Not difficult
- ○ Somewhat difficult
- ○ Difficult
- ○ Very difficult
- ○ Extremely difficult

Do you believe more riders would enroll in ERC's if there were increased incentives and availability?

- ○ Yes
- ○ No

Do you have any additional comments that you feel will help to reduce motorcycle fatalities? (limit 200 words)

We appreciate your time filling out this survey.

Appendix C. Dealership Survey

Rowan University

NJMVC Motorcycle Survey

What type of motorcycles do you sell? (Please Check all that apply)

- ☐ Cruiser
- ☐ Sport Touring
- ☐ Sport
- ☐ Dual Sport
- ☐ Off Road

Do you require customers to obtain a motorcycle endorsement prior to **purchasing** a motorcycle?

- ○ Yes
- ○ No

Do you require customers to obtain a motorcycle endorsement prior to **riding** a purchased motorcycle off the lot?

- ○ Yes
- ○ No

Do you encourage new riders to take a safety course prior to purchasing a motorcycle?

- ○ Yes
- ○ No

Do you know what safety courses are available to riders in your area?

- ○ Yes
- ○ No

Do you believe there should be more locations offering the course?

- ○ Yes
- ○ No

Do you feel that motorcycle safety courses are effective tools to help riders?

- Not effective
- Somewhat effective
- Effective
- Very effective
- Extremely effective

Do you feel the MVC written test covers enough information?

- Not enough information
- Less than enough information
- Enough information
- More than enough information
- Too much information

Do you feel the MVC motorcycle road test adequately assesses whether a person has the skills to become licensed to operate a motorcycle?

- Yes
- No

Do you encourage customers to wear protective helmets when they ride?

- Yes
- No

If YES, What kind of helmet is your PRIMARY recommendation?

- Half
- 3/4- Face
- Full Face/Flip-up
- Novelty
- None

Do you encourage customers to wear protective gear when they ride?

- Yes
- No

What kinds of protective gear do you suggest? (Please check all that apply)

- ☐ Gloves
- ☐ Protective Pants (Not Jeans)
- ☐ Boots
- ☐ Protective Jacket
- ☐ Joint/Spine protectors
- ☐ None

What kind of protective gear do you sell? (Please check all that apply)

- ☐ Gloves
- ☐ Protective Pants (Not Jeans)
- ☐ Boots
- ☐ Protective Jacket
- ☐ Joint/Spine protectors
- ☐ None

What types of situations do you feel are most dangerous to a motorcyclist?

- ○ An intersections
- ○ Highways
- ○ Two lane rural roads
- ○ Parking lots
- ○ Residential roads/areas

What do you feel is the most likely cause of motorcycle accidents?

- ○ Inattentive or distracted drivers
- ○ Wildlife / Animals
- ○ Stunts/Excessive Speed
- ○ Inexperienced riders
- ○ Curves

Do you feel that the conditions of roadway surfaces ever compromises the safety of a rider?

- ○ Yes
- ○ No

Do you have any additional comments that you feel will help to reduce motorcycle fatalities? (limit 200 words)

Appendix D. Motorcycle Crash Site Data Collection Protocol

Date		**Time**		**Investigators**	
Route No./ Street					
Crash ID				**Accident Type**	
Accident Date				**Accident Time**	
Direction of Travel		**Milepost**		**Roadway Type**	
Location	Median	Roadside		**Latitude**	
				Longitude	

Barrier Characteristics						
Type	Guardrail	Concrete	Cable	Tree	Pole	Other:
Possible Purpose of Barrier	Roadside Object	Tree	Slope	Other:		
Irregularities in Barrier	(describe)					
Additional Notes						

Roadway Characteristics						
Surface	Asphalt	Concrete	Dirt	Gravel	Other:	
Surface Change	Yes	No	**Type**	to		
Lighting	Luminaire	High Mast	None	Other:		
Rumble Strip	Right Side	Left Side	Both Sides	None		
Alignment	Straight	Curve Right	Curve Left			
Profile	Level (< 2%)	Upgrade	Downgrade	Crest	Sag	
Curb	Barrier	Mountable	None			
No. of Lanes						
Speed Limit						
Obstructions of view						
Proximity to Other Road or Ramp						
Warning Signage	(list and describe)					
Additional Notes						

Road Surface and Surrounding Conditions				
Painted Surface	Yes	No	**Location**	
Potholes	Yes	No	**Description**	
Patches	Yes	No	**Description**	
Notable Cracks	Yes	No	**Description**	
Reflectors in Road	Yes	No	**Location**	
Contaminants *				
Irregularities **				
Surrounding Area †				
Additional Notes				

* i.e. oil, sand, gravel, etc.
** i.e. manholes, abrupt changes in surface elevation, etc.
† Note any other factors about the area that might influence the crash, i.e. wooded, signage, etc.

Roadway Measurements	
Lane Width (Average)	
Curb Height	

Grade Around Curve			
	Left Side	Center Line	Right Side
PC			
PI			
PT			

Stopping Sight Distance	
Ms	
Δ	
Δv	

Grade (Direction of travel)	
Height 1	
Height 2	
Distance	
Digital Level	

Grade (Super elevation)	
Height 1	
Height 2	
Distance	
Digital Level	

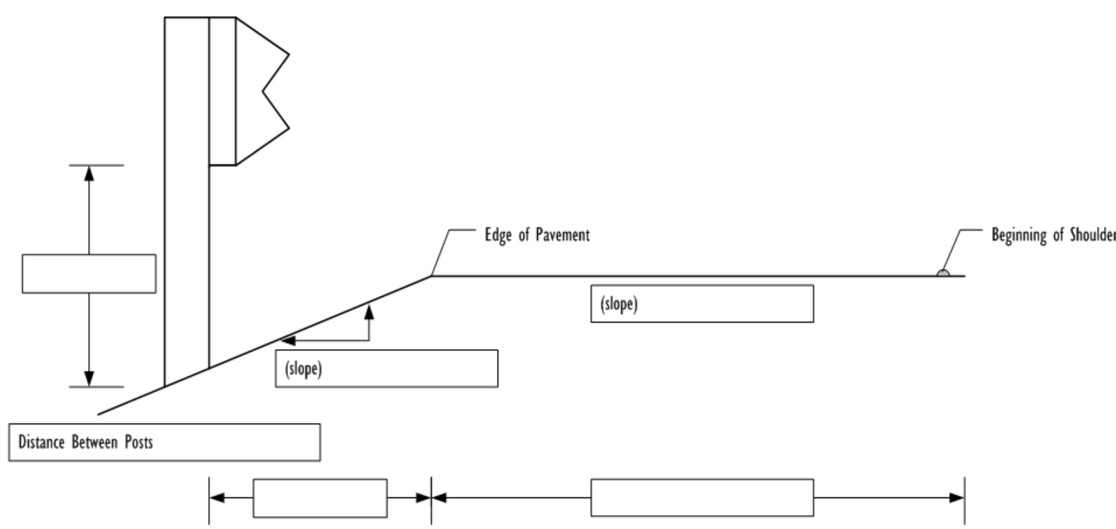
Shoulder Characteristics							
Shoulder		Yes	No				
Rumble Strip		Yes	No				
Surface		Asphalt	Concrete	Dirt	Gravel	Grass	Other:
Road Condition	**Division Shoulder/Road edge**		None	Paint	Curb	Other:	
	Potholes	Yes	No	**Description**			
	Patches	Yes	No	**Description**			
	Notable Cracks	Yes	No	**Description**			
	Contaminants *						
Additional Notes							

* i.e. oil, sand, gravel, etc.

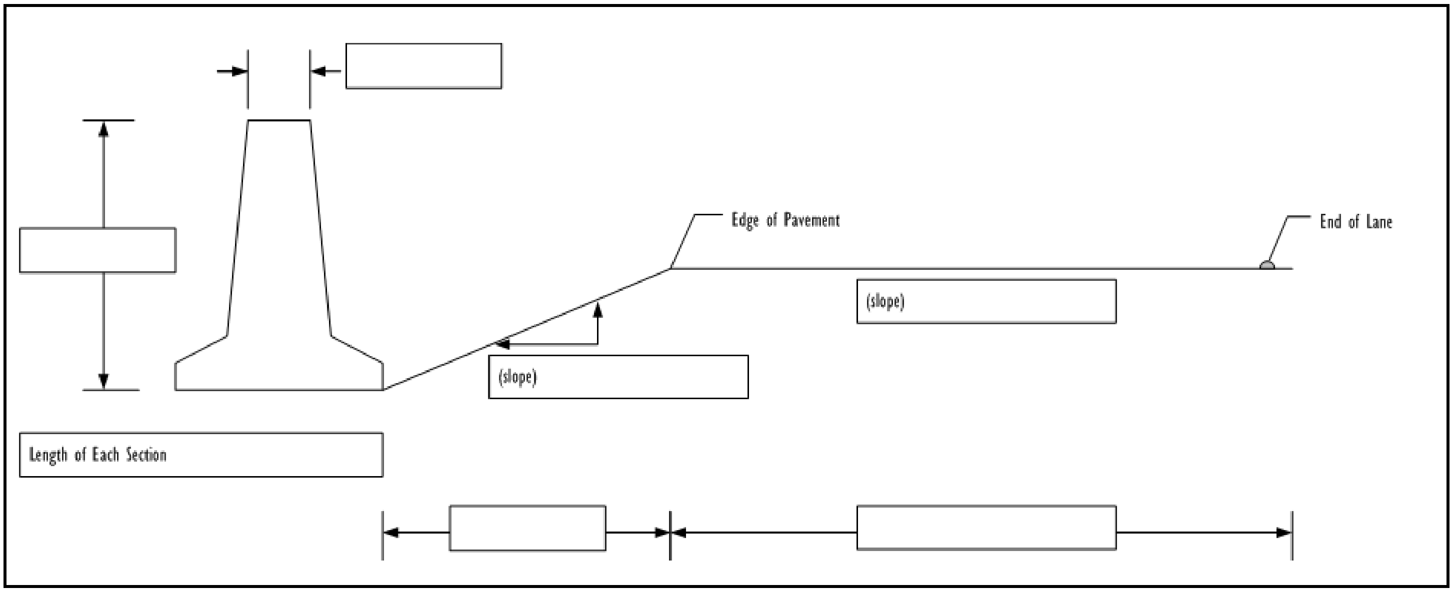
Median Characteristics							
Rumble Strip		Yes	No				
Surface		Asphalt	Concrete	Dirt	Gravel	Grass	Other:
Road Condition	**Division (Median/ Road Edge)**		None	Paint	Curb	Other:	
	Potholes	Yes	No	**Description**			
	Patches	Yes	No	**Description**			
	Notable Cracks	Yes	No	**Description**			
	Contaminants						
Additional Notes							

Guardrail Characteristics						
Post Type	Strong	Weak	Wood	Other:		
Rail Type	W-beam	Thrie Beam	Box-Beam	Double Nested W-beam		Other:
Block	Wood	Steel	Recycled Plastic	None	Other:	
Terminal Type	(if applicable)					
Damage to Rail	(describe)					
Damage to Post	(describe)					
Motorcycle Safety Measures (if any) *		(describe)				
Additional Notes						

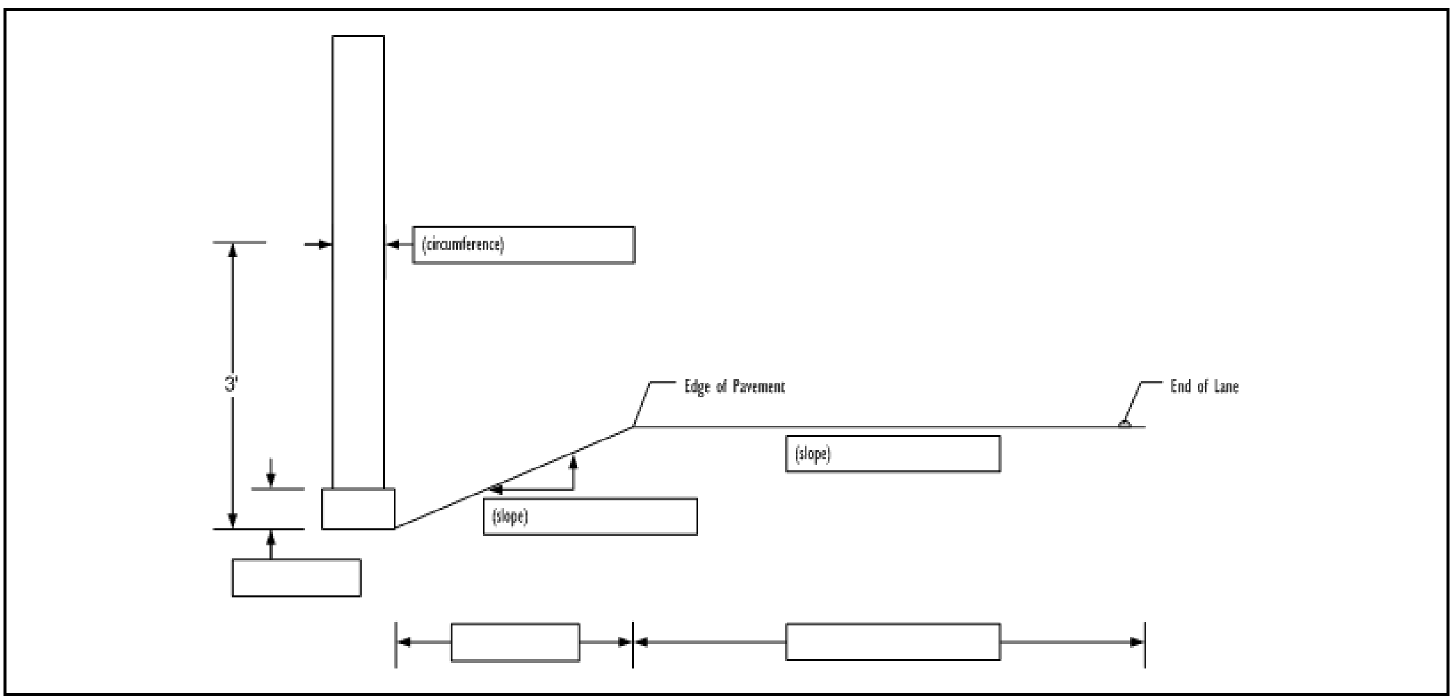
* i.e. additional W-beam, protection around post, shield between W-beam and ground



Concrete Barrier Characteristics							
Type	New Jersey	Vertical Wall	90" New Jersey	Temporary	F-Shaped Safety	Single-Slope	
	Other:						
Damage to Barrier							
Additional Notes							



Pole Characteristics				
Material	Metal	Wood	Concrete	Other:
Pole Type	Utility	Luminaire	Sign	Other:
Base Location Material	Concrete	Soil	Asphalt	Other:
Location	Right Side	Left Side	Median	Other:
Breakaway	Yes	No		
Breakaway Device	Frangible Transformer Base		Slip Base	Other:
Additional Notes				



Pictures Required for Each Site

☐	Barrier	☐	Road Surface
☐	Rail	☐	Road-barrier interface
☐	Post	☐	Roadside Environment
☐	Block	☐	Notable Cracks/Potholes
☐	Irregularities	☐	Objects Barrier may be in place for
☐	Damage	☐	Other areas of interest
☐	Terminal End	☐	Speed Limit
		☐	Warning Signage

As-Built Drawings