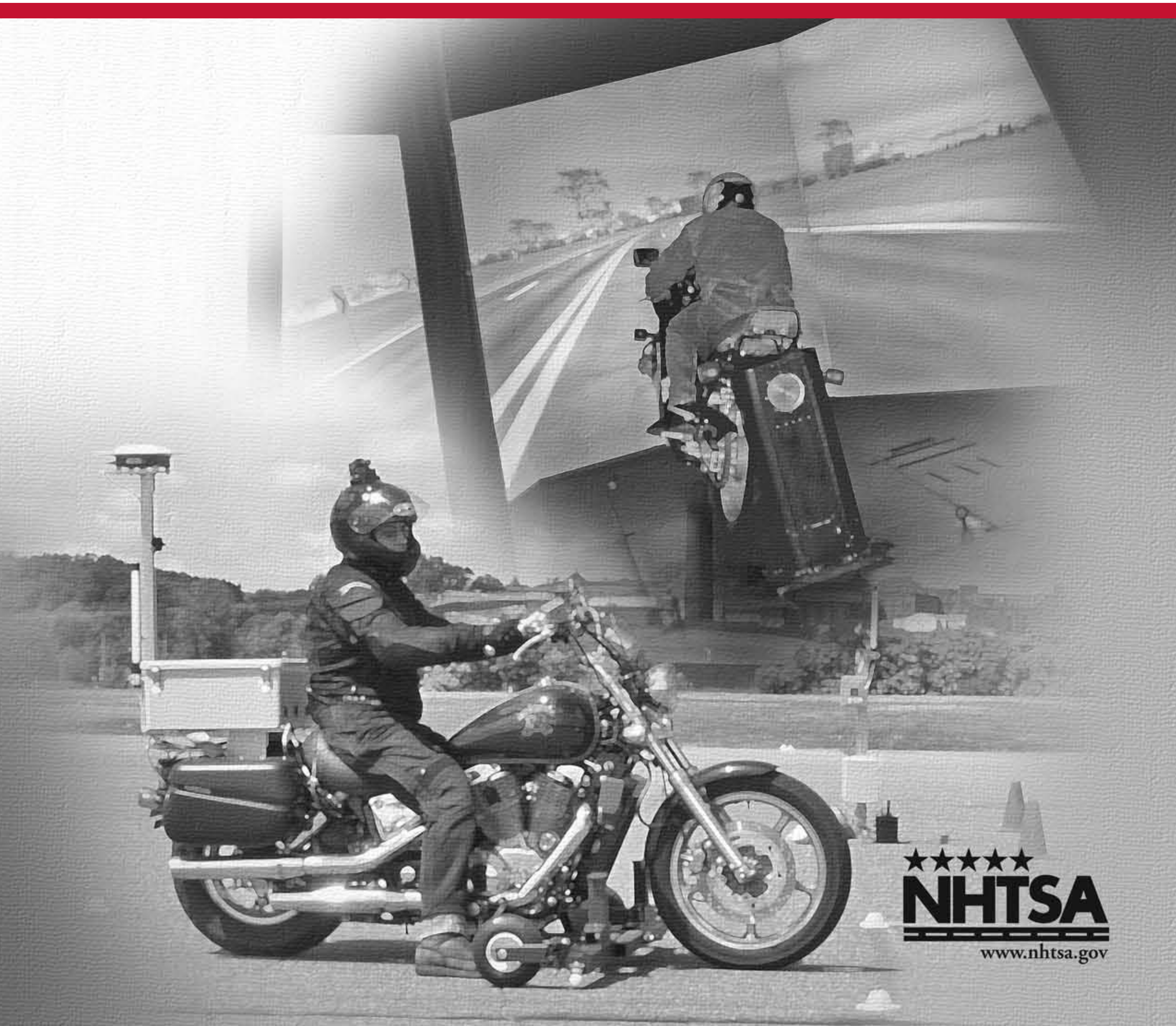
Methodology for Determining Motorcycle Operator Crash Risk and Alcohol Impairment

Volume I: Synthesis Report on Alternative Approaches With Priorities for Research



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16. Abstract

Alcohol-involvement continues to be a prominent factor in motorcycle crashes. Automobile-driver drinking and driving has been researched extensively, and the relationship between drivers' blood alcohol concentrations (BAC) and crash risk is well-understood. Unfortunately, our current understanding of the effects of BAC on motorcycle operation is insufficient. This project examined a variety of approaches by which the effects of alcohol on motorcycle rider impairment and crash risk can be measured. A two-volume report was prepared.

This is *Vol. I: Synthesis Report on Alternative Approaches with Priorities for Research*. Various research methods were reviewed in the literature (see Volume II, Literature Review), and an expert panel was convened for detailed discussion and prioritizing of possible methods. Different methods were grouped by assessed scientific value and estimated cost. Generally, it was determined that methods using existing data would be the lowest cost, but would also have the lowest scientific value. Conversely, the best data will come from new, more detailed data collection methods specifically defining the population-at-risk. Methods examined include "field" studies that collect actual highway data, and "simulator" or "closed course" studies that collect data in a controlled setting. Priorities for future research were assigned to each methodology. The highest priority methodologies were assigned to "Contemporary Case Control," Simulation and Induced Exposure studies.

Vol. II: Literature Review Report reviewed: (1) past research on impaired motorcycle operation; (2) past research methodologies used to understand alcohol's effects on human performance, including laboratory simulation, closed-course operation, self-report surveys, crash investigation and analysis of archival crash data; and (3) methodologies used to measure exposure in populations-at-risk, including roadside surveys. The literature review revealed a dearth of research on impaired motorcycle operation. In addition, an in-house study of fatal motorcycle crashes was conducted and discussed in this report.

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Executive Summary

Background

In 2004, 4,008 motorcyclists were killed and an additional 76,000 were injured in traffic crashes (NHTSA Traffic Safety Facts, 2004). Motorcyclist fatalities have been steadily increasing since 1997, when 2,116 fatalities were recorded.

It is apparent that alcohol use continues to be a significant problem in motorcycle crashes. In fatal crashes in 2004, motorcycle operators had higher blood alcohol concentration (BAC) levels (.08 grams per deciliter [g/dL] or higher) as compared to other types of motor-vehicle operators. The percentages for vehicle operators involved in fatal crashes were 27 percent for motorcycles, 22 percent for passenger cars, 21 percent for light trucks, and 1 percent for large trucks.

In 2004, there were 1,264 motorcycle operators killed who had been drinking (BAC .01+), of whom 1,025 (81%) were intoxicated (BAC .08+).

Drinking and driving has been researched extensively, and the association between drivers' BAC and crash risk is well-understood. On the other hand, there is insufficient research to understand the effects of BAC on motorcycle operation, which is very different from automobile operation due to issues of balance, coordination, and vulnerability. Though there are BAC data available for some crash-involved riders, there are essentially no data available on the incidence of alcohol involvement in the on-road motorcycle-riding population.

The National Highway Traffic Safety Administration sponsored a project to investigate alternative methodological approaches for determining: (1) the relative risk of alcohol impaired motorcycle riders being involved in a crash and, (2) rider impairment at different BAC levels. This project was conducted in two steps: first by reviewing the literature, and second, by inviting a panel of national experts in alcohol and field data collection to a workshop to discuss, compare, contrast, and rate various methods of data collection. The results of this project are reported in two volumes:

- *Volume I: Synthesis Report on Alternative Approaches with Priorities for Research* – This report summarizes the project findings, including a detailed account of information discussed at an expert panel workshop convened for this project. Among the topics discussed at the workshop were the advantages, disadvantages, scientific validity, and costs related to each alternative methodology. In addition, each methodology was prioritized as to its future research potential.
- *Volume II: Literature Review Report* – This report discusses past research on impaired motorcycle operation, past research methodologies used to understand alcohol's effects on human performance, and methodologies used to measure exposure in populations-at-risk. This report was provided to panel participants in support of the expert panel meeting. Two appendices are included. The first contains detailed descriptions of documents referenced in the report. The second contains detailed descriptions of documents reviewed for the report, but not referenced.

Methods

A literature search was performed that focused on: (1) past research on impaired motorcycle operation; (2) past research methodologies used to understand alcohol's effects on human performance, including laboratory simulation, closed-course operation, self-report surveys, crash investigation, and analysis of archival crash data; and (3) methodologies used to measure exposure in populations-at-risk, including roadside surveys. The literature review revealed a dearth of relevant research on impaired motorcycle operation. The most significant problem identified was the lack of scientifically valid information on BAC levels among on-road non-crash-involved motorcycle riders (i.e., the motorcycling population at risk). A total of 143 reports and Web sites were reviewed for this project; 61 of these are cited in the Reference sections of Volumes I and II, and described in detail in Appendix A. Appendix B provides detailed descriptions of documents reviewed but not cited in either Volume I or Volume II of this report. In addition, an in-house study of fatal motorcycle crashes was also conducted and discussed in this report.

An expert panel was assembled. Panel members were specialists in motorcycle safety, alcohol, and survey research, as well as law enforcement and other related fields. For each methodology under consideration, advantages, disadvantages, cost, and other issues were discussed. At the end of discussion, panelists provided their personal opinions as to which methodologies should be considered the highest priority for future research, based on feasibility and validity of the research methodologies.

Methodologies Assessed

The following methodologies were considered as being potentially capable of contributing to a better understanding of crash risk and alcohol impairment among motorcycle operators. Some of the methodologies listed provide data from crashes. Some provide comparison data from the population at risk. Some would provide both. Most would require collecting new data, though the last method listed could be done with existing data.

Studies Providing Data on the Impairing Effects of Alcohol

Simulation Study—Using a laboratory-based motorcycle simulator with alcohol-dosed subjects, impairment can be determined by comparing performance of each rider at various positive BAC levels. Performance at different BAC levels are compared to the same rider's performance when sober (.00 BAC) on different measures, such as rider balance, steering control and other rider tasks.

Closed-Course Study—Alcohol-dosed subjects would ride a motorcycle at low speeds on a closed (off-road) course outdoors. Performance of riders at various BAC levels would be measured and compared to their performance at the .00 g/dL BAC level.

Field Studies Providing Both Crash and Comparison Data

Contemporary Case Control—Data associated with crashes (including BACs of riders) is recorded and compared to similar data from non-crash-involved riders at or near the same location as the crash. Factors such as time of day and day of week would be matched carefully between crash and comparison cases.

Cohort Study—A sample of riders would be selected and alcohol use (e.g., BAC while riding) would be recorded over time, under naturalistic riding conditions along with data on any crashes that occur. Data would be collected using an instrumented motorcycle (to obtain BAC data, etc.) and other methods, including surveys and diaries.

Emergency Department—Similar to Contemporary Case Control study except that the interview with the crash-involved rider and BAC testing take place at a hospital.

Survey Study—Traditional survey techniques (e.g., phone, mail, or in-person surveys) would be used to collect self-reported data from riders concerning alcohol use and crash histories. Survey respondents would answer questions about past drinking and riding incidents which may or may not have resulted in a crash. Height, weight, gender, and number of drinks consumed would be used to estimate BAC of riders during these drinking and riding incidents. Crash risk would be determined from these self-reports.

Studies Providing Crash Case Data

Fatal Crash Records—BAC data from motorcycle rider cases in the Fatality Analysis Reporting System (FARS) would be obtained and compared to BAC data from motorcycle population-at-risk (exposure) data from a different source.

Injury Crash Records—BAC data on motorcycle riders from hospital records of motorcycle non-fatal injury crashes would be compared to population-at-risk data from a different source.

Studies Providing Comparison Data

Geo-General Comparison Data—Population-at-risk BAC data would come from general roadside surveys of motorcyclists, *not* from specific sites of previous crashes. Crash data would come from a different source (e.g., FARS).

Geo-Specific Comparison Data—Population-at-risk BAC data would be collected from visits to *specific sites* of previous motorcycle crashes found in archival data, such as FARS, which serves as the crash data source.

Fuel Station Survey—This would be similar to the roadside collection of BAC and other data except that the survey takes place when riders stop to refuel. Data is then compared to data from another source (e.g., FARS).

Study Using Existing Data for Crash and Comparison Cases

Induced Exposure—Using archival data (e.g., FARS), the BACs of crash-involved riders deemed not to be at fault would be used for the population-at-risk and compared to BAC data for at-fault riders.

Findings

Based on input from the expert panel, each methodology was assigned to one of the three following cost categories: Low Cost = <$250K, Medium Cost = $250K-$500K, and High Cost = >$500K. Within each of these cost categories, methodologies were assigned to one of three levels of scientific validity (high, medium, and low), that is, the expected scientific validity of findings from the methodologies, given the barriers to collection of complete and accurate data. The assessment of scientific validity was determined by the contractor's project team, based on input from the expert panel, results of the literature review, and past experience of the project team. With some exceptions, the methodologies rated highest for scientific validity were considered to be highest priority within their cost categories. Assigning priorities within cost categories will make it possible to select different promising methodologies depending on the funds available for future research. In one case, a methodology that would be highly valid scientifically (the cohort study) was rated a low priority because it would likely be so costly and time consuming as to be prohibitive to conduct. In another case, a methodology of relatively low scientific validity (induced exposure) was given a high priority by the project team because it would likely be very inexpensive to conduct. The authors point out that the cost categories are fairly broad, and that relative priorities could change as more exact cost information for each methodology becomes known.

Highest Priority Methodologies

The highest priority methodologies determined by the project team are as follows:

- Lowest Cost Category—Simulation, Induced Exposure
- Medium Cost Category—None
- Highest Cost Category—Contemporary Case Control

Medium Priority Methodologies

- Lowest Cost Category—Closed-Course Study
- Medium Cost Category— Fuel Station Survey paired with Fatal Crash Records, Fuel Station Survey paired with Injury Crash Records
- Highest Cost Category—Emergency Department, Geo-Specific paired with Fatal Crash Records

Lowest Priority Methodologies

- Lowest Cost Category—None
- Medium Cost Category—Survey Study
- Highest Cost Category—Geo-General paired with Fatal Crash Records, Cohort Study

Summary

Compared to drinking and driving, relatively little is known about the effects of alcohol on motorcycle operation. There are many methodologies that could be used to better understand these effects, each with its own set of advantages, disadvantages, and issues to be considered. None of the methodologies considered as part of this project were completely ruled out by the project team, although three methodologies were deemed highest priority: the Simulation and Induced Exposure studies, from the low-cost category, and the Contemporary Case Control study from the highest cost category.

1. Background

Drinking Rider Problem

In 2004, 4,008 motorcyclists were killed and an about 76,000 were injured in traffic crashes (NHTSA Traffic Safety Facts, 2004). Motorcyclist fatalities have been steadily increasing since 1997 when 2,116 fatalities were recorded.

It is apparent that alcohol use continues to be a significant problem in motorcycle crashes. In fatal crashes in 2004, a higher percentage of motorcycle operators had BAC levels of .08 g/dL or more, higher than any other type of motor vehicle driver. The percentages for vehicle operators involved in fatal crashes were 27 percent for motorcycles, 22 percent for passenger cars, 21 percent for light trucks, and 1 percent for large trucks.

Also, in 2004, 28 percent of all fatally injured motorcycle operators had BAC levels of .08 g/dL or higher. An additional 6 percent had lower alcohol levels (.01 – .07), and 41 percent of 1,672 motorcycle operators who died in single-vehicle crashes had BAC levels of .08 g/dL or higher.

Other important findings concerning alcohol use in fatal motorcycle crashes from Shankar (2003) include the following:

- Alcohol involvement in fatal crashes among motorcycle operators has shown an improvement from 49 percent in 1992 to 37 percent in 2001. However, still over one-third of operators were alcohol-positive in fatal crashes in 2001, with a majority of them intoxicated (BAC≥.08).
- Males were operating the motorcycle in 97 percent of fatal motorcycle crashes.
- Riders in the 40- to 49-year-old age group had the highest percentage of alcohol involvement (46%).
- Alcohol was involved in 49 percent of single-vehicle fatal motorcycle crashes and 25 percent of multiple-vehicle fatal motorcycle crashes.
- Alcohol was involved in 54 percent of nighttime fatal crashes and 19 percent of daytime fatal crashes.
- Three-fourths of operators involved in fatal crashes between midnight and 3 a.m. were alcohol-positive.
- Motorcycle operators not wearing helmets or who were improperly licensed or speeding at the time of a fatal crash were more likely to be alcohol-positive than other operators.

Project Objectives

In 2000, the National Agenda for Motorcycle Safety (NAMS) cited alcohol as a "prominent factor in serious motorcycle crashes" (NAMS, 2000). It states that we need a better understanding of the following:

- Why alcohol continues to play a role in motorcycle crashes more frequently than in those of other vehicles;
- Alcohol use and substance abuse patterns of motorcyclists; and
- The role of alcohol and substance abuse in motorcycle crashes.

This report summarizes the results of a NHTSA-sponsored project to assess alternative methodological approaches for determining the effects of varying blood alcohol levels on alcohol-impairment among motorcyclists as well as motorcyclists' likelihood of crash involvement. Some of the methodologies examined would provide information on alcohol's impairing effects on motorcycle operation. Others would provide a measure of relative risk of crash involvement through the comparison of crash data with population-at-risk data.

This project was performed by a team comprised of staff from the Pacific Institute for Research and Evaluation (PIRE) of Calverton, Maryland, and the Head Protection Research Laboratory (HPRL) of Paramount, California. The basic approach involved the project team developing a literature review document (see Vol. II) and providing it as a background document to a panel of national experts. The panel was invited to a workshop to discuss, compare, contrast, and rate various methods of data collection. Subsequently, project staff, *using panel member comments and priorities*, created a system for prioritizing the various research methodologies discussed in this project.

One way to determine the relative risk of being involved in a crash when a motorcyclist has been drinking would be to collect and analyze both motorcycle exposure and crash data. The crash data becomes the numerator and the exposure data is the denominator for use in statistical comparisons and analysis. Currently, there is no national resource for *both* crash and exposure data for motorcyclists. Of course, crash data is reasonably well documented. Generally the more serious the crash outcome, the better documented the crash is. The Fatality Analysis Reporting System (FARS) is NHTSA's nationwide resource for fatal crash data. There is no comparable data set for motorcycle exposure data.

In addition to crash risk it is possible to obtain a fuller understanding of the effects of alcohol on motorcycle operation by examining performance based changes (decrements) and decision errors associated with drinking alcohol. Studies involving use of riding simulators and motorcycles operated on closed course have been used to assess rider impairment.

The methodologies under consideration for this project should ultimately permit addressing the questions regarding the likelihood of being involved in a crash at various BAC levels—questions such as "Are motorcycle riders more vulnerable at lower BAC levels compared to drinking automobile drivers?" The methodologies considered may also allow more effective targeting of countermeasures to those who drink and ride, by answering questions such as "Are younger riders at a greater risk of crash involvement after drinking compared to older riders at similar BAC levels?"

2. Method

Literature Search

The literature was reviewed for previous work in several areas including motorcycle fatal and injury crash statistics, alcohol involvement in crashes, population-at-risk studies, roadside sampling, crash risk studies, motorcycle riding simulators, alcohol impairment, and other factors in injury outcome (e.g., crash type, helmet use). A detailed bibliography is found in Appendices A and B of *Volume II: Literature Review Report*.

Expert Panel

Another important part of this project was an expert panel meeting to discuss the issues involved in satisfying the project objectives. The panel's selection was in part driven by the literature search. That is to say, the project staff attempted to involve many of the very researchers who had previously worked in one or more of the areas in question. These included motorcycle safety, alcohol, survey technique, law enforcement, risk assessment, and related fields. Because of the sensitive nature of field data collection of a particular type of vehicle operator, panel members included representatives from motorcycle safety and motorcycle rider organizations. A suggested panel list was submitted to the Contracting Officer's Technical Representative (COTR) for review and approval. The COTR suggestions were incorporated and a workshop was conducted with the selected panel members.

Determining Relative Risk

Prior to the introduction of the methodologies discussed by the panel, it is important for the reader to understand the concepts of crash data and comparison data and how each is necessary to understand the potential effects of alcohol impairment on motorcycle operation.

A common measure of the influence of alcohol on crash risk is that of the "relative risk" of crashing while impaired, compared to that of crashing while unimpaired. The most commonly used relative risk measures for drinking and driving show the risk of being involved in a fatal crash at a given BAC. These relative risk values are created by determining the proportion of drivers in fatal crashes at a given BAC and dividing that by the proportion of non-crash involved drivers in the population at risk who are operating at that same BAC. The result is the relative risk of being involved in a fatal crash at that BAC level.

$$\frac{\textbf{Crash Data Variable}}{\textbf{Population-at-Risk Data Variable}} = \textbf{Relative Risk}$$

Table 1 shows the relative risk of being involved in a crash as reported by Compton et al. (2002). The relative risk of crash for automobile drivers begins to increase at low BAC levels and increases more than two-fold at BACs ≥ .07 g/dL.

Table 1. Relative Crash Risk by BAC

BAC Level	Crash Risk	BAC Level	Crash Risk
.00	1.00	.13	12.60
.01	1.03	.14	16.36
.02	1.03	.15	22.10
.03	1.06	.16	29.48
.04	1.18	.17	39.05
.05	1.38	.18	50.99
.06	1.63	.19	65.32
.07	2.09	.20	81.79
.08	2.69	.21	99.78
.09	3.54	.22	117.72
.10	4.79	.23	134.26
.11	6.41	.24	146.90
.12	8.90	.25+	153.68

By plotting the relative risk for a range of BAC levels, the increasing effects of alcohol on crash risk can be observed as BAC increases. Figure 1 shows a relative risk curve from Compton et al. 2002.

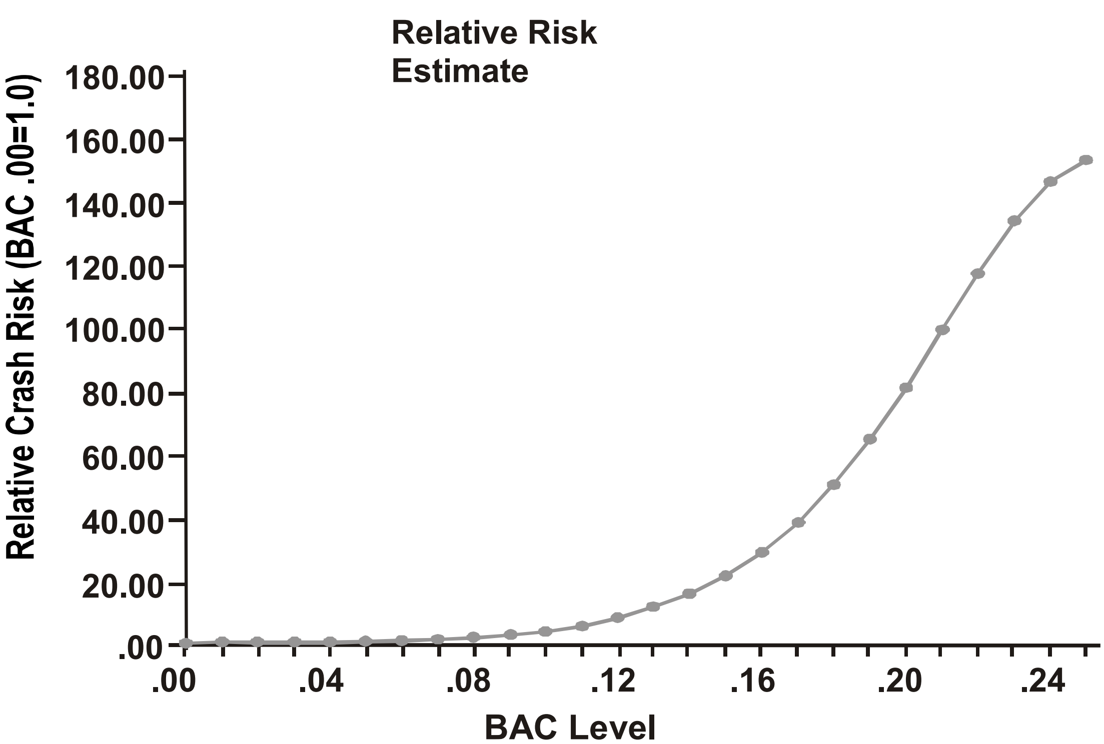

Figure 1. Relative Risk Estimate

The same basic concept could also be used to create curves showing relative risk of other potential consequences of alcohol impairment on motorcycle operation, such as injury crashes.

It would also be possible to develop risk curves for simulated crashes using a motorcycle simulator, or for performance errors (e.g., lane exceedance) on a simulator or closed course. However, due to differences between these settings and real-world operation, data from simulators and closed-course operation are generally considered more indicative of impairment than true crash risk.

As will be summarized below, the methodologies for understanding the effects of alcohol impairment on motorcycle operation involve collecting both crash data and population-at-risk data. Where potential methodologies do not result in the collection of both types of data, methodologies for collecting crash data must be matched with methodologies for collecting data on the population-at-risk. Because population-at-risk data is used for *comparison* purposes, it will be referred to in this report as "comparison data."

Table 2 shows methodologies identified as ways to collect data necessary to understand the effects of alcohol impairment on motorcycle operation. The table begins with methodologies that would provide laboratory data on impairment, followed by studies which would provide new crash and comparison data, methodologies that would provide new crash data, methodologies that would provide new comparison data, and finally a methodology that could be done entirely using existing data.

Table 2. Brief Description of Methodologies

Method	Description
Studies Providing Data on the Impairing Effects of Alcohol	
Simulation Study	Using a motorcycle simulator with alcohol-dosed subjects. Rider impairment would be measured by comparing performance within rider at various BAC levels.
Closed-Course Study	Alcohol-dosed subjects would ride a motorcycle on a closed course. Rider impairment would be measured by comparing performance within rider at various BAC levels.
Field Studies Providing Both Crash and Comparison Data	
Contemporary Case Control	BAC and other information concerning crashes are recorded at the scene (as much as possible) and afterward. Later, similar data is recorded for non-crash-involved riders at or near the same location, time of day, and day of week.
Cohort Study	A sample of riders would be selected. Alcohol use (e.g., BACs while riding) would be recorded over time, along with data on any crashes that occur. Data would be collected using various methods, which could include surveys, diaries, and use of an instrumented motorcycle.
Emergency Department	Interviews conducted with crash-involved riders and BAC testing takes place at a hospital. This data would then be compared to BACs and interviews (if available) to on-road population-at-risk data taken from a different source.
Survey Study	Traditional survey techniques (e.g., phone, mail, or in-person surveys) would be used to collect self-reported data from riders concerning alcohol use and crash histories. Height, weight, and number of drinks would be used to estimate BACs of riders when they were not involved in crashes versus when they *were* involved in crashes.
Studies Providing Crash Case Data	
Fatal Crash Records	Crash data for motorcyclists would come from FARS. This data would then be compared to BACs and other information (if available) to on-road population-at-risk data taken from a different source.
Injury Crash Records	Crash data would come from records of motorcycle injury crashes. This data would then be compared to BACs and other information (if available) to on-road population-at-risk data taken from a different source.
Studies Providing Comparison Data	
Geo-General Comparison Data	Population-at-risk data would come from general roadside surveys, not from specific sites of previous crashes. Oversampling of population-at-risk data makes it possible to control statistically for factors such as age. Crash data would come from elsewhere (e.g., FARS).
Geo-Specific Comparison Data	Population-at-risk data would come from visits to specific sites of previous crashes found in archival data. Data is then compared to data from another source (e.g., FARS).
Fuel Station Survey	Similar to roadside collection of BACs and other data except that survey takes place when riders stop to refuel. Data is then compared to data from another source (e.g., FARS).
Study Using Existing Data for Crash and Comparison Cases	
Induced Exposure	Using archival records (e.g., FARS) BAC data from crash-involved at-fault riders is compared to crash-involved riders deemed not to be at fault (population-at-risk). The at-fault riders are then compared to the non-at-fault riders to yield a measure of risk.

3. Detailed Report of Discussion

Expert panel members convened for a meeting lasting one and a half days. The purpose of this meeting was to thoroughly discuss ways to determine the effects of BAC levels on motorcycle operator impairment. Prior to the meeting, members received a document containing background information on the issues to be discussed. This document was generated from the literature review and has been incorporated into Volume II of this report. Workshop participants reviewed the document before the panel meeting. The meeting began with introductions of panel and project team members followed by a description of background, prior research, and project history by the contractor. Subsequent panel discussion included methodologies and elements of methodologies described in the background information, plus any alternative methodologies suggested by panel members. One alternative methodology (the cohort study) that was not considered in the background report was added to the discussion. Also discussed were strengths and weaknesses for each methodology, procedures which would be used for each methodology, measures of effectiveness, data analysis techniques, and promising research sites. Discussions were largely open-ended though discussion was guided by a moderator. After the main discussion ended on the second day, panel members gave their opinions on the relative priorities of the various methodologies for future research. Detailed notes of the discussions were recorded and used to generate this report. A draft of the report was sent to panel members for review. Changes suggested by panel members were incorporated where deemed appropriate.

The following section discusses the various methodologies under consideration (Table 2) and summarizes the expert panel's review of the methodologies including their primary advantages, disadvantages, and an estimate of general cost category. Cost categories used were: estimates of less than $250,000; between $250,000 and $500,000; and over $500,000.

Simulation Study

Driving simulation has been used for many years in research studies on driving behavior for automobiles, trucks, and other vehicles. There are many simulators available for these vehicles at various levels of cost, complexity, and fidelity; however, very few motorcycle simulators are known to the project staff and panel members. Most motorcycle simulators are not of sufficient fidelity to be useful for a study of the type proposed. The National Advanced Driving Simulator (NADS) does not have a motorcycle "cab" simulator. Dynamic Research, Inc., in Torrance, California, has a relatively high-fidelity driving simulator with a motorcycle and scooter cabs and associated hardware and software.[1]

There are two important aspects of fidelity or realism of the simulator: cue fidelity and dynamics and control fidelity.

[1] In the interest of full disclosure we note that John Zellner, who is a co-author of this report, is also president of Dynamic Research, Inc. (DRI), which maintains a motorcycle simulator described in some detail in this report. Research by project staff at PIRE and HPRL indicated that the DRI simulator was the only motorcycle simulator suitable for the type of research discussed in this report at the time the project was being conducted. The discussion of the DRI simulator is not intended to advertise the DRI product, or promote its use in research. Rather it has been contributed by Zellner in the interest of providing the reader with as much useful information on the subject of motorcycle simulation as possible.

Cue fidelity pertains to the display the operator interacts with, including visual, motion, and sound. If they are suitably designed, motorcycle simulators can more readily achieve higher cue fidelity regarding their ability to simulate the riding task faithfully, in comparison with automobile simulators. This is largely because real motorcycles, like aircraft, are "bank-to-turn" vehicles, which means that the operator experiences and senses mainly visual cues, rather than a combination of visual and motion cues that car drivers experience. Both pilots and riders must see a "horizon" (either real or artificial) to control and stabilize the vehicle; if they loose that visual reference, they can be essentially unaware (via motion cues) of whether they are turning or level, because the turns are "coordinated" and for the most part cannot be sensed by the body's motion-sensing apparatus (tactile, proprioceptive, vestibular, kinesthetic, etc.). Consequently, high-fidelity motorcycle simulators can be less expensive than high-fidelity automobile simulators, because motorcycle simulators can function well with much simpler motion systems. The four-wheeler simulators *need* more elaborate motion systems, which are an expensive part of the system, to induce realistic operator responses and delays.

Dynamics and control fidelity pertain to the simulated vehicle response to various kinds of operator inputs. For a motorcycle, the vehicle response and operator inputs are considerably more complex than for a car. For a motorcycle, the responses include motorcycle roll, yaw, and pitch angles and rates, and forward and lateral translation. The operator inputs include steer torque and steer angle; lateral and fore-aft upper-body lean angle; and braking, throttle, and gearshift control inputs. The dynamics and control mathematical relationships have been well established since about 1970, and NHTSA-sponsored research (e.g., Weir et al., 1979) experimentally measured and verified these dynamics and control relationships. A motorcycle simulator needs (a) to include these dynamics and control "equations of motion," and (b) measure the relevant operator control inputs.

In contrast to cue fidelity, motorcycle dynamics and control fidelity is relatively more complex and difficult to provide than it is for cars and other four-wheelers. There are more motion degrees-of-freedom, stronger interactions among them, and more operator inputs to measure. Therefore, for motorcycle simulators, the overall complexity required to provide a suitable vehicle dynamic model and responses to operator inputs, in addition to high-fidelity visual cues, can be substantially greater than it is for four-wheeler simulators. For example, riding a motorcycle through a curve requires that the motorcycle be leaned with respect to the horizon. Opposing physical forces allow the motorcycle to operate leaned over without falling down. This type of phenomenon can be accounted for in creating the simulator, which requires that the simulated cues be different from those for typical four-wheeled-vehicle simulators. As noted, this does not mean that motorcycle simulators are necessarily more expensive; to the contrary, their hardware can sometimes be less costly than comparable automotive simulators. Rather, they are technologically much more complex to develop from a dynamics and control viewpoint, and therefore much less common than four-wheel simulators.

It may be advantageous to create scenarios using real-world situations known to have resulted in motorcycle crashes. It may also be possible to increase the validity of a simulator study by anchoring it to the real world. Examples of this include selecting crash scenarios and impairment measures that, when run with cars and drivers, provide impairment curves mirroring the Borkenstein (1974) and Compton (2002) relative risk curves for drivers; or calibrating the simulation by duplicating the low-speed closed-course test described subsequently, collecting impaired versus unimpaired riding data from a sample of riders on both closed-course and simulated versions of the test, and comparing results.

For the findings of a simulator motorcycle study to be accepted as relevant, they must be validated using real-world information. This issue is discussed in greater detail under the closed-course study.

If the simulation was intended to duplicate reality, to the extent that crash likelihood is similar to actual riding in traffic, it would be necessary to expose subjects to many hours of riding before a crash might be seen. This is not to say that the "many hours" need to be concurrent or that fatigue is a main cause of crashes. The Hurt report (1981) found the bulk of crashes occurred within a few minutes after the start of a trip. However, hundreds of trips may have been completed successfully before the crash. To expose subjects to hundreds of hours of simulation would be prohibitive. More likely, researchers would create a simulation with a higher frequency of potential hazards. This would increase the likelihood of a crash or some other measure of impaired operation.

The ability to record very precise data about the operation of the simulator (e.g., control inputs, lane position, responses to other vehicles) makes it possible to use measures other than crashes to identify impaired operation.

Generally, a simulator study with dosed subjects exposes each subject to a series of different scenarios, each at a different BAC level. This approach requires that the sequence of scenarios be randomized such that each subject faces each one once, and across all scenarios each one is seen an equal number of times at each BAC level. This is done to avoid order effects and scenario effects. By one panel member's estimation, at least 10 subjects per scenario/BAC combination would be needed to get reliable data. The most typical protocol as used in car alcohol research would be to administer alcohol in a controlled and monitored way, such that crash avoidance/involvement would be measured at multiple (e.g., four) BAC levels, the maximum being just above the typical current legal limit (e.g., .10 g/dL) [See Moskowitz et al., 2000]. Such protocols are well established and have been approved in the past by various internal review boards.

Because dosed-subject simulator studies usually involve multiple trials over time as BAC rises and falls, it is important to make certain that subjects receive enough practice on the simulator to get past the learning curve before actual trials begin. Otherwise, the BAC effects will become confounded with learning effects.

The study design must acknowledge that there is a potential difference between effects of a given BAC while drinking, as BAC is going upward, versus the same BAC after drinking when the BAC is coming down. This would be done by continuing the experiment after maximum BAC had been reached and drinking had been halted, and by recording whether trials were recorded before or after this point.

Advantages

There are many advantages to the use of simulation for impaired-operator research. The same subjects can be used for impaired and unimpaired conditions, removing inter-subject differences as a possible confounding variable. Differences in performance at varying BAC levels could also be examined for simulated car driving for the same subjects and compared to their motorcycle data. This would increase the validity of the findings compared to generating BAC and performance curves from a motorcycle-riding population, then comparing them to automobile-driving curves from a population that may be very different.

Another advantage of simulation is that the riding experience can be completely controlled so that all subjects are exposed to the same situations across all conditions. Riders can be subjected to simulated risks, in the form of dangerous situations and higher BACs, which could only safely be experienced using simulation. Measurements and data collection are relatively easy compared to that with instrumented real vehicles. A wealth of data can be collected on performance (e.g., speed, response latency, eye movements, close calls) rather than relying completely on crashes as a measure of performance. Differences in judgment might be measured. Data would have some face validity because it would come from actual operation of a (simulated) vehicle comparing impaired to unimpaired conditions in a typical (albeit only visual) crash scenario (e.g., based on a real crash reconstruction); yet it would be safer than having actual impaired subjects riding on a closed course or in traffic (cohort study). BAC levels could be controlled to a greater extent than could those collected in natural occurrences of crashes and other comparison cases found in the field. BAC measurements could be extremely accurate, both in terms of getting a good measure and getting it as close to the time of riding as possible. A videotape of the simulated ride would demonstrate the effects of alcohol on riding and would provide a good teaching tool.

Disadvantages

Simulator studies have limited face validity. Although similar to actual riding, it is *not* actual riding. It will not necessarily be possible to relate simulated crash likelihood to actual crash likelihood, although relative comparisons are common in simulator studies. There will be problems motivating subjects to perform safely in the same way they would if the consequences were real injury. The number of simulator subjects in such a study would probably be far lower than the number of crashes that can be studied using archival data. Although safer than actual riding, there is still the potential for simulator motion sickness, as well as general risks related to dosing subjects. IRB approval is required for such a study. It has been theorized that crashes are more likely for motorcycles than for cars at a given BAC due to the greater skill necessary to operate a motorcycle. To the extent that this is true, it becomes extremely important that a simulated motorcycle operate as much as possible like a real one, especially under emergency conditions. This can be much more difficult with a motorcycle simulator than with an automobile simulator. It was suggested that a simulator study would be most useful if it could be done in conjunction with a low-speed closed-course study with dosed riders, because similarities in performance and impairment, between simulated and actual low-speed operation would tend to validate use of the simulator. However the closed-course study may be difficult to get approved by an IRB.

Cost

<$250,000

The major cost of performing a simulator study is in the construction and programming of the simulator. Assuming a suitable simulator is available the next-most-costly aspects of a simulator study are creating scenarios and preparing to run subjects. Once everything is set up to run the first subject and analyze subjects' data, the additional cost of running more subjects is generally minimal unless a large number of subjects are to be used. Per-subject costs would include subject payments, additional staff time to recruit, schedule, and run subjects, and additional data manipulation and analysis costs.

Closed-Course Study

Experiments involving dosed automobile drivers have occasionally been used over the years to investigate the effects of alcohol on operation of automobiles. These studies have generally involved fairly low speed and low BACs. There have been very few examples of experiments to determine the effects of alcohol on motorcycle operation using subjects operating motorcycles on a closed course. Some examples were found as articles in the motorcycling magazines. These experiments were run by staff of the magazines involved and efforts were made to adhere to protocols necessary for a valid controlled research study. However there were sufficient problems with the methodologies that these studies can not be considered entirely valid. If future studies are performed by professional researchers, they will be subject to approval of an IRB.

Because of the increased vulnerability of motorcyclists, the tasks involved in such studies need to be fairly simple and need to be performed at lower speeds and lower BACs than studies with car drivers. It would be important that the closed course be free of fixed objects (e.g., poles, guardrails) that would pose a threat to a fallen rider even at low speeds. It would also be important that riders not be required to do anything that they are uncomfortable doing when unimpaired; obviously, riders should be capable of performing the task safely at baseline before attempting to perform it with a BAC.

There are known motorcycle skill tests that involve operating at as low a speed as possible which are extremely challenging and present little risk of injury and minimal damage to motorcycles in case of a crash. Some police motorcyclists perform these tests on a regular basis. They may be willing to participate in a dosed-rider study. Other types of expert riders may be good candidates for such a study because they may already be insured for risky riding, may be able to operate at relatively high BACs, and may show impairment while having reduced risk of injury. These would include motorcycle racers and or stunt riders. Use of such professional riders as subjects, and operation at lower speeds could make it easier to obtain IRB clearance for a closed-course study, however the relevance of findings to non-professional riders at higher speeds, would be questionable.

Another possibility would be to conduct an off-street study using motorcycles equipped with outriggers to prevent the motorcycle from falling over. These have been used in the past for research. This would potentially reduce the chances of a complete capsize and fall-down. However the outriggers will likely effect handling and maximum lean angles, such that findings may not reflect normal riding circumstances. Their presence may alter rider risk-taking behavior. Further, the outriggers may not completely prevent any possibility of injury. For example, a rider could still fall off an outrigger-equipped motorcycle, or, depending upon the outrigger configuration, have a foot trapped between the outrigger and the pavement.

As with the simulator study, it will be extremely important to provide enough practice on the measure to guarantee that there is no confounding between alcohol effects and practice effects. The study design must also acknowledge that there is a potential difference between effects of a given BAC while drinking, as BAC is going upward, versus the same BAC after drinking when the BAC is coming down.

Advantages

Many of the advantages for the simulator study apply to the closed-course study as well: face-validity due to measurement of motorcycle operation, ability to use same riders in both impaired and unimpaired conditions, ability to compare motorcycle and automobile operation (though obviously two different courses would be necessary for the two different vehicles). Although it would not be possible to measure as many aspects of operation as can be measured with a simulator, it would still be possible to measure aspects of operation (e.g., stopping distances, low-speed dropping of the motorcycle, lane excursions) that would not be measurable using archival data, interviews, surveys, and so on. BAC data would be of the highest quality. As with the simulator study, riders could be videotaped performing the test and footage could be used as a teaching tool.

Disadvantages

Closed-course studies share many of the disadvantages of simulator studies. Getting IRB approval for such a study would likely be more difficult than for a simulator study. The extent to which this becomes an obstacle will vary depending on the funding agency and local rules and regulations. Like simulator studies, closed-course studies gain some validity from the fact that they involve actual operation of motorcycles. However, depending on the tasks involved, closed-course operations may bear little resemblance to those involved in on-street operations. As an example, extreme low-speed (i.e., 5 mph or less) handling of a motorcycle is a very different skill than operation at normal speeds. It would be difficult to say much about the connection between study results using this approach and actual crash likelihood. Tests of skill that require riders to go as slow as possible will not reflect tendency for drinking riders to use poor judgment by riding faster than appropriate, though they may still allow riders to exhibit poor judgment in some other form. Although it may be possible to run a closed-course study in such a way as to minimize crash likelihood and severity, there is still the possibility of injury. Liability issues will be important to whoever does such a study. It may be easier to get clearance to run such a study by using professional riders (e.g., motor officers, racers) but these are not representative of the skill level of the general rider population. Findings from a closed-course study are not completely applicable to on-street operation.

Cost

<$250,000

To create a low-speed course will not require a great deal of real estate. Existing training facilities could be used. Motorcycle police in some jurisdictions are currently conducting this type of exercise regularly as a part of training and retraining. Often these exercises are conducted in parking lots. It may be possible to obtain riders on a volunteer basis or it may be necessary to pay subjects. Subject participation fees should not be terribly costly, depending on the number of subjects. It was suggested that this study would be most effectively performed in conjunction with a simulator study. In that case it must be acknowledged that available funds would have to pay for both studies. Additional costs to be considered are the possible need for additional insurance and the cost of repair and maintenance.

Contemporary Case Control

The Contemporary Case Control study involves conducting an on-scene investigation of a crash as soon as possible after it occurs. A "go-team" monitors police radios or otherwise gets up-to-the-minute news of any crashes in the area. When a motorcycle crash occurs, the go-team travels to the crash site, interviews the rider involved, and records BACs and other pertinent data. If necessary, the go-team goes to the hospital to collect whatever data could not be collected at the crash site. If all data cannot be collected between the crash site and hospital (e.g., the motorcyclist is fatally injured and doesn't go to a hospital), the go-team uses whatever means necessary to collect as much of the desired data as possible.

At a later time, the team goes to the crash site and attempts to collect BAC and other data from randomly passing motorcyclists who serve as comparison cases. The comparison cases will ideally be recorded at approximately the same time on the same day of the week, unless that would be inappropriate (e.g., one of the days is a holiday). In some cases, the comparison case will be located as near as possible to the crash site, when safety or other issues prevent using the exact site. The study protocol may call for one or more comparison case for each crash case. Having multiple comparison cases makes it easier to control statistically for differences between comparisons and crash case riders. An informal power analysis was conducted as part of this project, to determine the number of cases that would be necessary to obtain statistically significant results in a Contemporary Case Control study. The analysis indicated that 500 pairs of case and comparison riders (1,000 riders total) should be sufficient (Peck, personal communication, 2002).

Both crash and comparison data can be difficult to obtain. Both require the cooperation of the riders. In the case of the crash-involved rider, the rider may be gone by the time the go-team arrives—if the crash was relatively minor, the rider may have left quickly afterward. This may skew the sample toward more severe crashes. In more serious crashes the rider may go to the hospital, requiring the go-team to determine where the rider has gone and to attempt to get there before the rider is released. Once the rider is contacted, the rider may choose not to cooperate, although in some cases it may be possible to get BAC measurements through the police or the hospital. Comparison-case riders need to be pulled out of the traffic stream. This generally requires the cooperation of police, who conduct the actual traffic stop. Once again, riders may choose not to participate. In the only major Contemporary Case Control study of motorcyclists in the United States, *The Motorcycle Accident Cause Factors and Identification of Countermeasures*, a.k.a. the "Hurt" Report (1981), cooperation levels of both crashed riders and comparison riders was considered sufficient. Riders may be more inclined to participate if the field interviews are conducted by motorcyclists – a technique that was used in the Hurt study. Comparison cases may be more cooperative if police stops are conducted by motorcycle officers. Evidence indicates that male and female riders may both be more comfortable stopping for female researchers than male researchers. There may also be value in advertising the research project within the motorcycling community and getting the cooperation of motorcycle organization leadership so that riders are prepared for the possibility of stops and less inclined to see motorcyclist-only traffic stops as being unfair. One way to get around the appearance of singling out motorcyclists would be to stop cars as well, although this would increase the cost and complexity of the study with no real value added in the data collected (if any) from car drivers.

Whether a police officer conducts the stop (comparison case) or the researchers attempt it, there may be benefit to advertising the stop in advance by means of a sign or signs upstream from the stop location. Given the fact that the go-team is interviewing riders and visiting the crash scene, there is a possibility of collecting large amounts of useful data (e.g., roadway type, road geometry, first main event, etc.). The more that such data are collected, the more important it becomes that the go-team be trained in crash investigation.

The Organisation for Economic Co-operation and Development (OECD) has created an international methodology for On-Scene In-Depth Motorcycle Accident Investigations that contains information useful to groups wishing to conduct a case control study of motorcycle crashes (OECD, 2001).

Any study of this nature will most likely be subject to Office of Management and Budget (OMB) approval. It will also be necessary to secure the cooperation of local law enforcement agencies and hospitals.

Advantages

The Case Control study is generally capable of collecting large amounts of high-quality data for each case. Because data come from actual crashes and provide good BAC data, it is possible to generate relative risk ratios for crash involvement. Data come from a range of crash severities, from property damage only (PDO) through injury crashes to fatal crashes, though crashes are limited to those reported to police. This method is not as likely to suffer from the problem that using archival data has, of examining only more serious cases that tend to reflect higher BACs, and of BAC testing being more likely for higher-BAC victims. The comparison data collection at the same site, same time, same day of the week, one or two weeks later, provides a control over many of the factors that could influence BAC in crashing riders.

Disadvantages

A great deal of effort goes into the data collection for each case, compared to other methodologies (e.g., the use of archival data). Comparison cases may not be well matched on all pertinent factors (e.g., age, gender, experience). Characteristics of the day in which data are collected may not match either. For example, of two successive Mondays, one might be a holiday, or a payday for one of the riders. Weather may also differ. The crash may have been due in part to roadway characteristics such as construction or debris in the road that is gone a week later so that the crash cases and comparison cases are not equal with respect to crash likelihood. In some situations (e.g., a multilane highway crash) it may be impossible to collect comparison data. It may be difficult to find motorcyclists passing during the time set aside to find the comparison case.

Though this type of study has the potential to provide data from a range of crash severities, they will tend to be skewed toward the more severe injury or fatality crashes, since the less-severe crashes may go unreported or be cleared before the go-team can arrive.

It may be difficult to obtain the cooperation of all necessary parties (e.g., rider, law enforcement, hospital personnel). Law enforcement agencies may have rules governing who can be stopped in traffic (e.g., need probable cause) and traffic stops for research studies may not be allowed under these rules.

Cost

>$500,000

Factors contributing to the cost of this methodology include maintaining a go-team with sufficient expertise to do the job properly and that is prepared to travel to a motorcycle crash site at a moment's notice. This go-team would need to be kept in place for many months to collect sufficient data. To obtain data for comparison cases, a team may need to spend several hours at each crash site waiting for motorcyclists to survey.

It may also be necessary to reimburse police agencies for their participation in helping with the roadside survey portion of this type of study.

Similar case-control studies of automobile drivers have been very costly and time-consuming.

Cohort Study

A cohort study would attempt to select and follow a representative sample of riders and record their drinking and riding behavior over time. This type of study has never been attempted or accomplished for motorcycle riders. BAC levels for trips that result in crashes, close calls, or other measures of unsafe riding are compared to BAC levels for trips that do not. Recent advances in technology have made this more of a possibility than it may have been in the past. Devices such as alcohol interlocks used to prevent impaired drivers from starting and operating cars can be modified for use in a cohort study of motorcyclists. These devices could require that riders provide breath measurements before starting the motorcycles. If a breath measurement is not provided, the motorcycle would not start, but regardless of the outcome, once a breath measurement is provided, riders could proceed. If the motorcyclist was prevented from riding after drinking, subsequent rider behavior could not be recorded. Other on-board instrumentation could be used to record physical conditions that indicate crashes or close calls (e.g., moving motorcycle becomes stopped on its side). Global Positioning Satellite (GPS) equipment could be used to record such information as crash locations and speeds. Participation might be increased through the incentive of providing the instrumented vehicles to riders for free, at a discount, or as a loan for the period of the survey. Alternatively, surveys could take the place of much of the technology mentioned for data collection. Reports of drinking behavior or crashes/close calls could be elicited through surveys or recorded in logbooks. It may be possible to get more accurate data by using frequent phone surveys (e.g., twice weekly) rather than less-frequent surveys (e.g., monthly mail-in surveys). Internet survey instruments might also be used. Issues of liability and human subject protection would significantly affect the feasibility of such a study. For example, some would consider it unethical to create a situation where riders can record a high BAC on an interlock device that then permits them to start the motorcycle and ride it. If instrumented motorcycles or other incentives are provided only to subjects who can be expected to occasionally ride after drinking, there is potential to view the study as encouraging drinking and riding. The fact that BACs are being recorded also creates a potential legal issue in the case of a crash.

Advantages

If such a study could be done with a sufficient number of participants and highly accurate data, it could be the most accurate way of determining relative risk curves for motorcycle operation.

Participating riders have the potential to be both the crash case and the comparison case. There is a potential for recording far more data than could be obtained using archival data. These additional data could strengthen the study and may also be of interest to potential project sponsors (e.g., motorcycle manufacturers). Even if much of the data come from surveys of participants (rather than automated data collection via instrumented vehicle), the response rate would likely be far higher than for the Survey studies described below, because participants have agreed in advance to participate.

Disadvantages

As with any study in which participants are aware that they are being observed, participation in the study may change the behavior it is attempting to study.

There is no guarantee that all pertinent data would be collected. If an interlock device is used, participants may attempt to circumvent it when they have been drinking, or they may choose to use other forms of transportation, including different motorcycles, when planning an outing that may involve riding after drinking.

Other people could use the participant's motorcycle. If an alcohol interlock is used to capture BAC data it might take advantage of technology which requires the user to learn a coded system of blowing in order to start the engine. Still, it would be possible for someone who borrows the motorcycle to learn the system, or for the owner to blow for another rider.

Participants may not accurately report crashes and close calls.

Any other data collected through a survey has the potential to be inaccurate if the subject incorrectly recalls or misreports the facts. In particular, if BAC measures were collected using survey methods, the data would be no more accurate than for the survey study (described below).

There is a potential for self-selection bias due to some riders agreeing, and others not agreeing, to participate in the study. There is also the problem of identifying potential subjects in a way that does not bias the sample. For example, recruiting subjects through licensing rolls would preclude having unlicensed riders in the study.

To the extent that data are collected by means of survey instruments, the study would require OMB clearance. The use of human subjects creates a requirement for review by an IRB committee, which may choose not to permit it. Steps would need to be taken to prevent survey data from being used against participants in the case of a crash. To use crashes as a dependent variable, many riders and/or many years of data may be necessary to obtain a large enough sample of crashes. A study that takes several years of data collection is not very attractive to agencies that want the research question answered as soon as possible. Use of instrumented vehicles also creates cost/maintenance issues.

Cost

>$500,000

The cost of such a study would vary depending on the extent to which automated data collection systems are involved. If instrumented vehicles are used, it may be that motorcycles would be purchased and instrumented out of project funds and provided to study subjects as an inducement to participate. Cost could conceivably include purchasing and maintaining motorcycles, alcohol interlocks, crash detection equipment, GPS equipment, and other potentially expensive technologies. Prices of some of these technologies may come down in the future. Costs might also include incentives for subjects to participate.

Another element that adds to the potential cost of this methodology is the large number of people and/or time needed to generate enough crashes or close calls to have significant results.

Emergency Departments

This methodology would involve a go-team going to hospital emergency departments to interview injured motorcyclists to obtain BACs, demographic, and other data. An alternative would be to have staff of the emergency department conduct interviews and collect data. This methodology would be similar to the Contemporary Case Control study in that it is a way of providing in-depth data on crash victims and would require some way of obtaining comparison data. It would be similar to the Injury Data study in that it would be necessary to obtain cooperation of local hospitals, in this case to allow interviews and institute a policy of BAC measures for all injured motorcyclists. As with the Injury Data study it may be difficult to get data on riders with only minor injuries and fatally injured riders. OMB and IRB clearance would likely be issues. It would be necessary to consider all issues associated with whichever method is used to provide comparison data (e.g., Contemporary Case Control or Geo-General Comparison Data study roadside rider surveys). Some hospitals, such as some Level I Trauma Centers, are already collecting BAC data on many of their patients (primarily those who are admitted to the hospital). As with other studies, it would be beneficial to conduct this study in an area with a large riding population. It seems likely that the more frequently a given hospital has motorcyclist victims, the more likely they will be to remember that there is a study and to correctly perform the survey protocol.

A possible variation on this methodology would be to combine it with the Contemporary Case-Control method for obtaining crash data. This hybrid system is currently being used for research in Thailand (Kasatikul, 2001). The go-team monitors police frequencies and hospital admissions (typically via the 911 system). This provides leads to Property-Damage-Only (PDO) crashes via the police, while also providing injury cases not reported to the police (riders will often go straight to hospitals to avoid police involvement in order to avoid prosecution, insurance issues, etc.). In the case of the Thailand study, a go-team makes its headquarters at the hospital to pickup unreported cases as they enter the hospital. The go-team monitors police activity and, based on information provided by the police, decides whether to go to the crash site or to conduct the interview at the hospital. The go-team has an ambulance on-call so that they can easily get to the PDOs, should they choose to go to the crash site.

Advantages

This study would include injury crashes, which would be more representative of all crashes, and would provide more cases from a given area/time, than studying fatalities only. The BACs would likely be obtained from a blood sample, which facilitates the study of contributions of other drugs to the crash.

Disadvantages

This study would not include PDO crashes. BACs are more removed in time from BACs collected at the scene. This study also would require cooperation from the hospital and crash victims. If emergency department staff is used to collect data, there will be a higher potential for erroneous and missing data due to the fact that hospital staff have other, higher, priorities, and would not have as complete an understanding of the project's research needs as researchers would have. Hospital staff will also have difficulty providing roadway data and other variables that are routinely included in a police-reported crash report. It may be difficult to determine the crash site from data collected at the hospital. Lastly, limiting data collection to the area served by a single hospital may not provide sufficient numbers of cases.

Cost

>$500,000

Cost issues for this methodology would be similar to those of the Contemporary Case Control study. If a go-team is used to collect crash data at hospitals, the costs would be similar to a Contemporary Case-Control study. If hospital staff collects crash data, costs could be reduced but with the potential effect on data quality discussed above. In either case, the cost of collecting comparison data in the field will be high.

Survey Study

There are many ways in which a survey study could be conducted. Possibilities include telephone surveys, mail surveys, and in-person surveys at motorcycling events. A survey would attempt to understand the effects of alcohol on crash likelihood by asking riders to recall their drinking behavior in the recent past, along with information regarding crashes and close calls. There is evidence that people can remember recent drinking experiences well enough to estimate the number of drinks consumed over a given period. This information, along with rider weight, height, gender, and other factors, can be used to estimate BAC. Typically, surveys will ask a participant to recall a specific incident in the recent past (within a set time window) in which drinking took place. A recent study on drowsy driving used a similar approach (Royal, 2003).

In many cases, the use of surveys requires OMB clearance that can add significantly to the time and complexity involved in performing the study. This report will not assume that OMB approval will always be an issue because of the possibility that the work could be funded by other organizations that are not subject to OMB guidelines.

As with any survey, the method used to identify participants and the response rate of participants has a great effect on the validity and generalizability of results. The American Motorcyclist Association's experience with surveys in their magazines has been that only one percent will respond. A random survey to identify enough motorcyclists to have a valid survey would require a great deal of effort. Narrowing the search by focusing on people with motorcycle licenses would miss the large proportion of riders who are riding unlicensed, which would lead to skewed results. Focusing on people with registered motorcycles may be a better strategy, though there is no guarantee that such a person rides on a regular basis. A mail-out survey of motorcyclists in Pennsylvania, used for a study by McKnight and McKnight (1989), received a 66 percent response rate using registration data. Collecting information at a motorcycling-oriented event would skew results toward reflecting only the type of rider who would attend that particular event. Some have suggested that motorcyclists may be suspicious of the motives of the safety community such that it may be difficult to get a high degree of cooperation from some segments of the riding community. A balancing belief is that riders enjoy talking about issues related to riding and may be forthcoming with information once any initial hesitance is overcome. A good way to get a "foot in the door" would be to approach riders with someone who is (or is perceived to be) a member of the riding community. In the form of mail or phone surveys, this could be done by having the survey nominally sponsored by a motorcycling organization. In the case of in-person surveys at motorcycling events, surveys would be conducted by people who were visibly identifiable as being riders. In the case of door-to-door surveys, interviewers would actually ride to the house.

Advantages

It may be possible to administer a survey by including questions in an existing survey, such as those being administered by the Motorcycle Safety Foundation, American Motorcyclist Association, National Household Transportation Survey, Mortality Followback Survey, National Drinking and Driving Survey, National Household Study on Drug Abuse, and Behavioral Risk Factor Surveillance System (more information is provided on these under "General Issues, Data Sources" near the end of this report). In some cases, data from these surveys can be linked to existing data (e.g., FARS).

Disadvantages

Although it may be possible to estimate a rider's BAC based on survey results, the estimate will be very rough compared to an actual BAC measurement. Participants may incorrectly recall, or misreport information. Other self-reported information (e.g., crashes, mileage) may be inaccurate. Although it may be possible to include survey questions in an extant survey, historically many of these surveys require that agencies requesting additions make a contribution of funds or resources, which eliminates some of the advantage of piggybacking on these surveys.

Cost

$250,000-$500,000

Surveys tend to be costly, mostly because it takes several attempts at contacting the same people to get a sufficiently high response rate. If interviewers attempt to reach motorcyclists by surveying random households, costs will be extremely high due to the relatively few motorcyclists. The Motorcycle Industry Council conducts such a survey. For the 1998 survey they called 270,000 households to get 1,500 motorcycle owner interviews. They also interviewed 1,500 non-motorcycle-owning households. Based on their experience they estimate that the telephone interview portion of such a survey would cost about $350,000. Surveys that attempt to reduce costs by targeting motorcyclists more directly run the risk of having biased results, depending on the avenue used to reach riders, and could still become costly in an attempt to get a sufficient response rate.

It may be possible to get survey questions answered by piggybacking questions on another survey. Although it seems as though this may be a way to get survey questions answered for less cost, it should be noted that some of the surveys discussed as having potential for this purpose have historically asked for large sums of money to include questions on their survey.

Fatal Crash Records

A methodology using fatal crash records would compare BACs found in motorcyclists involved in fatal crashes to BACs found in the public-at-large. The fatal crash data would come from

FARS. Because of the relative infrequency of fatal motorcycle crashes, several years of data would be used. Also, because collecting comparison data may need to be done in certain locations where a sufficient number of motorcyclists can be found, consideration needs to be given to restricting FARS cases to those same areas. As with the Injury Crash Records methodology, this methodology provides data only on crashes, so consideration must be given to the issues, advantages, and disadvantages that apply to the method used to collect comparison data. Thought also would need to be given to whether to include riders involved in crashes where the rider was not fatally injured (e.g., passenger or pedestrian was fatally injured).

Advantages

In general, fatal crashes are the best documented crashes, and FARS data are relatively complete with respect to BAC data. For cases in which there is no BAC, it is possible to impute BACs. In the past, this has been accomplished using the Klein (1986) imputation procedure. Currently, the Subramanian (2002) imputation method is being used. In the opinion of some, fatal crashes are the most important to prevent. To be able to say "chances of being *killed* in a crash are increased x percent at a given BAC" would be more persuasive for these people than to talk about injuries. For this reason, study results that are generalizable to fatal crashes may be more valuable than alternatives for such audiences.

Disadvantages

Data are limited to fatal crashes only. There may be a gap in time of several years between a crash case and the comparison case. Because there are relatively few fatal crashes, the sample size would be much smaller than for using injury cases from an equivalent time period. Where BACs are missing, there is likely to be a systematic reason (rather than missing BACs randomly). This may reduce validity of findings. As with the Injury Crash Records methodology, this methodology only provides part of the data needed. It would be necessary to collect the comparison data, which is a considerable task. There is a possibility that confounding variables linked to alcohol use might obscure the correlation between BACs and crash risk. For example, drinking riders have been shown to be less likely to wear helmets. This affects their likelihood of being included in the FARS dataset. There is also some evidence that alcohol itself may increase the likelihood of dying for a given level of injury (Waller et al., 1986; Luna et al., 1984).

Cost

>$500,000

The cost of a study using FARS data is labeled as *high* here, not because an analysis of FARS data is costly, but because, for the most part, FARS data are not useful without comparison data, which will be costly to obtain. The exception would be an Induced Exposure study (see below).

Injury Crash Records

One way to determine the effect of BAC on crash likelihood is to compare BACs of crash-involved riders with BACs of the rider population at large. One possibility for obtaining BACs and other pertinent data from riders involved in crashes would be from hospital records. A study that uses injury crash data would need to get the BAC data for the riding population at large from some other source.

In this type of study, researchers would rely on hospital records of BACs for crash-involved riders at the hospital. Not all hospitals collect BAC data as a matter of course. By some counts, only 10 percent of injury cases have a BAC measurement (Liedtke & DeMuth, 1975; Flamm et al., 1977). In hospitals where it is measured only occasionally, measurements tend to be in cases where hospital staff suspect the patient has been drinking. This causes the BACs measured to skew high. For this reason, it is necessary to work with hospitals that can record BACs for all or nearly all of their motorcycle crash-involved patients. Level I Trauma Centers are more likely to have protocols that encourage recording of BACS for all patients, though these procedures may not always be followed strictly. In some cases, hospitals may have been recording sufficient data, for long enough, that archival hospital data can be used for this study. In other cases, arrangements may need to be made with the hospital to get them to start recording some of the data. Because a given hospital may see relatively few motorcycle crash victims, it may be necessary to use several years' data to get a large enough sample.

Because this methodology only provides data on crashes, consideration must be given to the issues, advantages and disadvantages that apply to the method used to collect comparison data.

Advantages

There are many more crashes involving injury than there are fatal crashes, therefore more data are available for analysis for a given time period than are available from using fatal crash data alone. Using injury crash data also allows generalization to injury crash population. It may be possible to obtain additional data by linking to larger database (e.g., through the use of the NHTSA's Crash Outcome Data Evaluation System (CODES) data system).

Disadvantages

This methodology provides only half of the data necessary to generate relative risk curves; it would still be necessary to get comparison data from non-crash-involved riders. This methodology would exclude PDO and minor-injury crashes. It may be harder to get BACs on all cases than it is in some other methodologies, depending on the hospital, policies and other factors. Time between crash and BAC measure may be greater than for Contemporary Case Control method, which may make BAC measures less reliable. It may be difficult to determine where the crash took place for the purposes of finding matching comparison case, although in-hospital follow-up may provide sufficient data, as would obtaining a copy of the Traffic Collision Report (TCR), which could be a source of much of the data for the case. There is a range of completeness of BAC data in hospital records: some hospitals collect a lot, some collect very little. Due to the tendency to collect BAC data more often when the evidence of drinking is more obvious, anything less than 100 percent testing has the potential to result in overestimated average BACs.

Not all motorcycle crash victims will go to the hospital, and not all who go will be admitted. Riders with minor injuries may not go to the hospital or be admitted. Single-vehicle crashes in which the rider can still operate the vehicle often lead to emergency room visits, but very often entail no police report, so that information is lost. Fatally injured riders may be pronounced dead at the scene and not go to the hospital. Often, BAC and other data will not be collected until the victim has been admitted. Because riders with minor injuries may not be represented in the sample of crashed riders, this necessarily skews the sample toward more severely injured riders.

Cost

>$500,000

Because this method uses crash data collected as part of the hospital's procedures (assuming the cooperation of the hospital), the costs of obtaining crash data would be relatively low, although the cost of additional BAC tests may have to be considered. The main cost of conducting this study would be obtaining comparison data through roadside surveys (Case Control, Geo-General Comparison Data, or some other method). The cost of obtaining comparison data, then, could be considerable.

Geo-General Comparison Data

This methodology provides comparison data by using a roadside survey to collect BACs and other data. Rather than attempting to match crash data by going to the exact sites of previous crashes to collect comparison BACs, this method is a stratified sampling system that samples cases from several locations. Analysis of BAC, location type, and demographic data allows a more accurate determination of probable BACs at crash sites. In the past, data from this type of study have been compared to FARS data, though it may also be possible to find other sources of crash data.

In some cases, this methodology includes asking surveyed riders where they have been, rather than simply recording where they are. This allows researchers to determine not just where the rider is at the time of the survey, but also all the places the rider has been on this trip, which gives a more accurate picture of where riding after drinking is taking place.

In studies conducted with automobile drivers, survey locations are based on road usage data (i.e., data showing where automobile traffic is concentrated). Ideally, rider survey locations would be based on knowledge of where motorcyclists tend to ride. However, panel members felt that road usage data specific to motorcycles were lacking.

Because this methodology involves collecting data for motorcyclists alone, not for automobile drivers, it will probably be necessary to single motorcyclists out for traffic stops. This could be perceived as persecuting, harassing, or profiling of motorcyclists, many of whom already feel as though they are being treated unfairly by the government and by other road users. It would be beneficial to advertise to local riders that a survey is taking place, and to gain the backing of rider organizations, if possible, to gain support among the rider population when rider-only surveys are conducted. An alternative would be to also stop some car drivers, to avoid the appearance of singling out motorcyclists. This would likely add to the cost and complexity of the study with little benefit beyond the public relations benefits. Another possibility would be to obtain motorcyclist data by including riders in the next national roadside survey. However, based on the numbers of drivers stopped in the last national roadside survey, Voas et al. (1998), and the proportion of riders generally found in traffic, it would not be possible to get enough rider data by simply including motorcyclists in a single national roadside survey.

As with all surveys, OMB clearance would be needed with this methodology.

Advantages

Compared to collecting comparison BACs in the Case Control study, there would be a greater likelihood of finding riders within a reasonable period. The greater number of riders sampled may make it possible to more accurately assess the distribution of BACs in the rider population at large. Based on past experience with this methodology (Zador et al., 2000), there is a high likelihood of obtaining accurate BAC readings on a high percentage of those surveyed. Compared to the Case Control study there is less need to survey at specific (prior crash) sites, some of which may be more dangerous survey sites than those used for the Geo-General Control Data study.

Disadvantages

This methodology has disadvantages generally associated with surveys (e.g., a need to stop motorcyclists, need for cooperation from local police agencies, need for cooperation from motorcyclists, potential impacts on traffic flow, safety issues, IRB issues).

Because there are relatively few motorcyclists in the traffic stream, it would take much longer to survey a sufficient number of riders than it takes to find a usable sample of drivers.

Evidence indicates that selecting survey sites randomly may underestimate drinking compared to going to motorcycle crash sites, because random sites may not be where riding takes place or where drinking and riding takes place. As well, the randomly selected sites have no direct relationship to the crash sites, thus confounding the two data sources.

Cost

>$500,000

The cost associated with this type of study would mostly be related to roadside surveys. A survey crew would be necessary. If the same crew is used in multiple parts of the country, there will be travel costs. Because of the low frequency of motorcycles in the traffic stream, it will be necessary to spend far more time at the roadside to get the same number of cases collected in surveys of drivers. If the decision is made to survey drivers as well as riders, to address the appearance of discriminating against motorcyclists, this may result in increased workload and, therefore, increased costs. In some cases, offers of payment to survey subjects may be a cost-effective means of ensuring higher response rates, but these need to be figured into the cost of doing the study. It may also be necessary to reimburse law enforcement officials for their participation.

Geo-Specific Comparison Data

Geo-Specific Comparison Data are comparison data collected at the sites of crashes in archival datasets. Most likely, crashes would come from the FARS dataset. Field researchers would go to the site of the original crash and stop one or more passing motorcyclists to collect population-at-risk data. Ideally data would be collected at the same time of year, day of the week and time of day as the original crash. If possible, multiple riders would be surveyed at each site. If it is not possible to find riders, or to survey riders at the exact location of the original crash, it may be necessary to obtain riders at a higher-traffic location somewhere near the original site. To do so would reduce the validity of results to some extent. In many ways, this method for collecting comparison data would be similar to the collecting of comparison data within the Contemporary Case Control study. Overall, this study would be very similar to the Geo-General Comparison data study.

Advantages

This study has many of the same advantages as the Geo-General Comparison Data and Contemporary Case Control studies. The primary advantage of this methodology *over* the Geo-General study is that comparison data obtained at the location of the original crash may be a more valid comparison than data collected in different neighborhoods, cities or States, as may be the case with the Geo-General approach. The primary advantage over the Contemporary Case Control study is that it takes advantage of archival crash data.

Disadvantages

The disadvantages of this study are also similar to those of the Contemporary Case Control and Geo-General Comparison Data studies. OMB clearance will be needed to survey riders, and the cooperation of riders, and possibly local law enforcement, will be necessary. The main disadvantages of this study over the Geo-General are that it may be difficult to find riders at the sites of the original crashes, and there will almost certainly be fewer riders surveyed. The main disadvantages compared to the Contemporary Case Control will be the greater time elapsed between case and comparison data and the fact that archival case data will not be as complete nor as accurate as the data collected by a go-team at the crash scene.

Cost

>$500,000

The costs associated with this study will be almost entirely in collecting the comparison data. Using archival crash data would result in great savings over the Contemporary Case Control study. However, the cost of obtaining the comparison data would be significantly high; therefore, this methodology has been placed into the high-cost category. It is not certain, but it seems likely, that the Geo-Specific method for collecting comparison data would be more expensive than the Geo-General method, given the labor involved in collecting data for each case, the large number of cases that would be needed, and the high likelihood that finding a motorcycle at some sites would require a long wait, and in some cases no motorcycles would be found.

Fuel Station Survey

This approach would be used to obtain data comparable to that collected from a roadside survey (e.g., BAC, demographic data). These data would then be paired with archival crash data, such as FARS. Fuel stations within the sampling region would either be randomly selected or selected based upon close proximity to a crash site. Motorcyclists would be approached at these stations while refueling and asked to participate in the study. Willingness to participate will be an issue, as with any survey. If response rates aren't reasonably high, results may be of questionable validity. If the survey is kept short, it may be possible to administer it during the time it takes to refuel. Because this would be a survey, issues of OMB clearance will be in effect. Ethical issues when the survey team identifies a rider who is clearly impaired will also be a concern. It may not be necessary to have the cooperation of local police for this study, but it will be necessary, instead, to get the cooperation of fuel station owners and managers. The OECD uniform motorcycle crash data collection protocol contains procedures for conducting such a survey (Organisation for Economic Co-operation and Development, 2001). While this method has been used in Europe and Asia, it has not yet been used to collect alcohol data. An attempt to survey riders at fuel stations in Southern California met with several obstacles. Managers at fuel stations were unwilling to give permission to interviewers to approach people in their station. Senior officials at fuel companies also refused permission. A researcher counted the number of motorcycles at a fuel station in a period of several hours. There were very few motorcyclists. The potential difficulty in obtaining permission to survey, and the limited cost-effectiveness if too few riders can be surveyed, raise some doubts about the use of this method to collect comparison data in the United States (Prof. Hugh H. Hurt Jr., personal communication, 2003).

Advantages

Riders would already be stopped and, therefore, may be more willing to participate. Avoiding the need for police cooperation may greatly simplify the project, and may reduce the cost if police agencies require that officers be paid out of project funds for their participation.

Disadvantages

Because different motorcycles have different gas tank capacities and burn fuel at different rates, some motorcycles need to stop more frequently. This increases the likelihood of these riders being surveyed, which would cause them to be overrepresented in the survey results. Also, riders may be less likely to refuel after they've been drinking, either because of decreased willingness to stop or increased likelihood of deciding to refuel at the beginning of an outing, eliminating the need to refuel later. Because there are relatively few motorcycles on the road, interviewers may have large amounts of downtime between surveys. It may not be possible to obtain permission from owners/managers to survey riders on fuel station property. Conducting surveys during nighttime hours (e.g., 11 p.m. to 2 a.m.) may also present some security issues for the survey team. Conducting surveys in an area with some vehicular traffic raises safety concerns for researchers. This study would likely involve IRB clearance and OMB clearance would almost certainly be necessary.

Cost

$250,000 – $500,000

This study would likely be less expensive to perform than a roadside survey involving traffic stops. Some savings may come from the fact that it would probably not be necessary to use law enforcement personnel. The time necessary to set up a safe area into which to direct survey traffic would be saved as well. On the other hand, not working with law enforcement may make it more necessary to pay subjects to participate.

Induced Exposure Study

In automobile studies, an Induced Exposure study gets crash case data from drivers who are judged culpable in a multi-vehicle collision (Cerrelli, 1973). Nonculpable drivers are the comparison group. Differences between BACs in the culpable group and the nonculpable group would be considered indicative of the extent to which BAC contributed to the crash, as opposed to being generally present in the population at large. The primary reason for conducting such a study is to take advantage of BACs recorded as part of the crash report. If this methodology were to be conducted exactly the way in which it is done for four-wheeled vehicles, it would be necessary to find crashes in which two motorcyclists, ideally operating independently of each other (as opposed to riding together in a group), collided. This occurrence is extremely rare. An alternative would be to use crashes between motorcycles and four-wheeled vehicles and compare culpable versus nonculpable riders. Using this method, comparisons would no longer be from the same crash and would, therefore, not be automatically matched for location, time of day, and so on.

Such a study could be done using archival data (e.g., FARS data). Determining culpability could be attempted by using information already in the FARS file. In the case of multiple vehicle crashes, cases in which the rider was speeding or otherwise operating unsafely could be considered rider-culpable cases. In the past, studies have been conducted in which vehicles that were struck from behind or were not moving when struck were deemed nonculpable.

There are several ways in which single-vehicle crashes could be handled. The first would be to exclude all single-vehicle motorcycle crashes. Because a high percentage of total motorcycle crashes *are* single-vehicle (Shankar, 2001), this would result in a large reduction in the number of cases. A second technique would be to try to find a way to separate single-vehicle crashes into rider-culpable and rider-nonculpable cases. To our knowledge this system would have to be developed, because no system to identify nonculpable riders in single-vehicle crashes currently exists. A third system, and one that has been used before, would consider all riders in single-vehicle crashes culpable, the idea being that, in the absence of another motorist, the rider would be the only person who *could* be culpable. This ignores the possibility that another motorist may have caused the rider to crash and then left the scene. The crashed rider may be unable to report, or police may be unable to verify, the influence of the other motorist.

Another way to determine culpability would be to use data that contains police determinations of culpability (acknowledging that police determinations seek culpability from a legal perspective) or to have research staff determine culpability from crash reports. FARS does not have this information, though it may be possible to identify cases of interest through FARS and go back to Traffic Collision Reports (TCRs) in the States' files to obtain enough information to determine culpability. At the panel meeting, mention was made of work done by Terhune (1983) that dealt with "Responsibility Analysis" – in which objective criteria were developed to assign culpability in a crash. A team of raters would assign culpability based on reading crash reports. The team would first establish inter-rater reliability by rating the same cases and comparing results. After a sufficiently high level of reliability had been established, the raters could split the remaining cases between them (Terhune, 1992).

There may be an advantage to doing a preliminary study to determine what demographic and driver-history differences exist between culpable and nonculpable samples. If the samples differ for age, gender, previous violation history, and other factors determined to be correlated with crash likelihood, this would indicate that any differences in BACs between them cannot solely explain differences in culpability.

Advantages

The sole advantage to this methodology is that it could be conducted entirely using existing data. It is, nevertheless, a very significant advantage.

Disadvantages

This methodology would require crashes in which motorcycles crash into each other (probably not feasible) or would compare one motorcycle/auto crash with another (which loses the advantage of having culpable and nonculpable participants matched for time and place).

It is likely that alcohol increases rider's risk of being involved in a crash in which the rider is deemed nonculpable. For example, an impaired rider may be less able to avoid a collision with a car that pulls into his path. To the extent that this is true, it would tend to mask the effects of alcohol's contribution to crashes of both culpable and nonculpable riders. Subsequent comparison of BACs of "crashing" (culpable) and "comparison" (nonculpable) riders would result in an underestimation of alcohol's contribution to the crash.

A problem with using single-vehicle off-road crashes as indicators of motorcyclist culpability is that it is possible that another vehicle could have forced the motorcycle off the road.

While it may be possible to determine whether the crash and comparison riders are similar with respect to age, gender, and other demographic variables that could be related to crash risk, there are other variables, such as miles ridden per year, that could be different between the two samples, which would affect crash likelihood, and which could not be determined from the data. Another potential problem is that BAC measures are not taken in all cases and, when they *are* taken, are often taken for the purpose of convictions. Therefore, this dataset may be skewed.

Cost

<$250,000

The fact that an Induced Exposure study can be conducted using entirely archival data makes it relatively inexpensive to do. However, such a study relies heavily upon the accuracy and reliability of the data collected within the TCR and the FARS. Any extra effort expended to judge the culpability of riders in crash records will increase the costs of performing the study, but probably not so much that it would put it in a higher cost category.

General Issues

Other important issues related to the data collection for a drinking-riding study are discussed in this section.

Site Selection

Issues to be considered when selecting sites for data collection or areas from which to analyze archival data should include the following:

- The likelihood of finding sufficient motorcycle crashes. Some areas of the country have relatively longer riding seasons that encourage more people to ride motorcycles and to ride more miles per year. States such as Florida, Texas, and California would be ideal for doing research in this respect.
- The likelihood of finding sufficient riders for participation in surveys. This consideration can be addressed by conducting surveys in States with longer riding seasons.
- The generalizability of results to the larger population. Throughout the United States and the world there are physiological, cultural, demographic, and other differences among riding populations, their drinking behavior, their willingness to drink and ride, and the way in which their bodies process alcohol. To the extent that differences exist among rider populations, data showing the prevalence of riding

after drinking and the relationship of BAC to impairment in one area may not generalize to another. On the other hand, it may be reasonable to assume that whatever effect the BAC has on motorcycle operation, it is primarily physiological, and would apply to people of similar physiology regardless of location. For that reason, it seems appropriate to conduct research where it can be done most cost-effectively with confidence that the result can be generalized to other areas, provided there are no general differences between the physiologies of riders in the two areas.

- Differences between States in terms of the existence and enforcement of helmet laws will lead to different rates of helmet usage. Different States may also have different levels of usage of "novelty" helmets—helmets which do not meet DOT standards and offer little protection. Because unhelmeted (or "improperly-helmeted") riders are likely to be more severely injured in a crash, and more severe crashes are more likely to be reported, any methodology that depends on motorcycle crash reporting will likely see a higher proportion of unhelmeted riders than exist in the population at large. Because there is a correlation between riding unhelmeted and riding while impaired (as well as other demographic variables), some State laws and practices may skew results with respect to BACs of the crashing rider sample. For this reason, it may be impossible to generalize results across States.
- Some cities or areas will have different types of roadways that will influence the types of crashes and the outcome severities. For example, cities having the highest numbers of motorcycle fatalities tend to be in the southern and western States where roads tend to be wider and average speeds within the city are faster. To get representative results, it would be best to examine areas with a variety of road types and speeds.
- Consideration of the relationship between the crash data and the comparison data is necessary. This will reduce the number of confounding variables (e.g., environment, roadway type).
- The San Diego Trauma System was specifically mentioned as a site where quality data could be collected from a relatively large sample of motorcycle crash victims.

Data Sources

The following sources of data were identified as being potentially useful for some of the approaches described above. Some are data repositories which may be useful. Some are existing surveys to which motorcycle/alcohol-related questions might be added.

- National Roadside Survey (NRS)—National Roadside Surveys have been conducted three times in the past (1973, 1986, and 1996). "The National Roadside Survey of 1996 collected data between 10 p.m. and 3 a.m. on Friday and Saturday nights in the 48 contiguous States. Drivers were selected for interviews and breath tests by a geographically stratified sample. The NRS collected data on BAC, seat belt use, number of passengers, type of vehicle, and demographic characteristics of surveyed drivers" (Web site: www.nhtsa.dot.gov/people/outreach/traftech/tt266.htm). Motorcyclists have been excluded from the two previous National Roadside Surveys due to the added complexity of transporting impaired motorcyclists and their motorcycles, compared to automobiles. Planning for and including motorcyclists in a future NRS could collect significant amounts of data. However, given the relative infrequency of motorcycles in the traffic stream, it is unlikely that enough cases could be collected using this data source alone.

- Fatality Analysis Reporting System (FARS)—FARS has been a primary source of data for studies using fatal crash data. The following description of FARS has been compiled from multiple NHTSA Web sites: The Fatality Analysis Reporting System (FARS) contains data on a census of fatal traffic crashes within the 50 States, the District of Columbia, and Puerto Rico. To be included in FARS, a crash must involve a motor vehicle traveling on a trafficway customarily open to the public and result in the death of a person (occupant of a vehicle or a nonoccupant) within 30 days of the crash. FARS has been operational since 1975 and has collected information on over 989,451 motor vehicle fatalities and collects information on over 100 different coded data elements that characterize the crash, the vehicle, and the people involved. Data on fatal motor vehicle traffic crashes are gathered from the State's own source documents, and are coded on standard FARS forms. FARS analysts obtain the documents needed to complete the FARS forms, which generally include some or all of the following: Police Accident Reports (PARs), State vehicle registration files, State driver licensing files, State Highway Department data, vital statistics, death certificates, coroner/medical examiner reports, hospital medical records, emergency medical service reports. All data elements are reported on four forms. The Accident Form records information such as the time and location of the crash, the first harmful event, whether it is a hit-and-run crash, whether a school bus was involved, and the number of vehicles and people involved. The Vehicle and Driver Forms record data on each crash-involved vehicle and driver. Data include the vehicle type, initial and principle impact points, most harmful event, and drivers' license status. The Person Form contains data on each person involved in the crash, including age, gender, role in the crash (driver, passenger, nonmotorist), injury severity, BAC and restraint use. Additionally, there are FARS Alcohol files which contain driver and nonoccupant BAC values and estimates, where BAC is not available (Web site: www.nhtsa.dot.gov/people/ncsa/fars.html).
- Crash Outcome Data Evaluation System (CODES) —"CODES is a collaborative approach to obtain medical and financial outcome information related to motor vehicle crashes for highway safety and injury control decision making. It evolved as the result of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, which provided funds to the National Highway Traffic Safety Administration to report to Congress about the benefits of safety belts and motorcycle helmets for persons involved in motor vehicle crashes. To measure benefits in terms of reducing death, disability, and medical costs, NHTSA determined that statewide data were needed that included all persons involved in police-reported crashes -- those who were injured or who died as well as those who were not injured. In this manner, comparisons between those using and not using safety belts or motorcycle helmets could be made by identifying and contrasting the characteristics of the injured and uninjured persons within each of the restraint use groups. The CODES *Report on the Benefits of Safety Belts and Helmets* was delivered to Congress in February, 1996, and is available for download as a pdf document" (Web site: www.nhtsa.dot.gov/PEOPLE/ncsa/codes/codes2.html).

- National Trauma Data Bank (NTDB)—A product of the American College of Surgeons (ACS), "The National Trauma Data Bank (NTDB) is a national repository of data. The NTDB is a database which serves as a central repository of data for a broad variety of commercial registry programs. The NTDB encourages broad participation and is a subscription service. Periodic standard reports are generated from the NTDB providing data on a national basis. This allows facilities to compare trends and other important data. The NTDB is located at the ACS in Chicago, Illinois" (Web site: www.facs.org/trauma/ntdbwhatis.html).
- Crash Injury Research & Engineering Network—"The Crash Injury Research & Engineering Network (CIREN) is a multi-center research program involving a collaboration of clinicians and engineers in academia, industry, and government. Together, they are pursuing in-depth studies of crashes, injuries, and treatments to improve processes and outcomes. CIREN's mission is to improve the prevention, treatment, and rehabilitation of motor vehicle crash injuries to reduce deaths, disabilities, and human and economic costs" (Web site: www-nrd.nhtsa.dot.gov/departments/nrd-50/ciren/CIREN.html). The CIREN database is not currently structured to allow the collection of data related to motorcyclists.
- Behavioral Risk Factor Surveillance System (BRFSS)—"In the early 1980s, Centers for Disease Control (CDC) worked with the States to develop the Behavioral Risk Factor Surveillance System (BRFSS). Now active in all 50 States, the BRFSS is the primary source of information on major health risk behaviors among Americans. States use standard procedures to collect data through a series of monthly telephone interviews with U.S. adults. Telephone surveys conducted to monitor State-level prevalence of the major behavioral risks among adults associated with premature morbidity and mortality. The basic philosophy is to collect data on actual behaviors, rather than on attitudes or knowledge, that would be especially useful for planning, initiating, supporting, and evaluating health promotion and disease prevention programs. CDC developed a standard core questionnaire for States to use to provide data that could be compared across States. The BRFSS, administered and supported by the Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, CDC, is an ongoing data collection program. By 1994, all States, the District of Columbia, and three Territories were participating in the BRFSS" (Web site: www.cdc.gov/brfss/about.htm).
- National Household Survey on Drug Abuse—"The Substance Abuse and Mental Health Services Administration's (SAMHSA) National Household Survey on Drug Abuse (NHSDA) is the primary source of information on the prevalence, patterns, and consequences of drug and alcohol use and abuse in the general U.S. civilian noninstitutionalized population, age 12 and older. It is conducted by SAMHSA's Office of Applied Studies (OAS). Occasionally OAS produces methodology reports, detailed tables, and other NHSDA reports that are available only on the Web" (Web site: www.oas.samhsa.gov/nhsda.htm).
- National Survey of Drinking and Driving Attitudes and Behavior—"Every two years the National Highway Traffic Safety Administration conducts a nationwide survey on the attitudes and behaviors of the general public related to drinking and driving.

The findings of these surveys are intended to guide people working in the prevention and law enforcement fields in programmatic planning, and to provide data that will assist in obtaining funding for such programs. Due to the length of the report, the summaries have been divided into three sections: (1) attitudes and behavior, (2) intervention strategies, and (3) attitudes about DWI laws" (No Web site currently available).

- Multiple Cause-of-Death Mortality Data from the National Vital Statistics System of the National Center for Health Statistics "provide mortality data by multiple cause of death for all deaths occurring within the United States. Each record in the microdata is based on information abstracted from death certificates filed in vital statistics offices of each State and District of Columbia. Causes of death were coded according to the International Classification of Diseases, Ninth Revision" (Web site: www.nber.org/data/multicause.html). There was concern expressed at the meeting that it is not possible to reliably identify motorcycle operators in these data.
- National Household Transportation Survey (NHTS)—"The National Household Travel Survey [formerly known as the Nationwide Personal Transportation Survey and the American Travel Survey] are household-based travel surveys conducted every five years by the U.S. Department of Transportation. Survey data are collected from a sample of U.S. households and expanded to provide national estimates of trips and miles by travel mode, purpose, and a host of other characteristics. The survey collects information on daily, local trips and on long-distance travel in the United States" (Web site: http://199.79.179.77/nhts/).

Other potential sources of data that might be used, many of which have already been mentioned earlier in this report, include Hospital Admissions Records, Emergency Room Records, Coroner's Records, EMS Records, Court Records, and Roadside Surveys. In the past, useful data have been collected through the use of supplemental crash report forms for police. This involves providing police in a specific area with forms that are to be used for specific types of crashes (e.g., motorcycle crashes).

General Exposure Data

For various reasons, it may be beneficial to obtain data on how many motorcyclists are riding on which roads, the demographic characteristics of those riders, and how many miles per year they are riding. These data might be obtained from the following sources:

- Motorcycle sales data—Data are available concerning the number of motorcycles sold in the United States every year, which would help provide a rough estimate of the number of motorcycles which may be on the road. These data would not be particularly helpful in understanding the number of miles ridden or demographic data for riders. These data would not reflect miles ridden on older motorcycles or miles ridden by non-owners. Also, many motorcyclists own more than one motorcycle, which potentially skews the data.
- Motorcycle registration data—Registration data contain demographic data and data on the nature of the motorcycles themselves. Registration data can do little to tell us how much these motorcycles are being ridden. Issues that cloud the connection between registration data and exposure data include the fact that some motorcycles

may not be registered (though unregistered motorcycles are probably untagged and therefore not ridden on public roads); some riders own and register multiple motorcycles (but can ride only one at a time); the registered owner may not be the person riding a motorcycle.

- Motorcycle license data—All States require motorcyclists to have a separate motorcycle license or endorsement. However research shows that there is a high proportion of riders who have not gotten a motorcycle license. There is also possibly an equally high population of licensed motorcycle riders who do not ride. Because there is a correlation between riding unlicensed, drinking and riding, and riding un-helmeted, there would be methodological problems inherent in any study that attempted to understand the effects of drinking and riding using only licensed riders.
- Federal Vehicle Miles Traveled (VMT) Data—Data are available on yearly VMT through the Bureau of Transportation Statistics of the Federal Highway Administration. It has been suggested that VMT for motorcycles is being underestimated.
- Highway usage data—States are required to keep data on the number and nature of vehicles using major highways. These may give some insight into the number of motorcycles on these roads and the numbers of miles being ridden. These data focus on highways, which are not necessarily where most motorcycles are being ridden, nor are they where most crashes are taking place.
- Travel demand data—States keep data on the extent to which roads are being used so that forecasts can be made of future needs and the effects of traffic on the environment can be determined. These data may not contain information on how much of this traffic is comprised of motorcycles.
- Surveys of motorcyclists—It may be possible to determine all of this information by surveying motorcyclists. The advantage of doing so would be that a large amount of information could be obtained concerning the riders. The disadvantages would be the disadvantages of survey research discussed above, plus the fact that all data would be self-reported (self-reported exposure data may not be accurate).
- Roadside counts—One way to determine the number, and to some extent, the nature of motorcycles on a particular roadway would be to stand beside the road and count motorcycles. Estimates of motorcycle size and type (e.g., sport bikes, cruisers) could be made. Determination of helmet status (e.g., no helmet, novelty helmet, full-face helmet) could also be made. Determination of age, race, and gender may be difficult depending on helmet status.
- Videotaped footage of traffic from traffic cameras—Many States and local jurisdictions have traffic cameras that are capable of being used to videotape roadways. This would be similar to surveying from the side of the road except that roads would be limited to (generally) larger roads, and the point of view would be farther away, which would make the collection of some data difficult or impossible.
- Insurance company data—Insurance companies keep records that may contain information on number of motorcycles in a household, number of riders and

percentage of use of each motorcycle by each rider. Data would also include demographic data and may include crash data. Insurance companies do not generally make data available for research purposes and the data are often not sufficiently detailed for research purposes.

Human Subjects Protection

Any researcher conducting a study involving human subjects has a responsibility to make certain that subjects come to no harm as a result of the research. In recent years, the research environment in the United States has placed increasing emphasis on this issue. To assure that researchers do not conduct experiments that might result in harm to subjects, research methodologies are presented to Institutional Review Boards (IRBs) which review the proposed methodology and determine whether the study can be conducted as proposed. Some methodologies that might yield a clear picture of the effects of alcohol on motorcycle operation would likely be considered too dangerous and would be disallowed by an IRB. More information on human subjects' protection and IRBs can be obtained from the U.S. Department of Health and Human Services, Office for Human Research Protections (http://ohrp.osophs.dhhs.gov).

Researcher Safety Issues

In addition to concerns about the safety of subjects, research methodologies must consider the safety of the researchers themselves. For example, studies that require researchers to work near traffic place those researchers at risk. This issue must be considered when designing research protocols.

Office of Management and Budget (OMB) Clearance

In many cases, surveys require clearance from the Federal Office of Management and Budgets (OMB) which may add significantly to the time and complexity involved in performing the study. Survey work performed for NHTSA is subject to OMB approval.

Cooperation of Other Agencies

Many potential methodologies will require researchers to obtain cooperation from agencies such as law enforcement and hospitals. Because these agencies are primarily concerned with other functions, and because they may not be familiar with research, effort must be taken to assure that agency staff will be cooperative and remain cooperative throughout the project. Staff from other agencies may require training to perform the tasks required by the project. They will also require supervision. Because of their regular duties, it may be difficult to gain access to staff in order to conduct training and provide supervision. In some cases it may be necessary to pay staff of other agencies to do some or all of their research work while they are officially off duty. It may be necessary to provide other financial compensation or incentives to the agencies in exchange for cooperation.

Legal Issues

Some research methodologies hold potential risk for subjects, researchers, or other parties. Researchers need to consider their potential legal liabilities as well as their potential for being sued when designing study methodologies. The best defense against lawsuits obviously is to not create research situations where a risk exists and for which the research agency could be held liable. Additionally, given the potential costs of defending against even frivolous lawsuits, researchers should endeavor to design and conduct studies in ways that minimize if not eliminate methods and situations that could be construed by the average person to put them at risk and invite a potential lawsuit.

Given that effective research methods sometimes involve a degree of risk, researchers should use previously tested methodologies and safeguards that have been shown in the literature to be the standard and most accepted practices providing the greatest documented legal protection and the least exposure.

Alcohol Dosing of Subjects

Alcohol dosing of subjects can help provide valuable data on the effects of alcohol as part of a controlled experiment, however the process of dosing subjects must be approached carefully, with a great deal of control. Issues to consider when dosing subjects include prescreening of subjects, measurement of BAC, dosing schedules, monitoring of subjects, protecting subjects during and after the experiment, arranging transportation, and methods of administration of alcohol.

The National Institutes for Alcohol Abuse and Alcoholism (NIAAA) have specific guidelines for alcohol dosing procedures. These can be found at www.niaaa.nih.gov/ResearchInformation/ExtramuralResearch/default.htm.

Incentives to Participate

Researchers will need to consider what incentives will be used to obtain participation and/or cooperation from research subjects. Incentives have the advantage of increasing the likelihood of cooperation. However, incentives can create problems. There can be concern from IRBs that an inordinately high incentive would be coercive; it would cause people to do things that might be detrimental that they would not ordinarily do. There is also the possibility that subjects who agree to participate only for the incentive will not be interested enough in the study to provide valuable data. For example, a subject might quickly create a false diary to satisfy the requirements for payment, rather than making the effort to maintain a factual daily diary.

The cost of incentives can be a very large part of the cost of doing research. Researchers must consider this when planning a study. It is possible that the amount of monetary incentive necessary to obtain cooperation may raise the cost of a study to the point that it is not economically feasible to do.

Researchers can also consider other ways to provide incentives beyond paying cash to individual subjects. Organizations may provide subjects from its membership in exchange for donations or contributions in kind to the organization. Individuals may participate in exchange for gift certificates or a chance at getting an incentive (e.g., drawing tickets for a door prize).

Summary of Costs & Research Issues

Table 3 provides a brief representation of many of the issues surrounding the various methodologies and the ways in which they apply to each. This table is intended to provide an at-a-glance view of the issues associated with each methodology.

In the table, the following abbreviations are used: L = Low, M = Medium, H = High, a blank cell indicates "not applicable" or "nonexistent."

Entries for Cost Category are as follows: Low Cost = <$250K, Medium Cost = $250K-$500K, and High Cost = >$500K. Assignment of methodologies to cost categories was agreed upon by expert panel members and is based on estimates only.

Entries for "Quality of Data Provided" reflect the relative level of data quality that is likely to be achieved with each study. For example, an "H" indicates a methodology is likely to provide high-quality data. A blank cell indicates that this study would not provide the type of data in question. Values for relative data quality were generated by the project team based on their understanding of the issues and upon information provided by the expert panel.

Entries for "Practical Issues" reflect the likelihood of encountering an issue which may increase the level of difficulty in performing the study. In order to have these values oriented in the same direction as the data quality values (i.e., higher is better), these values are expressed in terms of the likelihood of *avoiding* the issue. For these entries, the higher the value, the less complicated, and therefore more feasible, the study becomes. Values for practical issues were generated by the project team based on their understanding of the issues and upon information provided by the expert panel.

It should be noted that, while values for costs are based on specific ranges of dollar values, other values in the table are *not* based on specific measurable values, but on what seemed likely to the project team, based on their knowledge of this issues. For example, while there is no way to *measure* the likelihood that the Contemporary Case Control study will provide high quality data on injury crashes, and will very likely involve police cooperation, it seems likely that it will, based on the information provided in this report.

Table 3. Summary of Costs and Research Issues

Quality of Data codes: L = Low, M = Medium, H = High, a blank cell indicates “not applicable” or “non-existent”. Cost Category values are as follows: Low Cost = <$250K, Medium Cost = $250K-$500K, and High Cost = >$500K	Simulation Study	Closed-Course Study	Cohort Study	Contemporary Case Control Study	Emergency Department Study	Survey Study	Fatal Crash Records	Injury Crash Records	Geo-General Comparison Data	Geo-Specific Comparison Data	Fuel Station Survey	Induced Exposure
COST CATEGORY	L	L	H	H	H	M	H	H	H	H	M	L
DATA ISSUES												
Provides Crash Data	✓	✓	✓	✓	✓	✓	✓	✓				✓
Provides Comparison Data	✓	✓	✓	✓		✓			✓	✓	✓	✓
Quality of Data Provided: Crash Data												
Fatal Crash			L	H	H		M	M				
Injury Crash			M	H	H	L		H				
PDO Crash		M	M	M		L						
Any Crash (no further data)	M	M	M	M		L		L				
Near Miss	H	H	M			L						
Behavior	H	H	M			L						
Quality of Data Provided: Comparison Data	H	H	H	H		L			H	H	M	L
PRACTICAL ISSUES												
Avoids Need for Motorist Cooperation				L	L				L	L	L	
Avoids Need for Police Cooperation				L	L				L	L	M	
Avoids Need for Cooperation of Hospital & EMS Staff				L	L							
Avoids Traffic Stops				L	L				L	L		
Avoids Road Block/Check				H	L				L	L		
Avoids Need for Dosing Subjects	L	L										
Avoids Requirement for OMB Clearance	H	H	H	L	L	L			L	L	L	
Avoids Potential IRB Difficulties	H	L	L	H	H	H			H	H	M	
Avoids Potential Liability Issues	H	L	L	M	H	H			M	M	M	
Avoids Field Data Collection Requirement				L	L	M			L	L	L	
Avoids Researcher/Subject Safety Issues		H		L	M				L	L	L	

4. Research Priorities

As part of the expert panel meeting, panelists were asked to assign priorities to each methodology discussed. A high priority would mean that panelists felt that the methodology was among the best candidates for future research funding because it provided a high likelihood of providing scientifically valid data. No attempt was made to reach a consensus on these priorities, and there was some disagreement as to the relative priorities of each methodology. Panelists used their own system for expressing their priorities, making it impossible to calculate "scores" for each methodology. However an examination of the comments given by panelists provides an excellent sense of how they viewed each methodology. For example, of the panelists expressing an opinion on the priority of the case control study, one described it as "highly recommended," one described it as high priority if sufficient funding could be obtained to do it properly, one said this it was highest priority, one said it was second highest, and one rated it third highest. One panelist listed it as low priority out of a concern that it may be too difficult to get valid comparison data.

Project staff, *using panel member comments and priorities*, created a system for prioritizing the various research methodologies discussed within this project. Using the comments made by the attendees of the meeting, both in their listing of priorities and the comments made during the panel meeting, one of three levels of "scientific validity" (low, medium, and high) was assigned to each methodology. These levels represent how scientifically valid the results for each methodology would likely be, given the barriers to obtaining complete and accurate data for that methodology. The ratings of scientific validity *contribute* to the assigning of priorities for each methodology. It is important to note, however, that scientific validity was not the only contributing factor to assignment of priorities. The relative cost (low, medium, and high) and practicality of a methodology could affect its priority. Because cost categories were broad and costs were only estimates, it is possible that priorities would be revised if accurate cost figures were available for each methodology.

Part of the process of assigning priorities was to pair methodologies that only provide crash data with methodologies that only provide comparison data (e.g., Geo-General Comparison Data with Fatal Crash Records). Table 4 shows the methodologies arranged in a matrix. One dimension of the matrix shows cost categories (low, medium, and high), whereas the other shows levels of scientific validity (low, medium, and high) of the results expected from the methodologies. For the most part, the table serves as a good indication of which methodologies are the highest priority, i.e., those methodologies with the highest scientific validity within each cost category would be the best candidates for future research within that cost category. Exceptions to this rule of thumb occur when a methodology would either be so inexpensive as to be warranted, or so expensive as to be practically impossible. It should also be noted that the cost categories are somewhat broad. Of two methodologies in the same cost category, one may ultimately be sufficiently less expensive than another so as to increase its priority relative to the other. This might occur when the actual costs are estimated. It should also be noted that levels of scientific validity are set relative to other methodologies within the same cost category. For that reason, a methodology rated as "low" or "medium" within a given cost category (e.g., Geo-General + FARS) may be more scientifically valid than one rated "high" in another cost category (e.g., Fuel Station Survey with Injury Crash records).

Table 4. Cost by Validity Matrix

		Cost		
		L	**M**	**H**
Scientific Validity	**H**	Simulation	None	Cohort* Contemporary Case Control
	M	Closed-Course	Fuel Station Survey with Fatal Crash Records Fuel Station Survey with Injury Crash Records	Emergency Department Geo-Specific + Fatal Crash Records
	L	Induced Exposure*	Survey	Geo-General + Fatal Crash Records

* Note that the position in the table for these two methodologies does *not* correspond with the priority ultimately given to them.

Highest Priority Methodologies

Methodologies discussed in this section were determined to be the best candidates for future research.

Lowest Cost Category < $250,000

Simulation

Simulation would provide a relatively low-cost method of determining the effects of alcohol impairment on motorcycle operation. Unlike automotive simulators, motorcycle simulators can provide reasonably high fidelity motion cues without using expensive motion-base platforms. This is largely because real motorcycles, like aircraft, are "bank-to-turn" vehicles, which means that the operator experiences and senses mainly visual cues, rather than a combination of visual and motion cues that car drivers experience. Simulation would not provide risk curves directly comparable with those from drinking/driving case-control studies. However, it could provide crash risk curves for involvement in simulated crashes. If a simulated driving task was used along with a simulated riding task, it would be possible to compare the relative risk curves for the two as a way to determine the differential effect of alcohol impairment on motorcycling. It was also suggested that testing a sample of riders at relatively low BACs, performing both simulated low-speed riding tasks and actual low-speed riding tasks, could help establish the validity of simulation in measuring rider performance. In this type of study, relative risk curves could be produced by determining the number of crashes or near misses for riders at BACs = .02 g/dL, .04 g/dL, .06 g/dL, and .08 g/dL compared to their performance at BAC = .00 g/dL.

Induced Exposure

The general consensus regarding an induced exposure study for motorcycles is that this type of study does *not* lend itself well to motorcycle crashes. Determining culpable motorcyclists from nonculpable motorcyclists will require some additional work, and may ultimately not be viable. This method, however, can be accomplished with existing data and probably at very little cost. It was suggested that if an induced exposure study is done, a first step would be to compare any "culpable" group and "nonculpable" group of motorcycle riders to determine whether the two groups were similar with respect to demographic variables. If they are not, then it will be difficult to separate the effects of alcohol from the effects of the general differences between the two samples.

Medium Cost Category $250,000 to $500,000

None.

Highest Cost Category $500,000 +

It should be noted that the cohort study, while being rated as highly valid, would certainly be too expensive to seriously consider funding, and is therefore *not* considered a high priority methodology by the study authors.

Contemporary Case Control
This methodology is probably the most scientifically valid of all methods that might be practically implemented. The Contemporary Case Control methodology was used in the landmark motorcycle crash study conducted by Hurt et al. (1981), though this study did not conduct sufficiently detailed alcohol data to generate relative-risk curves. This methodology was used by Borkenstein et al. (1974) to create the drinking-driving relative-risk curves that have been used for the past 25 years to understand the effects of alcohol on driving. There was a high level of agreement among panel members and project staff that a Contemporary Case Control study, if conducted properly, would be the best way to determine the relative risks of operating a motorcycle at various BAC levels.

Medium Priority Methodologies

Methodologies discussed in this section should be considered lower in priority than those discussed in the previous section, though they still offer some value in understanding the effects of alcohol on motorcycle operation.

Lowest-Cost Category

Closed-Course Study
It was estimated that an off-road study of riders performing low-speed maneuvers at a range of BAC levels could be conducted relatively inexpensively, and would provide good data on the effects of alcohol on motorcycle operation. This study was not rated as scientifically promising by the study authors partly because simulation has the potential for studying operation at higher (albeit simulated) speeds, which are more representative of those at which most severe crashes occur. Human-subjects protection issues are another reason that simulation might be a better candidate for future research. As mentioned above, it was suggested that a study combining simulation and low-speed off-road riding could be valuable.

Medium-Cost Category

Fuel Station Survey with Fatal Crash Records, Fuel Station Survey with Injury Crash Records
Both of these methodologies would rely on drinking-riding exposure data collected at fuel stations where motorcyclists come to refuel. This method of collecting exposure data is taken

from the OECD International Methodology for On-Scene In-Depth Motorcycle Accident Investigations. Crash data would come from the area local to the fueling station, either from FARS data or injury data collected from local hospitals. While the exposure data collected in this manner would not be as scientifically valid as that collected using the Contemporary Case Control, Geo-Specific, or Geo-General methods, it may be possible to obtain useful data on the drinking and riding of local riders at a lower cost using the Fuel Station Survey than using other methods. While this method has been used in Europe and Asia, it should be noted that it has not been used to collect BAC data from riders. It should also be noted that attempts to conduct a Fuel Station Survey in the United States met with resistance from station owners and fuel companies in California, casting some doubt on the ability to conduct such a study in the United States.

Highest-Cost Category

Emergency Department

This methodology would provide roughly the same data as the Contemporary Case Control Study, however some of the crash case data would be collected by Emergency Department staff when crash victims arrive at the hospital. Costs would be reduced by avoiding the use of an on-call "go-team," however costs would still be relatively high due to the need to collect comparison data in the field. This study was not rated as scientifically valid as the Contemporary Case Control due to concerns over the quality of the crash data that would be collected, compared to the Contemporary Case Control.

Geo-Specific + Fatal Crash Records

This methodology would generate relative risk curves by matching archival crash data from FARS with comparison data collected from motorcyclists at or near the site of the FARS crashes. This methodology was rated as more scientifically valid than the Geo-General + Fatal Crash Records Study due to the increased scientific validity of collecting data at crash sites rather than at random locations in other parts of the city, State or country. However, due to the nature of the availability of FARS data, the comparison data would probably be collected at least a year or more after the fatal crash occurrence.

Lowest Priority Methodologies

Lowest-Cost Category

None

Medium-Cost Category

Survey Study

Survey research (other than roadside surveys with BAC testing) was generally considered to be a poor way to gain an understanding of the effects of alcohol on motorcycle operation. The costs would be relatively high while the quality of data to be gained would be suspect because it would depend upon self-reports.

Highest-Cost Category

Geo-General + Fatal Crash Records

This methodology would generate relative risk curves from FARS crash data, and comparison data collected through the use of roadside surveys. This methodology does hold some promise for generating reasonably accurate relative-risk curves (see Zador, 2000), but has been placed at a low priority because it is not likely to produce as scientifically valid results as the other methodologies in this cost category. If it can be determined that this type of study could be conducted for significantly less funding than other studies in this cost category, this methodology could be considered a medium- or high-priority methodology.

Cohort Study

As was mentioned previously, the cohort study, while being highly valid scientifically, is considered too expensive and would take too long to be practical, and is therefore assigned a low priority.

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Patricia Waller also served as moderator for the expert panel meeting.

Appendices

Appendix A
List of Attendees

This appendix lists the most current address for attendees. Where affiliation has changed since the panel meeting, the affiliation at the time of the meeting is shown in parenthesis.

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Appendix B
Agenda

Pacific Institute FOR RESEARCH AND EVALUATION

HPRL The Head Protection Research Laboratory

Motorcycle Alcohol Methodology Panel Meeting

Agenda – April 2002

Thursday, April 4th		
8:30 a.m.	Continental Breakfast	
9:00	Welcome and Introductions of Participants	Robert Voas & Richard Compton
9:05	Project Objectives – NHTSA's Perspective	Marvin Levy
9:10	NHTSA's Motorcycle Program	Joey Syner
9:15	Previous NHTSA Motorcycle Alcohol Research	Umesh Shankar
9:25	Project History, Initial Request for Additional References and Suggestions for Additional Methodologies	Scott McKnight
9:45	Overview of the Meeting Process and Outline of Background Report	James Fell
Discussion of Methodologies		
10:00	This discussion will include methodologies and elements of methodologies already described in the Background Report, plus any suggested by panel members. Suggestions for alternative methodologies and elements of methodologies should be made during this discussion. The purpose of this discussion is to thoroughly understand ways in which to determine the effects of BAC levels on motorcycle operator impairment and to generate a list of strengths and weaknesses for each. Also discussed will be procedures used in each methodology, measures of effectiveness, data analysis techniques and promising research sites. The discussion will roughly follow the outline below.	Dr. Patricia Waller will serve as moderator for the remaining discussion

Outline of Possible Methodologies

10:10	Using FARS to collect Fatal Crash Data
10:20	Collection of Non-Fatal Crash Data
10:30	**– Break –**
10:45	Collection of Exposure Data
11:00	• Classic Relative Risk Study
11:10	Go-Team to Crash Site
11:40	Go-Team to Emergency Room
Noon	**– Lunch –**
1:00 p.m.	• Relative risk studies employing existing crash records
1:10	Use of FARS data for a national study
1:25	Use of FARS data for specific-state studies
1:40	Use of State Crash Files
2:40	• Other Methods
2:45	Questionnaire surveys of riders
3:00	Simulation
3:30	**– Break –**
3:45	Closed Course Studies
4:00	Others?
5:30 – 7:30 p.m.	Reception at PIRE

Friday, April 5th

9:00 a.m.	Finish any incomplete discussion from Thursday
10:30	**– Break –**
10:45	Summarize Discussion
Noon	**– Lunch –**

Summarize Discussion and Prioritize Alternative Methodologies

1:00 p.m.	In this portion of the meeting, we will record the basic methodologies and variants discussed in Thursday's meeting. Participants will be given a form to individually assign priorities to methodologies based on likelihood of their providing the most useful and complete information. We will also make rough estimates of the cost of each methodology.
2:00	Where do we go from here?
3:00	Adjourn

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