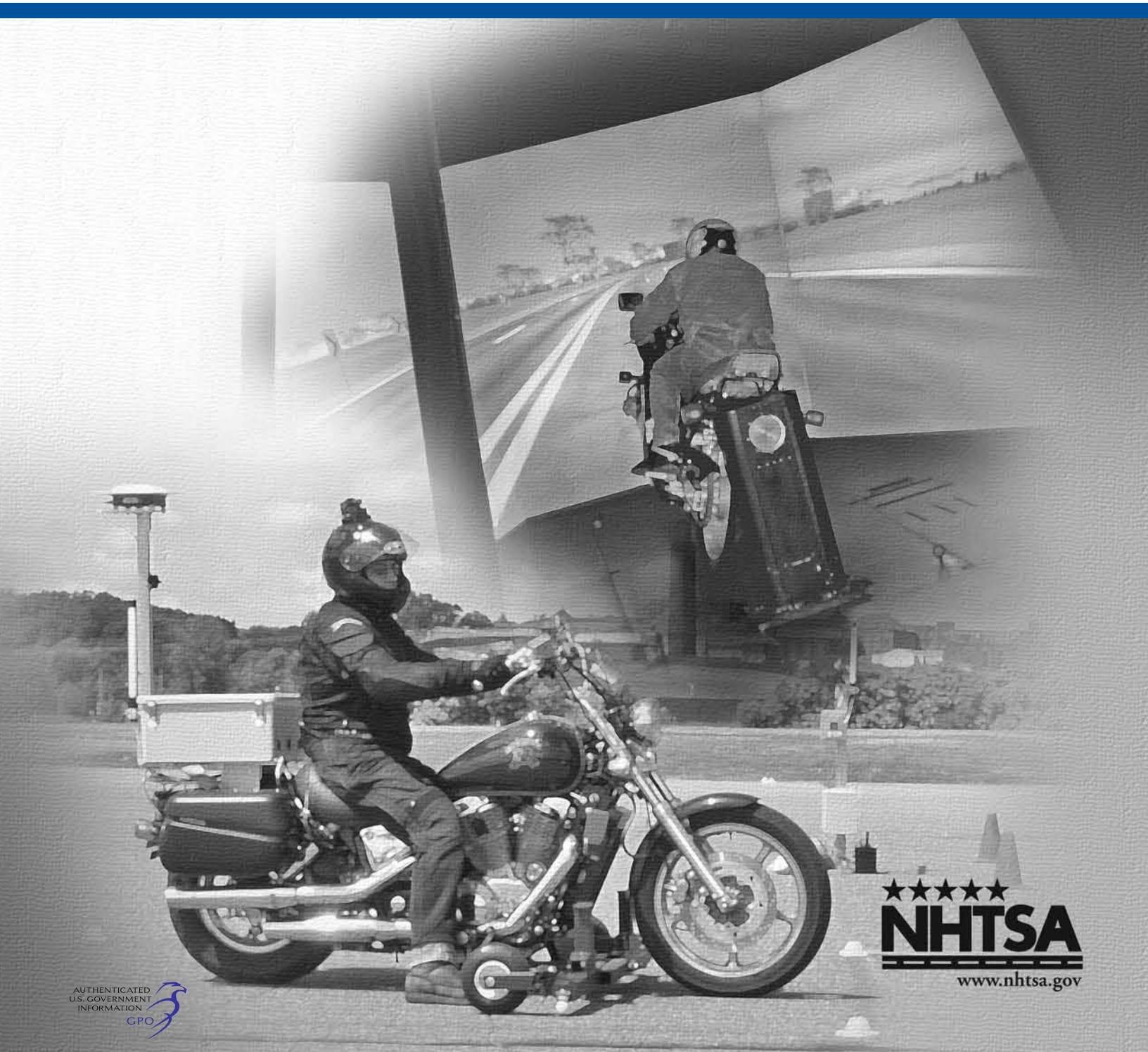
Methodology for Determining Motorcycle Operator Crash Risk and Alcohol Impairment

Volume II: Literature Review Report



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16. Abstract

Alcohol involvement continues to be a prominent factor in motorcycle crashes. Drinking and driving have been researched extensively, and the relationship between a drivers' blood alcohol concentration (BAC) and crash risk is well understood. Unfortunately, our current understanding of the effects of BAC on motorcycle operation is insufficient. Though there is some data available on BAC for crash-involved riders, there is essentially no data on the incidence of alcohol involvement in the on-road motorcycle-riding population. 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 document is Vol. II: Literature Review Report. 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 research on impaired motorcycle operation relative to the objectives of this project. The collection of BAC data from on-road non-crash-involved motorcycle riders was the most significant need identified from the review. A total of 143 reports and Web sites were reviewed for this project and described in detail in Appendices A and B of this report. Sixty-one of these are cited in the two volumes of this report. An in-house study of fatal motorcycle crashes was also conducted and discussed in this report.

Vol. I: Synthesis Report on Alternative Approaches with Priorities for Research provides information on an expert panel workshop that discussed alternative methodologies and provided recommendations for future research.

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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 which 1,025 (81%) were intoxicated (BAC .08+).

Drinking and driving have been researched extensively, and the association between driver 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. Sixty-one 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 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 gathering 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) are 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 Only

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, such as 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 are 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 BAC 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 regarding four-wheeled vehicles, relatively little is known about the effects of alcohol on motorcycle operation. There are many methodologies which 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. Introduction

This is the second volume of a two-volume report entitled "Methodology for Determining Motorcycle Operator Crash Risk and Alcohol Impairment." Volume I of this report is a "Synthesis Report on Alternative Approaches With Priorities for Research." The continuing concern with the high level of motorcycle fatalities led to a recent collaboration between the Motorcycle Safety Foundation and the National Highway Traffic Safety Administration to support a nationally selected Technical Working Group tasked with creating a *National Agenda for Motorcycle Safety* (NAMS). This document provides a blueprint for possible motorcycle safety activities for the next decade. The authors of the NAMS noted the continuing problem of alcohol in motorcycle crashes and recommended that a study of the alcohol, drug, and other substance abuse patterns of motorcyclists should be conducted. Such a study should not be limited to those injured or killed, but should include all riders in the population at risk (NAMS, 2000). The NAMS noted that it is not known at what blood alcohol levels motorcycle-specific skills are impaired.

Based in part on the findings from the NAMS document, NHTSA awarded a contract to the Pacific Institute for Research and Evaluation (PIRE) and the Head Protection Research Laboratory (HPRL) to determine the current state of knowledge regarding the crash risk of alcohol-impaired motorcycle operation and make recommendations for a research program to address that problem. A key element of the award was organizing a workshop of experts to review research needs and opportunities and make recommendations for studies needed to better determine rider crash-risk and impairment related to alcohol consumption. This report contains key background information provided to participants attending the workshop. This literature review was conducted to help the contractor's project team and the expert panel:

- Review what is known about the relationship of alcohol to motorcycle crashes.
- Determine the limits of our knowledge of the crash risk of alcohol-impaired riders.
- Identify the relative strengths and weaknesses of the various procedures for determining rider alcohol-related crash risk.

The initial literature review identified 119 references which were reviewed. The literature review included searches of the Transportation Research Information Service, the NHTSA Web site, Dialog, Medline, Lexis-Nexis, Human Factors and Ergonomics Society Journal, Accident Analysis and Prevention, Injury Control and Safety Promotion, Injury Prevention, Journal of Safety Research, Prevention Science, Traffic Injury Prevention, the AAA Foundation for Traffic Safety, reference sections of applicable reports, and general searches of the Internet. Also searched was PIRE's extensive library of transportation safety publications, and our "End Notes" digital reference list containing over 10,000 entries. The search included any reports on the effects of alcohol on motorcycle operation, plus general studies of measurement of motorcycle operator performance, effects of alcohol on operation in modes of transportation other than motorcycles, effects of alcohol on general human performance, methodologies for collecting all data to be used in determining drinking and driving crash risk and impairment, and methods for collecting motorcycle exposure data.

This document summarizes information collected in preparation for the workshop meeting and includes abstracts of the most significant articles related to alcohol-impaired riders.

Because the literature review report was prepared prior to the expert panel meeting, it does not discuss some of the methodologies which were discussed at the panel meeting. It does contain more detail about the background of the drinking and riding problem, and discusses some issues of conducting alcohol research in greater detail than is found in the Synthesis Report (Vol. I).

2. Background

Studies Using Fatal Crash Information

Much of what is known about motorcycle safety and alcohol comes from analysis of the Fatality Analysis Reporting System or FARS (see Shankar 2001, 2003). In 2001, 29 percent of fatally injured riders had a BAC ≥.08 g/dL and an additional 9 percent had some level of alcohol involvement. Forty-nine percent of motorcyclists who died in single-vehicle crashes were alcohol-positive. It is noteworthy that the percentage of fatally injured riders with a positive BAC has steadily declined from 52 percent in 1990 to 38 percent in 1999.

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.

FARS provides a basis for comparing the impaired-rider problem with the larger impaired-driver problem over the last decade (1990 through 2000). The following information comes from an in-house analysis of FARS data conducted at PIRE. To make the operators of the two types of vehicles roughly comparable, it is necessary to include only males because the proportion of crash-involved motorcycle operators who are male is significantly greater than that of the drivers in fatal crashes (see Table 1). The proportion of riders and drivers in fatal crashes who are tested for BAC with known results is approximately the same (Table 2); therefore, it appears appropriate to impute BAC values for missing BACs. In the past this has been done using the Klein (1986) imputation technique. [Since 2002, the Subramanian (2002) method has been used.]

Table 1. Comparison of the Gender of Riders and Drivers in Fatal Crashes, FARS 1990-2000

		GENDER		Total
		Male	Female	
Drivers	Count	364,945	150,777	515,722
	Percent	70.8	29.2	100
Riders	Count	26,969	685	27,654
	Percent	97.5	2.5	100
Total	Count	391,914	151,462	543,376
	Percent	72.1	27.9	100

Table 2. Proportion of Riders Compared to Drivers' BAC Tested With Known Results (Males Only), FARS 1990-2000

		Drivers	Riders
Test Rate	Survivors	27.9%	30.8%
	Killed	71.1%	71.2%
N	Survivors	200,289	2,838
	Killed	164,524	24,127

From 1990 to 2000, there was a decline in the proportion of riders with positive BACs that paralleled the reduction observed in drivers in fatal crashes (Figure 1). Throughout this period, the proportion of male motorcyclists in fatal crashes who had positive BACs was higher than that of the male drivers of four-wheeled vehicles. However, the relative difference decreased during that period. This can best be visualized by computing the odds ratio of drinking motorcyclists to drinking passenger-car drivers. This is done by first determining the odds ratio for drinking riders (motorcyclists with alcohol divided by motorcyclists with no alcohol) and dividing that by the odds ratio for drivers (drivers with alcohol divided by drivers with no alcohol). The trend in this odds-ratio is shown in Figure 2. In 1990, the odds that a motorcyclist in a fatal crash would be drinking compared to the odds that a driver of a four-wheeled vehicle in a fatal crash would be drinking was 1.8. By 2000, that ratio had been reduced to about 1.4, a reduction significant at the p=.001 level. This indicates that male motorcyclists have been more likely to have been drinking than male drivers, but that the difference between them narrowed in the years between 1990 and 2000.

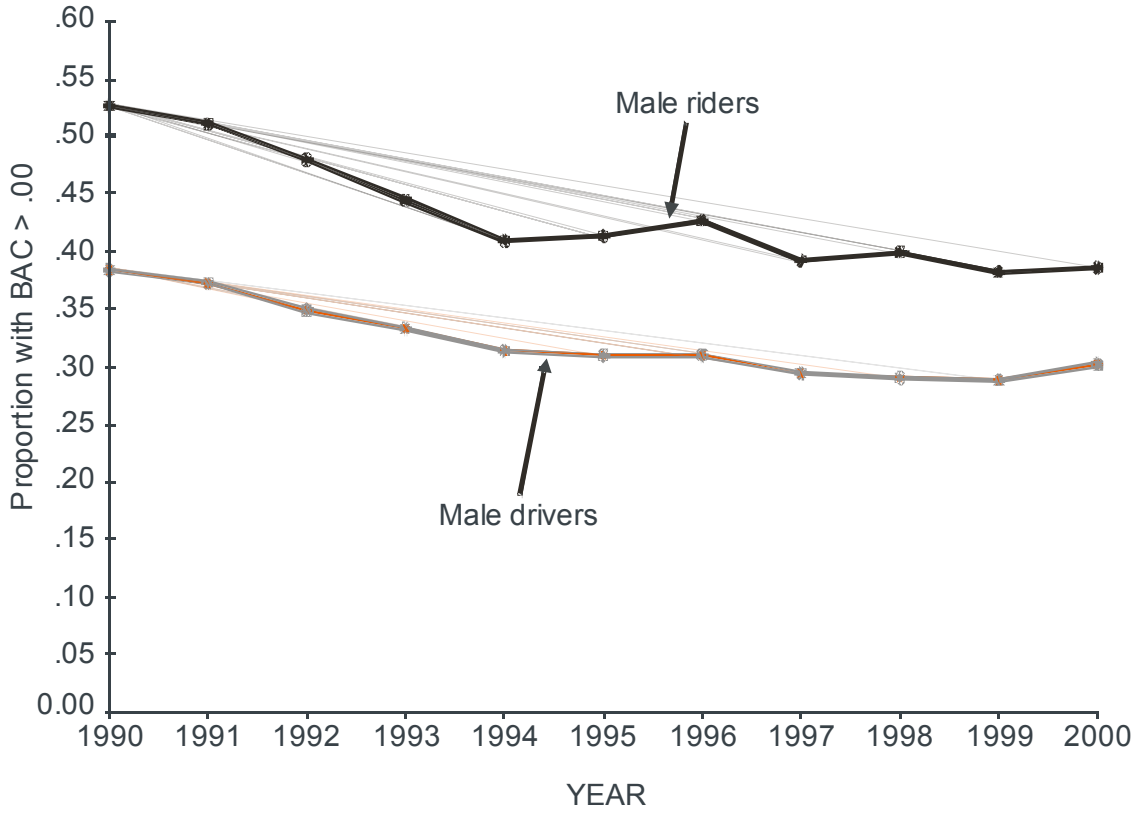


Figure 1. Proportion of Drinking Riders Compared to Drinking Drivers in Fatal Crashes From 1990 to 2000

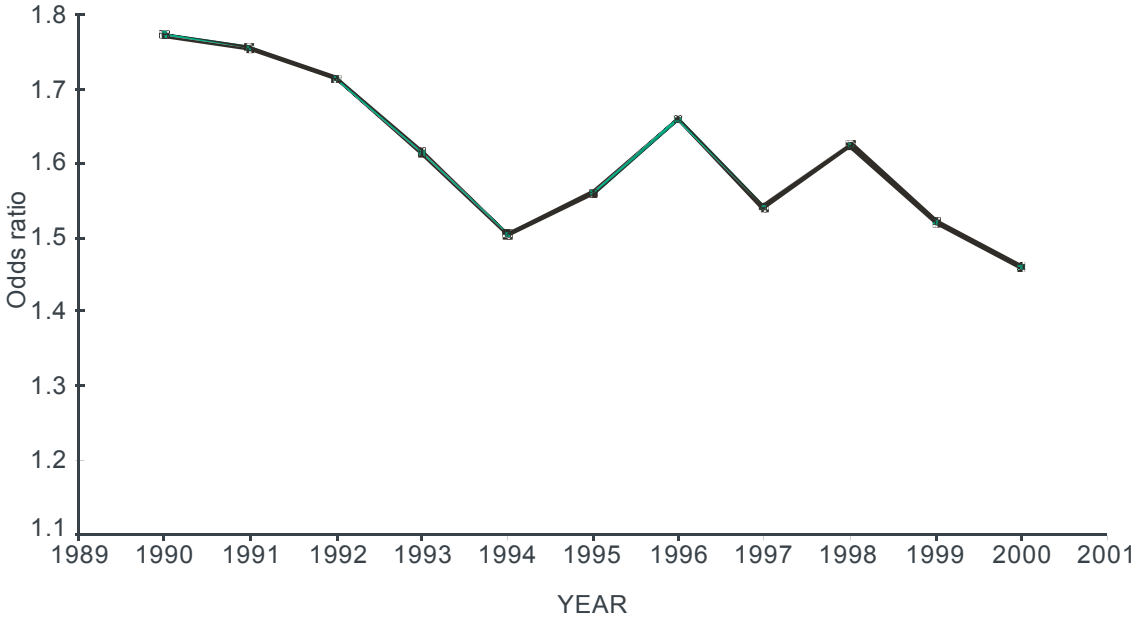


Figure 2. Likelihood of Alcohol-Involvement Among Male Riders Relative to Alcohol Involvement of Male Drivers in Total Crashes From 1990 to 2000

This reduction in the relative odds of a male rider having a positive BAC probably was influenced by several factors. Age, which is recognized as one of the principal factors associated

with rider crash involvement (Kim & Yamashita, 2000), is likely to have played a significant role (see Figure 3). The average age of a crash-involved male rider increased by 7 years (from 30 to 37), whereas the average age of a male passenger car driver increased by only 2.5 years (from 36.5 to 39) in the same period (figures based on all crashes, not just alcohol crashes). The age distribution of riders compared to drivers is shown in Table 3.

Table 3. Age Distribution of Riders and Drivers in Fatal Crashes, FARS 1990–2000

		Age Category						Total
		1-11	12-15	16-20	21-34	35-59	60+	
Drivers	Count	39	3,024	81,234	178,663	169,603	81,593	514,156
	Percent	0.01	0.6	15.8	34.8	33.0	15.9	100
Riders	Count	46	380	3330	13,254	9,705	914	27,629
	Percent	0.17	1.38	12.1	48.0	35.1	3.3	100

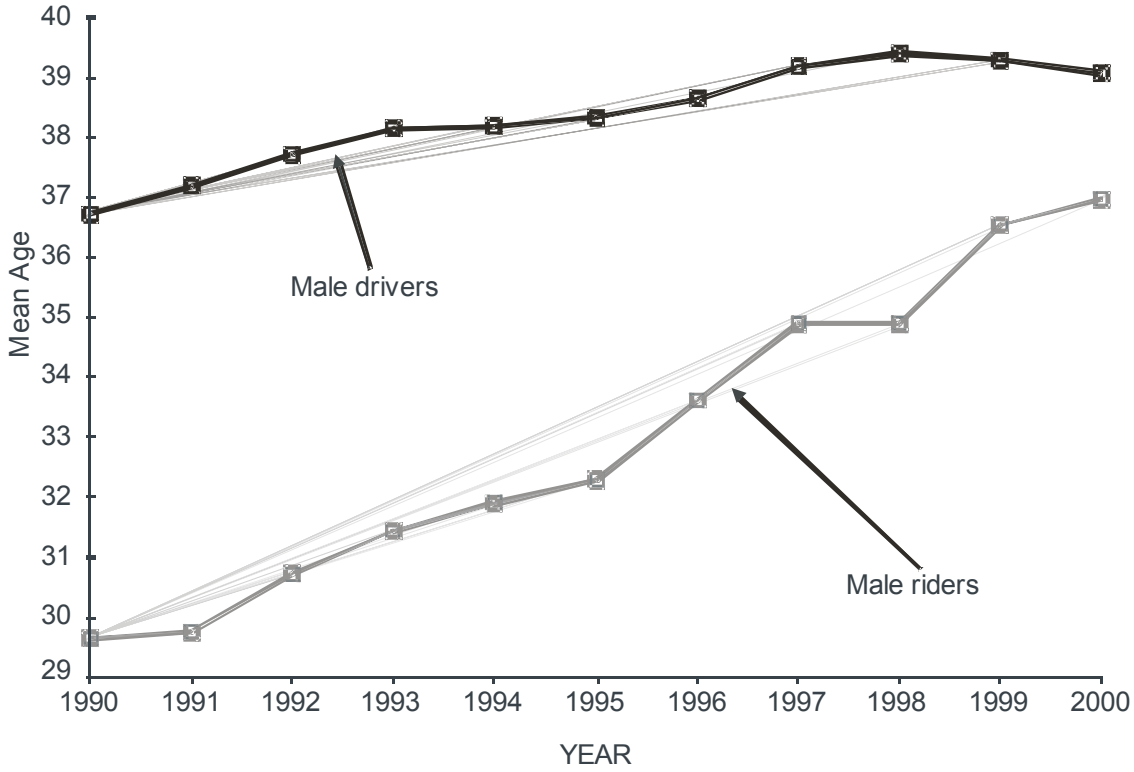


Figure 3. Trend in the Age of Male Riders and Male Drivers in Fatal Crashes From 1990 to 2000

The distribution of BACs of male riders and male drivers in fatal crashes from 1990 through 2000 is shown in Table 4. The distribution for the fatally injured male operators appears very similar for riders and drivers, suggesting that there are not large differences in the role of alcohol in crash causation between the two groups. To the extent that there are differences, more riders fall into the low-BAC interval between .00 and .10 than drivers, which suggests that riders may be more likely to be involved in a fatal crash at lower BACs than are drivers. Seven in 10 BACs for both groups of fatally injured operators are based on actual measurements. This suggests that the numbers are relatively reliable. The picture is substantially different for

surviving operators, where a larger portion of the riders falls into the highest BAC category. However, measured BACs are available for only 3 in 10 of the surviving drivers, which creates some question as to the validity of the statistics for surviving drivers.

Table 4. Distribution of BACs for Riders and Drivers Involved in Fatal Crashes, FARS 1990-2000

	SURVIVING		KILLED	
	Drivers	Riders	Drivers	Riders
BAC = .00	78.4%	62.2%	54.7%	55.6%
BAC = .01–.09	7.2%	13.1%	7.3%	11.3%
BAC ≥ .10	14.4%	24.7%	37.9%	33.2%
Total	100.0%	100.0%	100.0%	100.0%

As is well known, riding is a seasonal activity for most of the United States. Larger numbers of motorcyclists are on the road during the warm months of June, July, and August, when 40.9 percent of the rider involvements in fatal crashes occur. As shown in Table 5, this time of the year is also when riders in crashes are most likely to be drinking. During those 3 months, 44.9 percent of riders in crashes have positive BACs, compared to 41.4 percent in December through February. According to the FARS classification, 96.7 percent of all rider involvements in fatal crashes during the 1990s occurred under "normal" weather conditions.

Table 5. Seasonal Distribution of Drinking (BAC > .00) and Nondrinking (BAC = .00) Riders, FARS 1990–2000

		BAC = .00	BAC > .00	Total
Spring (Mar-May)	Count	4,123	2,971	7,094
	Percent	26.3	24.8	25.6
Summer (Jun-Aug)	Count	6,236	5,080	11,316
	Percent	39.8	42.3	40.9
Fall (Sep-Nov)	Count	3,874	2,933	6,807
	Percent	24.7	24.4	24.6
Winter (Dec-Feb)	Count	1,434	1,013	2,447
	Percent	9.2	8.4	8.8
Total	Count	15,667	11,997	27,664
	Percent	100.0	100.0	100.0

During the 1990s, 42.6 percent of all rider involvements in fatal crashes occurred on a Saturday or Sunday, and 51.1 percent of the riders in the Saturday fatal crashes and 48.7 percent of the riders in Sunday crashes had been drinking (Table 6). Rider alcohol involvement parallels that of driver by time of day. In each hour from 8 p.m. to 6 a.m., the majority of fatal crash-involved riders have been drinking. Between midnight and 1 a.m., 73.5 percent of riders in crashes have positive BACs.

Table 6. Distribution of Drinking (BAC > .00) and Nondrinking (BAC = .00) Riders by Day of Week, FARS 1990–2000

Weekday		BAC = .00	BAC > .00	Total
Sunday	Count	2,878	2,728	5,606
	Percent	18.4	22.8	20.3
Monday	Count	1,728	1,061	2,789
	Percent	11.0	8.8	10.1
Tuesday	Count	1,787	942	2,729
	Percent	11.4	7.9	9.9
Wednesday	Count	1,899	1,088	2,987
	Percent	12.1	9.1	10.8
Thursday	Count	1,946	1,267	3,213
	Percent	12.4	10.6	11.6
Friday	Count	2,410	1,759	4,169
	Percent	15.4	14.7	15.1
Saturday	Count	3,011	3,145	6,156
	Percent	19.2	26.2	22.3
Total	Count	15,659	11,990	27,649
	Percent	100.0	100.0	100.0

Because of the tendency to ride when the weather is good, the largest number of riders in fatal crash involvements tends to occur in large urban areas in the southern-most half of the United States. Table 7 presents the 30 U.S. counties with the largest number of riders in fatal crashes from January 1, 1990, to December 31, 2000. The first column of the table provides the total number of rider involvements over the 11-year period. Those numbers are, of course, a reflection of the county population and are related to total motor vehicle registration. To provide an indication of the population and traffic level in each county, the number of drivers in fatal crashes is provided in the second column. The third column provides the rate of rider involvement per hundred drivers in fatal crashes. There are substantial variations in these rates, perhaps related to weather and vacation patterns.

The next two columns of Table 7 compare the percentage of drinking riders to the percentage of drinking drivers in fatal crashes. In every case, a larger percentage of the riders were drinking. The sixth column gives the odds ratio of the rider alcohol involvement relative to the driver alcohol involvement. The odds ratios average about 2 and all are greater than 1. Given that the national average odds ratio for the 11-year period is about 1.6, it appears that those localities with the largest number of fatal crash-involved riders will also be the location where riding after drinking is greatest. The number of riders over the 11-year period with positive BACs appear in the next to last column and the number with BACs at or above .10 appears in the last column.

Table 7. Thirty Counties With the Greatest Number of Riders in Fatal Crashes, FARS 1990–2000

State	County	Riders in fatal crashes	Drivers in fatal crashes	Rider involvement density (per 100 drivers)	Percent of alcohol-involved riders	Percent of alcohol-involved drivers	Odds of rider/driver alcohol involvement	FARS-involved riders with BAC>.00	FARS-involved riders with BAC≥.10
CA	Los Angeles	864	11,596	7.45	39.0%	23.6%	2.06	336.9	240.6
IL	Cook	423	5,648	7.49	40.1%	26.1%	1.89	169.5	112.4
AZ	Maricopa	399	5,393	7.40	42.6%	23.8%	2.38	170.0	122.8
CA	San Diego	330	3,602	9.16	36.5%	25.5%	1.68	120.6	83.6
FL	Dade	257	4,180	6.15	28.9%	14.5%	2.39	74.2	53.9
TX	Harris	237	4,812	4.93	51.7%	42.4%	1.45	122.4	89.3
CA	Riverside	218	3,427	6.36	35.3%	22.7%	1.86	77.0	53.2
CA	San Bernardino	209	4,030	5.19	36.7%	23.4%	1.89	76.7	53.6
CA	Orange	193	2,610	7.39	33.2%	20.8%	1.89	64.1	51.9
FL	Volusia	181	1,063	17.03	46.0%	26.7%	2.34	83.3	59.8
TX	Dallas	167	3,230	5.17	52.2%	40.4%	1.61	87.2	63.5
FL	Broward	165	2,793	5.91	33.0%	16.7%	2.45	54.4	38.3
FL	Hillsborough	161	2,554	6.30	31.6%	22.4%	1.60	50.8	41.9
MI	Wayne	146	3,350	4.36	38.5%	27.1%	1.69	56.2	37.8
HI	Honolulu	136	799	17.02	44.4%	27.9%	2.07	60.4	37.8
NV	Clark	135	2,245	6.01	39.5%	32.9%	1.33	53.4	40.6
NY	Suffolk	135	2,483	5.44	34.7%	21.1%	1.98	46.9	30.3
PA	Philadelphia	127	1,703	7.46	34.4%	26.5%	1.45	43.6	26.3
CA	Alameda	124	1,378	9.00	39.6%	23.8%	2.10	49.1	32.8
AZ	Pima	124	1,511	8.21	44.0%	25.5%	2.30	54.6	42.4
FL	Palm Beach	122	2,468	4.94	41.2%	19.2%	2.95	50.2	36.4
FL	Pinellas	121	1,598	7.57	32.5%	16.2%	2.49	39.4	31.0
CA	Sacramento	118	1,716	6.88	41.9%	23.4%	2.36	49.4	33.7
CA	Santa Clara	116	1,336	8.68	37.7%	23.4%	1.98	43.8	35.7
WA	King	115	1,610	7.14	39.9%	29.1%	1.62	45.9	31.3
FL	Orange	113	1,841	6.14	38.3%	21.5%	2.27	43.3	26.8
NY	Kings	113	1,527	7.40	18.8%	12.5%	1.62	21.2	14.7
OH	Cuyahoga	109	1,111	9.81	44.2%	26.4%	2.21	48.2	35.4
CT	New Haven	107	958	11.17	56.1%	31.7%	2.75	60.0	43.1
TX	Tarrant	105	1,819	5.77	54.4%	39.0%	1.87	57.1	46.4

Studies Using Nonfatal Crash Information

Nonfatal motorcycle crash information typically is obtained retrospectively from either police-based sources or hospital-based sources. There have been a limited number of on-the-scene, in-depth studies that have included nonfatal motorcycle crashes. The most well-known study in the United States was conducted by Hurt and his colleagues (1981). In that study, 900 motorcycle crashes were evaluated on-the-scene and included complete medical follow-up. The presence of alcohol was coded; however, detailed BAC values were not collected. Haworth et al.

(1997) collected data for 222 crash-involved motorcycle riders who were admitted to the hospital; BAC values were collected for each rider, where applicable. Because Haworth found very few comparison cases with elevated BACs (BAC > .05), she was limited in terms of her ability to determine crash risk for a range of BACs. Many of her analyses were confined to comparing riders with BAC = 0.00 to riders with any measurable BAC. She concluded that riders operating with any BAC had a five times higher odds of crashing than riders with no BAC.

Police reports have often been the source of crash information for both fatal and nonfatal crashes. Many studies have involved retrospective analysis of traffic collision reports, and for most of these studies, the presence of alcohol was either checked or not checked on the original traffic collision report. Police-based studies have been conducted in Hawaii (Kim, Kim, & Yamashita, 2000; Kim et al., 2002), Florida (Turner et al., 2000), and California (Peek-Asa et al., 1996). Hurt et al. (1981) also included a study of 3600 motorcycle crash reports. Each of these studies has included both the presence of alcohol as well as a categorization of the injuries sustained by the rider (e.g., mild, moderate, severe).

Studies of Non-Crash-Involved Riders

We were unable to find any record of BAC data collected for motorcyclists in traffic in the United States. However, there have been two projects internationally that collected BAC data for riders in traffic without crash involvement. Haworth et al. (1997) studied a comparison sample of 1,195 motorcyclists passing through or near sites of 222 crashes, 24 of which were fatal. The comparison riders were stopped at the same time of day and day of week that the crash occurred. BAC data was acquired for 100 percent of the fatal crashes and 61 percent of the nonfatal crashes, resulting in a comparison group of 563 riders interviewed. Ninety percent of the comparison group allowed themselves to be breath-tested. Seven (1.3%) of the riders had a positive BAC of <.05, and a single rider (0.2%) had a BAC of >.05. Because stopping was voluntary, this may be an under-representation of the actual alcohol involvement of the riding population. Haworth et al. (1997) noted that in Australia motorcycles make up about 0.5 percent of the traffic volume for all road types. Specifically, they found the highest average motorcycles per hour on arterials (4.05) and the smallest number on collector roads (1.23).

The second study, conducted in Canada in 1986, included both automobiles and motorcycles. This nighttime survey took place in the late evening to early morning hours (9 p.m. to 3 a.m.). Of the 12,777 drivers surveyed in this project, 312 (2.4%) were riding motorcycles. Approximately 20 percent had a BAC of .02 or higher (Stewart & Lawson, 1987). Hurt and colleagues (1981) conducted roadside interviews of riders passing through the sites of previous crashes. The riders who voluntarily stopped to be interviewed were subjectively assessed for their level of impairment, but no quantification of BAC levels was attempted. From a total of 585 riders interviewed, they reported 47 riders as “had been drinking, not under influence” (8.0%), 4 riders as “had been drinking, driving under influence” (0.7%), and 9 riders as “had been drinking, impairment unknown” (1.5%).

3. Methods

Measuring Relative Risk

The BACs of crash-involved motorcycle operators reveal the prevalence of alcohol in their crashes but, in and of itself, does not indicate the extent to which alcohol contributes to those crashes. Alcohol becomes a risk factor when its presence in riders who crash exceeds that of riders who do not crash. Therefore, the valid use of crash data in estimating the contribution of alcohol to motorcycle crashes requires similar data on the operation of motorcycles not in crashes all other factors being equal.

To estimate the crash risk, it is necessary to use a case control study where the "case" is the condition of interest. Therefore, the "case" would be a crash-involved rider, and the "control" or "comparison" case would be a rider in a condition similar in all respects except for the crash involvement.

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. Once the relative risks are known for a range of BAC levels, they can be plotted to show relative a risk curve for that BAC range.

Figure 4 shows the relative risk curve for automobile drivers by BAC, published in a recent NHTSA study (Compton et al., 2002).

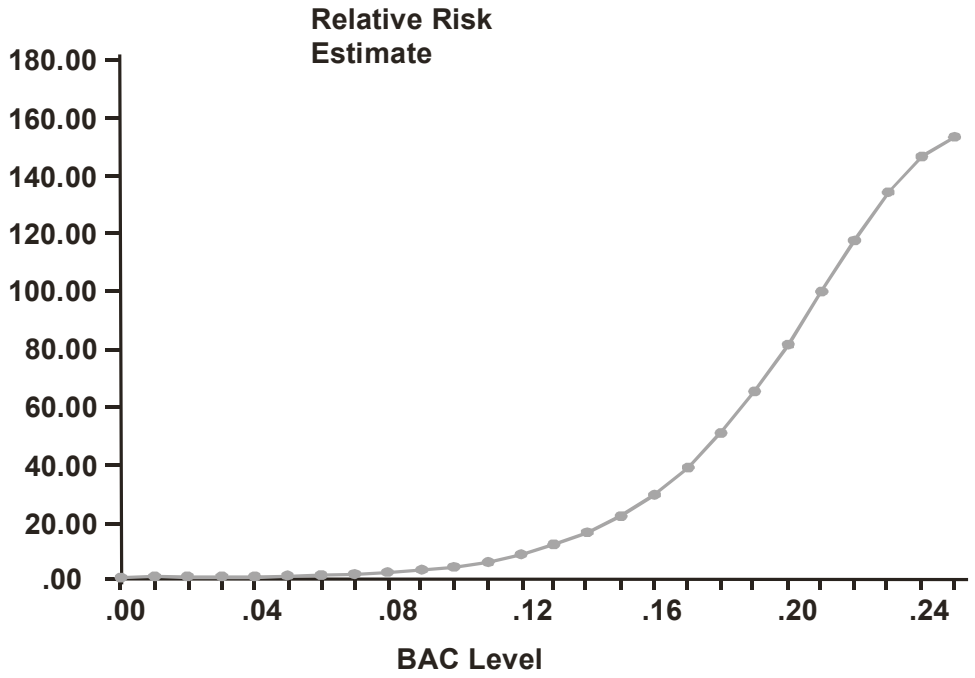


Figure 4. Relative Risk Curve

Generally, the case control studies which provide relative risk data are field studies using real crash cases and comparison data from other drivers in the real world.

Field studies in turn have generally been of two types:

- Case control studies in which the researcher goes to the crash site at the same time and on the same day of the week that the event occurred and collects a random sample of comparison drivers not involved in crashes. Because crash and comparison data are collected at roughly the same time, this type of case control study will be referred to as "contemporary case control" in this report.
- Archival data case control studies that compare archival records of crashes with data drawn from a separate survey of drivers.

It would also be possible to conduct a form of case control study in a laboratory using a driving simulator, where BACs for riders who crash the simulated motorcycle are compared to BACs for riders who do not crash when presented with the same situation. An advantage of such a study would be the control that the experimenter would have over the environment and the subject's BAC. However such a study would have the general disadvantages of simulator studies, primarily a lack of certainty over how well the results generalize to real-world crashes.

The best-known example of the contemporary case control study was the Grand Rapids study (Borkenstein et al., 1974) that developed the most widely used relative-risk curve for drivers. The Grand Rapids risk estimates have been generally confirmed in a recent replication of the study funded by NHTSA (Compton et al., 2002). Haworth et al. (1997) has conducted the only contemporary case control study of motorcycle riders.

Two studies by Zador (Zador, 1991; Zador et al., 2000) illustrate the use of archival data for case control studies. They compared data from National Roadside Breath-Test Surveys to existing archival crash data from FARS. In these studies, the National Roadside Survey plan was based on the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) crash record sampling plan so that the data could be weighted to match the FARS data, but specific matches with crash location and time were not possible due to the limited data available (Lestina et. al., 1999). Thus, there are many more uncontrolled factors in this archival data approach to the estimation of relative risk than in the contemporary case control study.

Contemporary Case Control Studies

As noted, the development of risk estimates requires the collection of crash (numerator) data for comparison with exposure (denominator) data. The classic methodology—exemplified by the Borkenstein Grand Rapids study (1974) and the NHTSA-sponsored California and Florida studies (Compton et al., 2002)—is to measure the BACs of crash-involved drivers and return to the crash location to collect a random sample of the drivers passing the crash scene at the same time and day of the week the crash occurred.

The validity of the exposure data is dependent on the similarity of all the conditions associated with the crash, including weather, traffic, and lighting conditions. In practice, it is difficult to ensure the complete similarity of conditions, so some errors in the result can be expected. In some cases, it may be possible in the data analysis to reduce the effects of dissimilar conditions such as weather, where both the crash data and the exposure data have information on the characteristic. Due to the cost of this type of study, data collection is generally limited to one or

two sites (as in the current NHTSA study). This assumes that the results for a limited location, such as the city of Grand Rapids, can be extrapolated to the Nation as a whole. This assumption is generally accepted because the risk measure is assumed to be a function of the human operator and, therefore, applicable to the human operator wherever the data are collected.

Two types of data must be collected: case data-crash involved riders and control data-riders using the road at the same time and places. Crash data are generally drawn from one of three sources: police records, hospital records, or roadside interviews.

Collection of Case or Crash Data

Collection of Crash Data in the Field

The replication of the Borkenstein study (Compton et al., 2002) established a "go-team" that received police reports of crashes in real time and proceeded as soon as possible to the crash site to interview motorists and collect breath tests. For injured drivers transported to the hospital emergency department, the team followed them in an effort to conduct an interview and obtain a breath sample. Control cases can be collected by the go-team from motorists passing the site of the crash shortly following its occurrence, or at the same location at a later date, but on the same day of the week and time of day that the crash occurred. This is perhaps the "gold standard" of the methods for collecting crash case data. However, with the relatively small number of motorcycle crashes, the maintenance of a capability to respond to crash events is likely to be too expensive to implement. Hurt et al. (1981) conducted such a study of motorcyclists, using a go-team to gather crash data at the site of a motorcycle crash, and returning to the site to stop motorcyclists to collect comparison data. Unfortunately BAC data were not collected as part of this study.

Collection of Information in Emergency Departments

Another approach to the collection of crash case data is to establish agreements with local hospitals to monitor emergency department cases. This permits interviews with injured riders and the collection of BAC data at the hospital. This was the method used by Haworth et al. (1997) in the only existing contemporary relative-risk study of motorcyclists. This method has an advantage: it permits the study of injury events because BAC measures are available on surviving riders. Another advantage is that more details can be obtained on the crash cases through interviews in the emergency department. Haworth et al. (1997) collected information on the circumstances of the crash, the previous riding history, medical records, helmet use, and other factors relevant to the crash. Such details were not available from police crash records.

A similar arrangement with emergency departments, where a representative of the project could be alerted when a motorcycle crash victim entered the emergency department, could provide data on at least those injured riders taken to local hospitals. The collection of BACs from fatally injured riders by coroners, together with the information collected from the hospital emergency departments, would provide a relatively complete set of BACs on seriously injured riders. In his study, however, Haworth et al. (1997) failed to obtain BAC data on 34 percent of the riders who were admitted to the emergency department. Further, this procedure would miss those injured riders who were not transported to the hospital, most of whom could have minor injuries. The crash-involved riders would have to be contacted, at least for those cases where police data were not available, to determine the time and location of the crash. It should be easy to monitor hospital data with a part-time staff. The cost of collecting the crash data using this approach should be less than trying to maintain a go-team to get to crash sites in

time to interview the riders involved. When the data collected from hospital emergency departments can be correlated with a date, time, and location, a corresponding comparison case survey site could be established and comparison crash data could be collected later from riders at that location, at the same time of day, day of week, etc.

Collection of Control Case Data

In the Contemporary Case Control study, comparison cases are collected by going to the scene of a crash, or as nearby as possible, at some time soon after the crash, generally at the same time of day and the same day of week. One or more comparison cases are collected by stopping passing motorists. In the case of a motorcycle study, the number of motorcycles in the traffic stream is an issue, as are other issues normally associated with any study involving stopping motorists and administering breath tests. These issues are discussed in the following sections.

Roadside Sampling Procedures

The relative low frequency of motorcycles compared to four-wheeled vehicles on the highway will both limit the scope of and increase the cost of collecting comparison data no matter what type of crash data is used. Table 8 shows two methods of calculating the relative frequency with which one might expect to encounter a motorcycle among four-wheel vehicles on U.S. roadways. Both methods suggest a 1-in-250 frequency.

Table 8. Frequency of Motorcycles in the Traffic Stream

Estimate Method 1			
• U.S. Department of Transportation • Bureau of Transportation Statistics			
Vehicle Miles Traveled (VMT) – 1995			
Passenger vehicles	1.500	X	10,000,000,000,000
Trucks	0.700	X	10,000,000,000,000
Combination trucks	0.100	X	10,000,000,000,000
Motorcycles	0.009	X	10,000,000,000,000
	2.309	X	10,000,000,000,000
.009/2.309 = .0039 or 1 of 256			
Estimate Method 2			
• National Highway Traffic Safety Administration • National Occupant Protection Usage Survey – October 2000			
Passenger cars	93,916		
Pickup trucks	24,747		
Other vehicles	39,031		
Motorcycles	645		
	158,339		
645/158,339 = .0041 or 1 of 244			

In the 1996 National Roadside Survey (Voas et al., 1998), it was necessary to exclude entirely the counties with a population of less than 20,000 and, within larger counties, to exclude roadways with fewer cars than one every 5 minutes because of the cost of obtaining a usable sample on a

roadway with very low traffic counts. Given that the average frequency of motorcycles on the road will be one of every 250 vehicles, few roadways will be reasonable candidates for roadside surveys.

However, the frequency of motorcycle traffic can be expected to vary substantially by the location within the country and the season of the year. The third column of Table 7 (above) gives the number of crash-involved riders for each 100 crash-involved drivers. These rates vary substantially, suggesting that there are locations in which the frequency of motorcycles would be considerably more common than is suggested by the national averages shown in Table 8 (above). Further, the data in Table 7 do not consider the seasonal factors in riding that might further increase the frequency of cyclists.

The problem presented by the limited number of riders in the traffic stream is illustrated by the Haworth et al. (1997) study. She estimated that, in Victoria, Australia (where the study was conducted), motorcyclists make up one percent of the vehicle traffic. She was able to capture data on 1,225 control cases, but because only 4 percent of her roadside sample (8 cases) had BACs greater that zero, and only 1 percent had BACs greater than .05 g/dL, she had too little data to draw a detailed risk curve and presented her relative risk values for only two points: BAC>.00 and BAC>.05.

In the 1996 National Roadside Survey (Lestina, 1999), much of the police officer time and police vehicle cost was donated by cooperating departments. However, in several cases, it was necessary to reimburse the departments for those expenses. A minimum estimate for the cost of a one-officer/one-interviewer roadside team with the necessary vehicles and equipment is $200 per hour. In the 1996 survey, five interviews per hour were collected for a cost of $40 per interview. Assuming, given the low frequency of motorcyclists on the roadways, that a single interviewer could capture as many as two an hour, the cost per interview would be $100.

The primary issue related to the feasibility of using the roadside-survey technique for motorcycles will be the external validity of the results that will be limited by the types of roadways that can be economically sampled because of the low frequency of motorcycle traffic. Although the occurrence of a crash should be associated with the frequency of motorcycle traffic at that point on the roadway, locations with very low frequencies of riders will have to be excluded from the study for economic reasons. The corresponding crashes also will have to be deleted from the analysis. The extent to which such exclusions will impair the validity of the resulting study will need to be considered. In any case, the limitations of the external validity of a motorcycle study due to the inability to survey at certain times and locations will be much greater than for the corresponding four-wheeled vehicle surveys.

Another significant issue for the conduct of motorcycle roadside surveys will be the willingness of the police departments to provide an officer to select motorcyclists from the traffic flow and direct them into a safe location for an interview. As noted, the number of jurisdictions willing to cooperate with the 1996 survey was fewer than that observed in the 1986 national survey. If the surveys are limited to one or two large departments, as is the case with the current NHTSA-funded repetition of the Grand Rapids study (Compton, 2002), it should be possible to obtain similar cooperation for a motorcycle survey. Although there may be some concern that only cyclists were being inconvenienced by the survey, as the results pertain only to them, this is not expected to be a major barrier given that the department is willing to participate in any survey.

The final issue for the collection of control data is the cooperation of motorcyclists. The observed cooperation rate for four-wheeled vehicle drivers has generally been more than 90 percent (e.g., it was 96 percent in the 1996 roadside survey). Haworth et al. (1997) obtained a 90 percent breath-test compliance rate in her survey of riders. The popular stereotype of the motorcycle operators is that they will be much less likely to participate in a roadside survey. This may be a misapprehension if motorcyclists can be convinced that the survey is for their benefit. Certainly, it will be important to obtain the endorsement of leading motorcycle organizations in support of the survey. It may also be important to provide a significant incentive for participation. Given the probable cost of $100 per interview, an incentive of about $25 may be cost effective.

Collecting a Breath Sample

The proportion of roadside respondents willing to take a breath test has generally been high, as was demonstrated in the 1996 National Roadside Survey in which 95.7 percent of the motorists who entered the survey site provided a breath test. In the case of this survey, breath tests of motorists were conducted using a breath-test device that does not provide a BAC reading at the site. The reading was recorded internally on the device and downloaded into the research file the next day. The respondent's name was not recorded at any time, so this procedure encouraged participation by ensuring not only that there will be no consequence at the time of the interview, but also that there will be no record of BAC associated with a name to cause future problems.

It is possible to collect a passive breath sample without the participant's knowledge. Public Services Technologies in Fredericksburg, Virginia, produces a passive sensor flashlight (PAS III; Leaf & Preusser, 1996) that can pick up breath alcohol at a distance of six inches. The National Roadside Survey provided an opportunity to evaluate the accuracy of passive sensing when a quantitative measure was also available. The study indicated that the PAS III sensor could identify 70 percent of the drivers with BACs higher than .08 (Farmer et al., 1999). However, because the interview and breath test results are completely anonymous, it should be possible to obtain this permission as it was for the National Roadside Survey.

Number of Officers

As noted, a significant cost factor in the use of roadside interviews is the relatively small number of motorcyclists likely to be encountered at sites where crashes have occurred. This can be offset partially by using only one interviewer and one police officer as has been done in past surveys where the traffic counts are low. However, many jurisdictions require officers to work in pairs; consequently, it has been necessary to employ two officers in these jurisdictions.

Transporting Impaired Riders

Another significant source of expense is transporting operators judged to be unfit to ride home. In some localities, it has been possible to recruit volunteers from local civic groups to drive the participant home, with a second driver to return the team member to the survey site. In other communities, it has been necessary to contract with taxi companies to provide the service as needed. Even where the BAC test result is not provided at the survey site, the survey team is responsible for preventing an obviously intoxicated motorist from driving away from the survey site. Consequently, motorcyclists have not been selected for inclusion in previous national surveys, as it would require the availability of a motorcycle operator or a truck to haul the cycle to the participant's home. If roadside surveys of motorcyclists are to be conducted, either safety riders or a truck to transport the motorcycle will be needed at the survey site.

Archival Case Control Studies

Collection of Crash Case Data

An alternative approach to the selection of specific crash sites for the collection of exposure data is to use an existing crash database for a geographical area and collect exposure data representative of that area. A recent example of that approach is the 1996 National Roadside Survey funded by NHTSA (Voas et al., 1998) and the subsequent comparison of those data with crash information from the FARS file (Zador et al., 2000), which NHTSA supported. Using FARS is particularly attractive because of the high percentage of fatally injured drivers for which there are measured BACs.

The use of the NASS/CDS to establish a stratified random sampling plan can be a powerful technique for use with the relatively numerous four-wheeled vehicles on U.S. highways. However, the much smaller number of motorcycles on the roadways almost surely will place the cost of collecting a representative national sample of riders with this procedure beyond the budget available for this study. Even with surveys involving four-wheeled vehicles, it has been necessary for economic reasons to exclude counties with populations of less than 20,000 and roadways not yielding a vehicle every five minutes (Lestina et al., 1999). It is likely that the probability of encountering a motorcycle on the roadway, even in the summer season, is less than 1 percent of that of encountering a car. To use the National Roadside Sampling technique with motorcycles will involve much more restrictive limits on the sites that can be sampled economically.

Another limitation on a national survey of riders is obtaining cooperation from the police agencies selected by the NASS/CDS sampling system. In comparison to the 1986 National Roadside Survey, the 1996 survey encountered considerably more resistance from police departments. In 1996, 39 of the 102 police jurisdictions contacted to participate in the national survey declined, 22 due to legal or liability concerns and 17 because of personnel shortages. Several departments that had participated in 1986 refused to participate in 1996. Because it will require more time on the road for each interview with a motorcyclist compared to a motorist, it is likely there will be less cooperation from police departments than was obtained in 1996.

This suggests that selecting an area where motorcycle riders are more frequent and where police cooperation can be assured will provide a lower cost alternative to a national probability sample. The distribution of motorcycle riders varies by region and season. As shown in Table 7, southern urban counties will provide environments where riders are present throughout the year. California and Florida have sufficient numbers of FARS cases to permit reasonably valid risk estimates if an adequate sampling system can be constructed in the counties with the highest frequency of motorcyclists. Obtaining the cooperation of the police in a single county should be much easier than attempting to get the cooperation of 17 States, which was the case in the 1996 National Roadside Survey.

Another alternative for an archival data case control study would be to use data from State crash files, which would permit the study of nonfatal injury cases. However, this possibility would be limited by the general lack of BAC data for injury crashes.

State Crash Record Data

State motor vehicle files or local police files will contain information on all crashes reported to the police (about half of all the incidents that occur on public highways). These records will

generally only contain BAC information on fatally injured vehicle occupants where the responsibility of collecting the information lies with the coroner. The collection of alcohol information for nonfatal crashes depends heavily upon the police officer's ability to record the data using the Traffic Collision Report (TCR) forms currently in-use by police agencies. Comparison of the TCR data forms for the three States with the largest number of registered motorcycles (*Traffic Safety Facts,* 1998) shows the collection of similar alcohol-use information; however, the reporting is not uniform. Of these States, only Ohio reports the BAC levels (see Table 9). Standardized State crash reporting has been addressed by NHTSA with the Model Minimum Uniform Crash Criteria Program (NHTSA, 1998).

Table 9. Police Reporting of Alcohol and Drug Use in California, Ohio, and Florida

CALIFORNIA CHP 555, 8/98	OHIO OH-1 (REV 10/99)	FLORIDA HSMV-90003 (REV 1/01)
Sobriety – Drug Physical Check 1 or 2 items	***Alcohol/Drug Suspected Code one item***	***Alcohol/Drug Use Code one item***
☐Had not been drinking ☐HBD—under influence ☐HBD—not under influence ☐Under drug influence ☐Impairment—physical ☐Impairment not known ☐Not applicable ☐Sleep/fatigued	1 – None 2 – Yes—alcohol suspected 3 – Yes—HBD not impaired 4 – Yes—drugs suspected 5 – Yes—alcohol/drugs suspected 6 – Unknown	1 – Not drinking or using drugs 2 – Alcohol—under influence 3 – Drugs—under influence 4 – Alcohol & Drugs—under influence 5 – Had been drinking 6 – Pending alcohol/drug test results
	Alcohol Test Type Code one item	
	1 – None 2 – Blood 3 – Urine 4 – Breath 5 – Other	
	Alcohol Test Result	
	Drug Test Result Code one item	
	1 – None 2 – Marijuana 3 – Cocaine 4 – Opiates 5 – Amphetamines 6 – PCP 7 – Other 8 – Unknown at time of reporting	

Collection of Control Data

The collection of control cases for archival data case control studies raises essentially the same issues as were discussed for control data for contemporary case control studies. However, the contemporary case control survey sites for comparison data are specified by the crash case for which control data are being collected. In archival studies, the specific location of the crash may not be known, and in any case, the sampling plan calls for the selection of sites in the area (county or State) that are representative of the area as a whole. Thus, a random site selection system could be used such as in the 1996 National Roadside Survey where the local police

department sites were selected by placing a grid over the area and randomly selecting locations for survey sites. This may be a more problematic method for selection of control sites because motorcycle riders may not be distributed evenly within the jurisdiction concerned.

A potentially effective method of collecting control data for archival crash data studies where control data representative of an area is sought is a system used in a study of motorcycle crashes in Thailand (Kasantikul, 2001) and currently being used in a European study (European Motorcycle Manufacturers Association, 2004). The European system involves developing a random sampling plan for surveying petrol (fuel) stations that are within the sample region for the crash database (Organisation for Economic Co-operation and Development, 2001). A specific schedule is developed in which investigators travel to the fuel station and conduct interviews of motorcycle riders and passengers who have stopped to refuel their motorcycle. Vehicle inspections and human factor interviews, including questions regarding alcohol involvement, are conducted at this time so that these data may be used as the control population for the risk analysis. To develop relative risk data, it would be necessary to add a breath test to this procedure.

Another alternative for getting control data for an archival case control study using FARS as the crash data set would be to conduct a nationwide telephone survey of individuals with licenses to operate motorcycles. An appropriate sample of operators might be collected in several ways. The addresses of a random sample of licensed operators might be obtained from the department of motor vehicles. This is generally difficult to accomplish because of privacy considerations. Voas and Taylor (1997) received the cooperation of the California Department of Motor Vehicles (CDMV) in a survey of driving-while-suspended (DWS) offenders, in which the CDMV agreed to mail questionnaires to selected drivers and turn the responses over to the research team. However, this technique generally results in a large group of contacts not responding to the solicitation, leaving significant questions about the extent to which the sample may be biased.

A more standard procedure is to provide questionnaires to local DMV offices and request that clerks hand them out to individuals waiting in line to register vehicles or renew operator's licenses. If all hours that the local DMV office is open are covered, this technique can produce a reasonably random sample of motorists. However, with the relatively small proportion of those visiting the DMV who are motorcycle riders, this procedure would probably not be feasible. It may be possible to identify a State in which the DMV has a concentration of motorcyclists moving in at a particular time and place (e.g., a day set aside for motorcycle skills tests).

The use of self-reports of drinking before riding raises at least two issues: (1) willingness to report accurately, and (2) ability to recall the amount of consumption. There is considerable evidence that individuals can recall the number of drinks consumed at recent drinking sessions within the last 30 days. However, the willingness to be candid is obviously problematic in situations where the respondent may be concerned that the information could have negative consequences. In a recent focus group study of drinking and riding, conducted for NHTSA (Becker et al., 2003), it was very difficult to find and recruit riders who would admit to riding after drinking within the last 30 days. More significantly, such surveys will not provide a BAC test. If the number of drinks is reported accurately and the weight of the individual is ascertained, it might be possible to make a rough calculation of the BAC, but this procedure would introduce considerable error into the control case BAC data.

Laboratory Studies

Laboratory studies can be divided into two broad types:

- Simulator studies which use a driving simulator, and
- Closed-Course studies which use off-road driving ranges.

A special requirement of laboratory studies is that they cannot cause harm. Field studies can study the actual harmful event because it results from a naturally occurring situation. The price of this realism is that the researcher has no control over the "case." In laboratory research, the experimenter gains control but must avoid risk and, consequently, deals with artificial situations.

Simulation

One laboratory approach that might be suitable to meeting the project objectives is simulation of motorcycle operation tasks. Numerous research efforts have used car-driving simulators in studying the effects of alcohol impairment on motor vehicle operation. In a recent study, Moskowitz et al. (2000) used a simulator to measure the effects of impairment on 168 subjects at a range of BACs between .02 g/dL and .10 g/dL. They found impairment began at the very lowest BAC levels, increased as BAC increased, and that all measures of performance exhibited degraded performance at BAC = .04 and above.

In these types of simulator studies, the simulator presents drivers with various highway traffic situations and records their responses primarily through manipulation of the vehicle controls, as well as physiological sensors.

Most early car simulator studies were limited by technology (i.e., interactive devices to provide visual displays of the highway traffic environment that present the complexity of the real world). Much of the early alcohol work was confined to measuring driver error in tracking a primitive road outline or in simplified obstacle avoidance. Early examples of such car studies include Allen et al. (1973), Jex et al. (1973), Allen et al. (1981), and Stein et al. (1985). Colburn et al. (1993) conducted a motorcycle-specific study in which an interactive screen with a road display portrayed events encountered during normal riding. The subjects were asked to physically maneuver the simulator, which controlled a facsimile of a motorcycle shown on the computer-generated roadway image. All the normal motorcycle controls (e.g., throttle, brake, steering) were considered to be realistic by the authors, and the subjects were asked to complete a simulated motorcycle course after consuming controlled doses of alcohol. They found a positive correlation between total errors and breath alcohol concentrations at BACs starting well below BAC = .10. They found a highly significant increase in the tendency to leave the roadway, as well as a reduction in ability to complete a timed course.

Recent advancements in computing power have improved the complexity of visual patterns that can be displayed without introducing unacceptable lags. The Federal Highway Administration's Highway Driving Simulator is an example of an early simulator with an enriched roadway delineation display, which was subsequently enhanced for use in visibility studies. Weir and Clark (1995) reviewed 15 midlevel car research driving simulators worldwide, focusing on their technical features and capabilities. NHTSA's National Advanced Driving Simulator, now being tested at the University of Iowa, is the world's largest and most sophisticated automobile-driving simulator (currently without a motorcycle "cab"), and

numerous driver behavior experiments including those involving alcohol impairment are planned using it. Two other research-grade simulators (i.e., with significant motion, detailed visual fields, acceptably small time delay) exist in North America: the Dynamic Research Simulator (www.dynres.com/simulator.html), in Torrance, California, and the Ford Virtual Test Track Experiment Simulator (www.ford.com/en/innovation/safety/driverDistractionLab.htm), in Detroit, Michigan. The Dynamic Research Simulator currently has a motorcycle "cab" and has been used previously in motorcycle rider research studies.[1]

Past car simulator studies have focused on a wide range of attentional, perceptual, cognitive, and psychomotor aspects of vehicle operation. Yet, several aspects of motorcycle operation impose further demands on simulator technology. These include various aspects of visual and motion fidelity including proper representation of the bank-to-turn response of motorcycles; the crucial "reverse steer" initial response; dynamic g-vector turn coordination and noncoordination present in real motorcycles; "balancing" of the motorcycle by the operator; the role of upper body leaning or hip movement; control via steer torque at high speeds and steer angle at low speeds; potential roll instability that may result from overbraking either the front or the rear wheel; loss of stability; and others.

Simulation Requirements

The following issues must be addressed when considering the use of simulation as a means of studying the effects of alcohol upon motorcycle operation:

- Task and scene complexity —The effects of low BACs seem more likely to manifest themselves when dealing with tasks that demand more attention (e.g., perceptual and cognitive activity such as observing and responding to a pedestrian or driver looking the other way) amid a complex pattern of vehicular and pedestrian traffic. Existing motorcycle simulators can be assessed regarding their capabilities in displaying a complex and dynamic visual environment involving roads, traffic, structures, terrain, and persons.
- Balance and response—The ability to keep the motorcycle balanced is a critical requirement that may be seriously affected by blood alcohol concentration. Balance control, or roll stabilization, involves a combination of visual, vestibular, and proprioceptive responses, cognitive equalization, and suitable arm/hand response (Weir et al., 1979), all of which can be degraded by excessive rider time delays and thresholds induced by blood alcohol concentration. For this to be studied via a riding simulator requires that the latter have suitable and realistic dynamic response. This can be evaluated by measuring the motorcycle simulator's motion response (e.g., roll angle and yaw angle response to steer torque and steer angle inputs, as a function of frequency) and comparing this to that of a real motorcycle in proving ground or over-the-road conditions.

One of the earliest forms of motorcycle simulation used a motorcycle mounted on a moving belt, which allowed it to be operated in a fixed position. However, such a simulator is not research grade, and ignores bank-to-turn control, and centripetal and other forces and accelerations that are crucial in motorcycle balance control.

[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 the motorcycle simulator described in some detail in this report. Research by project staff at PIRE and HPRL suggests that the DRI simulator may be suitable for the type of research discussed in this report. 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 additional information on the subject of motorcycle simulation.

For proper simulator fidelity for investigating balance control, its dynamic response must closely match that of real motorcycles. Normally this requires a suitable vehicle dynamics simulation model, a suitable horizon-tilting visual display, and a moving base with both relative and absolute (i.e., inertial) degrees of freedom.

- Decision-making and risk-taking—Higher cognitive functions such as decision-making and risk-taking are impaired by alcohol, and motorcycle simulators should be evaluated with regard to their capability to present complex time-sequenced and concentrated decision tasks. Typical challenges here for both advanced simulators and even full-scale proving ground scenarios with cars are to present suitable and realistic fear-of-consequence scenarios to subjects. In a simulator, the scenario can also be enhanced by means of sound cues (e.g., collision or skid sounds) and motion cues (e.g., shaking or impulse).
- Control complexity—One of the key motorcycle crash involvement factors frequently identified in past crash research is rider brake control or lack thereof. Motorcycles are equipped with separate front and rear brake controls for one fundamental reason. If the front wheel locks due to overbraking, the motorcycle will capsize very quickly (i.e., within about 0.1 seconds, which is much faster than typical human reaction times). If the rear wheel locks, the motorcycle will become somewhat unstable, and the rider might not be able to stabilize it, depending on skill, conditions, and factors such as impairment (Zellner & White, 1981). Blood alcohol concentration degrades the proprioceptive, cognitive, and neuromuscular responses, which are vital for avoiding a vehicle or object impact while avoiding front wheel lock and controlling the motorcycle if the rear wheel locks.
- Measurement capability —To conduct suitable human factors experiments involving alcohol impairment effects on motorcycle riders, it is essential that a simulator be capable of recording the motion, control, and physiological variables needed to monitor for rider perception, decision-making, and response performance. Motorcycle simulators should be evaluated in terms of their ability to record rider control inputs, vehicle motions including capsize, path exceedance and obstacle impacts, and human-centered variables such as eye-point-of-regard.
- Car versus motorcycle operation —Ideally, as indicated in the objectives of this study, it will be useful to be able to compare the effects of the same levels of BAC on both driver and rider safety-related performance, in identical crash causation or avoidance experimental scenarios. Motorcycle simulators should be evaluated in terms of their ability to record rider control inputs, vehicle motions including capsize, path exceedance, simulated obstacle impacts (i.e., failed collision avoidance maneuvers), and human-centered variables such as eye-point-of-regard as influenced by BAC.
- Motion sickness—One aspect of simulators that can affect their use as experimental tools is their individual motion sickness characteristics. Depending on the individual simulator's design and motion fidelity, this can potentially limit or interfere with its usefulness as a research tool. The relevant factors include whether the motion and visual cues are in agreement or harmonized with each other; the presence and level of motion artifacts; and the particular experimental scenario, duration, and sequence. Motion sickness characteristics are probably especially important for motorcycle simulators, because of the much larger visual (orientation) cues. Motorcycle simulators should be evaluated in terms of their tendency to produce or suppress motion sickness in an experimental context.

- Available simulators—Consideration of simulation as an approach in studying the effects of alcohol on motorcycle operation depends on the availability of simulators capable of creating tasks and measuring responses that are susceptible to the effects of alcohol on motorcycle operation.

Closed-Course Studies

In terms of realism, the best vehicle simulator is the vehicle itself. The only recorded studies of actual motorcycles on a protected course for the study of alcohol impairment were by non-researchers reported in magazine articles. Ford (1987) reported in *Motorcyclist* magazine on the experience of four magazine editors who found increasing numbers of performance errors on a closed course over several trials conducted at increasing BACs. A *Motorcycle Cruiser* magazine article by Elvidge, titled "Rolling Stoned: Friends Let Friends Ride Drunk" (1999) reports on five riders of varying skill levels and drinking tolerances who rode a closed-course test route and performed other exercises at BAC levels ranging from .00 to nearly .25. At lower BAC levels, performance improved. She notes, however, that the participants reported increased difficulty in attention sharing and that such a decreased ability to attend to other vehicles would probably have affected driving under real-world conditions. At higher BAC levels, nearly all riders experienced decreased performance. She noted that a control sober driver continued to improve throughout the experiment. This was interpreted as an indication that later performances by drinking riders may have been improved by the effect of practice, despite the fact that riders had pretest training. It should be noted that these were not controlled research studies conducted by trained researchers, and that articles in magazines such as these are intended for the entertainment of readers and are therefore not necessarily a source of reliable scientific information.

For four-wheeled vehicle research, where the participant can be restrained and is protected by a metal shell, useful studies of alcohol impairment have been conducted on protected driving ranges. The motorcycle, however, does not offer the same protection to the rider, and balance, which is strongly affected by alcohol, is an important factor in safe operation. Researchers must follow set rules regarding the protection of human subjects. These rules will limit the maneuvers which motorcyclists will be allowed to perform, at what speeds and at what levels of impairment. These limitations will affect the validity of results of closed course studies. There have been motorcycles developed with outriggers and other features that would help protect a dosed rider in the event of a fall. Historically, these have changed the handling characteristics of the vehicle to a high degree.

4. Special Issues

Passengers in Impaired Rider Research

Passenger impairment represents a more significant problem in rider studies than in research on drivers. In passenger vehicles, other vehicle occupants can be a source of distraction, and at least among underage drivers, passengers can support high-risk driving. However, in estimating relative risk, passengers in four-wheeled vehicles are generally ignored in roadside surveys and relative-risk studies. The motorcycle passenger potentially has a much more direct effect on the safe operation of the vehicle, both through the direct contact with the rider and

through the influence on cycle dynamics. It is possible that if the rider is drinking the passenger will also be drinking; therefore, it is possible that the alcohol-related crash risk for riders with passengers will be significantly higher than for solo riders. This raises the issue of whether interviews and breath tests should be sought from passengers as well as riders in any field study. It also raises the issue of whether sufficient numbers of cases of riders with passengers can be collected to permit a separate analysis of this risk group.

Impairment and Helmet Use

Luna et al. (1984) found that intoxicated riders were less likely to wear helmets. Nelson et al. (1992) confirmed this finding noting that in their study, 18 percent of the helmeted riders in crashes in New Mexico, compared to 51 percent of the nonhelmeted riders, were legally intoxicated at the time of their crash. Kim et al. (2002) also found a correlation between alcohol involvement in motorcycle crashes and unhelmeted riding. Clearly, it will be important in collecting crash case data to go to a source that will provide good information on helmet use.

5. Summary

Relatively little data are available on the relationship of rider BAC levels to crash involvement. Although it is believed that riding skills may be more sensitive to alcohol than are driving skills, the information currently available is too limited to confirm that belief. Currently, those factors such as age, gender, time of day, day of week, and restraint use, which are associated with driver impairment, appear to also characterize rider impairment. There appear to be several relative-risk methods developed for passenger cars that can be adapted to motorcycle studies; however, only at significantly increased cost due to the relatively few cyclists on the roads.

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Appendix A
Detailed Reference List

Authors	Allen, R. W., Jex, H. R., McRuer, D. T., & DiMarco, R. J.
Year	1973
Title	**Alcohol effects on driving behavior and performance in a car simulator**
In	*10th Annual Conference on Manual Control*. Wright-Patterson Air Force Base, Ohio: Air Force Institute of Technology.
Abstract	Abstract not available

Authors	Allen, R. W., Stein, A. C., & Jex, H. R.
Year	1981
Title	**Detecting human operator impairment with a psychomotor task**
In	*1981 Annual Conference on Manual Control.*
Abstract	Abstract not available

Authors	American College of Surgeons
Year	2003
Title	**National Trauma Data Bank. American College of Surgeons**
In	Retrieved April 2003 from www.facs.org/trauma/ntdbwhatis.html
Abstract	Not available.

Authors	Becker, Les R., McKnight, A. S., Nelkin, V. S., & Piper, D. L.
Year	2003
Title	**Drinking, riding, and prevention: A focus group study**
In	DOT HS 809 490. Washington, DC: National Highway Traffic Safety Administration
Abstract	Motorcyclist fatalities accounted for 7 percent of the total traffic fatalities in 2000; yet, motorcycles represent less than 2 percent of all registered vehicles and only 0.4 percent of all vehicle miles traveled. Motorcyclist crash fatalities had been decreasing in the mid-to-late 1990s, until 1998 and 1999 when fatalities increased dramatically. More riders older than 40 years were dying as a result of these crashes and high BAC levels were involved. To identify effective prevention and intervention approaches, 20 motorcycle focus groups---16 Rider Groups and 4 Leadership Groups---were held in 5 cities or regions across the United States. The findings of these groups indicate that (1) riders often discourage their peers from riding after drinking, but a culturally reinforced respect for rider freedom and individual responsibility set boundaries for peer actions; (2) rider concern for the safety and security of the motorcycle nearly always overshadows concern for individual safety and contributes to drinking and riding; and (3) motorcycle impoundment and court-ordered payment of costs for vehicle storage, alcohol treatment programs, and other costs are considered persuasive countermeasures. The results suggest that future drinking-and-riding prevention efforts should incorporate peer approaches and social norms modeling. Crisis Intervention Techniques may be valuable in preventing already impaired riders from operating their motorcycles.

Authors	Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., & Zylman, R.
Year	1974
Title	**The role of the drinking driver in traffic accidents**
In	Blutalkohol, 11(Supplement 1), 1-132.
Abstract	The general picture of the association of alcohol with crashes was made much clearer by the classic study of crashes in Grand Rapids, Michigan, conducted in the early 1960s by Robert F. Borkenstein and his colleagues at Indiana University. The Grand Rapids study aimed to examine the entire universe of reported crashes in that city, rather than merely fatal crashes or crashes occurring at limited hours of the day, as had been done previously. Nearly 5,000 drivers involved in crashes were studied, along with an even larger number of non-involved drivers from sites and times that had been matched to the crash distribution. Blood alcohol concentration was measured by the highly reliable Breathalyzer technique, and much supplementary information was obtained on each driver. The Grand Rapids study found relations between crash involvement and a wide variety of variables including age, driving experience, and education, in addition to alcohol. However, the relationship with alcohol was by far the most important.

Authors	Bureau of Transportation Statistics and Federal Highway Administration
Year	2001
Title	**National household travel survey 2001**
In	U.S. Department of Transportation. Retrieved April 2003 from http://199.79.179.77/nhts/
Abstract	Not available.
Authors	Centers for Disease Control and Prevention
Year	2003
Title	**Behavioral risk factor surveillance system**
In	National Center for Chronic Disease Prevention and Health Promotion. Retrieved April 2003 from www.cdc.gov/brfss/about.htm
Abstract	Not available.
Authors	Cerrelli, E.C.
Year	1973
Title	**Driver exposure: The indirect approach for obtaining relative measures**
In	*Accident Analysis & Prevention,* 5:147-156
Abstract	The induced exposure procedure is used to obtain three indices: relative exposure index, liability index, and hazard index. Values of these indices are computed for the following categories: rural/urban, male/female, age (7), day/night, time of day, weekend/weekday for 1.7 million crashes in 25 States. The liability index comparing males younger than 20 with males 21-24 agrees quite well with established weighing factors for an insurance group.

Authors	Colburn, N., Meyer, R. D., Wrigley, M., & Bradley, E.L.
Year	1993
Title	**Should motorcycles be operated within the legal alcohol limits for automobiles?**
In	*Journal of Trauma,* 35(2):183-186
Abstract	A motorcycle simulator was used to assess operating performance of 14 experienced motorcyclists with varying breath alcohol concentrations. Riding error scores in three defensive and evasive maneuvers plus distance traveled in a standard time period were documented at baseline and at predetermined intervals following controlled alcohol consumption. The results revealed a positive correlation between total errors and breath alcohol concentrations within a range well below the commonly accepted legal limit of intoxication of .10 g/dL. There was a highly significant increase ($p < 0.0055$) in an operator's tendency to leave the roadway (an error that is frequently fatal for motorcyclists), as well as a reduction in ability to complete a timed course. Moreover, performance errors increased while operators were "sobering up," a dramatic finding not heretofore established in previous studies. Since the present definition of the legal limit of intoxication for motorcyclists is based on automobile studies, noted increases in reaction time and performance errors support the hypothesis that "legal alcohol levels" should be lowered for motorcycle operators.

Authors	Compton, R.P., Blomberg, R.D., Moskowitz, H., Burns, M., Peck, R.C., & Fiorentino, D.
Year	2002
Title	**Crash risk of alcohol impaired driving**
In	D. R. Mayhew & C. Dussault (Eds.), *Proceedings of Alcohol, Drugs & Traffic Safety - T 2002: 16th International Conference on Alcohol, Drugs & Traffic Safety, August 4-9, 2002* (Vol. 1, pp. 39-44). Montreal, Canada: International Council on Alcohol, Drugs and Traffic Safety (ICADTS).
Abstract	In order to determine the relative crash risk of drivers at various blood alcohol concentration (BAC) levels, a case-control study was conducted in Long Beach, California, and Fort Lauderdale, Florida. Data was collected on 4,919 drivers involved in 28,712 crashes of all severities. In addition, two drivers at the same location, day of week, and time of day were sampled a week after a crash, which produced 10,066 control drivers. Thus, a total of 14,985 drivers were included in the study. Relative risk models were generated using logistic regression techniques with and without covariates such as driver age, gender, marital status, drinking frequency, and ethnicity. The overall result was in agreement with previous studies in showing increasing relative risk as BAC increases, with an accelerated rise at BACs in excess of .10. After adjustments for missing data (hit-and-run drivers, refusals, etc.) the result was an even more dramatic rise in risk, with increasing BAC that began at lower BACs (above .03).

Authors	Elvidge, J.
Year	1999
Title	**Rolling stoned: Friends let friends ride drunk**
In	*Motorcycle Cruiser,* 50-58 – Ref Type: Magazine article 323-782-2230
Abstract	Magazine-sponsored drinking and riding experiment. Five riders of varying skill levels and drinking tolerances rode a closed-course test route and performed other exercises at BAC levels range from .00 to nearly .25. At lower BACs performance improved, though riders reported increased difficulty in attention sharing (i.e., performance could only be accomplished through concentration on operating the vehicle such that a decreased ability to attend to other vehicles would probably have occurred in real-world conditions). Increased performance is also attributed to decreased inhibition and increased aggression. At higher BACs nearly all drivers experienced decreased performance. One driver performed better at the highest BAC and poorest at low BAC on the downside of the BAC curve. Additionally, a sixth rider remained sober and performed the measures, improving performance throughout the experiment. This is taken as an indication that later performances by drinking riders may have been improved by practice effect, despite the fact that riders had pre-test training that was deemed sufficient by the time the first trials began.

Authors	European Motorcycle Manufacturers Association (ACEM)
Year	2004, under review
Title	**Motorcycle Accident in Depth Study (MAIDS) report to the European Commission**
In	Brussels: European Motorcycle Manufacturers Association
Abstract	An in-depth motorcycle crash causation study was conducted using a methodology developed by the Organisation for Economic Co-operation and Development (OECD). During the period 1999-2000, data were collected on 921 crash cases and 923 control cases in France, Germany, Netherlands, Spain, and Italy.

Authors	Farmer, C.M., Wells, J.K., Ferguson, S.A., & Voas, R.B.
Year	1999
Title	**Field evaluation of the PAS III passive alcohol sensor**
In	*Journal of Crash Prevention and Injury Control, 1*(1), 55–61
Abstract	Passive alcohol sensors (PAS) are screening devices designed to sample nonintrusively the ambient air around a driver's mouth to determine the presence of alcohol. Studies have shown that PAS devices can aid police officers in the identification of impaired drivers, particularly at sobriety checkpoints. Data from a 1996 nationwide survey, in which 5,392 drivers were evaluated for alcohol using both the PAS III (a passive sensor housed in a flashlight) and evidential breath test devices, have allowed the determination of appropriate criteria at various blood alcohol concentrations (BACs) for detecting impaired drivers in the field. Using the appropriate criteria, the PAS III can identify about 75 percent of the drivers with BACs at or above .10 g/dL, and 70 percent at or above .08 g/dL. This is a vast improvement over the 40-50% detection rate currently achieved by police officers at checkpoints not using sensors. Using the PAS III few drivers would be identified inappropriately. At the criterion recommended for detecting BACs at or above .08, about 14 percent of drivers with BACs of .02-.05 would be incorrectly identified as having a higher BAC. Field studies have shown that when police officers rely on observation alone about 20 percent of drivers with low BACs are detained for further evaluation. More widespread use of passive sensors by police officers would aid in the detection of drinking drivers. Sensors also could provide an additional deterrent to the general public if they believe that when stopped by the police after drinking they will be detained for further evaluation.

Authors	Flamm, E.S., Demopoulos, H.B., Seligman, M.L., Tomasula, J.J., & DeCrescito, V.; Ransohoff, J.
Year	1977
Title	**Ethanol potentiation of central nervous system trauma**
In	*J Neurosurg.*; 46:328-335
Abstract	Two models have been used to study the effects of ethanol on injuries of the central nervous system. The spinal cords of cats were injured by delivering a 200 gm-cm impact to the exposed dura mater. A second group of animals received a similar injury to the exposed dura mater overlying the cerebral hemispheres. The animals were divided into two groups, those that received an infusion of ethanol before injury, and control animals that received no ethanol. The parameters of injury used in this model produced small and insignificant lesions in those animals that received no ethanol; however, when the animals were pretreated with ethanol, a considerable increase in the extent of the injury was noted. These include alterations in membranes-bound enzymes and clotting mechanisms, and alteration of cell membranes through abnormal free radical reactions.

Authors	Ford, D.
Year	1987
Title	**Over the limit**
In	*Motorcyclist*
Abstract	Four editors negotiated a low-speed, parking lot course while gradually increasing their BACs with malt liquor doses based on body weight. Quantification consisted of time to complete the course, number of cones struck, number of crashes, as well as many subjective observations about the riders' deteriorating performance. The experimental tasks included stopping the motorcycle, placing it on the sidestand, and running around the motorcycle before remounting and continuing the course. Some of the subjects maintained pre-drinking lap times but consistently made other errors such as running over cones. All subjects easily maneuvered the course when sober but there were numerous crashes as the experiment went on. When interviewed, all subjects were amazed that California's BAC limit was so high (.08 g/dL) considering their performance at far lower levels.

Authors	Haworth, N., Smith, R., Brumen, I., & Pronk, N.
Year	1997 December
Title	**Case-control study of motorcycle crashes**
In	Monash University Accident Research Centre
Abstract	This report presents the findings of the Case-Control Study of Motorcycle Crashes. The cases comprised 222 motorcycle crashes occurring on public roads in the Melbourne metropolitan area from late November 1995 to 30 January 1997 in which the rider or pillion was taken to one of the participating hospitals or died. The controls were 1,195 motorcyclist trips, which passed the crash site at the same time of day and day of week that the crash occurred. The study collected three types of information: (1) detailed descriptive information about the crash and the resultant injuries, (2) comparison of features of cases and controls, and 3) motorcycle exposure information (gathered as part of collection of control data).

Authors	Hurt, H.H., Jr., Ouellet, J.V., & Thom, D.R.
Year	1981
Title	**Motorcycle accident cause factors and identification of countermeasures**
In	(DOT-HS-805-862) Final Report to National Highway Traffic Safety Administration.
Abstract	This report presents the data and findings from the on-scene, in-depth investigations of 900 motorcycle crashes and the analysis of 3,600 traffic crash reports of motorcycle crashes in the same study area. Comprehensive data were collected and synthesized for these crashes to cover all details of environmental, vehicle, and human factors. In addition, exposure data were collected and analyzed at 505 crash sites at the same time of day, day of week, and under the same environmental conditions. These exposure data define the population-at-risk so that comparison with crash data will reveal the factors which are over-represented in the crash population. The analysis and review of these data identify cause factors of motorcycle crashes, relates the effectiveness of safety equipment and protective devices, and identifies countermeasures for crash and injury prevention. Volume I is the Technical Report containing the most significant data, data analysis, findings, conclusions, and recommended countermeasures. Volume II is the Appendix with terminology, field data forms, and supplemental data and analysis.

Authors	Kasatikul, Vira, MD
Year	2001
Title	**Motorcycle accident causation and identification of countermeasures in Thailand: Volume I - Bangkok & Volume II - Upcountry**
In	Chulalongkorn University, Bangkok, Thailand
Abstract	A total of 723 on-scene, in-depth crash-involved motorcycles were investigated in Bangkok between December 30, 1998, and December 29, 1999. Approximately 97 percent of all cases were investigated at the crash location while vehicles, drivers and police were still present. The remainders were investigated within a few hours of the crash. Each investigation was conducted by a team of investigators trained in motorcycle crash investigation and analysis. After the initial investigation, the information collected was analyzed to provide a complete reconstruction of events before, during and after the collision. One week after the crash, investigators returned to the crash scene, where they observed, counted and recorded information about motorcycles and other traffic passing crash scenes. Several months later, they returned to the crash area to conduct interviews with riders who stopped at petrol stations near the crash scene. Such "exposure data" provided a comparison of crash-involved riders to the larger population of riders who were exposed to similar crash risks (by using the same roadways under similar conditions), but who were not involved in a crash. Comparisons between crash and exposure populations helped define the differences between crash-involved riders and others. Analysis included such factors as helmet use, alcohol use, training, rider gender, rider age, roadway design, and crash causation factors.

Authors	Kim, K., Kim, S., & Yamashita, E.
Year	2000
Title	**Alcohol-impaired motorcycle crashes in Hawaii, 1986 to 1995: An analysis**
In	*Transportation Research Record,* 1734:77-85
Abstract	The purpose of this research is to review and describe data on the nature and extent of alcohol-impaired motorcycle-riding crashes in Hawaii. Using comprehensive police crash data, the differences between impaired and unimpaired riders involved in crashes, in terms of various demographic characteristics, helmet use, license status, roadway environments, and injury outcomes, are described. In addition to various demographic and behavioral factors associated with impaired rider crashes, clear temporal patterns also have been detected. After summarizing these effects, a logistic regression model is built to explain the likelihood of an impaired motorcycle crash as a function of rider characteristics as well as environmental and temporal factors. In addition to age-specific determinants of impaired crash involvement, time factors such as weekends and nighttime, and licensing (out-of-State or no licenses) are strongly associated with impaired rider crashes. These findings could be used to enhance enforcement efforts as well as public information and safety education programs.

Authors	Kim, K., Boski, J., & Yamashita, E.
Year	2002
Title	**A typology of motorcycle crashes: Rider characteristics, environmental factors, and spatial patterns**
In	Department of Urban and Regional Planning, University of Hawaii at Manoa
Abstract	This paper reports the results of research investigating motorcycle and alcohol-impaired riding in Hawaii. The investigation expands the scope of rider characteristics analysis by examining the combined effects of rider behavior (helmet use, speeding, actions taken before the crash, etc.) environmental factors (urban versus rural locations, roadway alignment, etc.) and spatial patterns on motorcycle crashes. First a typology of motorcycle crashes is presented. This crash typology was then used to derive logistic regression models for explaining alcohol-involved crashes. Single-vehicle crashes, and injury outcomes (including fatalities) associated with motorcycle crashes. The logistic models enable comparisons of the relative importance of various rider characteristics, temporal and environmental correlates associated with motorcycle crashes and the associated crash types and injury outcomes. Finally, the results of a spatial cluster analysis are presented, using both GIS (geographical information systems) and spatial analytical tools. The analysis suggests that overall behavioral and temporal factors are more significant predictors of alcohol-involved crash patterns than environmental or roadway features. The findings are qualified both in terms of the usefulness of the methods to motorcycle safety researchers as well as in terms of the relevance to motorcycle safety initiatives within the State of Hawaii.

Authors	Klein, T.M.
Year	1986 July
Title	**Method for estimating posterior BAC (blood alcohol concentration) distributions for persons involved in fatal traffic accidents**
In	National Highway Traffic Safety Administration. DOT HS 807 094.
Abstract	A new method is proposed for estimating BAC distributions for persons with unknown BAC test results on the Fatality Analysis Reporting System (FARS) files. The method utilizes discriminant analysis to form linear combinations of variables associated with alcohol involvement in drivers and nonoccupants, and uses these linear functions to estimate posterior BAC distributions based on various person, vehicle and crash attributes. Crash-level BACs can be computed directly from the person-level BACs as the joint probability distribution of all drivers and nonoccupants involved in each crash. Validation tests are conducted using cases with known BAC test results from the 1984 and 1985 FARS. Results of these tests are presented and discussed.

Authors	Leaf, W.A., & Preusser, D.F.
Year	1996
Title	**Effectiveness of passive alcohol sensors**
In	Final Report Contract No. DTNH22-93-C-05022. Washington, DC: National Highway Traffic Safety Administration. 58p.
Abstract	This study evaluated the effectiveness of passive alcohol sensors for youth alcohol enforcement conducted as part of normal or typical police operations. Three municipal police departments of 100 or more sworn officers in three States with zero-tolerance legislation used each of three commercially available passive alcohol sensors for two-month periods in duty assignments likely to encounter youth and driving while intoxicated (DWI) enforcement opportunities. Applications of the sensors were logged, and after each test period each officer provided written evaluations and participated in debriefing discussions. Data for several years preceding the test period and the test period for underage liquor law violations and underage DWI arrests and convictions were also examined. Devices were used more 1,100 times in normal traffic stops, one sobriety checkpoint, youth encounters, and domestic disturbances. Overall judgments by the officers and their departments were positive, but there were differences between situations and devices. Officers were concerned about their safety when using the devices for initial screening in normal traffic stops. Comments and suggestions specific to each device were catalogued. Few of the uses of passive sensors led to alcohol-related arrests, and the underage liquor law and DWI data did not show changes over the test period compared to preceding periods. The discussion noted different requirements for portable alcohol sensors for low blood alcohol concentration (zero tolerance for youth) and DWI (.08 g/dL or .10 g/dL for adults) enforcement and for tests without and with active subject participation.

Authors	Lestina, D. C., Greene, M., Voas, R. B., & Wells, J.
Year	1999
Title	**Sampling procedures and survey methodologies for the 1996 survey with comparisons to earlier national roadside surveys**
In	*Evaluation Review, 23*(1), 28–46.
Abstract	This article describes the multistage sampling system employed in the 1996 national roadside survey and compares it to the sampling methods employed in the two prior surveys in 1973 and 1986. Also described are the data collection procedures at the selected sites, the breath-test devices used to collect blood alcohol concentration (BAC) data, and the methods used to impute BAC values where breath-test measures were not obtained. Overall, almost twice as many (6,298 in 1996, compared to 3,698 in 1973 and 3,043 in 1986) drivers were interviewed in the most recent national survey as in the previous efforts. The procedures implemented in the three surveys are sufficiently similar to permit comparison of these surveys conducted at 10-year intervals.

Authors	Liedtke, A.J.; DeMuth, W.E.
Year	1975
Title	**Effects of alcohol on cardiovascular performance after experimental nonpenetrating chest trauma**
In	*Am J Cardiol.*; 35:243-250
Abstract	Electrocardiographic and hemodynamic correlates were recorded before and after a standardized nonpenetrating blow to the chest in 9 anesthetized control dogs (Group I), 5 dogs, pretreated with alcohol, 0.4 g/kg intravenously (Group II), and 12 dogs undergoing chest trauma after alcohol infusions (Group III). In animals in Group I, transient major arrhythmias, including complete heart block and ventricular tachycardia, occurred immediately after impact. One animal died with ventricular fibrillation. In the eight survivors these disturbances were accompanied by acute reductions in aortic pressure and cardiac index; values for both variables gradually increased after restoration of sinus mechanism. Alcohol alone (Group II) produced no significant alterations in either hemodynamic performance or electrical activity, but when combined with nonpenetrating chest injury (Group III) it caused a mortality rate of 92 percent, the majority of animals dying with electromechanical dissociation. Mean survival time in Group III was 23.1 plus and minus 6.5 (standard error of the mean) minutes compared with 80.3 plus and minus 9.6 minutes in Group I. At autopsy, minor cardiac lesions of either the pericardium or myocardium were observed in all animals in Groups I and III, but none were considered lethal. It is concluded that administration of alcohol, even in small doses, can effect catastrophic reductions in mechanical performance in the presence of otherwise nonfatal cardiac injury secondary to nonpenetrating chest trauma. The clinical implications of this association are discussed.

Authors	Luna, G. K., Maier, R. V., Sowder, L., Copass, M. K., & Oreskovich, M. R.
Year	1984
Title	**The influence of ethanol intoxication on outcome of injured motorcyclists**
In	*The Journal of Trauma,* 24(8):695-700
Abstract	Previous reports have failed to demonstrate a statistically significant adverse effect of acute ethanol intoxication in the well-resuscitated trauma patient. In the present study the prevalence of acute alcohol intoxication and its effect on outcome was analyzed in a homogenous population of young, previously healthy motorcycle crash victims (N = 134). The incidence of intoxication was 25 percent. The intoxicated cyclists were at fault for the crash 50 percent more often than the nonintoxicated cyclists and were found to wear helmets one third as frequently. Furthermore, the protective effect of helmet use as seen in the nonintoxicated group was lost in the intoxicated group, who sustained head injuries twice as frequently. Only patients with critical head injuries died and, although the ISS levels of those dying were similar in the two groups, the mortality following the critical head injury was twice as high among intoxicated patients (80% versus 43%). Overall, the intoxicated group had a fourfold increased mortality rate. Thus, although intoxicated motorcyclists comprised 25 percent of the total population, they represent a mere 9 percent of the helmet-wearing population, and, in contrast, 39 percent of the severely head-injured victims and a majority (57%) of the mortality rate.

Authors	McKnight A.J & McKnight, A.S.
Year	1989
Title	**Evaluation of the Pennsylvania Motorcycle Safety Program: Final report**
In	National Public Services Research Institute, Landover, MD, June 30, 1989.
Abstract	This report describes the methods and results of an evaluation of the 1986 Pennsylvania Motorcycle Safety Program. All of the 3,126 MSP students who graduated and were licensed in 1986 were compared with a matched sample of untrained 1986 licensees with respect to self-reported and officially reported crashes. The 12-month official and self-reported crash rates for the two groups were almost identical when the effects of differences in covariates affecting crashes were controlled statistically. Significantly higher crash rates were found for the higher mileage, high violation, motorcycle owning, less experienced male riders, in that order of magnitude.

Authors	Moskowitz, H., Burns, M., Fiorentino, D., Smiley, A., & Zador, P.
Year	2000, August
Title	**Driver characteristics and impairment at various BACs**
In	DOT HS 809 075. Washington, DC: Southern California Research Institute, National Highway Traffic Safety Administration. 60p.
Abstract	This study examined (1) the magnitude of alcohol impairment of driving skills as blood alcohol concentrations (BACs) varied from .00 to .10 g/dL, and (2) whether age, gender, and drinking practice characteristics of the subjects would differentially affect alcohol impairment in a sample of 168 subjects who were broadly representative of the driving population. Participants at BACs of .10 for moderate and heavy drinkers and .08 for light drinkers were examined using a driving simulator and a divided attention task. Results indicated that with increasing BAC, the magnitude of the impairment increased. Differences in the magnitude of alcohol impairment between categories of age, gender, and drinking practices were small, inconsistent in direction, and did not reach statistical significance. Perhaps significant differences would have been seen if there had been a wider range of subject characteristics and BACs. BACs over .10 or under .02 were not tested, and the sample did not include subjects under 19 years old and over the age of 70, or very light and very heavy drinkers. Data indicated that alcohol impairs driving-related skills at .02 BAC, the lowest level tested. Findings indicated that by .04 BAC, all measures of impairment that are statistically significant are in the direction of degraded performance. No evidence indicated that there was a level of BAC below which impairment does not occur.

Authors	National Advisory Council on Alcohol Abuse and Alcoholism
Year	1989
Title	**Extramural research**
In	National Institute on Alcohol Abuse and Alcoholism (NIAAA). Retrieved April, 2003, from www.niaaa.nih.gov/ResearchInformation/ExtramuralResearch/default.htm
Abstract	Not available.
Authors	National Bureau of Economic Research
Year	2000
Title	**Multiple cause-of-death mortality data from the national vital statistics system of the national center for health statistics**
In	National Center for Health Statistics. Retrieved April 2003 from www.nber.org/data/multicause.html
Abstract	Not available.
Authors	National Center for Statistics and Analysis
Year	2003
Title	**Crash outcome data evaluation system (CODES)**
In	National Highway Traffic Safety Administration. Retrieved March 2003 from www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/CODES.html
Abstract	Not available.
Authors	National Center for Statistics and Analysis
Year	2003
Title	**Fatality Analysis Reporting System (FARS)**
In	National Highway Traffic Safety Administration. Retrieved April 2003 from www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa//fars.html
Abstract	Not available.

Authors	National Commission Against Drunk Driving
Year	1995
Title	**National survey of drinking and driving attitudes and behavior: 1995: Part I**
In	National Highway Traffic Safety Administration. Retrieved April 2003 from the Web. (No Web site currently available)
Abstract	Not available.

Authors	National Highway Traffic Safety Administration
Year	1999, October
Title	**Traffic safety facts 1998: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System**
In	DOT HS 808 983. Washington, DC: National Highway Traffic Safety Administration, National Center for Statistics and Analysis
Abstract	In this annual report, Traffic Safety Facts 1998: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System, the National Highway Traffic Safety Administration (NHTSA) presents descriptive statistics about traffic crashes of all severities, from those that result in property damage to those that result in the loss of human life. Information from two of NHTSA's primary data systems has been combined to create a single source for motor vehicle crash statistics. The first data system, the Fatality Analysis Reporting System (FARS), is probably the better known of the two sources. Established in 1975, FARS contains data on the most severe traffic crashes, those in which someone was killed. The second source is the National Automotive Sampling System General Estimates System (GES), which began operation in 1988. GES contains data from a nationally representative sample of police-reported crashes of all severities, including those that result in death, injury, or property damage. The next two sections provide a brief description of FARS and GES. Both systems were designed and developed by NHTSA's National Center for Statistics and Analysis (NCSA) to provide an overall measure of highway safety, to help identify traffic safety problems, to suggest solutions, and to help provide an objective basis on which to evaluate the effectiveness of motor vehicle safety standards and highway safety initiatives. Data from these systems are used to answer requests for information from the international and national highway traffic safety communities, including State and local governments, Congress, Federal agencies, research organizations, industry, the media, and private citizens.

Authors	National Highway Traffic Safety Administration and Motorcycle Safety Foundation
Year	2000 November
Title	**National Agenda for Motorcycle Safety (NAMS)**
In	DOT-NHTSA & Motorcycle Safety Foundation. DOT HS 809 156
Abstract	The National Highway Traffic Safety Administration (NHTSA) partnered with the Motorcycle Safety Foundation (MSF), a national, nonprofit organization promoting the safety of motorcyclists, to provide the leadership and resources to create the National Agenda for Motorcycle Safety (National Agenda). The National Agenda is a strategic planning document designed to provide a shared vision for future motorcycle safety efforts by incorporating input from a broad, multi-disciplinary spectrum of stakeholders. To develop this National Agenda, NHTSA and MSF talked with members of the motorcycling community and selected eight individuals who accepted the opportunity to participate in this key national effort to promote motorcycle safety. These experts formed the Technical Working Group (TWG) responsible for drafting a motorcycle agenda for the future. The TWG, which met for the first time in October 1998, represented motorcyclists, motorcycle and traffic safety advocates, law enforcement, insurance, and health care professionals, and members of the safety research communities. Using the Haddon Matrix as the foundation, the TWG determined the best way to proceed was to examine each issue from the standpoint of where we are today, where we want to be in the future, and how is the best way to get there. The National Agenda provides a comprehensive look at issues associated with motorcycle safety. It discusses research needs, as well as human, social, vehicle, and environmental factors that influence motorcycle safety. Twenty-three issues are discussed in detail in the National Agenda for Motorcycle Safety.

Authors	National Highway Traffic Safety Administration
Year	2002
Title	**Traffic safety facts 2001: Motorcycles**
In	DOT HS 809 473. Washington, DC: National Center for Statistics & Analysis, National Highway Traffic Safety Administration
Abstract	A public information fact sheet on motor vehicle and traffic safety published by the National Highway Traffic Safety Administration's National Center for Statistics and Analysis. In 2001, 3,181 motorcyclists were killed and an additional 60,000 were injured in traffic crashes in the United States — 10 percent more than the 2,897 motorcyclist fatalities and 4 percent more than the 58,000 motorcyclist injuries reported in 2000.

Authors	National Highway Traffic Safety Administration
Year	2003
Title	**The crash injury research and engineering network (CIREN)**
In	National Highway Traffic Safety Administration. Retrieved April 2003 from www-nrd.nhtsa.dot.gov/departments/nrd-50/ciren/CIREN.html
Abstract	Not available.

Authors	National Highway Traffic Safety Administration
Year	2005
Title	**Traffic safety facts 2004: Motorcycles**
In	DOT HS 809 919. Washington, DC: National Center for Statistics and Analysis, National Highway Traffic Safety Administration
Abstract	In this annual report, Traffic Safety Facts 2004: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System, the National Highway Traffic Safety Administration (NHTSA) presents descriptive statistics about traffic crashes of all severities, from those that result in property damage to those that result in the loss of human life. Information from two of NHTSA's primary data systems has been combined to create a single source for motor vehicle crash statistics. The first data system, the Fatality Analysis Reporting System (FARS), is probably the better known of the two sources. Established in 1975, FARS contains data on the most severe traffic crashes, those in which someone was killed. The second source is the National Automotive Sampling System General Estimates System (GES), which began operation in 1988. GES contains data from a nationally representative sample of police-reported crashes of all severities, including those that result in death, injury, or property damage. The next two sections provide a brief description of FARS and GES. Both systems were designed and developed by NHTSA's National Center for Statistics and Analysis (NCSA) to provide an overall measure of highway safety, to help identify traffic safety problems, to suggest solutions, and to help provide an objective basis on which to evaluate the effectiveness of motor vehicle safety standards and highway safety initiatives. Data from these systems are used to answer requests for information from the international and national highway traffic safety communities, including state and local governments, the Congress, Federal agencies, research organizations, industry, the media, and private citizens.

Authors	Nelson, D., Sklar, D., Skipper, B., & McFeeley, P.J.
Year	1992
Title	**Motorcycle fatalities in New Mexico: The Association of Helmet Nonuse with Alcohol Intoxication**
In	*Annals of Emergency Medicine,* 21(3):279-283
Abstract	The study objective was to determine the relationship among helmet use, alcohol use, and ethnicity in people killed on motorcycles. A retrospective review of all motorcycle fatalities in New Mexico from 1984 through 1988 is described. The research sample included all decedents of motorcycle crashes in New Mexico from 1984 through 1988 with data obtained from a review of all autopsies, medical investigator reports, traffic fatality reports, and toxicological studies on fatally injured motorcyclists. Nine of the helmeted drivers (18%) were legally intoxicated compared with 67 of the nonhelmeted drivers (51%); 42 of the white non-Hispanic decedents (37%), 10 of Hispanic decedents (12%), and none of the Native-American decedents were wearing helmets. The head and neck region was the most severely injured body region in 42 of the nonhelmeted cases (84%) and in 8 of the helmeted cases (50%). It is concluded that there is an association between nonuse of helmets and alcohol intoxication in fatally injured motorcyclists in New Mexico, and that strategies for preventing motorcycle fatalities should address alcohol abuse and ethnicity in conjunction with helmet use.

Authors	Office for Human Research Protections
Year	2003
Title	**Human research protections**
In	U.S. Department of Health and Human Services. Retrieved April 2003 from http://ohrp.osophs.dhhs.gov/
Abstract	Not available.

Authors	Organisation for Economic Co-operation and Development (OECD)
Year	2001
Title	**Motorcycles: Common international methodology for on-scene, in-depth accident investigation**
In	Technical Expert Group of the Coordinating Group for Motorcycle Accident Investigations; of the Road Transport Research Programme; of the Directorate for Science Technology and Industry; of the Organisation for Economic Co-operation and Development (OECD/DSTI/RTR/RS9/TEG)
Abstract	This Common Methodology has been prepared on the basis of methods used in past in-depth motorcycle crash research. Its purpose is to define specific procedures for in-depth investigation of motorcycle crashes which are done in various countries, and which are to be compared, in order to define a minimum and common set of definitions and procedures.

Authors	Peek-Asa, C., & Kraus, J.F.
Year	1996
Title	**Alcohol use, driver, and crash characteristics among injured motorcycle drivers**
In	*Journal of Trauma: Injury, Infection, and Critical Care,* 41(6):989-993
Abstract	This study examined alcohol use among a large sample of motorcycle drivers who received medical treatment after a crash, to determine how crash characteristics vary with the use of alcohol. The subjects were over 3,000 motorcycle drivers who crashed between January 1, 1991, and December 31, 1992. All fatally injured motorcyclists in 11 California counties and a sample of nonfatally injured drivers treated in 28 hospitals were included in the study if a crash report and medical record were available. Alcohol was present in 42 percent of drivers tested for it. Drinking drivers were more likely to be speeding and less likely to wear helmets, and were more likely to have a single-motorcycle crash than nondrinking drivers. Crash characteristics, but not alcohol use, predicted injury severity. It is concluded that alcohol use remains a significant factor in motorcycle crashes.

Authors	Royal, D.
Year	2003
Title	**Volume I: Summary report, national survey of drinking and driving attitudes and behavior: 2001**
In	DOT HS 809 549. Washington, DC: National Highway Traffic Safety Administration.
Abstract	This report represents the findings on distracted (including cell phone use) and drowsy driving. The data come from a pair of studies undertaken by the National Highway Traffic Safety Administration (NHTSA) to better understand drivers' behaviors and attitudes regarding speeding, unsafe driving, distracted driving, and drowsy driving. This volume reports respondents' behaviors and attitudes on various topics related to distracted and drowsy driving. Volume II presents the data on speeding and unsafe driving, while Volume III describes the methods used to conduct the interview and analyze the data, and also contains the questionnaires. The data will be used to help identify the extent to which potentially distracting behaviors are undertaken by drivers and to understand the characteristics of those engaging in these behaviors so that programs can be developed to reduce these behaviors where they have been shown to be dangerous. The data come from two surveys each conducted among nationally representative samples of drivers during the Spring of 2002. Interviews were conducted with a total of 4,010 drivers in the United States. The survey findings show that most drivers at least occasionally engage in behaviors that draw some of their attention away from their driving task. The most common of these behaviors include general activities of talking with other passengers (81%), changing radio stations or CDs (66%), and eating or drinking while driving (49%). While it is estimated that more than a billion driving trips are made weekly by drivers engaging in each of these behaviors, fewer than one in four drivers perceive these particular activities as distracting or as making driving much more dangerous. About one in four drivers uses a cell phone while driving for either inbound (26%) or outbound (25%) calls, while a similar proportion deals with children in a back seat (24%). Close to one-half of drivers perceive these behaviors as making driving much more dangerous, although drivers who use cell phones are only half as likely as nonusers to feel cell phone use is dangerous. Regarding drowsy driving, over a third (37%) of drivers report having nodded off or fallen asleep at least once since they began driving. Eight percent have done so in the past six months. Nearly half of drivers who nodded off report doing so between 9 p.m. and 6 a.m.. About one quarter (26%) of drivers have been involved in a crash in the past five years. About 3.5 percent of drivers attribute a crash they've had in the past five years to their being distracted (including 0.8% looking for something outside of their vehicle and 0.7% dealing with children), 0.7 percent attribute a crash they've had to drowsy driving, while 0.1 percent of drivers attribute a crash they've had to their cell phone use.

Authors	Shankar, U.
Year	June 2001
Title	**Recent trends in fatal motorcycle crashes**
In	DOT HS 809 271. National Highway Traffic Safety Administration.
Abstract	Motorcyclist fatalities decreased each year from 1993 to 1997, reaching a historic low of 2,116 in 1997. In 1998 and again in 1999 this trend was reversed with increases to 2,294 (8.7%) in 1998 and 2,472 (7.8%) in 1999. The overall increase in motorcyclist fatalities from 1997 to 1999 was 356 (16.8%). This reversal in the fatality trend prompted an analysis into the possible reasons for the surge in fatalities in recent years. The objective of this study is to analyze the combined motor vehicle crash data from the Fatality Analysis Reporting system (FARS) with the Motorcycle Industry Council (MIC), Federal Highway Administration (FHWA) and the U.S. Census Bureau for the recent increases in motorcyclist fatalities. The combined data is then used to calculate rates and identify possible causes for the recent increases in motorcyclist fatalities for developing crash prevention programs.

Authors	Shankar, U.G.
Year	2003, April
Title	**Alcohol involvement in fatal motorcycle crashes**
In	National Highway Traffic Safety Administration
Abstract	The National Highway Traffic Safety Administration's (NHTSA) National Center for Statistics and Analysis (NCSA) released a comprehensive analysis of fatal motorcycle crashes titled "*Recent Trends in Fatal Motorcycle Crashes*" (*DOT HS 809 271*) in July 2001 and two research notes "*Motorcyclist Fatalities in 2000*" (*DOT HS 809 387*) in December 2001 and "*Motorcyclist Fatalities in 2001*" (*DOT HS 809 548*) in February 2003. The report examined trends and rates of motorcycle riders (motorcyclists) killed in motor vehicle crashes during the 10-year period 1990-1999, and the research notes compared the trends and rates in the report with the 2000 and 2001 data. This research note focuses in detail on the problem of alcohol involvement in fatal motorcycle crashes based on who is involved, where and when the crashes occur, and other crash characteristics.

Authors	Stein, A.C., Allen, R.W., & Cook, M.L.
Year	1985
Title	**The interaction of alcohol and fatigue on driver simulator performance**
In	Proceedings of the 29th Annual Conference of the American Association for Automotive Medicine, Washington, DC: 7 Oct - 9 Oct 1985 (pp. 91-104).
Abstract	Interactive driving simulators have provided a safe and efficient mechanism for studying the effects of impairing agents on driving performance. Unfortunately, in the past, simulators have been limited in their ability to test drivers for long periods of time. A methodology was developed for testing drivers over a two-hour time period and for analyzing the possible effects that this long driving period had on driving performance. The basic results of the study are presented and effects of alcohol and fatigue on driver performance variables which may lead to crash involvement are discussed.

Authors	Stewart, D.E., & Lawson, J.J.
Year	1987
Title	**Results and inferences from the 1986 night-time surveys of driver's alcohol use**
In	*Proceedings of the Canadian Multidisciplinary Road Safety Conference* v. *Calgary, Canada*
Abstract	No abstract available

Authors	Subramanian, R.
Year	June 2002
Title	**Transitioning to multiple imputation - a new method to estimate missing blood alcohol concentration (BAC) values in FARS**
In	NHTSA Technical Report. DOT HS 809 403. Washington, DC: Mathematical Analysis Division, National Center for Statistics and Analysis, National Highway Traffic Safety Administration.
Abstract	The National Center for Statistics and Analysis (NCSA) of the National Highway Traffic Safety Administration (NHTSA) has undertaken several approaches to remedy the problem of missing blood alcohol test results in the Fatality Analysis Reporting System (FARS). The current approach employs a linear discriminant model that estimates the probability that a driver or nonoccupant has a blood alcohol concentration (BAC) in grams per deciliter (g/dL) of .00, .01 to .09, or .10 and greater. Estimates are generated only for drivers and nonoccupants (pedestrians, pedalcyclists) for whom alcohol test results were not reported. Beginning with the 2001 data, NHTSA will transition to Multiple Imputation, a new method to estimate missing BAC in FARS. The publications for the 2001 data will reflect the estimates of alcohol involvement generated using Multiple Imputation. The new methodology improves on the current model by imputing specific values of BAC across the full range of possible values rather than estimating probabilities. Imputing 10 values of BAC for each missing value will permit the estimation of valid statistics such as variances, measures of central tendency, confidence intervals, and standard deviations.

Authors	Substance Abuse and Mental Health Services Administration
Year	2003
Title	**National household survey on drug abuse (NHSDA)**
In	U.S. Department of Health and Human Services, SAMHSA Office of Applied Studies. Retrieved April 2003 from www.oas.samhsa.gov/nhsda.htm
Abstract	Not available.

Authors	Terhune, K.W.
Year	1983
Title	**An evaluation of responsibility analysis for assessing alcohol and drug crash effects**
In	*Accident Analysis and Prevention,* 15, 237-246.
Abstract	This paper evaluates judgments of driver crash responsibility to estimate alcohol and drug impairment effects when exposure data are unavailable to calculate crash risks. Previous studies using responsibility judgments provided some evidence that responsibility is related to BAC. Other studies, some inferring responsibility, indicated a relation between responsibility and relative crash risk. Data are presented showing that responsibility judgments with a rating scale have high interrater reliability, and systematic relations with BAC suggest some validity in the ratings. A method is demonstrated for estimating relative crash risk from responsibility judgments with crash data, and the limitations of responsibility analysis are discussed. While alcohol and drug impairment effects are best determined with relative crash risks determined from crash and exposure data. Responsibility analysis may provide useful indications in the absence of exposure data.

Authors	Terhune, K.W., Ippolito, C.A., Hendricks, D.L., Michalovic, J.G., Bogema, S.C., Santinga, P., Blomberg, R., & Preusser, D.F.
Year	1992, October 30
Title	**The incidence and role of drugs in fatally injured drivers**
In	DOT HS 808 065. Washington, DC: National Highway Traffic Safety Administration
Abstract	Blood specimens were collected from a sample of 1,882 drivers from 7 States, during 14 months in the years 1990 and 1991. The sample comprised operators of passenger cars, trucks, and motorcycles who died within four hours of their crash. Alcohol and 43 other drugs were studied to determine their prevalence rates; their casual role in the crashes; and associated driver, vehicle, and crash factors. Coroner or medical examiner reports were obtained on all cases to ascertain cause of death, time of death, and other details. Police crash reports and reports from the Fatality Analysis Reporting System (FARS) were also obtained. Alcohol was found in 51.5 percent of the specimens, and other drugs were found in 17.8 percent. Other than alcohol, the most prevalent drugs were cannabis (6.7%), cocaine (5.3%), benzodiazepine tranquilizers (2.9%), and amphetamines (1.9%). Responsibility analysis was used to suggest impairment effects, which were found for alcohol alone and for alcohol-drug combinations. Further research was recommended to follow up indications of alcohol-drug additive effects.

Authors	Traffic Tech
Year	2002, February
Title	**Characteristics of drivers involved in motor vehicle injuries and fatalities**
In	National Highway Traffic Safety Administration. Retrieved April 2003 from www.nhtsa.dot.gov/people/outreach/traftech/tt266.htm
Abstract	What groups of drivers are at high risk of being at-fault in multi-vehicle crashes or of being involved in a single-vehicle crash in which they died? Do factors such as drivers' prior behaviors, gender, race, education level, and annual miles driven influence risk? What groups of drivers are at high risk of being killed in crashes, based on drinking behavior, including binge drinking of five or more drinks on one occasion, problem drinking, drinking and driving, and seat belt use? To answer these questions, the National Highway Traffic Safety Administration (NHTSA) sponsored a study by the Center for Injury Research and Policy at Johns Hopkins School of Public Health to analyze data from the National Mortality Followback survey (NMFS), the 1996 National Roadside Survey (NRS), the 1993 National Survey of Drinking and Driving Attitudes and Behavior (NSDDAB), and the Fatality Analysis Reporting System (FARS) in three separate analyses.

Authors	Turner, P.A., Georggi, N., & McGovern, B.
Year	2000
Title	**Florida alcohol-related motorcycle crash study: Evaluation of alcohol-related motorcycle crashes & recommended countermeasures, 1993-1997**
In	Center for Urban Transportation Research, University of South Florida
Abstract	The first research objective was to obtain a better understanding of the characteristics of alcohol-related motorcycle crashes in Florida. This objective was accomplished by collecting data over a five-year period (1993-1997) on alcohol-related motorcycle crashes and analyzing the data using statistical software. The second research objective was to identify potential countermeasures that may be effective at reducing alcohol-related motorcycle crashes in Florida. This objective was accomplished by conducting a national survey of motorcycle safety programs and assimilating information on countermeasures targeting the motorcycle-alcohol problem. The report is organized in five chapters. Chapter 1 provides an introduction. Chapter 2 details the research methodology used to analyze alcohol-related motorcycle crashes and survey motorcycle safety programs nationally. Chapter 3 summarizes the data analysis and presents the results in graphical and tabular format. Chapter 4 discusses the results from the national survey. The final chapter includes the research conclusions and recommendations.

Authors	Turner, P. A. & Georggi, N.
Year	2001
Title	**The motorcycle-alcohol crash problem in Florida: Identification of characteristics and countermeasures**
In	International Motorcycle Safety Conference, 1993-1997, University of South Florida
Abstract	Much progress has been made in reducing alcohol-related crash fatalities involving motor vehicles. However, the same success with addressing the public health issue associated with alcohol use and motorcycling has not been demonstrated. Operating a motorcycle requires more physical skill, coordination, and balance than driving a car, and the use and abuse of alcohol impairs those skills. Because of the problem associated with motorcycling and alcohol is significant in Florida, the Florida Department of Transportation (FDOT) contracted with the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) to conduct a comprehensive analysis of alcohol-related motorcycle crashes. A major research objective was to obtain a better understanding of the causes and characteristics of alcohol-related motorcycle crashes in Florida. This objective was accomplished by analyzing five years of State traffic crash data on alcohol-related motorcycle crashes. The study examined human-related and physical aspects of alcohol-related motorcycle crashes to help establish an "identity" to this crash type. Human-related crash aspects examined included age and gender, alcohol use, licensing status, and helmet usage. Physical crash aspects examined include temporal patterns such as time-of-day, day-of-week, and monthly trends; and contributing factors such as first harmful event and road, environmental, and human factors that cause bodily injuries and/or property damage. A second research objective was to identify potential interventions that may be effective at reducing alcohol-related motorcycle crashes in Florida. This objective was accomplished by conducting a national and statewide survey of motorcycle safety programs and assimilating information on innovative programs targeting the motorcycle alcohol problem. Major study recommendations include increasing efforts to get more motorcyclists properly licensed, greater exposure of messages to motorcyclists about the dangers of drinking and riding, and more focused statewide public education and information campaigns. The study concludes with five major categories of countermeasures and recommendations to address the motorcycle alcohol problem including public information and education (PI&E) campaigns, promotional activities, enforcement efforts, community-based interventions, and data collection needs.

Authors	Voas, R. B., & Taylor, E.
Year	1997
Title	**Attitudes and expectancies of California drivers subject to vehicle impoundments**
In	National Highway Traffic Safety Administration
Abstract	On January 1, 1995, the State of California implemented two significant new pieces of legislation directed at reducing illicit driving by individuals who were suspended or never licensed to drive in California. The broader of these bills provides that police officers apprehending an individual who is driving-while-suspended (DWS) or driving-while-unlicensed (DWU) can immediately seize the vehicle and have it towed and impounded for a period of thirty days, subject to a hearing for the vehicle owner. The second piece of legislation provides that, upon a second offense for driving while suspended or driving while unlicensed, the vehicle can be seized at the time of apprehension and forfeited to the local government under civil forfeiture procedures. The National Highway Traffic Safety Administration entered into a cooperative agreement with the California Department of Motor Vehicles, Research and Development Branch and the Pacific Institute for Research and Evaluation to conduct a three-year study to evaluate the impact of this legislation on illicit driving and highway crashes. This is a preliminary report on that effort which describes the research plan and presents some initial data from a survey of DWS and DWU offenders.

Authors	Voas, R. B., Wells, J., Lestina, D., Williams, A., & Greene, M.
Year	1998
Title	**Drinking and driving in the United States: The 1996 National Roadside Survey**
In	*Accident Analysis and Prevention, 30*(2), 267–275. Should be NHTSA pub. DOT HS 809 019
Abstract	Following the same general principles of its two predecessors in 1973 and 1986, the 1996 National Roadside Survey of weekend, nighttime drivers in the 48 contiguous States interviewed and breath tested over 6,000 noncommercial four-wheel vehicle operators between September 6 and November 9, 1996. Results indicated that the total number of drinking drivers fell by about one-third between 1986 and 1996; however, there was no significant change in the number of drivers at or above blood alcohol concentrations (BACs) of .05. Compared to 1973, the proportion of female drivers on the roads during weekend nights has increased significantly. Moreover, relative to males, the proportion of female drivers who have been drinking has increased over the last decade. The number of drivers under the age of 21 with a BAC at or above .10 decreased significantly from 1986 to 1996.

Authors	Waller, P.F., Stewart, J.R., Hansen, A.R., Stutts, J.C., Popkin, C.L., & Rodgman, E.A.
Year	1986
Title	**The potentiating effects of alcohol on driver injury**
In	*JAMA;* 256:1461-1466
Abstract	It is well established that alcohol (ethanol) is associated with increased probability of traumatic injury. This relationship has been attributed to alcohol's impairment of judgment and psychomotor performance, leading to increased probability of an injury-producing mishap. Once a crash occurs, it is widely believed that alcohol may protect against injury. However, controlled laboratory studies using animal models indicate that alcohol exacerbates the injurious effects of trauma. In this study, detailed analysis of data from more than 1 million drivers involved in motor vehicle crashes indicates that when the effects of injury-related variables such as seat belt use, vehicle deformation, vehicle speed, driver age, and vehicle weight are taken into account, the drinking driver is more likely to suffer serious injury or death compared with the nondrinking driver. These findings do not support the widespread belief that alcohol is protective against injury, but rather indicate that alcohol increases vulnerability to injury in any given crash.

Authors	Weir, D.H., and Clark, A.J.
Year	1995
Title	**A survey of mid-level driving simulator**
In	SAE paper 950172
Abstract	No abstract available

Authors	Weir, D.H., Zellner, J.W., & Teper, G.L.
Year	May 1979
Title	**Motorcycle handling, Vol II: Technical Report**
In	DOT HS 804191. Washington, DC: National Highway Traffic Safety Administration.
Abstract	To better define and explore the potentially important relations between handling and safety performance of motorcycles, the National Highway Traffic Safety Administration sponsored this research contract with objectives that can be summarized as follows: to evaluate principal performance response parameters for a sample for motorcycles as a function of a broad range of operational variables, utilizing previously developed full-scale test and simulation methods; to develop additional test procedures that provide discriminating measures of motorcycle performance during combined cornering and braking, and cornering and acceleration influences, and possible on-center control instabilities; and to correlate performance parameters for directional control and transient handling with subjective evaluations, as a first step toward establishing the meaningfulness of test procedure results in the crash avoidance sense.

Authors	Zador, P.L.
Year	1991
Title	**Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex**
In	*Journal of Studies on Alcohol,* 52(4):302-310
Abstract	The relative risks of fatal crash involvement at various blood alcohol concentrations (BACs) were examined using data on fatal driver injuries from the Fatality Analysis Reporting System in conjunction with driver exposure data from the second national roadside breath-testing survey. Based on driver fatalities in single-vehicle crashes, it was estimated that each .02 percentage increase in the BAC of a driver with BAC >.00 nearly doubles the risk of being in a fatal crash. Crash risk was found to increase with increasing BAC among all of the six age and sex groups studied. At BACs in the .05-.09 g/dL range, the likelihood of a crash was at least nine times greater than at zero BAC for all age groups. Younger drivers with BACs in the .05-.09 range had higher relative-risks than older drivers, and females had higher relative-risks than males. At very high BACs (at or above .15 g/dL), the risk of crashing was 300 to 600 times the risk at zero or near-zero BACs. These relative risk estimates are considerably higher than estimated in other studies, but other studies have based their estimates on all crashes rather than single-vehicle crashes only. In this study, relative risks were also lower when based on driver fatalities in all crashes. However, when plausible assumptions were made about the BAC distributions of other participants in multiple-vehicle crashes (whose actual BAC is often unknown), the relative risks based on the maximum BAC of the crash participants were nearly as high as those estimated in single-vehicle crashes.

Authors	Zador, P. L., Krawchuk, S. A., & Voas, R. B.
Year	2000
Title	**Alcohol-related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: An update using 1996 data**
In	*Journal of Studies on Alcohol,* 61(3):387–395.
Abstract	OBJECTIVE: To re-examine and refine estimates for alcohol-related relative risk of driver involvement in fatal crashes by age and gender as a function of blood alcohol concentration (BAC) using recent data. METHOD: Logistic regression was used to estimate age-/gender-specific relative risk of fatal crash involvement as a function of the BAC for drivers involved in a fatal crash and for drivers fatally injured in a crash, by combining crash data from the Fatality Analysis Reporting System with exposure data from the 1996 National Roadside Survey of Drivers. RESULTS: In general, the relative risk of involvement in a fatal vehicle crash increased steadily with increasing driver BAC in every age/gender group among both fatally injured and surviving drivers. Among 16- to 20-year-old male drivers, a BAC increase of .02 g/dL was estimated to more than double the relative risk of fatal single-vehicle crash injury. At the midpoint of the .08 - .10 BAC range, the relative risk of a fatal single-vehicle crash injury varied between 11.4 (drivers 35 and older) and 51.9 (male drivers, 16-20). With only very few exceptions, older drivers had lower risk of being fatally injured in a single-vehicle crash than younger drivers, as did women compared with men in the same age range. When comparable, results largely confirmed existing prior estimates. CONCLUSIONS: This is the first study that systematically estimated relative risk for drinking drivers with BACs between .08 and .10 g/dL (these relative risk estimates apply to BAC range midpoints at .09 g/dL). The results clearly show that drivers with a BAC under .10 pose highly elevated risk both to themselves and to other road users.

Authors	Zellner, J.W., & White, M
Year	1981, November
Title	**Advanced motorcycle braking: Final report**
In	PB 81-206443, 81-206450. National Highway Traffic Safety Administration
Abstract	No abstract available

Appendix B
Detailed List of Documents Reviewed But Not Referenced

Authors	Baker, S. P., & Fisher, R. S.
Year	1977
Title	**Alcohol and motorcycle fatalities**
In	*American Journal of Public Health,* 67(3):246-249
Abstract	Results of a retrospective study of a series of 99 fatal motorcycle crashes in Maryland using police and medical examiner records are presented. Blood alcohol concentrations were determined for 62 motorcycle drivers; measurable amounts of alcohol were found in two-thirds (41) of the drivers, while one-half (31) had illegally high concentrations of 100 mg/100 ml or more. Police reports, however, mentioned alcohol in only nine instances. High blood alcohol concentrations were found most commonly among drivers ages 20-34. These data add to the evidence that impairment by alcohol is an important contributing factor in fatal motorcycle crashes.

Authors	Billings, C. E., Wick, R. L. Jr., Gerka, R. J., & Chase, R. C.
Year	1972
Title	**The effects of alcohol on pilot performance during instrument flight**
In	Aviation Medicine Research Laboratory, Paper No.FAA-AM-72-4, 1-40
Abstract	Sixteen instrument-rated pilots, eight of whom were experienced professional aviators flew Instrument Landing System approaches in a Cessna 172 under simulated instrument flight conditions while sober and while under the influence of 40, 80, and 120 milligrams percent of blood ethyl alcohol. The data collected during these approaches included continuous measurement of aircraft position with respect to localizer and glide path centerlines and airspeed. Note was made of procedural errors committed during the flights. The subjects showed significant and progressive decremental effects of alcohol at all levels studied. The more experienced pilots maintained their ability to guide the aircraft better than did the less experienced subjects, particularly at high levels of blood alcohol. Both groups, however, demonstrated progressive increases in the number of serious procedural errors with increasing levels of alcohol. It is concluded that even 40 milligrams percent of blood alcohol exerts decremental effects on performance which are incompatible with flight safety.

Authors	Breslow, N.E. and Day, N.E.
Year	1987
Title	**Statistical methods in cancer research: Volume I: The design and analysis of case control studies**
In	IARC Scientific publication 82, 1987.
Abstract	Abstract not available.

Authors	Breslow, N.E. and Day, N.E.
Year	1987
Title	**Volume II: The design and analysis of cohort studies**
In	IARC Scientific publication 82, 1987.
Abstract	Abstract not available

Authors	Brewer, R. D., Morris, P. D., Cole, T. B., Watkins, S., Patetta, M. J., & Popkin, C.
Year	1994
Title	**The risk of dying in alcohol-related automobile crashes among habitual drunk drivers**
In	*New England Journal of Medicine,* 331(8):513-517
Abstract	The risk of dying in alcohol-related automobile crashes for habitual drunk drivers was assessed. The research sample included files of drivers who died in motor vehicle crashes from 1980 through 1989 (N=1,646 case drivers and N=1,474 control drivers) whose driver-history files were analyzed. Driver history files for the five years before each death were searched to identify arrests for driving while impaired (DWI). The following results of the study were seen: (1) greater likelihood for case drivers to have been arrested for DWI; (2) a finding that case drivers 21 to 34 years of age were 4.3 times more likely than control drivers to have been arrested for DWI; (3) a finding that case drivers 35 years of age or older were 11.7 times more likely; and (4) apparent increase in the strength of the association with the number of prior arrests for DWI. It is concluded that arrests for driving while impaired are associated with the risk of eventual death in an alcohol-related crash.

Authors	Chesher, G., & Greeley, J.
Year	1992
Title	**Tolerance to the effects of alcohol**
In	*Alcohol Drugs and Driving,* 8(2):93-106
Abstract	This paper reviews the literature concerning the phenomenon of tolerance to alcohol. The experimental evidence reporting the effects of alcohol tolerance on the signs of drunkenness as well as on the performance of psychomotor tasks is described. The review is divided into two parts. Part I examines the extent and effect of tolerance at what might be termed “social” levels of alcohol use. Part 2 examines the small but unquantified proportion of the population who exhibit a very high degree of alcohol tolerance.

Authors	Chipman, M. L., MacGregor, C. G., Smiley, A. M., & Lee-Gosselin, M.
Year	December 1992
Title	**Time versus distance measures of exposure in driving surveys**
In	*Accident Analysis & Prevention, 24*(6):679-684. or AAAM Annual Meeting, 34:421-432
Abstract	A survey of drivers carried out in Ontario in 1988 has provided data on time spent driving as well as the distances driven for licensed drivers of both sexes in six age groups and three regions. Substantial differences were found in times and distances, but men spent only 30 percent more time driving than women; speed, averaged over each day's driving, was lower for older drivers than for younger drivers. Differences in speed reflect differences in the driving done in urban or rural areas, and differences in the opportunity for road crashes; such differences, whether based on units of time or distance, will affect both the comparisons of crash rates and the perceptions of risk among different groups of drivers. A definition of exposure to risk of road crash is required that considers both time and distance appropriately.

Authors	De Silva, M., Nellihala, L.P., & Fernando, D.
Year	2001, March
Title	**Pattern of accidents and injuries involving three-wheelers**
In	*Ceylon Medical Journal,* 46(1):15-6
Abstract	OBJECTIVE: To study the pattern of injuries and some causative factors of three-wheeler related crashes. DESIGN: Prospective descriptive study. SETTING: Accident unit, Colombo South Teaching Hospital, Kalubowila. METHODS: One hundred patients admitted to Colombo South Teaching Hospital with three-wheeler related crashes were interviewed, examined within 24 hours of admission and followed up by using a standard questionnaire. Detailed descriptions of the crash and the types of injuries were recorded. RESULTS: 54 crashes took place during daytime 7 a.m. to 7 p.m.) and the passengers were the most common victims (40%). Soft tissue injury was the most common injury observed (75%). The second most common type of injury was long bone fractures (21%). Toppling due to a sudden turn of the vehicle accounted for 30 percent of crashes. Of 28 drivers in the study group, 25 admitted breaking the handle-lock to increase the vehicle's turning angle. Toppling due to a sudden turn was identified as the cause of the crash in all those who had interfered with the handle-lock. At the time of the crash, 89 precent of the drivers and 28.1 precent of pedestrians were under the influence of alcohol. Alcohol was related to 67.4 percent of the night crashes. CONCLUSIONS: Alcohol consumption was recognized as a major contributory factor, in particular for night crashes. A strong association was observed between mechanical alteration of the vehicle's handle-lock and the risk of crash. Introduction of legislation to prohibit handle-lock alteration and strict implementation of the law regarding driving under the influence of alcohol would help to reduce three-wheeler related crashes.

Authors	DeYoung, D. J., Peck, R. C., & Helander, C. J.
Year	1997
Title	**Estimating the exposure and fatal crash rates of suspended/revoked and unlicensed drivers in California**
In	*Accident Analysis & Prevention,* 29(1):17-23
Abstract	There have been a number of studies conducted during the past three decades that show that most suspended/revoked (S/R) drivers violate their license action and continue to drive during their period of disqualification. Traffic safety researchers also suspect that S/R drivers are overinvolved in traffic crashes, but this is difficult to demonstrate because of the lack of good data on the prevalence among all road users. This paper applies the quasi-induced exposure method to fatal crash data obtained from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System, to generate exposure and crash rate estimates for S/R drivers in California. The results show exposure rates of 8.8 percent and 3.3 percent for S/R and unlicensed drivers, respectively, and that, compared to validly licensed drivers, the former are overinvolved in fatal crashes by a factor of 3.7:1 and the latter 4.9:1. These findings provide support for efforts to better control S/R and unlicensed drivers. The paper also discusses serious limitations to using quasi-induced exposure to estimate the numbers of such drivers on California roads, and concludes that it is not suited to this task.

Authors	Dionne, G., Desjardins, D., Laberge-Nadeau, C., & Maag, U.
Year	June 1995
Title	**Medical conditions, risk exposure and truck drivers' crashes: An analysis with count data regression models**
In	*Accident Analysis & Prevention, 27*(3):295-305, or AAAM Annual Meeting, 37:173-188
Abstract	Recent studies do not agree on the possible relationship between medical conditions and traffic safety; most of them do not control for exposure factors. This problem has become more pertinent for scientific studies because of litigation that showed that present regulations about access to driver permits might contravene human rights legislation. In this study, the authors estimate the effect of different medical conditions on truck drivers' distribution of crashes. Their data and models permit simultaneous control for age; medical conditions; exposure factors measured by hours, kilometers, and qualitative factors; and other characteristics of truck drivers. Their results show that diabetic truck drivers of the permit class for straight trucks have more crashes than drivers in good health. No other studied medical condition has a significant effect on individual crash distributions. Many risk exposure variables are also significant. The effect of age is discussed in detail.

Authors	Dischinger, P. C., Soderstrom, C. A., Shankar, B. S., Cowley, R. A., & Smialek, J. E.
Year	1988
Title	**The relationship between use of alcohol and place of death in vehicular fatalities**
In	AAAM Annual Meeting, 32:299-312
Abstract	No abstract available

Authors	Dischinger, P. C. & Cowley, R. A.
Year	1989
Title	**Alcohol use among victims of vehicular crashes admitted to a Level I Trauma Center**
In	AAAM Annual Meeting, 33:17-28
Abstract	No abstract available

Authors	Fell, J. C.
Year	1987
Title	**Alcohol involvement rates in fatal crashes: A focus on young drivers and female drivers**
In	AAAM Annual Meeting, 31:1-32
Abstract	Statistics are given to show that when alcohol involvement in fatal crashes is expressed in rates per mile driven, per licensed driver and per capita, young drivers have involvement rates two to six times those of older drivers. Female drivers ages 21-24 have relatively high alcohol intoxication rates in fatal crashes (compared to other female age groups). Female drinking and driving does not appear to have changed over the past four years for that age group. Young driver alcohol involvement rates have been decreasing. Minimum drinking age 21 laws along with grassroots activist groups and other alcohol programs probably played key roles in this decrease. It is suggested that the next generation target group might be drivers in their 20s, especially 21- to 24-year-olds.

Authors	Ferguson, S.A., Wells, J.K., & Lund, A.K.
Year	1995
Title	**The role of passive alcohol sensors in detecting alcohol-impaired drivers at sobriety checkpoints**
In	*Alcohol Drugs and Driving,* 11(1):23-30
Abstract	Sobriety checkpoints can be an important deterrent to alcohol-impaired driving if they are conducted frequently. However, for a sobriety checkpoint to be an effective deterrent, the police officers must be reasonably competent in identifying the alcohol-impaired drivers passing through it. Officers often have little time and few cues on which to make judgments about impairment. In this study, passive alcohol sensors were used by police officers as a screening device to provide an objective indication of alcohol in the driver's breath. Police officers who were using standard checkpoint procedures identified 26 percent of drivers with blood alcohol concentrations between .05 and .10 g/dL and 55 percent of drivers with blood alcohol concentrations of .10 g/dL or higher. When officers used the passive alcohol sensors, these detection rates increased to 39 percent and 71 percent, respectively.

Authors	Foss, R. D., & Bierness, D. J.
Year	1996
Title	**Drinking passengers and their drivers: Roadside survey results**
In	Paper presented to the 40th Annual Proceedings of the Association for the Advancement of Automotive Medicine, 1996.
Abstract	Among the approaches suggested for dealing with drinking and driving is for an unimpaired passenger to drive. However, at present little is known about the BACs of injured or killed passengers. A few studies have examined BACs of injured or killed passengers. We provide passenger BAC data for a representative sample of the nighttime driving population. In those vehicles with two or more passengers and at least one drinker, the passenger had the higher BAC in 68 percent of cases. However, 61 percent of legally impaired drivers had no passenger and among legally impaired drivers with a passenger, 53 percent of passengers also had an illegal BAC. Virtually all research on drinking and driving to date has focused, understandably, on drivers. However, in order to know whether programs designed to move drinkers out of the driver's seat and into other positions in vehicles or into other modes of transportation altogether, information is needed about passengers in automobiles and taxicabs, as well as mass transit passengers, and among pedestrians. Waller (1972) reported on alcohol consumption by fatally injured passengers as well as drivers in a small California study conducted in the early 1960s. He found that only about one in four passengers of impaired drivers would be been a suitable alternate driver. However, this study was conducted long before the idea of using a designated driver was promoted. In a study of over 20,000 casualty traffic crashes in British Columbia, Mercer (1984) found that passengers in the same vehicle as a drinking driver were the most likely victim (besides the drinking driver). Passengers with drinking drivers accounted for 5 percent of persons injured or killed by a drinking driver; passengers of sober drivers accounted for only 35 percent of their victims. Soderstrom, Dishinger, & Kerns (1996) examined BAC data for 109 pairs of drivers and passengers admitted to a Level I Trauma center in Baltimore. When both occupants had been drinking, the driver had the higher BAC in 68 percent of cases. When only one of the pair was BAC positive, it was more likely to be the driver than the passenger (58% versus 2%). In a similar study using national data from the U.S. Fatality Analysis Reporting System, Isaac, Kennedy, & Graham (1995) examined pairs of fatally injured drivers and passengers. In about one-third of the crashes examined, the passenger had a markedly lower BAC than the driver, and in 22 percent of crashes studied, the driver's BAC was .08 or above while at least one passenger had a BAC lower than .05. In a recent study of 2,606 fatally injured motor vehicle crash victims in Ontario, Bierness et al. (1995) reported that less than 20 percent of fatally injured passengers age 16 and older were tested for alcohol. Nevertheless, among the relatively small number of cases that were tested, there is a strong relationship between alcohol use among passengers and drivers riding in the same vehicle, as was also reported by Soderstrom et al. (1996) and Isaac et al. (1995). Among passengers who tested positive for alcohol, 86 percent were riding in a vehicle operated by a driver who had also been drinking. On the other hand, all fatally injured passengers who tested negative for alcohol were riding with a non-drinking driver. The tendency for drinkers to ride together in the same vehicle highlights the need for programs that provide drinkers with safe transportation home. For example, designated driver programs involve having one member of a group refrain from consuming alcohol. This person then serves as the driver for the group. The data presented above, however, indicate that passengers don't necessarily make good decisions about their choice of driver. The extent to which such programs are being used, and being used effectively, is not known. The present paper provides evidence that sheds some much needed light on the transportation of drinkers besides drivers in the driving population at large, rather than among those injured or killed in crashes. In particular, to supplement information available from the studies cited above, we provide data about the BACs of passengers in a sample of vehicles representative of the nighttime driving population.

Authors	Foss, R.D., Stewart, J.R., & Reinfurt, D.W.
Year	2001, July
Title	**Evaluation of the effects of North Carolina's 0.08% BAC law**
In	*Accident Analysis & Prevention,* 33(4):507-17
Abstract	This study was conducted to determine whether the lowered BAC limit for drivers in North Carolina resulted in fewer alcohol-related motor vehicle crashes. We used time-series analysis to examine several indicators of alcohol involvement in both injury and fatal crashes between 1991 and 1996. Data from North Carolina crash files as well as the Fatality Analysis Reporting System (FARS) are used. We also examined several indicators used in previous research on lower BAC limits using a before/after design to compare North Carolina with 37 States that did not change their BAC limit for 24 months before and after the BAC limit was lowered. When controlling for the preexisting downward trend in drinking driver crashes, along with other pertinent factors such as amount of travel and number of weekends per month, there was no evidence of either a significant shift or a change in the downward trend of alcohol-related crashes associated with the lowered BAC limit. In conclusion, although the lower BAC limit was actively enforced and a substantial proportion of drinkers were aware of the new BAC limit, the drinking-driving population in North Carolina, at the time the lower limit took effect in October 1993, was simply unresponsive to this change.

Authors	Fosseus, C.G.
Year	1983
Title	**Motorcycle accidents and alcohol. A survey of fatalities in the Cape Peninsula**
In	*South African Medical Journal,* 64:159-160
Abstract	Autopsy was performed on a total of 48 motorcycle crash victims (39 riders and 9 passengers) in Cape Town during 1982. Thirty-nine (81%) were under 30 years of age, while 61.3 percent of the riders tested were found to have alcohol in their blood, 42 percent having a blood alcohol concentration of more than .10 g/dL.

Authors	Goodnow, R. K.
Year	1990
Title	**Injury severity, medical costs and associated factors for helmeted and unhelmeted motorcyclist crash cases transported to hospitals In Amarillo, Austin, Corpus Christi, and San Antonio, Texas**
In	International Motorcycle Safety Conference, I, 3-14-3-43
Abstract	The main objective of the study is to determine the effects of helmet use by motorcyclist crash victims on the occurrence of head injuries, on the severity of head injuries, and on medical treatment and costs. The areas covered by the study, during the period September 1, 1986, through December 31, 1987, contained about 15 percent of the population of Texas in 1987. The study covered 1,174 crashes, involving 1,223 motorcyclists. Two-hundred and thirty-two crashes involving 255 persons resulted either in no injuries, treatment on the scene, outpatient treatment, or transportation to a hospital not included in the study. The major trauma centers in each area were included in the study. There were 920 crashes, 945 persons, that resulted in transportation to a trauma center or emergency room. There were 55 fatalities, with 23 persons Dead on the Scene (DOS), 17 Dead on Arrival (DOA) at a trauma center, and 15 dying after some period in a hospital. There were eight people discharged from a hospital to a Rehabilitation Center, seven with head injuries (all unhelmeted), and one with severe spinal injuries. One person was discharged to the Austin State Hospital for psychiatric evaluation and treatment. Eighteen hospitals that had received 10 or more transportees were asked to participate in the study, and 17 agreed. A list of people transported to each hospital, according to the crash reports, was sent to that hospital. Visits were made to each hospital, during which medical and financial records (where available) were carefully examined. All pertinent data was abstracted and recorded on an Accident Summary Form (ASF) for each case. Abbreviated Injury Scale (AIS) scoring was performed, for each case included in the study, by a medical student in San Antonio. As can be seen on the ‘Hospital Retrieval Rate’ sheet, 945 cases were included in the requests for data; medical records were found for 763 cases, and financial data was compiled for 637 cases. Statistical significance was found for: prevention of head injury by helmet use; and amelioration of head injury severity by helmet use. Medical costs were lower, and hospital stays were shorter for helmeted head-injury than for unhelmeted head-injured. The findings of this study are quire closely in agreement with comparable findings of the reference studies, as listed in the Reference Section.

Authors	Haight, F. A.
Year	1973
Title	**Induced exposure**
In	*Accident Analysis & Prevention,* 5:111-126
Abstract	Induced exposure "in the narrow sense" refers to exposure to vehicular collision only, and is modeled by a scheme which equates the proportion of single-vehicle collisions experienced by a category of driver/vehicles to the proportion of double vehicle collisions in which that driver/vehicle combination was guilty, and which equates the exposure for the category to the proportion not guilty in double vehicle collisions. Induced exposure "in the wide sense" refers to all types of hazard, and separates the data into four categories by a hypothesis that factors relating to a crash are either internal or external for each of the two driver/vehicle combinations involved, where, for single car collisions, one of the "driver/ vehicle" categories is the type of crash, with the restriction that internal factors do not exist in the case where driver/vehicle represents type of single-vehicle crash.

Authors	Holloway, F.A.
Year	1995
Title	**Low-dose alcohol effects on human behavior and performance**
In	*Alcohol Drugs and Driving,* 11(1):39-56
Abstract	The purpose of this review is to survey the literature examining alcohol effects on human behavior and performance, especially low alcohol dose effects. Other comprehensive reviews on this topic from 1975 through the mid-1980s found that alcohol could affect all classes of performance, but that the kinds of performance most sensitive to low dose effects depended on: (a) the analysis of skills or abilities (selective attention), (b) the kind of task (divided attention tasks), (c) task characteristics (multiple tasks with high demand and/or complexity), and (d) categories of alcohol effects (negative subjective effects and controlled performance). This review examined 155 empirical studies dating from 1985 to mid-1993, using the alcohol effect schema of Krttger, and reached several general conclusions that were largely in agreement with previous reviews on this topic. First, sensitivity to the subjective intoxicating effects of alcohol was greater than that for all other performance classes and appeared to display a “threshold” with respect to blood alcohol concentration (BAC), rather than the linear relation evident in performance data. Second, sensitivity to performance impairment in “controlled” performance and simulator tasks was greater than that for psychophysical functions or “automatic” performance. Finally, a variety of task-, subject-, and environmental-characteristics or conditions were found to mediate the magnitude and sensitivity to alcohol effects, particularly at lower doses. This review concluded that since alcohol sensitivity can vary from time to time, person to person, and situation to situation, the setting of a “safe” BAC will always be arbitrary, being based on a low, but non-zero, incidence of effects below that level.

Authors	Holubowycz, O.T., McLean, A.J.
Year	1995 September
Title	**Demographic characteristics, drinking patterns and drink-driving behavior of injured male drivers and motorcycle riders**
In	*Journal of Studies on Alcohol,* 56(5):513-21
Abstract	OBJECTIVE: The demographic characteristics, usual drinking and impaired-driving patterns, incidence of problem drinking, precrash drinking behavior, and attitudes towards impaired driving of crash-involved male drivers and riders are described and related to blood alcohol concentration (BAC) on admission to hospital. A better understanding of these issues will enable impaired-driving countermeasures to target more specifically those individuals who are most at risk of being killed or injured in alcohol-related road crashes. METHOD: Between June 1985 and April 1987 interviews were conducted with a sample of 302 male drivers and motorcycle riders admitted to the Royal Adelaide Hospital in Adelaide, South Australia. RESULTS: With one exception, the likelihood of having a high BAC (i.e., .08 g/dL or above) did not differ with demographic profile. As BAC increased, there was a significant increase in: various indices of quantity and frequency of drinking; beer being the preferred beverage; percentages drinking alone, in a hotel, in a vehicle and for various less socially acceptable reasons; frequency of impaired driving; likelihood of previous impaired-driving suspension; and more liberal attitudes towards impaired driving. About 25 percent of those with a BAC of at least .15 g/dL were probably experiencing alcohol-related problems prior to the crash, compared with only a very small proportion of those with lower BACs. Precrash drinking most commonly involved drinking in a hotel, drinking with friends, and drinking beer, with no significant differences between BAC groups. CONCLUSIONS: The results suggest that usual drinking and impaired-driving patterns, as well as attitudes toward impaired driving, become more extreme as the BAC of male crash-involved drivers and riders increases.

Authors	Insurance Institute for Highway Safety
Year	1972
Title	**Motorcycle crashes explored by researchers: A status Report**
In	Insurance Institute for Highway Safety, 7
Abstract	No abstract available

Authors	Interministerial Committee on Drinking-Driving
Year	1986
Title	**Ontario survey of nighttime drivers: Summary reports**
In	Downsview, Ontario: Ministry of Transportation, 1988. 22 p.
Abstract	The objectives of this research project sponsored by the Ontario Interministerial Committee on Drinking and Driving were to: (1) provide comparative data to assess any changes in summer nighttime drinking and driving patterns which may have occurred since the previous survey in 1979; (2) evaluate the effectiveness of recent drinking/ driving legislation and countermeasures; and (3) contribute Ontario survey data to a national survey on drinking and driving and provide baseline measures for the assessment of future countermeasures. Researchers collected additional driver demographic data as well as data on trip lengths and origins, and seat belt usage. 298 sites were sampled from across the province including both rural and urban locations, and sites used previously in 1979 were used whenever possible. Drivers were selected from passing traffic and administered a 2-3 minute survey and given a breath test. 12,125 drivers participated in the study. Results of the survey and breath test determined the following: (1) levels of blood alcohol concentration (BAC) by categories (.02-.05, .05-.08, and over .08); (2) nights/times when highest percentage of impaired drivers were stopped; (3) age and sex of impaired drivers; (4) locations where drivers had been drinking; and (5) various attitudes of drivers concerning drinking and driving, their own impairment, and risks of drinking and driving. Results were then compared to those from the 1979 survey.
	Note: Inferences from the 1986 Nighttime Surveys of Driver's Alcohol Use, In: Proceedings of the Canadian Multidisciplinary road Safety Conference V, Calgary, Alberta, 1987)

Authors	Jex, H.R., Jewell, W.F., & Allen, R.W.
Year	1973
Title	**Development of the dual-axis and cross-coupled critical tasks**
In	8th Annual Conference on Manual Control, Univ. Michigan, AFFDL-TR072-92, pp. 529-552
Abstract	No abstract available

Authors	J.L. Kelsey, D. Thompson, & A.S. Evans
Year	1986
Title	**Methods in observational epidemiology**
In	Oxford University Press, 1986.
Abstract	Providing a comprehensive picture of the design, conduct, analysis, and interpretation of non-experimental studies of both infectious and non-infectious diseases, the Second Edition of this widely used text has been thoroughly updated to take into account the numerous developments in epidemiology over the past decade. Since the first edition was published in 1986, additional sources of data have become available through the increasing use of computerized records for health-related purposes. Also, a better understanding of the uses and limitations of certain epidemiologic concepts has been gained. Modifications of traditional study designs, including nested case-control studies and case-cohort studies, are now more frequently employed. Biological markers of exposure, disease susceptibility, and disease itself are used in many studies and methods of statistical analysis have been further developed.

Authors	Kiger, S.M., Lestina, D.C., Lund, & A.K.
Year	1995
Title	**Passive alcohol sensors in law enforcement screening for alcohol-impaired drivers**
In	*Alcohol Drugs and Driving,* 9(1):7-16
Abstract	The effectiveness of passive alcohol sensors in detecting impaired drivers during routine police traffic stops was assessed. Sixteen police officers in Columbus, Ohio, participated in a study in which passive alcohol sensors were used on alternate nights. On nights with the sensors, the number of drivers with blood alcohol concentrations of .10 g/dL or greater detected by the officers increased from 69 percent to 77 percent. The passive alcohol sensor correctly warned of likely alcohol impairment for 81 percent of the drivers with blood alcohol concentrations of .10 g/dL or greater. Only three false-positive readings (<l%) were obtained. When combined with other field studies, the results indicate a consistent pattern of increase in the detection of alcohol-impaired drivers when patrol officers use passive alcohol sensors in routine traffic stops. The sharp increase in detection of drivers with BACs between.00 and .10 suggests the use of passive alcohol sensors may be even more important in states that have lowered the per se blood alcohol concentration threshold from .10 to .08.

Author	Kim, Karl
Year	1999
Title	**Lie factor in traffic safety: Comparison of police and hospital reporting of seat belt and alcohol use in Hawaii**
In	*Transportation Research Record* 1665, Paper No.99-0386 141, Honolulu, HI
Abstract	A linked database composed of police crash reports and hospital records was used to compare seat belt and alcohol use. For these linked cases, the police reported a belt use rate of 88.1 percent; hospital records, however, indicated a use rate of 59.9 percent. Although police overreported the seat belt use rate, they underreported the alcohol involvement rate. Hospital records indicated alcohol involvement in 25.5 percent of the cases; police reporting captured only a fraction of the alcohol cases (8.4% of total cases). In addition to reporting the general patterns of inconsistency between police and hospital reporting across driver, vehicle, and crash characteristics, it was shown that there are significant problems associated with reporting of seat belt and alcohol use. The analysis is based on comprehensive information from Hawaii of about 369 drivers with linked crash and hospital records in 1990. Some recommendations for improving the quality and accuracy of reporting are provided.

Authors	Kim, Karl, & Boski, Joseph
Year	2001
Title	**Finding fault in motorcycle crashes in Hawaii: Environmental, temporal, spatial and human factors, University Of Hawaii At Manoa**
In	*Transportation Research Record*, 1779:182-188.
Abstract	The purpose of this paper is to examine patterns of fault among drivers and motorcycle riders involved in collisions in Hawaii. We begin by describing some of the personal and behavioral characteristics of drivers and riders involved in crashes, then move to a discussion of temporal, roadway, and environmental factors associated with crashes between motorcycles and other motor vehicles. We argue that focusing on fault provides a strategic starting point for educational and traffic enforcement programs for drivers and motorcycle riders alike. We built a fault model using logistic regression to predict the odds of fault for motorcyclists and vehicles involved in crashes. We map the spatial distribution of at-fault motorcyclists and drivers in order to determine if there are distinct spatial patterns for enforcement and educational efforts. We conclude with a discussion of the implications for motorcycle safety, driver education, law enforcement, and traffic safety research.

Authors	Kim, K., & Willey, M.R.
Year	1991
Title	**Improving motorcycle safety in Hawaii: Recommendations based on a survey of motorcycle owners and operators**
In	Transportation Research Record 1325, TRB, National Research Council, Washington DC, 1991
Abstract	A study on motorcycle safety was conducted for the Hawaii Department of Transportation by the Department of Urban and Regional Planning, University of Hawaii. The study is based on a telephone survey of 494 motorcycle owners and operators that was conducted in August 1989. Trends in motorcycle crashes are described, results from the attitudinal study are given, and several legislative, administrative, and programmatic recommendations for improving motorcycle safety in Hawaii are proposed, including restoring Hawaii's mandatory helmet law and requiring motorcycle safety education courses for all new riders. A disproportionately large share of those involved in fatal motorcycle crashes was found to be neither licensed nor insured. Some ways that licensing and registration systems might be enhanced to improve motorcycle safety in Hawaii are suggested. After the problem of motorcycle crashes in Hawaii is described, trends in motorcycle crashes and motorcycle-related deaths are discussed. Then a survey of motorcycle owners and operators conducted by the Department of Urban and Regional Planning, University of Hawaii, is described. An examination of licensing and registration laws in Hawaii is also included. It is concluded that there are three types of actions that can be taken to improve motorcycle safety in Hawaii: legislative actions refer to the enactment of new laws such as mandating helmet use or motorcycle education; administrative actions involve improving or enhancing current regulatory actions already in place, such as improved licensing and enforcement of existing traffic safety laws; and programmatic actions refer to the creation and enhancement of a variety of programs on education, public information, and further study and analysis of motorcycle crashes in Hawaii.

Authors	Kim, K., & Boski, J.
Year	2001
Title	**Motorcycling and impaired motorcycling in Hawaii: Rider characteristics, environmental factors, and spatial patterns**
In	International Motorcycle Safety Conference, "The Human Element" 1-14
Abstract	In this paper, we report the results of our research investigating motorcycling and alcohol-impaired motorcycling in Hawaii. Our investigation expands the scope of rider characteristics analysis by examining the combined effects of rider behavior (helmet use, speeding, actions taken before crash, etc.), and environmental factors (urban v. rural locations, roadway alignment, etc.) and spatial patterns on motorcycle crashes. We begin with the development of a typology of motorcycle crashes. This crash typology was then used to derive logistic regression models for explaining alcohol-involved crashes, single-vehicle crashes, and injury outcomes (including fatalities) associated with motorcycle crashes. The logistic models enable us to compare the relative importance of various rider characteristics, temporal and environmental correlates associated with motorcycle crashes and the associated crash types and injury outcomes. Finally, the results of a spatial cluster analysis are presented, using both GIS (geographic information systems) and spatial analytical tools. The analysis suggests that overall behavioral, and temporal factors are more significant predictors of alcohol-involved crash patterns than environmental or roadway features. We qualify our findings both in terms of the usefulness of the methods to motorcycle safety researchers as well as in terms of the relevance to motorcycle safety initiatives within our State.

Authors	Kim, K., Boski, J., & Yamashita, E.
Year	2002
Title	**A typology of motorcycle crashes: Rider characteristics, environmental factors, and spatial patterns**
In	Department of Urban and Regional Planning, University of Hawaii at Manoa
Abstract	This paper reports the results of research investigating motorcycle and alcohol-impaired riding in Hawaii. The investigation expands the scope of rider characteristics analysis by examining the combined effects of rider behavior (helmet use, speeding, actions taken before the crash, etc.) environmental factors (urban versus rural locations, roadway alignment, etc.) and spatial patterns on motorcycle crashes. First a typology of motorcycle crashes is presented. This crash typology was then used to derive logistic regression models for explaining alcohol-involved crashes. Single-vehicle crashes, and injury outcomes (including fatalities) associated with motorcycle crashes. The logistic models enable comparisons of the relative importance of various rider characteristics, temporal and environmental correlates associated with motorcycle crashes and the associated crash types and injury outcomes. Finally, the results of a spatial cluster analysis are presented, using both GIS (geographical information systems) and spatial analytical tools. The analysis suggests that overall behavioral and temporal factors are more significant predictors of alcohol-involved crash patterns than environmental or roadway features. The findings are qualified both in terms of the usefulness of the methods to motorcycle safety researchers as well as in terms of the relevance to motorcycle safety initiatives within the State of Hawaii.

Authors	Klein, T. M., & Burgess, M.
Year	1994
Title	**Alcohol involvement in fatal traffic crashes-1992**
In	NHTSA 1-23
Abstract	This compilation presents estimates of alcohol-related fatal traffic crashes that occurred during 1994. In order to demonstrate trends and changes, comparisons are made with data from the 1982-1994 Fatality Analysis Reporting System, including blood alcohol concentration (BAC) information. In 1994, at least one driver or nonoccupant involved in a fatal crash had a BAC of .10 or greater; this is a 30.5-percent reduction compared to 1982. Occupant fatalities resulting from crashes involving an intoxicated driver or nonoccupant totaled 10,780 and less than one-half of these in single-vehicle crashes involved an intoxicated driver. It is estimated that 36.4 percent of the fatalities in nonoccupant crashes involved an intoxicated driver or nonoccupant. Of the fatally injured drivers in single-vehicle crashes, 66.8 percent were intoxicated. Almost twice as many male drivers than female drivers were likely to be intoxicated. The highest intoxication rates were found among drivers 21-24 years of age, followed by drivers 25-29 years old. Estimated reductions in the proportion of intoxicated drivers involved in fatal traffic crashes between 1982 and 1994 are 37 percent for passenger car drivers, 34 percent for drivers of light trucks and vans, 65 percent for medium-weight trucks, 67 percent for heavy trucks, and 19 percent for motorcycles. Motorcycle drivers involved in fatal crashes had a high rate of intoxication (40.5% with a BAC level of .10 or greater). Additional comparisons with 1993 are provided. An index of the statistical tables is included.

Authors	Koornstra, M. J.
Year	1973
Title	**A model for estimation of collective exposure and proneness from accident data**
In	*Accident Analysis & Prevention,* 5:157-173
Abstract	NUMERICAL transformations on crash data for conversion of “raw” crash data into exposure or proneness corrected figures have been applied by Thorpe (1964) and Haight (1970). Their transformations are based on two axiomatic assumptions about the ratio of the number of crashes involving one single driver and two drivers and the ratio of guilty and innocent drivers for several classes of drivers. Carr (1969) used comparable assumptions and empirical ratios of guilty and innocent drivers. These transformations are dependent on k unknowns, solved by A: equations. The fit of the assumptions therefore cannot be tested empirically. The model developed here has been inspired by Haight’s attempt to weaken the axioms of Thorpe, and by the attempt to test the fit of the model on the basis of more equations than unknowns.

Authors	Koornstra, M. J.
Year	1973
Title	**Empirical results on the exposure-proneness model**
In	*Accident Analysis & Prevention,* 5:175-189
Abstract	The applicability and validity of the exposure-proneness model is investigated by the analysis of two sets of empirical data. The concept of comparable behavioral maneuverability is introduced and a slight revision of the model and its solution are given in order to explain the fits and departures of the model for these data. Within the range of applicability the model gives a statistical acceptable fit. Some tentative conclusions are stated in the last section.
Authors	Kraus, J. F., Franti, C. E., Johnson, S. L., Riggins, R. S., & Borhani, N. O.
Year	1976
Title	**Trends in deaths due to motorcycle crashes and risk factors in injury collisions**
In	*Accident Analysis & Prevention,* 8(4): 247-255
Abstract	In the past 25 years, the numbers of registered motorcycles in the United States and California have increased about 1,000 and 1,100%, respectively. In the same period, the motorcycle collision death rate per million population more than doubled. The purposes of the study were to examine time trends in deaths due to motorcycle collisions, examine a methodologic problem in the study of motor vehicle collision death rates, and to determine driver and vehicle factors which may discriminate in the production of motorcycle crash related injuries. With the exception of 1974, the increase in the ratio of registered motorcycles per 100,000 population in the United States corresponds to an increase in the crude death rate per million population. A similar pattern was also found in California. Stepwise discriminant analysis was used to determine an optimum set of factors associated with motorcycle collision injuries. The analysis indicated that for male drivers age was the single factor most significantly related to motorcycle collision injuries. Other factors, in addition to age, which added to the power of the discrimination included number of prior motorcycle driving violations, frequency of motorcycle use, number of prior motorcycle crashes, motorcycle drivers' training, and height of the drivers.
Authors	Lacey, J.H., Stewart, J.R., & Carroll, C.L.
Year	1980
Title	**Driver alcohol and medical problems**
In	Interim Report, 37 pp.
Abstract	The first year's activity of a project designed to examine North Carolina traffic crash and driver medical evaluation data with respect to alcohol, drugs, and specific medical conditions is reported. This project was undertaken to better understand how these elements affect traffic safety in North Carolina, and thus be better able to develop, focus, and evaluate countermeasure efforts. Data are presented from the following studies: (1) the role of alcohol in motorcycle crashes; (2) children as victims of alcohol-related crashes; and (3) the effects of liquor-by-the-drink on traffic safety.

Authors	Li, G., & Baker, S. P.
Year	1993
Title	**Alcohol in fatally injured bicyclists**
In	AAAM Annual Meeting, 37:129-142
Abstract	Bicycling injury results in about 580,000 emergency room visits and 900 deaths each year in the United States. Alcohol involvement in bicycling injury has not been well documented in the literature. Using data from the Fatality Analysis Reporting System (FARS), blood alcohol concentrations (BACs) among fatally injured bicyclists age 15 and older were examined for the years 1987-1991. Of 1,711 bicyclists who were killed at age 15 or older and tested for alcohol, 32 percent were positive and 23 percent legally intoxicated. Adjusted for age, time of crash, and other variables, male decedents were 3.3 times more likely than female decedents to be BAC positive, and 3.9 times more likely to be legally intoxicated. Decedents ages 25 to 34 and those who died from nighttime crashes also had significantly increased likelihood of being BAC-positive and being legally intoxicated. Even among decedents ages 15-19, who were legally prohibited from drinking, 14 percent had positive BACs. Further studies are needed to confirm the causal relationship between alcohol use and bicycling injury and to better understand the factors related to drinking and biking. The role of alcohol should be seriously considered in developing strategies of bicycling injury control and prevention.

Authors	Lyles, R. W., Stamatiadis, P., & Lighthizer, D. R.
Year	1991
Title	**Quasi-induced exposure revisited**
In	*Accident Analysis & Prevention,* 23(4):275-285
Abstract	Considerable attention is still given to developing and using alternate methods for determining exposure for calculating highway crash rates. A quasi-induced method of measuring exposure developed in the late 1960s is reexamined and found to be promising for determining relative crash-involvement rates. A new empirical investigation is offered as the first step in verifying that the characteristics of the “innocent victim” in two-vehicle highway crashes represent a random sample of the driver-vehicle combinations present on the highway system under specified conditions. Quasi-induced exposure estimates are shown to be, at a minimum, consistent and reproducible.

Authors	Mayhew, D.R., Donelson, A.C., & Simpson, H.M.
Year	1987
Title	**Alcohol and cannabis among fatally injured motorcyclists**
In	P.C. Noordzij and R. Roszbach, Eds., Alcohol, Drugs and Traffic Safety - T86, Amsterdam: Elsevier Sciences Publishers B.V. (Biomedical Division), pp. 267-270
Abstract	The epidemiology of alcohol and cannabis in motorcycle crashes in Canada is discussed. Results of a recent study indicate that the highest frequency of alcohol and cannabis use was found among motorcycle driver fatalities, while an earlier study indicated that these drivers were less likely to have been drinking than other drivers. The frequency of drinking was 66 percent in those motorcycle drivers ages 16-24, 78 percent in those age 30 or older. In contrast, young drivers are more apt to have been drinking than older drivers. While data on cannabis use is incomplete, early studies indicate that it is the younger drivers who use this drug, usually in combination with alcohol. It is suggested that future studies should examine the relationships between age, skill development, and psychosocial factors of those who drive both motorcycles and automobiles after using alcohol and/or cannabis.

Authors	Mayhew, D. R., & Simpson, H. M.
Year	October 1990
Title	**Alcohol as a risk factor in motorcycle collisions**
In	Proceedings: The Human Element: 1990 International Motorcycle Safety Conference: Motorcycle Safety Conference, Volume 2, Grosvenor Resort, Orlando, FL.
Abstract	It has been well established that the risk of fatal collision increases dramatically with increases in blood alcohol concentration (BAC), particularly at levels over .08-.10 g/dL. This relationship was fast demonstrated empirically in 1964 in the Grand Rapids study in which the frequency and quantity of alcohol detected in collision-involved drivers were compared statistically to those among drivers in the population-at-risk (1). More recently, this risk-factors research has been replicated by the present authors using a variation of the traditional case-control method (2). They have also shown that crash risk varies as a function of the age of the driver: younger individuals have a higher risk of fatal crash at all BACs (.03, .04, .05, .06). Other characteristics of the driver and/or the type of vehicle being rated have rarely been examined separately, owing primarily to the information available from surveys of the population-at-risk. The present paper examines the risk of collision for operators of motorcycles, who nave been drinking. A re-analysis of data from previous work in the United States provides some indication of the greater relative risk of collision faced by drinking motorcyclists. Contemporary data in Canada are then analyzed to address the central issue - is relative crash risk greater for drinking motorcyclists than for drinking drivers of other vehicles? The data for this analysis were derived from two sources. Information on alcohol in fatally injured riders was obtained from the TIRF Fatality Database. Information on alcohol in motorcycle riders in the population-at-risk was obtained form a recent nighttime roadside survey in IC province of Ontario. Relative risk estimates are determined for motorcyclists at various levels of blood alcohol. The paper compares these risk estimates to those of automobile drivers.

Authors	Mayhew, D.R., Brown, S.W., & Simpson, H.M.
Year	1997
Title	**Alcohol use among persons fatally injured in motor vehicle accidents: Canada 1995**
In	Transport Canada, TP 11759-95(E)
Abstract	This report presents findings from a project to obtain data on alcohol use by persons fatally injured in motor vehicle crashes on or off public highways in Canada. Data were obtained from police reports on victim characteristics and crash details and from coroners' and medical examiners' files for toxicological data from body fluid samples (mostly blood) on alcohol use among victims. The primary focus was on alcohol in fatally injured drivers, because they are the group of greatest interest to traffic safety officials, and the rate of testing for alcohol is higher among drivers than among other groups of road users. The report contains (1) general descriptive information on the frequency and quantity of alcohol found in drivers and pedestrians fatally injured in motor vehicles in Canada during 1996 and (2) trends in alcohol detected among fatally injured operators of automobiles, motorcycles, trucks, vans, and tractor-trailers and among fatally injured pedestrians.

Authors	Moskowitz, H., & Fiorentino, D.
Year	April 2000
Title	**A Review of the literature on the effects of low doses of alcohol on driving-related skills**
In	Final Report, HS 809 028, Washington, DC: National Highway Traffic Safety Administration
Abstract	A review of the scientific literature regarding the effects of alcohol on driving-related skills was conducted. One hundred and twelve articles—from 1981 to 1997—were reviewed. Results were indexed by BAC and behavioral area and entered into a database. Two separate analyses were conducted. The first analysis determined the lowest BAC at which impairment is reliably present in driving-related skills. The second analysis determined the thresholds of impairment for each of twelve separate behavioral areas. It was concluded that: Alcohol impairs some driving skills beginning with any significant departure from .00 BAC. By BACs of .05 g/dL, the majority of the experimental studies examined reported significant impairment. By .08 g/dL, more than 94 percent of the studies reviewed exhibited skills impairment. Specific performance skills are differentially affected by alcohol. Some skills are significantly impaired by BACs of .01 g/dL, while others do not show impairment until BACs of .06 g/dL. Discrepancies between the reported BAC threshold of impairment within a behavioral area reflected a lack of standardization of testing methods, instruments, and measures in the studies reviewed. All drivers are expected to experience impairment in some driving-related skills by .08 g/dL or less.

Authors	Moskowitz, H., Blomberg, R., Burns, M., Fiorentino, D., & Peck, R.
Year	2002
Title	**Methodological issues in epidemiological studies of alcohol crash risk**
In	Proceedings of the 16th International Conference on Alcohol, Drugs & Traffic Safety, Montréal, Canada, August 4 to 9, 2002.
Abstract	A literature review examined methodological problems which have arisen in epidemiological studies of the role of alcohol in traffic collisions. The methodological problems resulted in varying estimates of collision relative risk as a function of blood alcohol concentration (BAC). Based on the literature review, an improved epidemiological study of crash risk was performed in Long Beach, California, and Fort Lauderdale, Florida. The study arrived at considerably higher estimates of the relationship between BAC and collision crash risk than in prior studies.

Authors	National Highway Traffic Safety Administration
Year	2001 January
Title	**Geo-demographic analysis of fatal motorcycles crashes**
In	Washington, DC: National Highway Traffic Safety Administration (34 pp.)
Abstract	This report examines lifestyle factors and demographic data in fatal motorcycle crashes in order to develop appropriate safety messages and to identify effective media for communicating them. Data from the Fatality Analysis Reporting System and a geo-demographic database, Claritas, were analyzed and hypotheses formulated about factors involved in fatal crashes, including driver age and drug or alcohol involvement. Ten lifestyle clusters were identified that exhibited the highest propensity for fatal motorcycle crashes. These clusters are described in an appendix. Factors determined to be important elements of a prevention program were (1) age under 40, (2) involvement of alcohol in two out of every five fatal crashes, (3) male gender almost exclusively, and (4) targeting of key ethnic factors. Based on lifestyle factors, productive media for safety messages were concluded to be country radio and country music TV stations, and motorcycle and fishing or hunting magazines.

Authors	Newman, J.A., & Webster, G.D.
Year	1973
Title	**The mechanics of motorcycle accidents**
In	Proceedings of the American Association for Automotive Medicine.
Abstract	This paper deals with an examination of motorcycle crashes in Ottawa, Canada, during the summer months of 1973. Among the principle objectives of the study was to investigate in some detail the actual mechanics of motorcycle collisions, to categorize such collisions in terms of the kinematic behavior of the vehicles and motorcycle occupants and to examine the mitigating circumstances in each crash. Of particular concern has been an examination of the crash causative factors and the injury-producing mechanisms. 1:32 scale models have been used to reconstruct the crash and have been employed in providing a graphic description of the various pre-crash, crash and post-crash geometries.

Authors	Olkkonen, S., & Honkanen, R.
Year	1990
Title	**Role of alcohol in nonfatal bicycle injuries**
In	*Accident Analysis & Prevention,* 22(1):89-96
Abstract	To assess the risk of nonfatal bicycle injury related to blood alcohol concentration (BAC) an unmatched case-control study was conducted in Helsinki in 1986. Eligible cases included 140 adults injured either in motor vehicle or other bicycle crashes that occurred between 3 p.m. and 10 p.m., who arrived at the hospital within 6 hours of injury. Seven hundred bicyclists from the street were randomly selected as controls. BAC was measured with a breathalyzer. A major difference in alcohol involvement was found between cases (24.1%) and control (4%). The injury risk estimate (odds ratio) of an inebriated bicyclist was at least 10-fold at BACs above .10 g/dL compared to a sober bicyclist. Alcohol increased the bicyclist's risk of injury from falling more than from collision. As an unprotected road user, an inebriated bicyclist greatly increases personal risk of injury but seldom causes danger to other road users.

Authors	Orsay, E. M., Wiggins, L. D., Lewis, R., Lucke, R., & RamaKrishnan, V.
Year	1994
Title	**The impaired driver: Hospital and police detection of alcohol and other drugs of abuse in motor vehicle crashes**
In	*Annals of Emergency Medicine,* 24(1):51-55
Abstract	Detection by hospital and police personnel of alcohol and other drugs in victims of motor vehicle crashes is discussed. The study data were derived from a retrospective review of 634 charts from two Level I trauma centers of hospitalized drivers involved in motor vehicle crashes and a review of the corresponding police reports. The following results of the study were seen: (1) a finding that 200 drivers were legally drunk and 132 had positive urine drug screens; (2) a finding that 285 patients were impaired with BACs of .10 g/dL or more and/or positive drug screens; (3) highest prevalence for cocaine, which was present in 51 subjects; (4) a relationship between impairment and young age, maleness, less likelihood of wearing a seatbelt or helmet, and severity of injury; (5) availability of policy reports for 446 patients, 139 of whom were legally drunk and 67 of whom had positive drug screens; and (6) citations for driving under the influence (DUI) for 34 (16.5%) of patients. It is concluded that a very high rate of impairment existed in this population, the majority of whom were not charged by police.

Authors	Ouellet, J. V., Hurt, H. H., Jr., & Thom, D. R.
Year	1987
Title	**Alcohol involvement in motorcycle accidents**
In	SAE Technical Paper Series, Paper No.870602, 121-129. Proceedings of 1987 SAE International Congress & Exposition, Detroit, MI.
Abstract	The in-depth investigations of two studies involving 1,200 motorcycle crashes in Los Angeles were merged and analyzed for factors associated with alcohol involvement in motorcyclists and vehicle drivers who collided with motorcycles. A variety of factors converge around alcohol use to increase the likelihood of severe injury and death in alcohol related motorcycle crashes. Motorcycle riders who drank were more prone to operator error, to simply run off the road, to crash at higher speeds and less likely to have worn a helmet, hence more likely to be fatally injured than nondrinking motorcyclists. Fatally injured motorcyclists who showed evidence of prolonged alcohol abuse (1 in 7) were more likely to have been drinking or been intoxicated than nonabusers. Motorcycle operator and passenger alcohol consumption were strongly correlated. Drinking car drivers who struck a motorcycle were more likely to be in the striking vehicle in a rear-end or head-on collision and to be going faster when they collided.

Authors	Partners in Progress
Year	1995 March
Title	**Impaired driving goals and strategies for 2005**
In	Summary of Proceedings
Abstract	No abstract available

Authors	Pedder, J. B., Hagues, S. B., & Mackay, G. M.
Year	1979
Title	**A study of 93 fatal two-wheeled motor vehicle accidents**
In	IRCOBI, IV, 24-38
Abstract	This paper describes a sample of two-wheeled motor vehicle and pedal cycle crash casualties treated at a hospital in the city of Birmingham, England. Under reporting of two-wheeled vehicle crashes in national official statistics is shown and the possible reasons and implications of this finding are discussed. The patterns of injuries sustained by the two groups of casualties are described with comments on the likely reasons for the observed differences in their injury patterns. A comparison is drawn between the injuries sustained by the TWMV riders in this hospital study and a sample of fatally injured TWMV riders. Finally, the validity of the Treatment Period criteria of the Comprehensive Research Injury Scale is examined.

Authors	Peek-Asa, C.
Year	1999
Title	**The effect of random alcohol screening in reducing motor vehicle crash injuries**
In	*Am J Prev Med* 16(1S):57-67, 1999
Abstract	Objective: To determine if random breath testing reduces motor vehicle crashes and crash-related injuries. Search Strategies: We used Cochrane Collaboration search strategies of electronic databases, searched reference lists of past reviews and review articles, Cochrane International Register of RCTs, and studies from government agencies in the United States and abroad. Selection Criteria: Studies included in this review examined the effectiveness of random roving or checkpoint breath testing programs in a defined population. Studies were required to have a clear description of the program and outcomes evaluated, to have a comparison group or period, and to provide interpretable data from the evaluation Selection and analysis: Fourteen studies met selection criteria. Information was abstracted using standard data collection sheets. Proportional decreases in fatalities, injuries, or alcohol-related fatalities and injuries in the RBT population compared to the control population was the variable of interest. Studies using multivariate techniques to control for other factors were considered separately. Main results: All fourteen studies found that random breath testing for alcohol use while driving was effective in reducing either fatalities or injuries from motor vehicle crashes. The decreases found had wide variation, but did not seem to depend on the size of the population under study or the length of the study period. However, one study found that in the second year of random breath testing crash fatalities did not decrease. Alcohol-related fatalities generally showed the greatest decreases, ranging from 8 percent to 71 percent reduction from the comparison period prior to introduction of RBT. Total fatalities, injuries, and crashes also consistently showed reduction. Very few of the studies controlled for other factors which could potentially decrease alcohol-related traffic injuries and fatalities, but the studies that did found that checkpoints were among the strongest predictors of decrease in alcohol-related fatalities and injuries. Conclusions: Random breath testing appears to be effective in a wide range of both United States and international populations although detailed follow-up studies have not been conducted. One important feature often mentioned as important to the effectiveness of the programs is the presence of a public campaign to raise awareness of the program and/or highly visible police activity. One path through which the programs are effective could be to increase the perception of being caught while driving under the influence. There was some disagreement among authors as to how long the effects of random breath testing persist.

Authors	Preusser, D.F., Williams, A.F., & Ulmer, R.G.
Year	1995 December
Title	**Analysis of fatal motorcycle crashes: Crash typing**
In	*Accident Analysis & Prevention,* 27(6):845-51
Abstract	There were 2,074 crashes fatal to a motorcycle driver in the United States during 1992. A computer program was developed to convert Fatality Analysis Reporting System (FARS) data for these crashes into standard format English language "crash reports." The computer-generated reports were analyzed and crash type categories were defined. Five defined crash type categories accounted for 1,785 (86%) of the 2,074 crash events: Ran off-road (41%); ran traffic control (18%); oncoming or head-on (11%); left-turn oncoming (8%); and motorcyclist down (7%). Alcohol and excessive speed were common factors associated with motorcyclist crash involvement. Left turns and failure to yield were common factors associated with the involvement of other motorists. Suggested countermeasures include helmet use and enforcement of speed and impaired driving laws.

Authors	Reilly, R. E., Wall, W. E., Evans, R. A., Allen, L. L., Shaw, W. W., Thompson, J., Escott, C., & Lewis, E.
Year	2001
Title	**Introduction to NASS field techniques study guide and workbook**
In	NASS U.S. Department of Transportation National Accident Sampling System Field Techniques, Contract No. DOT-HS-7-01577, 1-1-21-3
Abstract	No abstract available

Authors	Reiss, M.L., Berger, W.G., & Vallette, G.R.
Year	1974
Title	**Analysis of motorcycle accident reports and statistics**
In	Motorcycle Safety Foundation Sponsored Study D-1-D-25. National Safety Council, Safety Research Information Service SRIS-750698R. Falls Church, VA: Biotechnology Incorporated.
Abstract	A study of motorcycle crashes was conducted to determine what is available in the research literature as well as in the state and national computer crash files. The study was to determine four points: motorcycle causal relationships which are normally complex, efficacy of both motorcycle and motorcycle rider safety equipment, efficacy of existing motorcycle operating practices, operator knowledge skills and attitudes. The study lasted from October 1973 to February 1974. It consisted of three tasks: an evaluation of the existing motorcycle-crash-related literature, a detailed analysis of current motorcycle crashes, and the grouping of the findings into educational and crash data oriented programs. Detailed motorcycle crash information is not available in the literature in the following areas: motorcycle operator physical impairments, education and training, motorcycle conspicuity, identification of culpability and of primary and secondary motorcycle crash causation factors. The NHTSA has significant information relating to motorcycle crashes at three levels: Multi-Disciplinary Accident Investigations, Michigan-Illinois Data Base, National Accident Summary Data Base. The 1971 National accident Summary File indicates statistical facts about most motorcycle crashes. Analysis of the MSF-Maryland Data Base has permitted identification of crash culpability, primary and secondary causal crash data voids, and significant differences between motorcycle crash types. The University of Michigan M/C Task Analysis revealed comparison of crash data to principals of operation. Recommendations have been broken into immediate and long-range programs.

Authors	Rothman and Greenland
Year	February, 1998
Title	**Modern epidemiology, 2nd edition**
In	Lippincott Williams & Wilkins (Eds), (pp. 737) 1998.
Abstract	Text discussing principles that link analytic techniques with scientific aims. New to this edition: infectious disease; and field, clinical, genetic, and nutrition epidemiology.

Authors	Schultz, U.
Year	1990
Title	**Factors affecting different kinds of motorcycle accidents**
In	Proceedings of the International Motorcycle Safety Conference, I, 1-14-1-33
Abstract	Current research has shown that frequencies of motorcycle crashes depend on riders' exposure and age. A direct influence of engine capacity on crash involvement is questionable. The present study examines the influence of riders' age, exposure, and of engine power on different kinds of crashes. Crashes are categorized according to seriousness of injury and involvement of other road users. Items concerning motorcycle crashes in a two-year period were answered by 754 motorcyclists. Data were analyzed by Poisson regression techniques. A strong influence of different factors was observed in the frequencies of minor crashes. Significant differences were due to riders' age and exposure as well as to engine power. Frequencies of serious crashes were almost totally uninfluenced by all factors.

Authors	Scott, R. E.
Year	1983
Title	**Motorcycle accidents and motorcycle injuries – a review**
In	UMTRI Final Report
Abstract	This report provides information on the relationship between motorcycle helmet laws and usage, describes more than a decade of motorcycle crash experience in Michigan, and examines the relation between helmet usage and the cost of injury and the incidence and severity of injuries to the head, face, and neck. Several States have repealed or weakened their helmet laws in the past eight years and studies of the consequences have been conducted in a number. The results of such studies in Colorado, Kansas, South Dakota, and Louisiana are reviewed. In each State, helmet usage dropped, typically to near 50 percent. Fatality rates increased as did the incidence of serious to fatal head injury. A description of the fatal crash experience of Michigan over the last twelve years is provided, along with a study of all motorcycle crashes which have occurred from 1978 through 1982. The National Automotive Sampling System (NASS) provides nationally representative information on traffic crashes that includes detailed injury descriptors and the costs of trauma as measured by length of hospital stay and days work lost. The consequences of motorcycle crashes as they are related to helmet use is evaluated using the NASS data of 1980 and 1981.

Authors	Shankar, B.S., Ramzy, A.I., Soderstrom, C.A., Dischinger, P.C., Clark, C.C.
Year	August 1992
Title	**Helmet use, patterns of injury, medical outcome, and costs among motorcycle drivers in Maryland**
In	Accident Analysis & Prevention, 24(4), 385–396.
Abstract	A comprehensive study was conducted of all motorcycle traffic crashes occurring in Maryland during a one-year period. All available medical and cost data were linked with police crash reports. During the study period, 1,900 motorcycle drivers were involved in crashes. The data indicated that (i) helmet use was 35 percent overall, 30 percent among fatally injured drivers, and only 16 percent among drivers with a history of drug/alcohol conviction; (ii) unhelmeted drivers seen at an emergency department were almost twice as likely to have sustained head injury (40%) as were helmeted drivers (21%) (the corresponding percentage for hospitalized drivers were 55% and 38%); and (iii) acute care cost for unhelmeted drivers was three times ($30,365) that of helmeted drivers.

Authors	Shankar, U.G.
Year	Dec. 2001
Title	**Research note: Motorcyclist fatalities in 2000**
In	DOT HS 809 387. Washington, DC: National Highway Traffic Safety Administration
Abstract	No abstract available

Authors	Simard, R.
Year	1990
Title	**Motorcycle accidents in the province of Quebec during the 1980s**
In	Proceedings of the International Motorcycle Safety Conference, I, 1-34-1-44: Motorcycle Safety Foundation.
Abstract	The aim of this report is to analyze motorcycle crash trends in Quebec during the 1980s in both a legal and a statistical context, using data from various computer files processed by the Regie de l'assurance automobile du Quebec. The legal context is presented in light of the major changes which occurred over the decade. Next, the report focuses on the chief aspects of the safety record for motorcyclists, such as the considerable reduction in the number of victims since 1983, the lack of change in the breakdown of the victims based on the severity of injuries suffered, the drop in the number of motorcycles in use since 1983, and the increase in engine capacity and the age of motorcycle owners during the decade. Following analysis of the pattern of each of the 1,008 fatal crashes that occurred in Quebec during the 1980s, we were able to identify five major crash categories based on the operator maneuvers causing them. This analysis reveals several clearly defined trends which remained consistent throughout the decade. We also identified certain groups of motorcyclists who were overrepresented in the crash statistics, namely, those who received demerit points for traffic violations, and young motorcyclists. For young people in particular, we were able to identify elements common to all crashes involving them. Also, an additional analysis was carried out based on whether the violations involved speeding or going through a red light or stop sign. In conclusion, Quebec statistics for this past decade show that a significant, sustained drop in the number of motorcycle crash victims and bodily injuries calls for coordinated, integrated action on the part of all those concerned.

Authors	Simpson, H. M., & Mayhew, D. R.
Year	1990
Title	**Trends in alcohol involvement in motorcycle collisions in Canada and the United States**
In	Traffic Injury Research Foundation Proceedings of the 1990 Motorcycle Safety Conference 8-17-36, OR Motorcycle Safety Foundation, “The Human Element,” Orlando, FL.
Abstract	In North America, the 1980s were a watershed for concern about the impaired-driving problem as well as for the development and implementation of prevention programs targeted at the impaired driver. Commensurate with this activity there has been a change in the frequency of impaired driving by motorists and a decline in the incidence of alcohol-related collisions among automobile drivers. The purpose of this paper is to examine trends in the incidence of alcohol involvement among fatally injured motorcycle riders in Canada and the United States to determine whether this group of road users has shown positive changes similar to those found among automobile drivers during the 1980s. Results indicate significant changes have occurred in the incidence of alcohol involvement among motorcycle riders. As well, the paper examines changes in the levels of alcohol (quantity) detected among motorcycle riders. Despite the decrease in the incidence of alcohol, there has been no change in the levels of alcohol detected among rider fatalities. Of greatest importance, nearly three-quarters of the fatally injured riders have levels of alcohol indicative of impairment and nearly 50 percent have very high BACs suggestive of alcohol problems. The relevance of these findings for future directions in countermeasure initiatives are considered.

Authors	Smith, G.S., Keyl, P.M., Hadley, J.A., Bartley, C.L., Foss, R.D., Tolbert, W.G., & McKnight, J.
Year	2001
Title	**Drinking and recreational boating fatalities: A population-based case control study**
In	JAMA 2001 Dec 19;286(23):2974-80
Abstract	CONTEXT: Alcohol is increasingly recognized as a factor in many boating fatalities, but the association between alcohol consumption and mortality among boaters has not been well quantified. OBJECTIVES: To determine the association of alcohol use with passengers' and operators' estimated relative risk (RR) of dying while boating. DESIGN, SETTING, AND PARTICIPANTS: Case-control study of recreational boating deaths among persons aged 18 years or older from 1990-1998 in Maryland and North Carolina (n = 221), compared with control interviews obtained from a multistage probability sample of boaters in each state from 1997-1999 (n = 3,943). MAIN OUTCOME MEASURE: Estimated RR of fatality associated with different levels of blood alcohol concentration (BAC) among boaters. RESULTS: Compared with the referent of a BAC of .00, the estimated RR of death increased even with a BAC of 10 mg/dL (odds ratio [OR], 1.3; 95% confidence interval [CI], 1.2-1.4). The OR was 52.4 (95% CI, 25.9-106.1) at a BAC of 250 mg/dL. The estimated RR associated with alcohol use was similar for passengers and operators and did not vary by boat type or whether the boat was moving or stationary. CONCLUSIONS: Drinking increases the RR of dying while boating, which becomes apparent at low levels of BAC and increases as BAC increases. Prevention efforts targeted only at those operating a boat are ignoring many boaters at high risk. Countermeasures that reduce drinking by all boat occupants are therefore more likely to effectively reduce boating fatalities.

Authors	Snyder, M.B.
Year	1991
Title	**Lower alcohol levels, driver impairment and crash risk**
In	*Auto & Traffic Safety,* 1(1):2-44. Washington, DC: National Highway Traffic Safety Administration
Abstract	The National Highway Traffic Safety Administration recently submitted the first of two reports, prepared in response to a congressional mandate to study the alcohol concentration at which a driver should be considered under the influence. The report was reviewed and approved by various modal administrations and by the Office of the Secretary of Transportation before being submitted by the Secretary. This article covers a portion of the congressional report, specifically scientific literature on the influence of alcohol concentration on driver performance and crashes. The conclusions are the same as in the congressional report. A small amount of editing was done to the text selected from the report to smooth transitions and to clarify points raised by reviewers.

Authors	Soderstrom, C. A., Dischinger, P. C., Ho, S. M., & Soderstrom, M. T.
Year	1993
Title	**Alcohol use, driving records, and crash culpability among injured motorcycle drivers**
In	*Accident Analysis & Prevention,* 25(6):711-716
Abstract	Alcohol use, driving records, crash culpability, and crash conviction rates for 165 injured motorcycle drivers (MTCDs) were studied. Of the 165 MTCDs, 53.3 percent tested positive for alcohol (BAC+). Culpability determinations (n = 150) revealed the following prevalence of one or more convictions for BAC+ and BAC- MTCDs: impaired driving (29% versus 7%, $p < 0.001$); speeding (74% versus 58%, $p < 0.05$); and reckless driving (68% versus 44%, $p < 0.002$). Of the surviving culpable impaired MCTDs (n = 48), 16.7 percent received crash-related convictions, 12.5 percent received alcohol-related convictions. The reasons for the low conviction rates are probably multifactoral.

Authors	Soderstrom, C.A., Dischinger, P.C., Ho, S.M., & Shankar, B.S.
Year	April 1990
Title	**A study of alcohol use among 165 injured motorcycle drivers treated at Maryland trauma centers: Clinical and crash perspectives including crash culpability**
In	DOT HS 807 612. Washington, DC: National Highway Traffic Safety Administration
Abstract	For a one year period in 1987–88, 203 injured motorcycle drivers were admitted for treatment to a Maryland trauma center, of whom 165 had determined blood alcohol concentrations (BACs). Police reports of these cases were obtained and crash culpability in relation to alcohol use was determined. Over one-half (53.3%) of the drivers were BAC positive, with 73.9 percent with a BAC greater than .01 g/dL (=0./1% alcohol). One-third of underaged drivers tested positive for alcohol. For victims who survived a crash long enough to be transported to and admitted to a trauma center there was no association between alcohol use and injury severity, length of hospitalization, mortality, discharge to home, or the presence of a brain injury. A deleterious effect of alcohol on survival is suggested by the finding that 9 of 13 victims (69.2%) who died at the scene of injury or within 4 hours of admission tested positive for alcohol. A significant negative association was found between helmet use and alcohol use among the 111 drivers in which helmet use was known (p less than 0.001). A greater percentage of nonhelmeted (45.5%) drivers sustained brain injuries compared to helmeted (33.3%) drivers. Alcohol use was significantly higher in cyclists involved in single (67.1%) vehicle crashes compared to multiple (43.2%) vehicle crashes (p less than 0.002). Positive-BAC (82.7%) drivers were culpable at a significantly greater rate than negative-BAC drivers (45.7%) of causing the crashes in which they were injured (p less than 0.001). Alcohol use (68.6%) was associated with a significantly higher culpability rate for drivers in multiple-vehicle crashes compared to non use (28.6%) (p less than 0.002). The impact of alcohol use on the clinical course of injured drivers appears to be most apparent in the pre-hospital environment. Such use predisposes to injury. That predisposition is heightened by less frequent use of helmets, and a decreased ability to safely operate a motorcycle alone or in traffic.

Authors	Soderstrom, C.A.; Dupriest, R.W. Jr., & Benner, C.
Year	1979
Title	**Alcohol and roadway trauma: Problems of diagnosis and management**
In	*American Surgeon,* 45:129-136
Abstract	Blood alcohol concentration (BAC) was determined in 995 motor vehicle crash victims; 806 were automobile passengers or drivers, 92 pedestrians, and 97 victims of motorcycle crashes. Of the 48 percent with detectable BAC, 78 percent had a BAC of 100 mg/dL or greater. About 25 percent of those under 18 years had alcohol in their blood, and half of these had levels of 100 mg/dL or greater. About 52 percent of the patients over age 18 had detectable alcohol, but 81 percent of these had levels of 100 mg/dL or greater. The diagnosis of inebriation and injuries to the head and neck, thorax, abdomen and extremities and the management of cardiac disturbances, hemorrhage, fluid and electrolytes, anesthesia, hypothermia, hematologic changes, delirium tremens and infections are discussed.

Authors	Stein, A. C.
Year	1986
Title	**Factors affecting blood alcohol concentrations in humans: A review**
In	AAAM Annual Meeting, 30:15-32
Abstract	No abstract available

Authors	Stein, A.C., & Allen, R.W.
Year	1987
Title	**Effects of alcohol on driver decision making and risk taking**
In	P.C. Noordzij and R. Roszbach, Eds., Alcohol, Drugs and Traffic Safety - T86, Amsterdam: Elsevier Sciences Publishers B.V. (Biomedical Division), (pp 177-182)
Abstract	A study to investigate the effects of alcohol on driver decision making and risk taking is described. The research included two separate experiments, one a simulator study and the second involving full-scale validation, in which the driver was required to complete a 15-minute drive responding to various tasks. Subjects were male, 21-65 years of age, and heavy alcohol drinkers. The study results revealed that overall driving performance was degraded by alcohol as evidenced by an increase in crashes and tickets for both speeding and running red lights. An alcohol effect was seen in the probability of failure at a signal light task, although no effect was seen on completion of a given run. It is suggested that this indicates an impairment of speed perception although the driver was unaware of the impairment. However, drivers were consistent in risk acceptance behavior, proceeding through traffic lights with low perceived risk and stopping on signals with high perceived risk.

Authors	Sun, S., Kahn, D., & Swan, K.G.
Year	1998
Title	**Lowering the legal blood alcohol level for motorcyclists**
In	*Accident Analysis & Prevention,* 30(1): 133-136
Abstract	The blood alcohol concentrations (BAC) of all operators involved in motorcycle accidents (MCA) and drivers of motor vehicle accidents (MVA) admitted to a New Jersey Level I Trauma Center during 1992 (the first year such data were computerized) were evaluated. Comparable to other institutional statistics (one-third of vehicular crashes are related to alcohol consumption) our data showed 13 (33%) of 40 MCA operators and 117 (35%) of 340 MVA drivers had measurable BAC. These values, as well as their respective Injury Severity Scores (ISS), were recorded and compared for significance of apparent differences using the 't' test for unpaired observations. Mean BAC was 124 + 24 (SE) mg/dL for MCA and 180 ± 9 mg/dL for MVA ($p < 0.05$). The respective mean ISS for MCA was 13.1 + 5.4 and MVA was 7.9 + 0.9 ($p = 0.12$). These data indicate that drivers involved in MVA and MCA are frequently under the influence of alcohol. The mean BAC for motorcyclists is significantly less than that for drivers of four-wheeled passenger vehicles and is likely to reflect the need for greater coordination and balance when operating a two-wheeled vehicle.

Authors	Syner, J.W., & Vegega, M.E.
Year	2001
Title	**Impaired motorcycle riding: What motorcyclists think about alcohol and motorcycling**
In	Proceedings of the 2001 International Motorcycle Safety Conference
Abstract	This paper reports on focus groups conducted in 1994 among motorcycle riders who admitted to riding after drinking alcoholic beverages. At that time, available data indicated that alcohol-related fatalities had declined for passenger car drivers, but similar reductions had not occurred for motorcycle operators. The purpose for conducting the focus groups was to obtain insight on why alcohol-related fatalities had not declined among motorcycle operators, so that the information could be used to design appropriate approaches for reducing this problem. It is important to keep in mind that the results reported in this paper are based on focus groups of individuals who admitted to riding after drinking. Focus groups are a qualitative research technique used to gain insight and understanding into the nature of a problem, and should not be used for statistical purposes or generalized to larger populations; focus group data are not survey data. Hence, the results reported in this paper cannot be generalized to all motorcyclists. Motorcyclists who did not drink and ride were not included in the research because the focus was to identify the reasons motorcyclists ride after drinking, as well as approaches that might change the behavior of riders who rode after drinking. Qualitative analyses provided information on the behavioral and attitudinal characteristics of motorcyclists who drink and ride, as well as suggestions for program interventions. The results were used to develop public information materials focused on personal responsibility and the effects of motorcyclists actions on others (e.g., family). The results also suggest a need for more comprehensive prevention, education, and enforcement strategies.

Authors	Taylor, M. C. & Maycock, G.
Year	1990
Title	**Factors affecting the accident liability of British motorcyclists**
In	International Motorcycle Safety Conference, I, 1-45-1-69
Abstract	In Great Britain, as in many other countries, the riders of two-wheeled motor vehicles experience particularly high casualty rates – in 1988 (the latest year for which detailed statistics are available) a British motorcyclist was more than 20 times as likely to be killed or injured in a crash (per km traveled) as a British car driver (UK Department of Transport, 1989). Motorcyclists are therefore one of the groups of road users being studied in the behavioral research programme. The study presented in this paper aims to describe the way in which crash liability varies between motorcyclists by relating their involvement in crashes to individual characteristics (age, sex, riding experience, riding test passed), to exposure (distances ridden, types of road ridden on) and to the characteristics of their bike (engine capacity). This analysis together with other studies seeking social and behavioral explanations of the crash patterns will, it is hoped, lead to the development of improved crash remedial measures for motorcyclists.

Authors	Thom, D. R.
Year	1988
Title	**Motorcycle exposure data – 1988**
In	University of Southern California Motorcycle Accident Research
Abstract	Hurt et al. investigated 900 motorcycle crashes in Los Angeles. In order to determine the motorcycle population-at-risk, they gathered exposure data at 505 of those crash sites to determine the population-at-risk. In 1988, twenty of those sites were revisited at the same time of day, same day of week, and under the same weather conditions as the original crash in order to gather contemporary data. A total of 551 motorcycles were observed and numerous data points were collected related to motorcycle type, size, equipment, color, year, headlamp use, etc. The clothing and protective equipment was also noted. They noted 56 percent of the riders were wearing helmets, predominately full-facial coverage (80%). There were no interviews attempted either at the sites or via follow-up. No BAC data was gathered.

Authors	Thorpe, J. D.
Year	1967
Title	**Calculating relative involvement rates in accidents without determining exposure**
In	Research Review 3-8, Traffic Injury Research Foundation, Development of the methodology for a nighttime roadside survey in rural Alberta, (unpublished project conducted for RCMP, K Division Traffic Service)
Abstract	Of the numerous indicators used to measure the magnitude of the drinking and driving problem, roadside surveys provide the best assessment of the prevalence of impaired-driving behavior. Roadside surveys involve collecting actual breath test measurements from a random sample of drivers using the roads at night. The RCMP is interested in conducting such a survey in rural Alberta and commissioned TIRF to develop a methodology for the survey.
Authors	Traffic Injury Research Foundation (TIRF)
Year	2002
Title	**Development of the methodology for a nighttime roadside survey in rural Alberta**
In	Unpublished project conducted for RCMP, K Division Traffic Service
Abstract	ABSTRACT: Of the numerous indicators used to measure the magnitude of the drinking and driving problem, roadside surveys provide the best assessment of the prevalence of impaired-driving behavior. Roadside surveys involve collecting actual breath test measurements from a random sample of drivers using the roads at night. The RCMP is interested in conducting such a survey in rural Alberta and commissioned TIRF to develop a methodology for the survey. In a phone conversation, an RCMP staff member indicated that motorcycles were made part of a series of roadside surveys conducted in rural Alberta. Despite the fact that motorcycles were to be surveyed there were no motorcyclists encountered during the time that the surveys were conducted. The RCMP source said that a report is scheduled for release in Spring of 2002.

Authors	Turner, P. A., & Hagelin, C. A.
Year	2000
Title	**Novelty helmet use by motorcycle riders in Florida**
In	Washington, DC: Transportation Research Board 00-1497
Abstract	Although Florida law requires all motorcyclists to wear helmets, 16 percent of all motorcycle drivers and 30 percent of all their passengers killed in motorcycle crashes in 1996 were not wearing protective helmets. In addition, the use of novelty helmets may be on the rise in states with universal helmet laws. The objectives of this research were to determine motorcycle helmet use rates on Florida roadways and to estimate the level of novelty helmet use by motorcycle occupants. A total of 2,498 motorcyclists in 13 Florida counties were observed over a 2-month period. Data were collected on helmet use and type, motorcycle type, gender, and use of other safety equipment. Almost all motorcycle occupants wore some type of helmet; the observed state-level usage rate was 99.5 percent. However, a significant number of these helmets were novelty helmets. The type of helmet motorcyclists choose to wear may be related to the type of motorcycle driven and the gender of the driver and passenger. Overall, novelty helmet use was higher for passengers than for drivers, and the majority of observed novelty helmets were on motorcycle occupants riding cruiser-type motorcycles. Moreover, females exhibited lower rates of compliance than males, especially when associated with cruiser-type motorcycles. Although the survey did not collect information about the reasons for the increase in novelty helmet use, possible explanations may be that novelty helmets are more readily available at lower cost, and that there is an overall perceived lack of enforcement of the motorcycle helmet use law.

Authors	Turner, P. A. & Georggi, N.
Year	2001
Title	**The motorcycle-alcohol crash problem in Florida: Identification of characteristics and countermeasures**
In	International Motorcycle Safety Conference, 1
Abstract	Much progress has been made in reducing alcohol-related crash fatalities involving motor vehicles. However, the same success with addressing the public health issue associated with alcohol use and motorcycling has not been demonstrated. Operating a motorcycle requires more physical skill, coordination, and balance than driving a car, and the use and abuse of alcohol impairs those skills. Because of the problem associated with motorcycling and alcohol is significant in Florida, the Florida Department of Transportation (FDOT) contracted with the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) to conduct a comprehensive analysis of alcohol-related motorcycle crashes. A major research objective was to obtain a better understanding of the causes and characteristics of alcohol-related motorcycle crashes in Florida. This objective was accomplished by analyzing five years of State traffic crash data on alcohol-related motorcycle crashes. The study examined human-related and physical aspects of alcohol-related motorcycle crashes to help establish an "identity" to this crash type. Human-related crash aspects examined included age and gender, alcohol use, licensing status, and helmet usage. Physical crash aspects examined include temporal patterns such as time-of-day, day-of-week, and monthly trends; and contributing factors such as first harmful event, road, environmental, and human factors that cause bodily injuries and/or property damage. A second research objective was to identify potential interventions that may be effective at reducing alcohol-related motorcycle crashes in Florida. This objective was accomplished by conducting a national and statewide survey of motorcycle safety programs and assimilating information on innovative programs targeting the motorcycle alcohol problem. Major study recommendations include increasing efforts to get more motorcyclists properly licensed, greater exposure of messages to motorcyclists about the dangers of drinking and riding, and more focused statewide public education and information campaigns. The study concludes with five major categories of countermeasures and recommendations to address the motorcycle alcohol problem including public information and education (PI&E) campaigns, promotional activities, enforcement efforts, community-based interventions, and data collection needs.

Authors	Villaveces, A., Cummings, P., Koepsell, T.D., Rivara, F.P., & Lumley, T.
Year	2001
Title	**Effect of alcohol-related laws on deaths due to motorcycles crashes in the United States, 1980-1997**
In	*American Journal of Epidemiology,* 153(11):s74
Abstract	National data were used in an interrupted time series study for longitudinal data to estimate the effects of selected drinking-and-driving laws on all fatal motorcycle crashes and crashes that were alcohol related. Motorcycle mortality rates during periods when laws were in effect were compared with mortality rates during periods when they were not in effect. Estimates were based on comparisons within states and a pooled estimate between States. There were 63,052 deaths due to motorcycle crashes, a rate of 1.42 per 100,000 person-years. Forty-nine percent of motorcycle fatalities were attributable to alcohol use. Alcohol-related mortality due to traffic crashes was lower during periods when .08 g/dL blood alcohol concentration (BAC) per se laws were in effect -- 0.87 (0.89 - 0.95). Alcohol-related mortality due to motorcycle crashes was also lower during periods when universal helmet laws were in effect -- 0.61 (95% confidence interval, 0.56-0.66). Sobriety checkpoints, zero tolerance laws, and administrative license revocation were not associated with a reduction in alcohol-related traffic crashes. It is concluded that the results support a national BAC limit of .08 g/dL for drivers and that other policies such as universal helmet laws are useful in reducing alcohol-related traffic mortality.

Authors	Waller, P. F., Barry, P. Z., & Rouse, W. S.
Year	1968
Title	**Motorcycles: 1. Estimated mileage and its parameters**
In	University of North Carolina, Highway Safety Research Center
Abstract	This study dealt with the student population who had motorcycles registered at the University of North Carolina at chapel hill during the academic year 1966-1967. It covers how far the motorcycles were driven, the demographic characteristics of the students using motorcycles and whether motorcycle mileage varied as a function of these characteristics, and how many crashes occurred. Odometer readings on 225 (64.8%) of the 347 registered motorcycles were obtained. Estimates of daily mileage made for each vehicle varied as a function of several demographic characteristics: undergraduate students had a greater proportion of high mileage drivers than graduate students, single students had a higher proportion of high mileage vehicles, undergraduate single students had the greatest proportion of high mileage drivers, and graduate married students the least. Drivers of the lightest weight motorcycles (lowest cc displacement) traveled less distance than drivers of heavier motorcycles. Students who lived the greatest distance from campus were more likely to be high mileage drivers than students who lived closer to campus. Estimates of annual mileage suggest that motorcycles may travel between 4,500 and 7,000 miles per year and that the greatest portion of this mileage is accumulated during the summer months. The motorcycle fleet had a rate of slightly more than 8 crashes per 1,000,000 miles compared with a rate of over 4 crashes per 1,000,000 miles for passenger cars.

Authors	Waller, P. F., Reinfurt, D. W., Retfler, C. B., & Koch, G. G.
Year	June 1969
Title	**Motorcycles vs. automobiles: How do their owners differ?**
In	Highway Safety Research Center, University of North Carolina, I, 1-35
Abstract	Comparisons were made between university students with motorcycles registered on campus and university students with automobiles registered on campus. Available demographic information included graduate-undergraduate status, home residence (in-State or out-of-State), local residence (on-campus or off-campus), and marital status. For undergraduates, information concerning cumulative grade point average was obtained, and for in-State students where were usually driving records available from the North Carolina Department of Motor Vehicles. Also, for students who entered the university as freshmen since the autumn of 1964, there were available results from the Minnesota multiphasic personality inventory. Results indicated that motorcycle students were less likely to be married, and more likely to be from out of state than were automobile students. There were no differences in grades found between motorcycle and automobile students. However, when grades were compared with driving records, both motorcycle and automobile students with poorer grades also tended to have poorer driving records. It is possible that both the poor grades and the poor driving records could result from greater time spent driving the vehicle, thus allowing greater possibility for accumulating violations and crashes and leaving less time for studying. In regard to the MMPI results, the motorcycle students on the whole appeared just as healthy as the automobile students, with the possible exception of a higher score on the paranoia scale for the motorcycle students.

Authors	Watson, W.A., & Garriott, J.C.
Year	1992
Title	**Alcohol and motorcycle riders: A comparison of motorcycle and car/truck DWIs**
In	*Veterinary and Human Toxicology,* 34(3):213-215
Abstract	Alcohol's effects on balance and motor coordination would be expected to have greater consequences for motorcycle riders than car/truck drivers. Driving while intoxicated/under the influence (DWI) reports for 1984 and 1985 from the San Antonio, Texas, Police Department were reviewed to evaluate motorcycle DWIs, and to compare them with car/truck DWIs. During the 2-year period there were 100 DWI reports involving motorcycle riders, which were compared to 100 involving car/truck drivers. Motorcycle riders were all male and younger (mean age 26) than car/truck drivers (p less than 0.05). Initiation of the DWI investigation of motorcycle riders was more frequently due to excessive speed, and less likely due to a crash, when compared to car/truck investigations. Breath alcohol testing demonstrated a significantly lower blood alcohol concentration in motorcycle riders, .14 +/- .05 g/dL, than in car/truck drivers, .16 +/- .05 g/dL (p = 0.016). The results of this study suggest that alcohol influences motorcycle riders to a greater extent than it does car/truck drivers. Further data is needed to determine whether lower blood alcohol concentration limits should be considered for the definition of "driving while impaired" in motorcycle riders.

Authors	Weir, D.H., Bourne, S.M.
Year	1995
Title	**An overview of the DRI driving simulator**
In	Society of Automotive Engineers 95-0173
Abstract	This paper reports on a simulator that can be used for driver/vehicle applied research and driver behavior studies. The simulator has so far been utilized in steering and pedal controls layout, high speed brake in turn, and driver workload related to the use of an in-dash navigation and route guidance system.
Authors	Zwahlen, H.T.
Year	1976
Title	**The effect of alcohol on driving skills and reaction times**
In	*Journal of Occupational Accidents,* 1:21-38
Abstract	Twelve subjects (20-37 years old) were tested in the laboratory and 11 out of these were also tested in a car in the field, first under a no alcohol condition and then under an alcohol condition (approximately .10 g/dL BAC). In the laboratory the subjects' simple and choice reaction times for two uncertainty modes were measured and their information processing rates were determined. In the field the subjects' driving skill for driving through a gap (soft obstacles, 20" clearance) at 20 miles/hour, their static visual gap (car and Post) judgment of abilities and their gap risk acceptance decisions for a 50 feet viewing distance (using psychophysical experimental methods) were measured. Based upon the driving skill measure (standard deviation of centerline deviations in the gap), the mean of the psychometric visual gap perception function and the mean of the psychometric gap risk acceptance function the Safety Distance and the Driver Safety Index (DSI), developed by Zwahlen were obtained. A conceptual model illustrating a hypothetical localized system failure, developed by Blumenthal (1968), has been modified in such a way that the system demands on the driver-vehicle system are represented in terms of choice reaction times, while the driver performance at any point in time is represented by two choice reaction time probability distributions, one representing the sober condition, the other representing the alcohol condition. This modified system model is used to demonstrate that the combined time increase in mean performance and performance variability under the influence of alcohol provide a much better explanation for the higher small decrements in mean performance.

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