Motorcycle Crash Causation Study: Final Report

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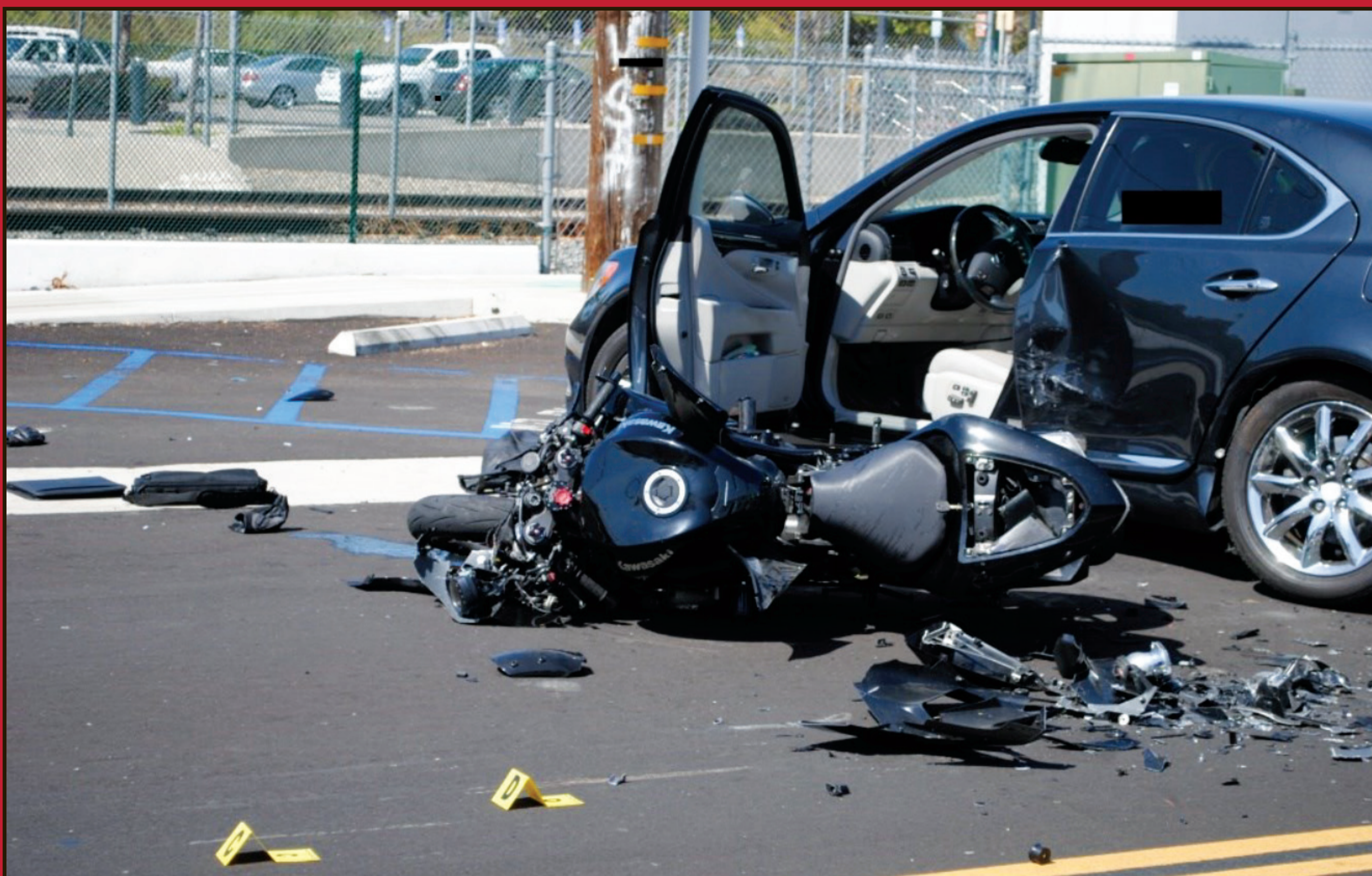

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

FOREWORD

The Motorcycle Crash Causation Study (MCCS), conducted through the Federal Highway Administration Office of Safety Research and Development, produced a wealth of information on the causal factors of motorcycle (MC) crashes and provides perspectives on what crash-countermeasure opportunities can be developed. This study used a crash- and control-case approach developed from the Organisation for Economic Cooperation and Development protocols, which as discussed in this report, has provided insights into more than 1,900 data elements that may be associated with motorcycle-crash causation. The research team produced a final report along with a 14-volume series of supplemental reports that provide an overview of the study and a summary of its observations, the data-collection forms and coding definitions, a tabulation of each data element collected from each form, and selected comparisons with previous studies. It is anticipated that readers will select those Volumes and data elements that provide information of specific interest.

This final report describes the development and conduct of the MCCS and contains tabulations of the results. It provides a background of the study, various protocols used to collect the data, the study design, and a summary of the findings. This report will be of interest to individuals involved in traffic safety, safety training, crash and injury reduction, and roadway design and policymaking, as well as MC designers and safety-equipment designers, crash investigators and researchers, MC and automotive manufacturers and consumers, roadway users, and human-factors specialists.

Brian P. Cronin, P.E.
Director, Office of Safety and Operations
Research and Development

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16. Abstract
This large-scale study, based on the Motorcycle Crash Causation Study (MCCS) sponsored by the National Highway Traffic Safety Administration, gathered data on motorcycle (MC) crashes by intensive post-crash investigations and control MC observations and interviews conducted in Orange County, CA. The study developed a dataset that researchers can use to investigate additional research questions. The database provides data from 351 injury crashes and 702 paired control observations. Of the crashes observed, 82 were single-vehicle crashes, and 269 were multiple-vehicle crashes, all of which involved a total of 294 other in-transit vehicles and 11 parked vehicles; 40 crashes resulted in fatalities, with 22 single vehicle–crash fatalities and 18 multiple vehicle–crash fatalities observed. The study compiled the observations on rider, passenger, and other-vehicle (OV) driver demographics; environmental factors; factors contributing to the crash; MC; and OV parameters; injuries sustained; and clothing/safety equipment used. The study also compiled observations on the crash and control riders, passengers, and MCs and OVs involved in the crashes. Within the crash observations, the study compiled and compared the data for single- and multiple-vehicle crashes, fatal and nonfatal crashes, along with selected previous studies and elements of the National Automotive Sampling System/General Estimates System and the Fatality Analysis Reporting System databases. The data are available in SAS® and Microsoft® Excel™ formats; MCCS Volume 2 defines all codes used.[1]

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

MOTORCYCLE CRASH CAUSATION STUDY REPORT SERIES

This document is the final report of the Motorcycle Crash Causation Study (MCCS). The final report is supplemented by a 14-volume MCCS research report series. Each volume is a description of a data-collection form or protocol used in the MCCS, and any reference to a report volume in this series will be referenced in the text as "MCCS Volume 1," "MCCS Volume 2," and so forth. A list of the report volumes follows:

Volume	Title	Report Number
1	Data Collection and Variable Naming	18-040
2	Coding Manual	18-039
3	Crash Form Data Tabulation	Unpublished, available on request
4	Environment Form Data Tabulation	Unpublished, available on request
5	Contributing Factors Form Data Tabulation	Unpublished, available on request
6	Motorcycle Rider and Control Rider Forms Data Tabulation	Unpublished, available on request
7	Motorcycle Passenger and Control Passenger Forms Data Tabulation	Unpublished, available on request
8	Motorcycle Mechanical and Control Motorcycle Mechanical Forms Data	Unpublished, available on request
9	Motorcycle Dynamics Form Data Tabulation	Unpublished, available on request
10	Injury Form Data Tabulation	Unpublished, available on request
11	Other Vehicle Driver Form Data Tabulation	Unpublished, available on request
12	Other Vehicle Form Data Tabulation	Unpublished, available on request
13	Helmet Form Data Tabulation	Unpublished, available on request
14	Study Comparison Report	Unpublished, available on request

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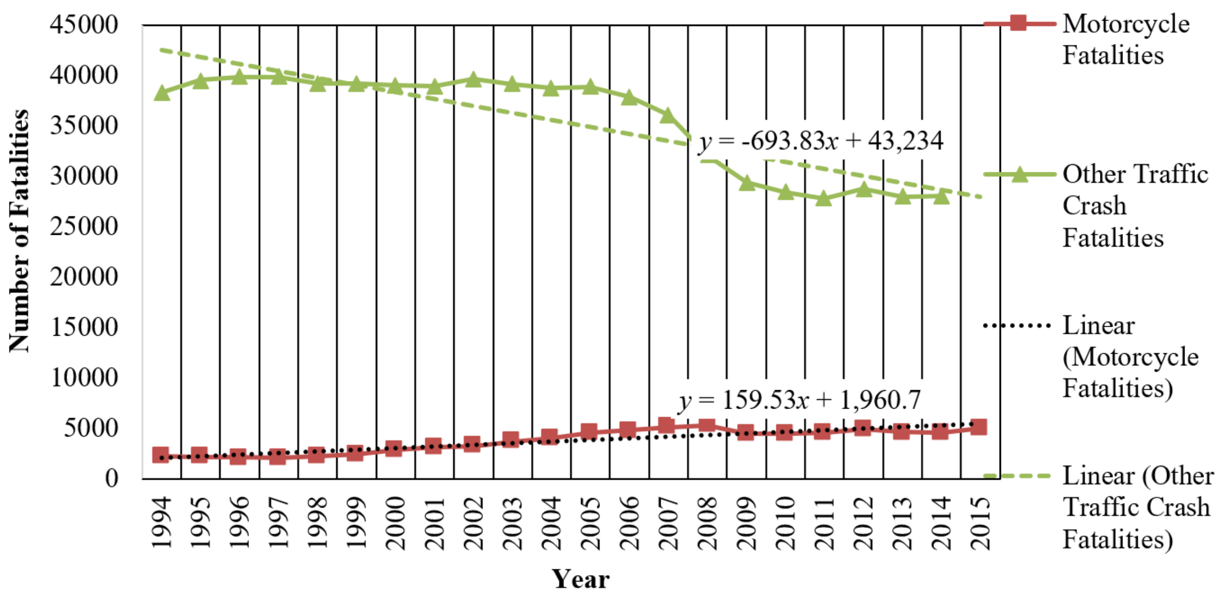
LIST OF ACRONYMS

ABS	antilock braking system
BAC	blood alcohol concentration
CHP	California Highway Patrol
CoC	Certificate of Confidentiality
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
GAD	Gadd Severity Index
GES	General Estimates System
GSI	Gadd Severity Index
HIC	head-injury criteria
IRB	institutional review board
MAIDS	Motorcycle Accident In-Depth Study
MC	motorcycle
MCCS	Motorcycle Crash Causation Study
NASS	National Automotive Sampling System
NHTSA	National Highway Traffic Safety Administration
NIH	National Institutes of Health
OECD	Organisation for Economic Co-operation and Development
OECD-CM	Organisation for Economic Co-operation and Development's Common Methodology
OV	other vehicle
PAR	police accident report
POI	point of impact
POR	point of rest
PWG	project workgroup
USDOT	United States Department of Transportation
VIN	vehicle identification number

EXECUTIVE SUMMARY

The number of motorcyclist crash–related fatalities has nearly doubled during the past 20 yr, from 2,304 fatalities in 1994 to 4,295 fatalities in 2014, with preliminary data from 2015 showing an estimated 10-percent increase (to 5,010 motorcyclist fatalities).(2) The Fatality Analysis Reporting System database shows that, in stark contrast to the 34-percent decline in nonmotorcyclist crash–related fatalities, motorcyclist crash–related fatalities were up 86 percent with only 3 yr-to-yr declines since 1997, while nonmotorcyclist crash–related fatalities had 13 yr-to-yr declines since 1997 (figure 1).(2)



Source: FHWA.

Figure 1. Graph. Crash-related fatality trends.(2)

U.S. Congress directed the Secretary of Transportation to conduct a comprehensive study of the causes of motorcycle (MC) crashes. The National Highway Traffic Safety Administration (NHTSA) awarded a contract to conduct a pilot study for developing and testing a methodology for indepth MC-crash investigation. Subsequently, the Federal Highway Administration (FHWA) awarded a contract to use the results of the pilot study as a basis for collecting data on 280 crashes and 560 non-crash-related cases for comparison. The cooperative agreement between FHWA and NHTSA was modified to increase the study to 350 crash cases and 700 controls in July 2014.

The primary focus of this project was to gather comprehensive data on MC crashes and information on similar non-crash-involved motorcyclists and their vehicles. This case–control approach provided data that can help identify factors that might lead to crashes and the resulting injuries. This report provides an overview of research results and exemplar data analyses of primary factors.

The project was conducted in strict adherence to institutional review board protocols. It also generally adhered to the Organisation for Economic Co-operation and Development's (OECD's) protocols and procedures, per requirements of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, albeit with some modifications based on U.S. laws, customs, local conditions, and best practices.(3,4) The case–control approach described in the OECD's Common Methodology[1] enables the comparison of the frequencies of key factors (e.g., age, impairment, MC style, motor displacement, braking system) in the crash and control (exposure) samples to identify differential involvement. Overrepresentation of some factors or combinations of factors in the crash sample relative to the exposure sample suggests that such factors are correlated with MC crashes, although correlation alone is insufficient to determine causation.

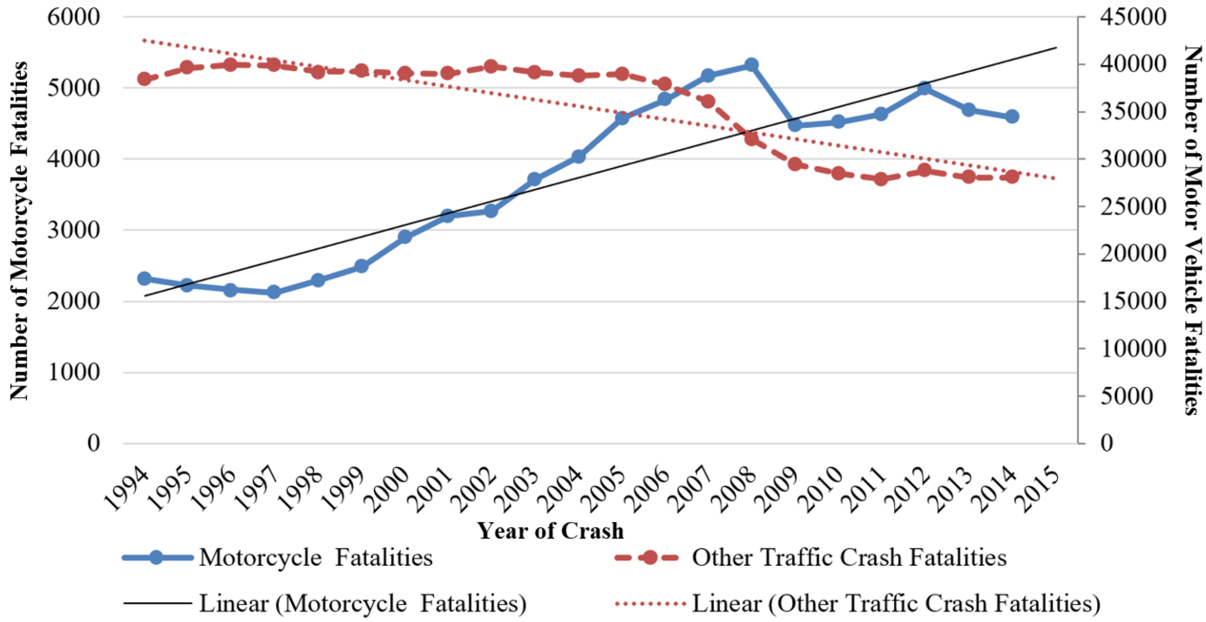
The final dataset includes 351 on-scene crash investigations and 702 control cases. The crash-investigation team responded in real time to 500 crashes under the jurisdiction of cooperating police agencies in Orange County, CA. Cases were retained in the study when a crash resulted in an injury to a motorcyclist or passenger and permission was obtained to inspect the crash-involved vehicles. The indepth investigations included extensive interviews, detailed recordings of environmental and crash-related scene data, and documentation of injuries. Case reports included coded and narrative data as well as diagrams and photographic documentation.

This final report describes the development and conduct of the MC Crash Causation Study and tabulations of the results. By design, research funds were dedicated to the collection and tabulation of crash and control data. Detailed analyses of the research results were beyond the scope of this project. The dataset is available through FHWA. (See section 4.2 for more information about obtaining this dataset.)

[1]OECD's Common Methodology is not available as a comprehensive document; rather, the Common Methodology is a general term used to refer to the OECD's practices and protocols in regard to proper research methodologies. Many of these practices stem from the Hurt Report.(5)

1.0 INTRODUCTION

The safety of motorcyclists on U.S. roads is a long-standing concern among traffic-safety professionals. Figure 2 compares the number of nonmotorcyclist crash–related fatalities (e.g., vehicle occupants, pedestrians, bicyclists) with motorcyclist crash–related fatalities over the past 20 yr. Although nonmotorcyclist crash–related fatalities have decreased, motorcyclist crash–related fatalities have steadily increased year after year with three exceptions: 2008–2009, 2012–2013, and 2013–2014.



Source: NHTSA.

Figure 2. Graph. Crash fatalities by year.[2]

With motorcyclist fatalities being the only category of crash fatalities not showing significant decreases and, in fact, being the only one that has increased over a 20-yr period, the research and safety community thought it important to conduct an indepth study of motorcycle (MC) crashes to develop data that can identify appropriate and effective countermeasures. Congress directed the U.S. Department of Transportation (USDOT) to conduct research that will provide a better understanding of the causes of MC crashes. Data gathered from a large number of crashes are needed to ensure this understanding. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users legislation required the Secretary of Transportation to provide grants to the Oklahoma Transportation Center to conduct the Motorcycle Crash Causation Study (MCCS), a comprehensive, indepth study using the Organisation for Economic Co-operation and Development's Common Methodology[1] (OECD-CM).[3,4] There has been no USDOT-sponsored comprehensive study in the United States of such crashes for over 30 yr.

[1]OECD–CM is not available as a comprehensive document; rather, the Common Methodology is a general term used to refer to the OECD's practices and protocols in regard to proper research methodologies. Many of these practices stem from the Hurt Report.[5]

1.1 BACKGROUND

In anticipation of a congressional mandate for the full MCCS, the National Highway Traffic Safety Administration (NHTSA) awarded a contract for a pilot study to adapt and test the methodology for the MCCS using the OECD-CM for indepth MC-crash investigation.[6] The project had four target outcomes: (1) develop comprehensive data-collection forms, a coding manual, and field protocol for crash investigations; (2) develop data-collection forms, a coding manual, and field protocol for the collection of control-group data; (3) create training materials that could be used for a future, larger-scale study; and (4) assess the levels of effort and resources required for each stage of an investigation so that more accurate plans could be made for this crash-causation study.

1.1.1 Project Workgroup and Research Question Development

A project workgroup (PWG) (see appendix), composed of stakeholders from the motorcyclist community, private industry, Federal agencies, and nonprofit organizations, was convened in June 2006 to establish the goals for the pilot and main studies. The PWG developed a set of potential questions and topics to be addressed by these studies. Two of the questions and topics fell outside the scope of this study: severity and cost of crash outcomes and emergency medical services' response. The remaining PWG questions and topics as well as the findings of the Hurt Report and the Motorcycle Accident In-Depth Study (MAIDS) served as the basis for the following 28 major research questions:[5,7]

Human Factors

1. What human factors of motorcyclists and other-vehicle (OV) drivers are associated with MC crashes? What is the relative frequency of each human factor labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing human factor?

   Likely human factors include age, health, training, riding experience, operator licensing, risk taking, frequency of riding, traffic violations, and socioeconomic status (e.g., education, occupation, gender, marital status, number of children).

2. What psychophysiological states of motorcyclists and OV drivers are associated with MC crashes? What is the relative frequency of each psychophysiological state labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing psychophysiological state?

   Likely psychophysiological states include alcohol, drugs, fatigue, sleep deprivation, and stress.

3. What riding habits are associated with MC crashes? What is the relative frequency of each riding habit labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing riding habit?

   Likely riding habits include solo riding, group riding, and preparing for riding.

4. What is the impact of riding/driving while engaging in an distracting task on MC crashes? What is the relative frequency of rider/driver distraction? What is the relative crash risk for distracted riding/driving?

   Likely inattentive tasks include talking to a passenger, reading, moving an object in the vehicle, dropping an object, reaching for an object in the vehicle, using a handheld device/phone, eating, smoking, daydreaming, being distracted by an insect in the vehicle or protective equipment, being distracted by other external distractions, etc.

5. What perceptual and decision errors of motorcyclists and OV drivers are associated with MC crashes? What is the relative frequency of each human error labeled as a "precipitating factor" for MC crashes?

   Likely errors include misjudging distances to other objects, misjudging speeds of OVs, riding too close to the vehicle in front, speeding, attempting to overtake a vehicle without noticing turn signals, failing to notice or anticipate that another vehicle might pull in front, violating right of way, making braking errors, making cornering errors, etc.

Environment, Roadway, Traffic, and Control Factors

6. What are the environmental conditions that contribute to MC crashes? What is the relative frequency of each environmental condition labeled as a "contributing factor" for MC crashes? What is the relative crash risk when riding while encountering these environmental conditions?

   Likely environmental factors include type of development, visibility, level of illumination, visual background of OV, roadside environment, and weather conditions.

7. What are the roadway conditions that contribute to MC crashes? What is the relative frequency of each roadway condition labeled as a "contributing factor" for MC crashes? What is the relative crash risk when riding while encountering these roadway conditions?

   Likely roadway factors include view obstructions along the operator's line of sight at the time of the precipitating event, cross-section elements (number of through lanes, lane width, lane in which the vehicle was traveling, presence of median, presence of exclusive turn lanes, etc.), horizontal alignment (curvature, horizontal curve data, superelevation rate), vertical alignment (grade tangents, vertical curves), roadway surface type and condition, roadway-surface special features, relation to junction, type of at-grade intersection, etc.

8. What are the contributing traffic conditions associated with MC crashes? What is the relative frequency of each traffic condition labeled as a "contributing factor" for MC crashes? What is the relative crash risk when riding while encountering these traffic conditions?

Likely traffic factors include traffic density, average speed, traffic composition, presence of parked vehicles and mobile obstructions, left-turn volume at intersections, etc.

9. What are the contributing traffic-control conditions associated with MC crashes? What is the relative frequency of each control condition labeled as a "contributing factor" for MC crashes? What is the relative crash risk when riding while encountering these traffic-control conditions?

   Likely control factors include type of traffic control, type of signal phasing, pavement marking, traffic signage, temporary controls at work zones, etc.

Vehicle Factors

10. What are the MC mechanical factors that contribute to MC crashes? What is the relative frequency of each MC mechanical factor labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing MC mechanical factor or combination of such contributing factors?

    Likely MC mechanical factors include mechanical problems, tires (size, condition, and inflation pressure of front and rear tires), type and condition of front and rear suspension, brakes (brake control–system type, condition of brakes, antilock braking system (ABS)), frame type and configuration, wheelbase reduction, steering-stem adjustment, condition of rear swing arm, headlamp-assembly type and use, handlebar (type, mounting, and construction), seat type and seat-fastening mechanism, fuel-tank type and material, driveline type and condition, throttle control, front and rear crash bars, left-side and right-side rearview mirrors, rear turn signals, rear reflectors, etc.

11. What are the OV factors that contribute to MC crashes? What is the relative frequency of each factor labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing OV factor or combination of such contributing factors?

    Likely OV factors include mechanical problems, ABS, tires, turn signals, brake lights, etc.

12. What is the impact of MC type/style on MC crashes? What is the relative frequency of each MC type/style? What is the relative crash risk for each MC type/style?

13. What is the impact of motor displacement in cubic centimeters on MC crashes? What is the relative frequency of each MC motor displacement? What is the relative crash risk for each MC motor displacement?

14. What is the impact of the MC aftermarket modification on MC crashes? What is the relative frequency of each MC aftermarket modification? What is the relative crash risk for each MC aftermarket modification?

Speed Factors

15. What is the impact of vehicle speed on single- and multiple-vehicle MC crashes? What is the relative frequency of speeding-related MC crashes? What is the relative crash risk for driving too fast for conditions?

16. What is the relative frequency of speeding-related MC crashes for intoxicated riders/drivers (blood alcohol concentration (BAC) = 0.08 mg/100 ml or above)?

17. What is the relative frequency of speeding-related MC crashes for riders/drivers traversing a curve?

18. What is the relative frequency of speeding-related MC crashes for different types/styles of MCs and different MC motor displacements?

Trip-Related Factors

19. What trip-related factors are associated with MC crashes? What is the relative frequency of each trip characteristic labeled as a "contributing factor" for MC crashes? What is the relative crash risk for each contributing trip factor?

    Likely trip factors include origin, destination, trip length, miles ridden before crash, familiarity of road and environment, etc.

MC and Rider Conspicuity

20. What is the impact of the MC headlamp-assembly type, modulator type, and daytime-illuminated headlight on MC crashes? What is the relative frequency of each headlamp-assembly type, headlight modulator, and daytime-illuminated headlight? What is the relative crash risk while riding an MC with a certain headlamp-assembly type, modulator type, and daytime-illuminated headlight?

21. What is the impact of the MC's predominant color on MC crashes? What is the relative frequency of each MC's predominant color? What is the relative crash risk while riding an MC with certain predominant colors?

22. What is the impact of the MC's retroreflective parts on MC crashes? What is the relative frequency of MCs with retroreflective parts? What is the relative crash risk while riding an MC with retroreflective parts versus while riding an MC without retroreflective parts?

23. What is the impact of a rider's reflective clothing on MC crashes? What is the relative frequency of a rider's reflective clothing? What is the relative crash risk when riding while wearing reflective clothing as compared to that when wearing nonreflective clothing?

24. What is the prevalence of OV-driver responses of "looked but did not see the motorcycle" in MC crashes? What is the relative frequency of OV drivers who do not see MCs?

Training

25. What is the prevalence of MC safety training as well as the types/levels of rider training courses (e.g., none, basic, experienced, sport bike)? What is the relative frequency of the different types/levels of rider training courses? What is the relative crash risk for riders who completed different types/levels of rider training courses?

Protective Equipment

26. Do helmets limit the motorcyclist's visual field, impact hearing, or cause fatigue or inattention while riding an MC? What is the prevalence of the perceived potential negative effects of helmets on rider safety?

27. What is the prevalence as well as types of safety helmets worn by motorcyclists?

    Helmet types include Federal Motor Vehicle Safety Standards (FMVSS) 218-compliant helmets, novelty helmets, or no helmet.(8)

Crash Types/Configurations

28. What are the primary MC crash types/configurations? What is the relative frequency of each type of MC pre-crash motion by OV pre-crash motion?

The PWG reviewed all of the OECD data elements and made recommendations on the data elements to be collected to enable researchers to address these questions. As a result of this review, and with contributions and a review by the project team and staff from NHTSA and the Federal Highway Administration (FHWA), a modified set of data elements was created. The MCCS was designed to address the acquisition of these data elements using research protocols from MC research from the 1970s in the United States, current United States data-collection programs, and the methods developed by OECD for use in Europe.(4)

1.1.2. OECD Methodology

The OECD methodology is a comprehensive approach to investigating MC crashes. The 649-page methodology calls for investigating crashes of all severities, excluding noninjury cases, and collecting exposure data in the form of controls. Crash investigations include interviews with MC operators, passengers, the drivers of other involved vehicles, or their survivors. Human factors topics range from rider experience, licensing, and training to fatigue, drug and alcohol use, trip purpose, use of protective clothing, and risk-taking behaviors.

This study was developed by adapting the OECD methodology and variables to align with other MC studies and facilitate meaningful comparisons by researchers and policymakers. Not all OECD variables could be collected due to U.S. privacy laws.(9) The following list compares the 2007 OECD data forms to those used in the MCCS:

- The MCCS data forms collected 100 percent of the same information as OECD's A.2 Accident Typology, Classification and variables.

- The MCCS data forms collected 100 percent of the A.3 Environmental Factor variables. Note that while OECD variables were collected, the coding choices were revised based on U.S. engineering terminology. These changes were made under the advisement of FHWA and the first PWG based on review of the pilot study.

- Only one question/variable is missing from the A.4.1 Motorcycle Mechanical Factors variables, and it relates to recording the motorcycle license plate. This information cannot be collected in the United States due the Privacy Act of 1974.(9)

- With regard to the A.4.2 Motorcycle Dynamics variables, the MCCS data forms are missing three questions/variables. Two of the questions that were omitted have to do with the fact that the OECD definition of a crash differs from the U.S. definition of a crash (A.4.2.15 and A.4.2.16). The third variable (A.4.2.21a) that was omitted is asked twice in the OECD data forms.

- The MCCS data forms collected 100 percent of the same information as OECD's A.4.3 Other Vehicle Mechanical Factors variables.

- The MCCS data forms collected 100 percent of the same information as OECD's A.4.4 Other Vehicle Dynamics variables.

- The MCCS data forms collected 90 percent of the same information as OECD's A.5.1 Human Factors variables. The differences between them are as follows:

    - Three variables in the OECD data forms ask for the date of birth from the motorcyclist, MC passenger, and OV driver. Because OECD captures age, date of birth was not included in the MCCS data forms because it cannot be included in a public-use database.

    - Three variables in the OECD data forms ask for the citizenship of the motorcyclist, MC passenger, and OV driver. This information cannot be collected in the United States due to the Privacy Act of 1974.(9)

    - Three variables in the OECD data forms ask for the duration of formal education of the motorcyclist, MC passenger, and OV driver. This variable does not apply because the educational system in the United States is different from those in Europe. The question was modified for U.S. relevance.

    - Three variables in the OECD data forms ask the motorcyclist, MC passenger, and OV driver to recommend countermeasures. This is subjective information; hence, it was not included in the MCCS.

    - One question in the OECD data forms that asks about passenger position has three OECD variables so that more than one code can be entered. The problem is that each code is mutually exclusive. A rider cannot be "normal, straddle, seated behind rider," and "riding with both legs to the left." Therefore, only one code was captured.

  - The remaining variables that were not used (three) from the OECD data forms were excluded in the interest of ensuring that all data collected were objective. One variable regarding the distance the MC passenger rides on an MC each year was omitted. It seemed unlikely that a passenger pays attention to the mileage on each trip he or she takes; as such, the passenger, on average, would provide unreliable data. Researchers decided not to ask the MC passenger the number of traffic violations he or she had in the last 5 yr because the information was irrelevant to the cause of the crash. Researchers also decided to exclude the question about attention to passenger tasks because "passenger tasks" is not well defined in OECD.

- Even though the MCCS Injury Form looks very different from OECD's form, it still captures 100 percent of the variables on the OECD A.5.2 Injury Analysis form.

- In the OECD data forms, 0 and 00 represent "Not Applicable" or some other code such as "No Pedestrian Involvement," "Clear," "Conventional Street," "None," "Step-Through, Formed Sheet Metal," etc. A well-designed data form should have a unique identifier for any codes that consistently show up for most, if not all, variables. Therefore, the codes 97, 98, and 99 were used consistently and exclusively for "Not Applicable," "Unknown," and "Other (Specify)," respectively, for all variables in the MCCS data forms. In the instances when the value of a recorded metric (e.g., speed and feet) might overlap, additional leading 9s were used in the coding of these questions (e.g., 997 and 9997) to ensure clarity.

Overall, the MCCS data forms collected 1,689 elements, with 1,488 of the elements overlapping with the elements of the OECD data forms and many new collected data elements derived from OECD A.6 series interpretations.

Laboratory testing of crash-involved helmets is part of OECD protocol; though such testing was not conducted as part of the pilot study, it was conducted in the MCCS. A sample of 30 helmets was collected, and they were extensively analyzed during the MCCS whenever it was possible to collect the damaged helmets. Results from helmet testing were not tabulated for this report because the sample size was small.

The project team developed and maintained MCCS Volume 2 with pertinent instructions and specific definitions for every variable for all crash and control data forms throughout the study.[1] This coding manual guided the data-collection activities and defined all allowable responses. In this way, it was guaranteed that all case data were collected and recorded consistently, according to specific standards. Each data element for every crash and control form included the following information:

- Data form.
- Data element number and name.
- OECD reference number.
- Convention/coding source.

- Element attributes.
- Range.
- Source.
- Remarks.

During the MCCS, potential edits to the coding manual were noted on an issues form, and these issues were resolved and incorporated into the manual and used in the study. MCCS Volume 2 data definitions served as the basis for the range and edit checks that were incorporated in the Microsoft® Access™ database created for the collection and storage of the crash and control data during the study. The final coding manual is available in MCCS Volume 2.[1]

SAS® and Microsoft® Excel™ data files are also available for this study from FHWA (see section 4.2). To more easily locate variables of interest or variables that are common to different individuals in the study (e.g., age for motorcyclists and passengers as well as for OV drivers and passengers, pedestrians, and bicyclists), the list can be filtered by the common terminology used in the variable naming convention, such as motorcyclist. See section 2.0 of this volume for more detailed information on naming conventions used.

1.2 MCCS

Following completion of the pilot study and incorporation of lessons learned, the main MCCS was conducted under Cooperative Agreement Number DTFH61-06-H-00034. Originally contracted for the investigation of 280 crashes and 560 controls, the study was revised to investigate a total of 350 crashes and 700 controls in the workplan on June 16, 2014. The effort provided data from a total of 351 crashes and 702 controls collected in Orange County, CA, which had a year-round population of motorcyclists, a mixture of road types and urban and rural characteristics, excellent support from the law enforcement community, and the availability of the experienced crash investigators.

1.2.1 Study Design

The MCCS was designed to provide data that could be used by the research and safety communities and by other stakeholders to better understand the potential causes of MC crashes and assist in the development of countermeasures to reduce the occurrence and severity of such crashes. No comprehensive, large-scale study of MC crashes had been conducted in the United States since the study *Motorcycle Accident Cause Factors and Identification of Countermeasures*, commonly referred to as the Hurt Report, was conducted between 1976 and 1980.[5] The MCCS was tasked with adopting the methodology used in the more recent MAIDS conducted on behalf of OECD in Europe and modifying the protocol as needed for use in the United States.[7,4] The project team employed the basic OECD methods while incorporating best practices from U.S.-based crash investigation research, ensuring compatibility with current and previous crash studies, and modifying data elements to reflect American road characteristics, vehicles, licensing, and other factors.

The adoption of the case–control approach used in the Hurt Report and the MAIDS allows analysts to identify specific factors that may contribute to the occurrence and severity of MC crashes.[5,7] The comprehensive research design includes pre-crash, crash, and post-crash characteristics of the riders, drivers, vehicles, and crash sites. The comparison data are drawn from non-crash-involved controls matched by time of day, day of week, and crash location.

The primary focus of the project was to gather data relevant to MC crashes and provide these data to the MC community. Although simple tabulations and case–control comparisons are provided, a complete set of desired data analyses cannot be anticipated or provided by the MCCS due to limited time and resources. The study provides these data tabulations and limited data analyses to illustrate its use, and the full dataset and accompanying diagrams and photographs are available through FHWA in SAS® file format for additional, more detailed review and analysis by the MC research community.[(10)]

Environmental details were collected to get a full picture of the crash event. The time of event, roadway features, traffic controls, and other environmental factors that could have contributed to crash causation were recorded. In addition, circumstances such as line of sight and potential visual obstructions were noted.

Injury details and human factors, such as fatigue levels, demographics, medical conditions, and purposes of trips, were gathered through direct observation, interviews, and medical records obtained by the project team with appropriate permission. The MCCS sought to gather not only the events and outcomes of the crashes, but also the context and circumstances of those involved.

Vehicle inspectors gathered detailed examinations and judgments of pre- and post-crash conditions for MC components. The type, size, and handling characteristics of the MCs were also carefully documented. When other motor vehicles, such as cars and trucks, were involved in crashes with MCs, data on the points of contact and exterior vehicle damage were recorded.

Control data were gathered through detailed interviews with MC operators and passengers who were similarly at risk to those involved in each crash and included documentation of the condition of MCs they were riding. Environmental, contextual, and MC data were collected from the control group. The control subjects were solicited using roadside stops at safe locations at or near the accident location and near the time that the crash occurred. All control subjects were informed volunteers and received a $40 prepaid gas card for their participation.

Quality control was applied to the data for all cases in the first half of the MCCS to ensure consistent situation and code interpretations, crash reconstructions, and coding into the database. Once the investigation team gained experience and performed consistently, quality-control reviews were conducted on approximately 25 percent of the remaining completed cases. Quality-control review was also conducted on particularly complex cases to maintain the continuity of the monitoring process.

Regarding crash-investigator training, this study employed individuals, including former police MC officers, and provided them with additional training in research methods, interpretation, and coding. This study was able to secure and use a single set of crash investigators from the pilot study through the main study. Six weeks of training was provided to the crash investigators (with only one exception) before the pilot study commenced. All training was conducted by experienced crash investigators and MC-safety experts. Throughout this study, the quality control was performed by experts with experience in U.S. and international MC-crash studies.

The quality-control team monitored and provided feedback to the crash investigators to reinforce or clarify the proper practices and coding and to ensure uniformity in their application. The 100-percent case review for the first half of the main study and 25-percent case review for the latter half of the study ensured that crash investigators consistently applied their training when gathering and coding the data for this study.

1.2.2 Study-Design Review

PWG

A PWG (see appendix) comprising individuals across the breadth of the MC community was formed and developed a set of research questions that was used to guide a pilot study to test and validate the approach to be used in this study. The PWG was updated and consulted regarding the progress and execution of the main study.

Pilot Study

A pilot study was developed and executed to test and validate the MCCS design; develop training materials, data-collection forms, and a coding manual; create a sample database in Microsoft® Access™ with proper formatting and consistent quality-control checks; and develop and assess the research protocol planned for the main study.(1) At the conclusion of the pilot study in June 2010, minor edits were made to some of the data-collection forms and the related sections of the coding manual. These edits were primarily focused on adding helmet-testing procedures since these were not included in the pilot study. A more complete description of the pilot study can be found in the NHTSA report *Motorcycle Crash Causes and Outcomes: Pilot Study*.(6)

Institutional Research Boards

Two separate institutional review boards (IRBs), a prime IRB and a sub IRB, were used to oversee research studies involving human subjects. During the pilot study, a prime IRB reviewed and approved that portion of the MCCS; during the main study, a sub IRB reviewed the operations of that portion of the study.

The prime IRB provided approval for the project with the recommendation that a Certificate of Confidentiality (CoC) be obtained from the National Institutes of Health (NIH) to protect project data from disclosure and subpoena. Following an initial review, the application was transferred to the National Institute for Mental Health since much of the sensitive project data related to legal drug use, illegal drug use, and the pre-crash emotional state of the motorcyclist. The CoC (number AA-058-2010581) was received from NIH after the National Institute on Alcohol Abuse and Alcoholism provided a final review on March 11, 2009. It covered the period from March 11, 2009, to October 15, 2016.

The prime IRB focused on the informed-consent script, the collection and storage of sensitive data, privacy protection, and reporting protocol. Following its initial review, the prime IRB requested modifications to the consent forms for the crash-involved and the control subjects. In addition, parental consent forms and youth assent forms were developed for use in the pilot study with any motorcyclist, MC passenger, or OV driver who was under 18 yr of age. The prime IRB did not approve of inclusion of riders, drivers, or passengers under the age of 18.

The IRBs reviewed data confidentiality and data security protocols for the pilot and subsequent main study, and these protocols were used throughout the MCCS. Project data did not include any personal identifiers, such as names, addresses, and dates, nor did they include specific locations or location identifiers. During the course of an investigation, some identifying information, such as names and phone numbers, was maintained only until all required data were assembled. Protocol for the protection and storage of study data was reviewed and approved by the IRBs.

The crash investigators and project personnel completed the Human Subjects Protection training course offered by the contractor and NIH. The MCCS conducted background checks of its newly hired crash investigators before they were assigned to field investigation.

1.2.3 Study Management

Using lessons learned from the pilot study, the MCCS was conducted with a flattened organization structure by distributing various tasks, such as project administration and coordination, crash investigation, data-gathering and data-entry functions, analysis, and preparation of final reports, among different contractors involved in the project. The helmet testing and analysis was performed by a private contractor with expertise in this field. Several individuals who worked on the original Hurt Report provided technical expertise and reviewed the study.[(5)]

1.2.4 Crash-Response Logistics

The MCCS required the crash investigators to respond to the scene of the crash as soon as possible. Notification procedures were negotiated with each cooperating police agency. Cooperating police agencies were provided with a phone number and an email address to be used for case notification. The project team acquired cell phones dedicated solely to receiving crash notifications. Some dispatch officers would place a telephone call to notify the team of a crash; other jurisdictions preferred to send an email (which was received as a text message). The project team also monitored California Highway Patrol (CHP) websites and local news outlets in order to identify MC crashes.[(8)]

At least one crash investigator was on call via cell phone and email so that crash investigations could be initiated on scene 24 h per d, 7 d per week. After receiving notification, the crash investigator would initiate a case by notifying a second crash investigator (when available) and traveling directly to the crash scene.

The crash investigators responded to crash cases at the scene immediately after notification that the crash occurred when such notifications were timely. After arriving at the crash scene, the crash investigators parked their vehicle in a safe place and introduced themselves to the lead police officer. The police officer in charge determined when the crash investigators could begin documenting and collecting case data. The activities could range from allowing only photographs to providing full access to crash-involved vehicles, riders, drivers, and the scene. The crash investigators found that, since California allowed lane splitting, responding on an MC enabled them to arrive more quickly despite freeway backups.

The police were required, however, to clear the scene of more serious crashes as quickly as possible in order to restore traffic flow. Minor single-vehicle crashes were often cleared, especially on the freeways, before the investigation team could reach the area. It should be noted that the police generally did not file reports on such crashes. Noninjury collisions were not included in MCCS case-selection criteria, so these cases did not affect overall study results. The police jurisdictions were generally helpful in sharing their photographs and basic crash-scene information. The crash investigators also used satellite imagery and highway engineering data to enhance their scene documentation.

The crash investigators required information from police accident reports (PARs) in order to identify crash-involved individuals who were not interviewed on scene and the locations to which vehicles were towed. All agencies except one provided draft copies of their PAR cover sheets within 24 h. The remaining agency, on the advice of counsel, would not provide any information until the PAR was complete and had been reviewed and approved by the agency. This process often took 30 d or more. Thus, the crash investigators could not proceed with their cases until such information became available from that agency.

The crash investigators' field responses were subject to the direction of the lead police officer at each crash site and the particular circumstances of each crash. No vehicle or scene evidence could be disturbed. Riders, passengers, and drivers were not interviewed on scene if they were severely injured or suspected of criminal activity. Field sobriety tests were not administered by the project team if the police agencies administered such tests. In addition, the crash investigators' activities may have been limited if the scene was considered to be unsafe for any reason. In such circumstances, photographs were taken to record critical information such as the point of impact (POI), the final resting places of vehicles, and images of as much additional physical evidence as was possible.

Data collection essentially followed the guidelines laid out in the OECD-CM as modified by the protocol developed for the pilot study. Of course, the variability of crash scenes required crash investigators to remain flexible in the sequence in which they undertook the various investigation tasks. Generally speaking, the highest priority was given to obtaining data that were likely to be altered or to disappear quickly. Most often, this meant obtaining photos of the vehicles at their final resting positions and interviewing uninjured or slightly injured riders and drivers. Documenting the MC damage and crash-scene evidence was accomplished as soon as possible before details became modified or obliterated.

Repeat visits were made to crash scenes that were not located on freeways to complete the documentation of crash-related evidence, such as skid marks and fluid spills, and to make detailed measurements of the roadway, traffic-control devices, and other pertinent information. Interviews were guided by interview forms developed for the MCCS.

The crash investigators arrived at the crash scenes with no idea what the crash involved other than a report that an MC or scooter was involved and an injury to the rider or passenger was reported. In this way, no sampling bias was introduced by the researchers, and the broadest possible range of crashes was included in the MCCS. Crash investigations were assigned, on a rotating basis, to three crash investigators. When the workload became uneven due to the random assignment of a series of more complicated cases to an individual, the supervisor modified the assignments as necessary. The case criteria were that a crash must involve a single MC or scooter, or a multiple-vehicle crash must involve at least one MC or scooter, and the operator or passenger of the MC or scooter must have sustained a reported injury. Cases were subsequently dropped if the preliminary investigation indicated that no treatable injury occurred.

It should be noted that not all crash notifications were provided promptly. In some cases, notifications occurred hours or days after the crash occurrence. The project team responded by initiating investigations as quickly as possible for all cases. Information that could not be gathered immediately was collected through follow-up visits to the crash site, tow yards, salvage yards, and places of residence. The complete set of data-collection forms that were developed initially was used throughout the MCCS; this ensured comprehensive and consistent data collection and coding. The coding manual that was developed to document and guide the interpretation of the various codes was used throughout the data-collection period and received minor updates to reflect newly required attributes. The coding manual is available as MCCS Volume 2 of the study report (see section 2.0 for report organization).(1)

Crash-Scene Data

Using the prescribed crash-scene data-collection protocols (as adapted from the OECD-CM and the National Automotive Sampling System (NASS)), the crash investigator collected environmental, highway-related, and crash-related evidence while at the scene of the crash whenever possible.(4,11) Most freeway locations were not available for detailed inspection, and alternate methods were used as described in the next paragraph. The goal was to describe the crash scene in detail for the riders as well as the operators of OVs. Information regarding the pre-crash path of travel was documented, including type of area, illumination (daylight, dusk, night lighted, night not lighted, or dawn), type of intersection, traffic direction, lane dividers, roadside environment and obstacles, trafficway description, posted speed limits and roadway surface characteristics, and information about traffic conditions and weather at the time of the crash.

The crash investigator documented the exact location where the sequence of crash events occurred (POI, point of rest (POR), object(s) contacted, skid marks, etc.). Also, the crash investigator attempted to associate physical evidence (such as debris) with the MC or OV component involved in producing it. Once all of the physical evidence was identified, the crash investigator marked the important scene data with spray chalk.

After the scene evidence was completely marked, the crash investigator measured and photographed the POI, the POR, intermediate trajectory points of the MC and OV(s) involved, physical evidence, and pertinent items of the permanent environment. The presence of stationary view obstructions (e.g., road signs) or mobile obstructions (e.g., OVs) was documented along with other pertinent features of potential relevance to the case. The resultant data were recorded on the data-collection forms and were used as the basis for drawing a scaled diagram of the crash scene and related evidence.

Crash-Vehicle Data

While at the scene, the crash investigator(s) inspected and photographed the involved MC and OV(s), if appropriate and available. Complete vehicle inspections could not be accomplished at the crash scene, so the crash investigator(s) tracked the vehicle(s) to a tow yard, impound facility, or other location to finish their documentation. The crash investigator(s) gathered information regarding the MC manufacturer, model and style, year, colors, tire and rim sizes, suspension characteristics, brake-system type and condition, frame, handlebar, seat, fuel tank, drive train, throttle control, and exhaust system. The condition of each component and whether it was original equipment, modified, or aftermarket were also recorded.

Photographs were taken of each vehicle, with particular emphasis placed on verification and documentation of all coded data elements, especially as they related to the areas of interest for that crash. In some circumstances (e.g., poor light or inclement weather), further inspection of the involved vehicles was required, and as noted previously, the crash investigator then tracked the location of the vehicle and arranged for further inspection at a tow yard, impound lot, or other location.

The crash investigator identified and recorded all motorcyclist and passenger contact points using coded data and diagrams. Individual contact points were identified by physical evidence like deformations of the MC's instrument panel, fuel tank, and other surfaces; strands of hair, traces of makeup, and tissue fragments; and clothing embossments. Occupant contact points within the crash environment were also identified (e.g., bloodstains on a road surface). All identifiable contact points were photographed and diagrammed according to prescribed methodology.

Access to tow facilities and salvage yards was handled on a per-case basis. Additional cooperation was needed to access police tow facilities. For the CHP, the watch-commander's approval and a written release were required to access the tow facility. Other tow yards required the presence of the vehicle owner in order to provide access for a vehicle inspection.

Crash Involved–Individuals' Data

Information regarding occupants involved in the investigated cases was gathered from many sources (e.g., PARs, medical records, and autopsy reports), but for this study, interviews were most frequently used to gather and confirm information from the crash-involved individuals. This study focused on the events leading up to crashes, and those involved were sometimes best able to describe those circumstances. While at the scene, interviews were conducted with police officers, the motorcyclists and passengers, and OV occupants (when possible). These individuals contributed information about their roles, kinematics, injuries, and injury mechanisms. If the involved parties were not available for an interview because of injuries, for example, the crash investigator contacted them at a later time.

Demographic information was collected for all crash-involved persons (rider, passenger, and OV driver). This information included extensive human factors data (e.g., age, gender, educational status, occupation, and vision correction) and riding/driving experience (e.g., all vehicle experience, on any street MC, on the crashed vehicle, the number of days an MC is ridden, the ridden distance per year, training, MC percent-use estimate, and experience riding with a passenger or a cargo). Information was also gathered on riders' and passengers' clothing and safety equipment by body region, including the types and styles of clothing worn on hands, feet, and upper and lower torsos, as well as that on the head, such as goggles or glasses and helmets. Helmet data, such as the type of helmet, type of coverage provided by the helmet, manufacturer, model, and helmet condition before and after the crash, were collected by the crash investigator. The motorcyclist and passengers were asked if they would donate their helmet(s) to the MCCS; those who donated their helmet(s) received a $100 certificate to purchase a new helmet.

Crash-Context Data

Information regarding the trip (e.g., origin, destination, trip length, frequency of road use, length of time since departure) and possible impairment (e.g., alcohol/drug type of use, impairment, BAC, source of BAC information, physiological impairment, permanent or transient condition, presence of stress) was gathered. Interviewees who were available on scene and who consented were given voluntary breath tests for BAC. For injured parties, blood alcohol information was obtained from medical reports or PARs when possible.

Additionally, interviews covered activities such as any particular or unique situations that may have led to the crash (e.g., rider and passenger position at time of collision and attention to tasks). Interviews were needed to obtain releases for medical records and consent for breath tests and were useful in locating vehicles or occupants. They were also necessary in order to gather information that is not customarily recorded or provided in official documentation, such as type of injury, severity of injury etc. For these reasons, the crash investigators made every attempt to conduct the interviews on scene and in person.

Injury Data

Since the passage of the Health Insurance Portability and Accountability Act, access to medical information is generally carefully controlled.[(12)] Signed patient-release forms are required and were executed to obtain copies of patient records so that injury information could be examined, encoded, and related to possible or probable injury sources. Using interviews, medical records, and autopsy reports, the crash investigators compiled as complete a listing of occupant injuries as possible. Comprehensive descriptions of all (including slight) injuries were obtained only through occupant interviews. The best source for the descriptions of substantial injuries was official medical records.

When interviewing vehicle occupants, the crash investigator asked that a medical-release form be signed; a generic form was used. At times, certain hospitals required their specific patient-release forms be used. These were used whenever requested or made available. The crash investigators made personal visits to area hospitals to introduce themselves and explain the MCCS. The hospitals were generally responsive in providing the requested records once the appropriate patient-release forms were provided. Official medical records that were requested included emergency-room reports, patient-discharge summaries, and records from private physicians.

Autopsy reports were provided by the medical examiner. These are public records in California and, therefore, did not require special authorization for their release.

Some cases included riders who received first aid at the scene. When possible, injury information was obtained directly from the rider. Some riders agreed to be photographed, which allowed documentation of visible injuries as well as the types and post-crash conditions of the riders' clothing and protective equipment.

After weighing all of the gathered information, the crash investigator determined the rider or occupant kinematics, interaction between the rider, MC, and environment, as well as what role the components played in the crash outcomes. Then the crash investigator assembled the entire related official and interview-derived medical information and coded the injuries using the Abbreviated Injury Scale, the International Statistical Classification of Diseases and Related Health Problems, and the Injury Severity Score.[13–15]

Crash Reconstruction

When all interview, injury, scene, and vehicle data had been gathered, the crash investigator addressed the pre-crash motion of the involved vehicles and MC dynamics, including the following:

- Contributing environmental factors (e.g., roadway condition and design, traffic controls, defects, traffic hazards, weather-related problems).
- Contributing vehicle factors (e.g., tire size, tire-inflation pressure, MC mechanical component-related problems, pre-crash fires, and any contribution of the cargo or luggage).
- Contributing MC factors, indicating which, if any, mechanical elements may have contributed to rider injury causation.
- Contributing human factors (e.g., attention failure, lane choice, traffic scan, faulty traffic strategy, safe position, skills deficiencies, and medical condition).

The interviewee narrative description of the crash circumstances is included in each electronic case report.

1.2.5 Control Data-Collection Protocol

The MCCS followed the principles of collecting data on two non-crash-involved control motorcyclists for each focal crash. These control cases provided a basis for comparisons of operator and vehicle characteristics and were matched for time of day, weather, road type, urban/city, and other factors. The control subjects were matched with crash subjects based on location, travel direction, day of week, and time of day. Collecting exposure data on controls matched this way (i.e., similarly-at-risk controls) allows for the calculation of relative risks that can be used for developing countermeasures. For each investigated MC crash, every effort was made to collect concurrent exposure data from two control motorcyclists and, if applicable, passengers.

The OECD methodology included two methods that were approved by the prime IRB for acquiring the matched control subjects:

- Voluntary traffic stops at or near the crash scene (same time of day, day of week, and direction of travel).
- Recruiting motorcyclists who may be at nearby gas stations.

The first method was used exclusively for recruiting control motorcyclists because it has the potential of acquiring the most complete and relevant data, including BAC, on the control population. It involves interviewing motorcyclists (those who volunteered to participate) during the prescribed times at or near the sites of the investigated crashes. The stopping location selected allowed the safe collection of data without interference with traffic. Recruitment efforts continued until two control riders agreed to participate. If sufficient control data or volunteers were not obtained during initial data-collection efforts, the recruitment effort was repeated at the same location during a second time period. The matched time period covered approximately 1 h before and 1 h after the reported time of the related crash.

Control data-collection sites were established at locations that provided a safe stopping area for the crash investigators and study volunteers and were at or near the scene of the crash for which the controls were being gathered. Local police jurisdictions were notified of the time and locations of the MCCS's data-collection sites. At each site, signage was displayed indicating that volunteer motorcyclists and passengers were being asked to participate in an MC study; the displays indicated that a $40 gas card would be provided to those volunteering to participate.

Interviews with MC operators and passengers and inspections of their vehicles were conducted for all controls. As with the crash-involved riders, the questions included demographics, riding/driving experience, experience riding with a passenger or cargo, riders' and passengers' clothing and safety equipment by body region, information about the helmets worn, information regarding the trip, possible impairments, and for those riders and passengers who agreed, voluntary breath tests for BAC.

The crash investigators inspected and photographed the control MCs similarly to the inspection for crash-involved MCs. Data included the MC manufacturer, model and style, year, colors, tire and rim sizes, suspension characteristics, brake-system type and conditions, frame, handlebar, seat, fuel tank, drive train, throttle control, and exhaust system. The condition of each component and whether it was original equipment, modified, or aftermarket was also recorded when possible. Photographs were taken of each vehicle, with particular emphasis placed on verification and documentation of all coded data elements.

1.2.6 Data Entry and Organization

The Microsoft® Access™ MCCS database used to record the crash and control data includes range checks on every data element. This minimizes erroneous keystrokes, such as recording age as 150 yr. The acceptable range for each of the data elements is shown in MCCS Volume 2.[1] The database also includes several consistency checks for related data elements so that a certain response for a data element prohibits the entry of conflicting information in another data element. For example, if a respondent states that he or she has received no motorcyclist training, it is not possible to enter a year in which that training was received.

The crash investigator assigned to the case was responsible for all data entry. Following the complete entry of the information into the database for a crash investigation or control case, a senior crash investigator conducted a quality review. This reviewer relied on source documents (such as police reports, medical records, and tapes of interviews) and photographs as resources when reviewing all of the data entered into the database. When an external quality review also was conducted on the case, the external reviewers provided input on the observations and coding decisions of the crash investigator. The quality-control team, all of whom are highly experienced crash reconstructors, carefully reviewed all of the crash investigators' crash reconstructions and discussed their findings with the investigators; this helped improve reconstruction skill and consistency. As the first 100 cases were 100 percent reviewed, crash reconstructions, as measured by consistency of information between the crash investigators and quality-control team, became very consistent. This was confirmed during the review of the next 50 cases and a 25-percent sample of the last 200 crashes. All internal and external reviewer comments regarding errors and inconsistencies were noted and discussed with the investigation team. The case reviews served three purposes. First, they shared case experiences analysis among all the crash investigators. Second, they provided additional, continuous instruction and reinforcement regarding coding conventions and field protocol. Third, they offered the reviewer an opportunity to identify coding-manual problems and coding areas that were vague and in need of further clarification.

When all questions and issues were clarified and coding inaccuracies were corrected, the investigation team manager approved each case, marked it as final, and closed it in the database.

The Microsoft® Access™ MCCS database includes every data element for each of the crash and control data-collection forms. The database also links the narrative case description, diagrams, and photographs for every case to the encoded data. Text explanations for responses coded as "other" provided a means for recording unusual circumstances. For each crash investigation, the database tracked and indicated when data entry for each form was complete so that any/all missing data could be identified and provided. In addition to the data-collection forms, the electronic case files include the interviewee narrative description of the crash, diagrams, and photographs of the crash scene, involved vehicles, and personal injuries.

The Microsoft® Access™ MCCS database was built on the coding conventions included in MCCS Volume 2.[1] The acceptable ranges for each variable (for example, ages from 1 mo to 100 yr) are preprogrammed to help reduce keystroke errors. Consistency checks and skip patterns are built into the database to minimize inconsistencies. As an example, if a vehicle driver did not use alcohol or drugs before driving his or her vehicle, then the question of what kind of drugs were used would not be available for data entry. The database also includes completeness checks to ensure that the appropriate number of data-collection forms were used (for example, a vehicle form for every involved vehicle) and that all variables were coded.

During the course of data collection, minor changes to range checks were requested and completed so that legitimate data could be properly entered into the database. Such range checks reflect the acceptable responses for each data element that is listed in the coding manual. Modifications to these ranges in the coding manual must also be incorporated into the allowable response ranges in the database for consistency.

Each data element also included the attribute code "(98) Other (Specify)." A small text field was provided so that a description of the "Other" response could be added. These text boxes would not be included in data analyses; as the data collection was completed, when the same text was found repeated in several crash records, the item was assigned a code and included in the coding manual and in the subsequent tabulations and analyses.

All photography was digital, so the requirement in section 4.5.5 of the OECD-CM to mount all photos on paper was not applied.[4] Electronic versions of the photos were labeled and attached to the case file in the database. The image files were named in a structured alphabetic format so that the images for each case would appear in a consistent and logical order, when viewed through the database and with any file management application.

2.0 REPORT ORGANIZATION, DATA ELEMENTS, AND TABULATIONS

The focus of this study was the development of a dataset to be made available to the MC safety–research community for further analysis and application. The report and its supplemental volumes are organized to facilitate understanding of and access to the data elements.

2.1 REPORT ORGANIZATION

This MCCS final report provides an overview and description of the study and provides high-level observations from the data tabulations for each question and data element. Detailed information and quantitative comparisons are provided in the 14 report volumes. MCCS Volume 1 presents the details of the data-collection forms and the variable naming conventions used in the study.[(16)] MCCS Volume 2 is the coding manual, which enumerates and defines each of the response codes and includes instructions for consistent coding.[(1)] MCCS Volumes 3 through 12 tabulate and provide rudimentary analysis of the data gathered during the study. Each of these volumes tabulates the crash data that were gathered on one or more of the data-collection forms completed during the MCCS. Although most volumes reflect and provide overall tabulation, fatal versus nonfatal tabulation, and single-vehicle versus multiple-vehicle data tabulation and analysis for the crash data, MCCS Volumes 5 through 7 provide crash versus control data analysis and feature side-by-side comparisons of crash and control observations. MCCS Volume 13 provides analysis of helmets gathered from the small number of crashed riders who voluntarily donated their helmets post-crash and, where reasonable, similar exemplary helmets. MCCS Volume 14 provides a limited set of comparisons of the findings of this study with previous/other published data and the coding instructions used when completing the forms.[1]

Each data volume provides rudimentary statistical analysis consisting of a simple comparison of the means observed for each of the codes (when appropriate) and graphical displays of the responses to each of the questions. In the crash-only data volumes, the crash-data response frequencies are reported three ways: presentation of total observations and frequency for each question or code, presentation of code frequencies observed in fatal and nonfatal crashes, and presentation by frequency observed in single- and multiple-vehicle crashes. In the crash and control data volumes, the data are presented for the crash and control groups in tabular and graphical forms. As with the crash-only data, the crash and control data volumes provide a comparison of the frequency that each code was observed in each group during the study.

2.2 DATA NAMING AND CODES USED

2.2.1 Naming Conventions and Association of Data Elements for Research

Within the MCCS, variable-naming conventions were employed to enable identification of similar data elements. Within the SAS® and Microsoft® Excel™ data, variable names were developed as concatenations of acronyms to enable researchers to quickly and easily associate data elements that may be needed to address their research interests. All variable names were limited to 32 characters or fewer by the SAS® software. The general format used for variable

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[1]Volumes 3 through 14 are available through FHWA on request.

names concatenated the data-collection form acronym (table 1) with an entity acronym and a variable descriptor developed using block codes. For example, if the variable is from question 8 of the Crash Form, which tallies the number of MC passengers involved in the crash, the variable would be CF008_MCPASSENGERCOUNT, thus making it easy to filter the list of variable names for readability and should enable easy identification of variables of interest. In addition, one can filter specific data-collection forms to refine searches for variable names. For example, if one sought only motorcyclist or control motorcyclist data, one would filter the search using the acronyms for the data-collection forms, which are “MR” and “CR” as seen in table 1. Using the form acronyms would enable one to find all motorcyclist and control motorcyclist data elements, and if desired, particular data elements regarding the riders, such as age, clothing, or riding experience.

Table 1. Acronyms of forms as they appear in the database.

Form Acronyms	Form
CF	Crash Form
CM	Control Motorcycle Form
CP	Control Motorcycle Passenger Form
CR	Control Motorcycle Rider Form
EF	Environment Form
FF	Contributing Factors Form
HF	Helmet Form
IF	Injury Form
MD	Motorcycle Dynamics Form
MM	Motorcycle Mechanical Form
MP	Motorcycle Passenger Form
MR	Motorcycle Rider Form
OD	Other Vehicle Driver Form
OV	Other Vehicle Form

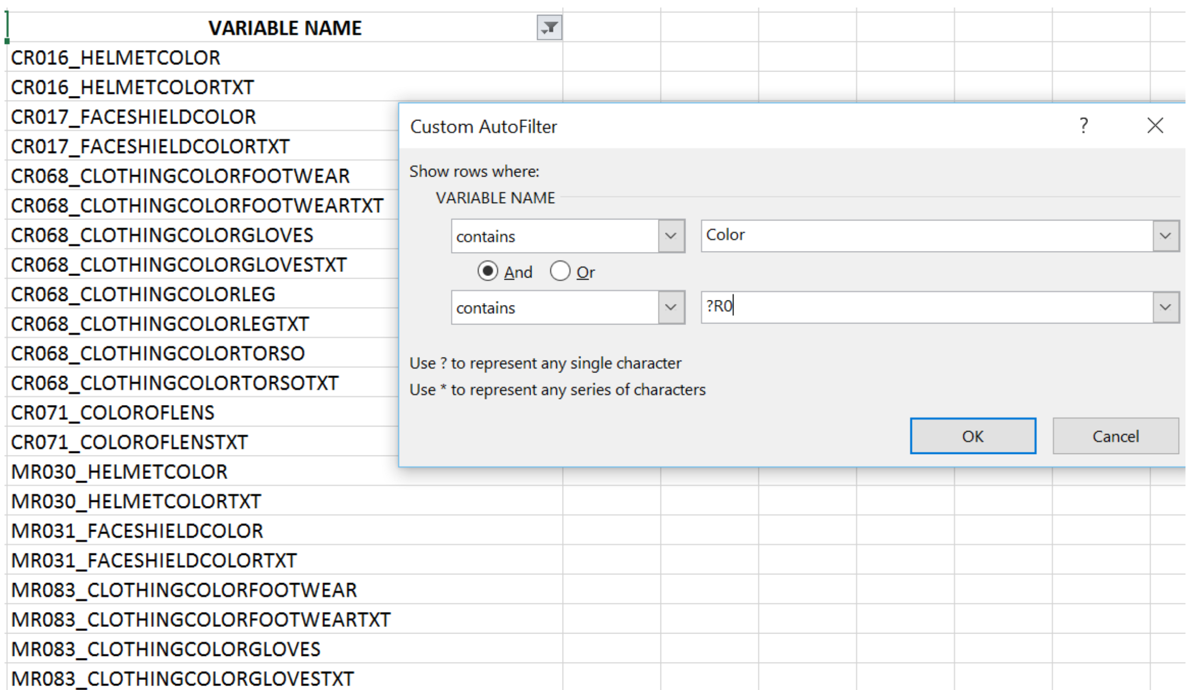
These acronyms are embedded in variable names to differentiate other entities. For example, if one was interested in studying the impact of color on crash rates, one could look for variables containing “COLOR” and then select appropriate subsets to support the focus of the inquiry. The list of the 72 variables related to color is provided in table 2: the first two letters of the variable identify the data-collection form, the next three numbers indicate the question number on the data-collection form, then an underscore, and last is a description of the data element. All variables in the list in table 2 contain “COLOR” in the descriptor.

Table 2. Data elements related to color.

Color Data Elements From CM014 to HF007	Color Data Elements From HF008 to MR086
CM014_MCCOLOR	HF008_FACESHIELDCOLOR
CM014_MCCOLORTXT	HF008_FACESHIELDCOLORTXT
CP008_HELMETCOLOR	MM010_MCCOLOR
CP008_HELMETCOLORTXT	MM010_MCCOLORTXT
CP009_FACESHIELDCOLOR	MP011_HELMETCOLOR
CP009_FACESHIELDCOLORTXT	MP011_HELMETCOLORTXT
CP042_CLOTHINGCOLORTORSO	MP012_FACESHIELDCOLOR
CP042_CLOTHINGCOLORTORSOTXT	MP012_FACESHIELDCOLORTXT
CP042_CLOTHINGCOLORWAISTDOWN	MP046_CLOTHINGCOLORTORSO
CP042_CLOTHINGCOLORWAISTDOWN TXT	MP046_CLOTHINGCOLORTORSOTXT
CP042_COLORFOOTWEAR	MP046_CLOTHINGCOLORWAISTDOWN
CP042_COLORFOOTWEARTXT	MP046_CLOTHINGCOLORWAISTDOWN TXT
CP042_COLORGLOVES	MP046_COLORFOOTWEAR
CP042_COLORGLOVESTXT	MP046_COLORFOOTWEARTXT
CP044_COLOROFLENS	MP046_COLORGLOVES
CP044_COLOROFLENSTXT	MP046_COLORGLOVESTXT
CR016_HELMETCOLOR	MP048_COLOROFLENS
CR016_HELMETCOLORTXT	MP048_COLOROFLENSTXT
CR017_FACESHIELDCOLOR	MR030_HELMETCOLOR
CR017_FACESHIELDCOLORTXT	MR030_HELMETCOLORTXT
CR068_CLOTHINGCOLORTORSO	MR031_FACESHIELDCOLOR
CR068_CLOTHINGCOLORTORSOTXT	MR031_FACESHIELDCOLORTXT
CR068_CLOTHINGCOLORWAISTDOWN	MR083_CLOTHINGCOLORTORSO
CR068_CLOTHINGCOLORWAISTDOWN TXT	MR083_CLOTHINGCOLORTORSOTXT
CR068_COLORFOOTWEAR	MR083_CLOTHINGCOLORWAISTDOWN
CR068_COLORFOOTWEARTXT	MR083_CLOTHINGCOLORWAISTDOWN TXT
CR068_COLORGLOVES	MR083_COLORFOOTWEAR
CR068_COLORGLOVESTXT	MR083_COLORFOOTWEARTXT
CR071_COLOROFLENS	MR083_COLORGLOVES
CR071_COLOROFLENSTXT	MR083_COLORGLOVESTXT
HF007_HELMETCOLOR	MR086_COLOROFLENS
HF007_HELMETCOLORTXT	MR086_COLOROFLENSTXT

Within the dataset, separate records are available and include the case number to allow association of all data related to a single crash and include one or more fields to distinguish multiple entities, such as data from the two controls, or distinguish or uniquely identify multiple passengers, multiple other crash-involved vehicles, and drivers. For example, for injury data, each injury has a separate record and is uniquely identified using the case number along with the rider, passenger, or other driver identifiers. As most of the crash-involved individuals experienced multiple injuries, the individual records can allow research on the injuries sustained by each individual involved in the crash as well as on subcategories, such as most severe injury, body region where it occurred, and correlations with crash configuration. In a similar vein, some data elements collected multiple responses to a question. For example, a rider may hold multiple licenses or endorsements (e.g., MC, auto, or chauffeur) or perform multiple predeparture MC checks (e.g., tire inflation, worn cables, and fluids). In these cases, multiple responses to the question were collected and uniquely identified by consecutively assigning numbers to each of the responses.

Thus, by filtering the data-element names (e.g., using text filters in Microsoft® Excel™), one can easily find the variables of interest. An example of a search for data elements related to color for both crash and control riders is illustrated in figure 3.



Source: FHWA.

Figure 3. Screen capture. Example of filtering data element names.

A complete listing of all data elements/names in the data files is provided in appendix B of MCCS Volume 1, where the data elements are grouped by the data-collection form used to collect them.[16]

2.2.2 Data Coding, Capture, and Code Additions During Study

Each question on the data-collection forms resulted in one or more data elements being captured. Generally, each question included an enumerated list of possible responses that were captured and input using their identifying code. Figure 4 is an example of one page from the Crash Form that includes questions and possible responses.

Crash Form Case Number ______________________

1. Day of Week Crash Occurred ____
(1) Monday
(2) Tuesday
(3) Wednesday
(4) Thursday
(5) Friday
(6) Saturday
(7) Sunday .

2. Time of Day Crash Occurred ____ ____: ____ ____
(24-hour clock).

3. First Harmful Event for Motorcycle ____ ____
(01) collision with other motor vehicle
(02) collision with fixed object
(03) collision with non-fixed object
(04) collision with pedestrian/cyclist/ non-motorist
(05) non-collision
(98) other event (specify) ________________
(99) unknown event or object.

4. If This Case is a MC vs. MC, Provide Matching Case Number

____

5. Presence at Crash Scene ____ ____
CODE UP TO 4 ____ ____
(00) not on-scene
(01) nothing present ____ ____
(02) crash vehicles present
(03) police present ____ ____
(04) EMS present
(05) motorcycle rider present
(06) motor vehicle driver(s) present
(07) motorcycle passengers present
(08) motor vehicle passengers present
(09) non-motorists present
(98) other present (specify): ______________
(99) unknown.

6. How Many Other Vehicles Were Involved in the Crash? ____ ____
(00) none
(01) one
(02) two
(03) three
(04) four or more
(96) non-contact with other vehicle
(97) not applicable
(98) other (specify) ________________
(99) unknown.

7. How Many Pedestrians Were Involved in the Crash? ____ ____
(00) none
(01) one
(02) two
(03) three
(04) four or more
(97) not applicable
(98) other (specify) ________________
(99) unknown.

8. Number of Passengers on the Motorcycle ____ ____
(00) none
(01) one
(02) two
(03) three
(04) four
(05) five
(06) six
(99) unknown.

9. Are There Any Fatal Injuries Involved? ____ ____
(00) no
(01) yes
(99) unknown.

Source: FHWA.

Figure 4. Photo. Example of questions in a data-collection form.

When possible, the form enumerates all possible responses. For example, under the question "Day of Week Crash Occurred," all 7 d are listed. When all possible responses could not be anticipated and enumerated, the responses include a code 98, "Other (Specify)," with an additional field where data can be specified. In the dataset, fields or variables are defined for response codes, and only in the case of response code 98, an additional field or variable would contain the other field-entered or specified text information; whenever a response code other than 98 is recorded, the "Other (Specify)" field will be blank. Over the course of the MCCS, these "Other (Specify)" responses were reviewed. Additional codes were assigned whenever multiple same or similar responses were specified in the "Other (Specify)" field so that the similar data could be aggregated and more easily included in statistical analyses.

2.3 DATA TABULATIONS AND COMPARISONS

Descriptions of the data collected during the MCCS are provided in separate volumes; each volume tabulates the data from one or more forms and provides comparisons of similar entities. MCCS Volumes 3 through 5 and 9 through 13 all focus on and contain crash data. In these volumes, the full dataset is tabulated and comparisons between fatal and nonfatal crashes, and single- and multiple-vehicle crashes are provided. In MCCS Volumes 6 through 8, data collected from crashes as well as control data gathered from volunteers traveling the same routes where the crashes occurred are tabulated, and comparisons between the crashes and control observations are provided. In these volumes, data on motorcyclists and control motorcyclists, MCs and control MC passengers, and crashed and control MCs are provided. MCCS Volume 14 provides some example comparisons of the observations of this study with previous studies and national data.

2.4 OBSERVATIONS SUMMARY

In the MCCS, 351 cases were investigated. Each case provided data for a crash-involved MC. Both riders from one MC-MC crash were investigated, and data from each motorcyclist's viewpoint were collected as a separate case. Thus, a total of 350 different crash events were studied, and the data pertaining to these cases were tabulated. Two controls were gathered for each crash case.

The 351-case breakdown and categorization are as follows:

- Of the 40 fatal cases and 311 nonfatal cases (i.e., 11.4 percent resulted in fatalities), 38 of the deaths occurred within 5 d of the crash, 1 at day 23, and 1 at day 62. Three cases involved unhelmeted riders, and one case involved an unhelmeted rider and an unhelmeted passenger; two of these cases were rider-fatality cases and one was an OV-driver fatality. Two MC passengers were fatally injured in crashes.

- There were 82 single-vehicle cases and 269 multiple-vehicle cases. When motorcyclists alleged other vehicles were present but had left the scene, the crash investigator used expertise to determine the likelihood of OV presence or contribution to the crash to determine if the crash was a single- (rider actions were solely responsible for crash) or multiple-vehicle crash. There were eight such cases: five were judged to be single-vehicle crashes, and three were judged to be multiple-vehicle crashes.

- Of the 40 fatal cases, 18 fatal cases were multiple-vehicle cases (6.7 percent), while the other 22 fatalities were single-vehicle cases (26.8 percent).

- In the 269 multiple-vehicle cases, a total of 294 in-transit OVs and OV drivers were involved in the crashes, of which 243 cases involved one OV, 24 cases involved 2 OVs, and 2 cases involved 4 OVs.

- Passengers were involved in 21 cases of MC-involved crashes.

- Six unoccupied, parked vehicles were struck (4 were involved in single-vehicle crashes, and 2 were involved in multiple-vehicle crashes); these parked vehicles are not considered “other vehicles” in NASS, per U.S. customary practice).

There were 702 control observations and interviews conducted, with 14 of these control observations being of MCs with passengers aboard.

These 351 cases resulted from 500 case investigations that were initiated. As described previously, crash investigations were initiated whenever a cooperating law enforcement agency notified the project team of a crash. The case was included in the MCCS only when the crash was verified to have resulted in injury and the PAR and the motorcyclist(s) medical records were available to the project team (interview, medical, and autopsy records). Although cooperation of all crash-involved parties was requested, it was not always given. In these cases, information from the accident reports and other parties was gathered; whenever specific information could not be gathered, the responses were coded “Unknown.” All control data were gathered from volunteers who agreed to participate in the MCCS. While all tabulations of data include all responses, all comparisons (crash versus control, single vehicle versus multiple vehicles, fatal versus nonfatal) made in this study do not include the “Unknown” or the “Other (Specify)” responses in the analyses.

3.0 FINDINGS

Although the primary goal of the MCCS was to gather and disseminate crash data so the dataset would be available for study by the research community, the study resources did enable simple frequency comparisons of crash versus control, fatal versus nonfatal crashes, and single- versus multiple-vehicle crashes. These comparisons are found throughout the data volumes and provide a basis for formulation of additional research questions that can be developed and economically addressed by other researchers.

CAUTION: Statistically significant differences or over- or underrepresentations may result from categorizations applied and are not necessarily indicative of cause and effect. Thorough analysis is required when drawing conclusions regarding the data.

3.1 FINDINGS LISTED BY FORM AND QUESTION

This section provides a high-level listing of findings from each question on each data-collection form. It highlights code frequencies and, when possible, statistical over- and underrepresentation within the data for the coded responses (codes) for each question.

3.1.1 Crash-Form Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Day of Week Crash Occurred
   - Single-vehicle crashes were overrepresented on Sundays.
   - There were nonsignificant differences between fatal and nonfatal crashes.

2. Time of Day Crash Occurred
   - Single-vehicle crashes were underrepresented during commute times and overrepresented at midday, midafternoon, and late night.
   - There were nonsignificant differences between times of fatal and nonfatal crashes.

3. First Harmful Event for Motorcycle
   - 95.1 percent of single-vehicle crashes first collided with a "Fixed Roadside Object."
   - 81.4 percent of multiple-vehicle crashes first collided with the "Other Motor Vehicle" and 17.5 percent first collided with a "Fixed Roadside Object."

4. MC Versus MC, Matching Case Number
   - One MC-MC crash was observed during the MCCS.

5. Present at Crash Scene
   - The crash investigator arrived while the crash scene was still active for 116 of 351 crashes (33 percent).

6. Number of Other Vehicles Involved
    - 23.8 percent of crash cases were single-vehicle crashes and 76.2 percent were multiple-vehicle crashes.

7. Number of Pedestrians Involved
    - Only one crash involved a pedestrian.

8. Number of Motorcycle Passengers
    - 94.6 percent of crashes involved MCs without passengers.
    - MCs with passengers were overrepresented in multiple-vehicle crashes and underrepresented in single-vehicle crashes.

9. Fatal Injuries Involved
    - 11 percent of crashes in this study resulted in fatalities.
    - Single-vehicle crashes were overrepresented in fatal crashes.

10. Crash Configuration
    - Left-turn scenarios were the most common crash configuration, followed by falling to avoid crash and running off the roadway.

11. Light Conditions
    - Most crashes occurred during daylight.
    - Single-vehicle crashes were underrepresented during “Daylight, Bright” conditions and overrepresented at night.
    - Fatalities were overrepresented at night.

12. Ambient Temperature
    - Observed temperatures ranged from 35–105 °F, with an average of approximately 70 °F.
    - Fatalities were overrepresented at lower temperatures.

13. Weather Description
    - Most crashes occurred during “Clear” weather with no significant differences between single- and multiple-vehicle crashes or fatal and nonfatal crashes.

14. Wind Description
    - “Calm” and “Strong” wind conditions were overrepresented in single-vehicle crashes, and “Strong” and “Moderate-with-Gusts” conditions were overrepresented in fatal crashes.

15. Wind Direction with Respect to MC Path
    - “Right Crosswinds” were overrepresented in fatal crashes.

3.1.2 Environment Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Type of Land Development on Same and Opposite Side of the Street
   - The most common types of land development where crashes occurred were "Commercial/Business" and "Single-Family Housing."
   - Single-vehicle and fatal crashes were overrepresented in "Single-Family" housing areas.
   - Single-vehicle crashes were overrepresented in "Rural Wilderness" areas.

2. Relation to Junction
   - Single-vehicle and fatal crashes were overrepresented at "Non-Junction."

3. Type of At-Grade Intersection
   - 58.5 percent of single-vehicle crashes in the MCCS occurred at "Not at Intersections," while 21.6 percent of the multiple-vehicle crashes observed occurred at "Not at Intersection."
   - Fatal crashes were overrepresented when the crash occurred "Not at Intersection."

4. Trafficway Description
   - "Two-Way, Undivided" trafficways were overrepresented in single-vehicle crashes. "Two-Way, with A Continuous Left-Turn Lane" and "Two-way, Divided, with Median Barrier" were underrepresented for single-vehicle crashes.
   - There were no significant differences between the frequencies of fatal and nonfatal crashes on trafficways.

5. Roadway Function
   - Crashes more frequently occurred on "Principal Arterial, Non-Freeway," "Minor Arterial," and "Local Road/Streets."

6. Posted Speed Limit in Miles per Hour
   - The majority of crashes occurred where the posted speed limit was less than 45 mph.
   - Low and high posted speed limits were overrepresented in single-vehicle crashes.
   - No significant differences were observed between fatal and nonfatal crashes on roadways with the various posted speed limits.

7. Number of Through Lanes
   - Single-vehicle crashes were overrepresented on two-lane, through-lane roads.
   - Fatal crashes were overrepresented on eight-lane, through-lane roadways.

8. Lane in Which Vehicle Was Traveling
   - "Left Turn Only" lanes were overrepresented in single-vehicle crashes.

9. Lane Width in Feet
    - Lanes where crashes occurred were most commonly 10–13 ft wide.
    - Wide lanes (20 ft) were overrepresented (at the 90-percent level) in single-vehicle crashes, and narrow lanes (11 ft) were overrepresented (at the 90-percent level) in fatal crashes.

10. Roadway Width in Feet
    - Single-vehicle crashes were overrepresented on the narrowest roadways (less than 24 ft).
    - Fatal crashes were overrepresented on roadway widths less than 36 ft.

11. Type of Surface
    - The most common surface on which crashes occurred was "Asphalt" (96 percent).

12. Surface Condition
    - Most observed crashes occurred on "Dry" pavement (91 percent).
    - "Dry" was underrepresented in single-vehicle crashes (at the 90-percent level).

13. Surface Special Features
    - "Pavement Edge Drop," "Tram/Train Rails," "Rumble Strips," and "Speed Bumps/Humps" were overrepresented (at the 90-percent level) in single-vehicle crashes.
    - "Grooved Pavement" was overrepresented in fatal crashes.

14. Vertical Alignment
    - Most crashes (56 percent) occurred on "Level" roadways.
    - No significant differences between single- and multiple-vehicle crashes and fatal and nonfatal crashes were observed.

15. Horizontal Alignment
    - "Curves Right" and "Curves Left" were overrepresented relative to "Straight" and "Corner Right" sections for single-vehicle crashes.
    - "Curve Left" sections and "Reverse Curve Left" sections were overrepresented for both single-vehicle and fatal crashes.
    - "Straight" sections were underrepresented in single-vehicle and fatal crashes.

16. Horizontal Curve Data
    - Single-vehicle and fatal crashes were more frequent on tighter curves.

17. Exclusive Turn-Lane Presence and Type of Signal Phasing
    - Crashes with "Protected/Permissive Right-Turn Signal Phasing" and "Protected/Permissive Right-Turn Signal Phasing with Separate Signal Face" were overrepresented in single-vehicle crashes.
    - Fatal crashes with "No Exclusive Right-Turn Lane" and "No Exclusive Right-Turn Lane, Permissive RT Signal Phasing" were overrepresented, and fatal

crashes with "Exclusive Left-Turn Lane, Protected-Only LT Signal Phasing with Lagging Green" were underrepresented.

18. Type of Traffic Control
    - Most crashes (62 percent) occurred where no traffic control was present.
    - "Stop Sign" control was overrepresented in single-vehicle crashes.
    - "Advisory Signs" was overrepresented in multiple-vehicle crashes.

19. Was Traffic Control Functioning Properly
    - No malfunctioning traffic controls were observed at any crash scene.

20. Traffic Control Visible to Vehicle Operator
    - Only one control-visibility problem was reported, which was not statistically significant.

21. Traffic Control Violated by Vehicle Operator
    - Traffic-control violations were observed 105 times. In those observations, MC-operator violations were observed to have occurred 20 percent of the time, while OV-operator violations were observed 33 percent of the time.
    - Violations were overrepresented in fatal crashes.

22. Traffic Density at Time of Crash
    - Single-vehicle and fatal crashes were overrepresented at lower traffic densities.
    - Most crashes occurred in light to moderate traffic densities.
    - Fatal crashes were overrepresented when "No Other Traffic" was present.

23. Visibility Limitation
    - Almost no visibility limitations (less than 2 percent) were reported, which was not statistically significant.

24. Direction of Traffic in Lane Adjacent to Vehicle
    - The absence or presence of an adjacent right lane or bicycle lane did not result in statistically significant differences in either single- or multiple-vehicle crashes or fatal crashes.
    - "Absence of an Adjacent Left Lane" and "Traffic in the Opposite Direction in the Adjacent Left Lane" were overrepresented in single-vehicle crashes.

25. Parked Vehicle Presence in Right Lane Adjacent to Vehicle
    - Single-vehicle crashes were overrepresented (at the 90-percent level) when parked vehicles were adjacent to the MC's travel lane.

26. Shoulder and Sidewalk Presence in Area Adjacent to Vehicle Lane of Travel
    - "Shoulder or Sidewalk on Right, Adjacent to Travel Lane" was overrepresented in single-vehicle crashes.

27. Longitudinal Pavement Markings at the Edge of the Lane Traveled by the Vehicle
    - "Edge Line, Right, White" was overrepresented for single-vehicle crashes, as were "Absence of Markings" on the left side and "Centerline, Solid Double, Yellow."

28. Pavement Markings Material
    - Material significance varied by the side of the lane on which the marking was located. "Thermoplastic" markings on the left side of lanes was overrepresented.

29. Delineator Presence
    - No significant differences were observed.

30. Roadside Environment
    - "Gravel Preparation" on the right side of lanes was overrepresented in single-vehicle and fatal crashes.
    - "Sidewalks" on both right and left sides were underrepresented for single-vehicle crashes.

31. Roadside Fixed Object
    - "Fence" and "Mailbox" on the right side of lanes were overrepresented while "Guardrail" and "Traffic Signs" were underrepresented in single-vehicle crashes.
    - "Embankment Transverse-Slope" and "Traffic Sign Support" on the right side of lanes were overrepresented in fatal and nonfatal crashes.
    - On the left side, "Guardrail," "Trees," "Embankment Foreslope," and "Traffic Sign Support" were overrepresented while the absence of roadside fixed objects was underrepresented in single-vehicle crashes.

32. Stationary View Obstructions Along the Operator's Line of Sight at the Time of Precipitating Event
    - "Buildings" and "Signs" were overrepresented in single-vehicle crashes, while "Vegetation" (underrepresented at the 90-percent level) and "Buildings" (overrepresented at the 95-percent confidence level) were significantly different in fatal and nonfatal crashes.

33. Mobile Obstructions Along the Operator's Line of Sight at Time of Precipitating Event
    - 74 percent of crashes had no mobile view obstructions present, although differences in the types of vehicles constituting the mobile view obstructions were observed in single-vehicle and fatal crashes.

34. Was This Crash Work-Zone Related
    - No single-vehicle or fatal work-zone crashes were observed.

35. Location of Crash Within Work Zone
    - All work-zone crashes were nonfatal, multiple-vehicle crashes and occurred throughout the work zone.

36. Type of Work Zone
- All observations were of either "Lane Closure" or "Work on Shoulder" zones.

37. Location of First Harmful Event
- Single-vehicle and fatal crashes were overrepresented on the "Shoulder," "Median," and "Roadside" and were underrepresented on the roadway itself.

38. If First Harmful Event Is a Noncollision
- Overturns (90 percent) were the dominant type of the first harmful event for the MC or OV in noncollisions.

39. If First Harmful Event Is a Collision with a Nonfixed Object
- Few crashes involved nonfixed-object collisions; the most frequently struck nonfixed object by an MC or OV was a powered two-wheeler.

40. If First Harmful Event Is a Collision With a Fixed Object
- "Curbs" was overrepresented in single-vehicle crashes, while "Paved Surfaces/Ground" was underrepresented in multiple-vehicle crashes.
- "Curbs," "Ditches," "Guardrails," "Trees," and "Traffic Sign Supports" were overrepresented while "Ground/Paved Surface" was underrepresented in fatal crashes.

41. Pedestrian Involvement in the Crash
- Only one pedestrian-involved crash was observed.

42. Location of the Pedestrian at the Time of Precipitating Event
- The only pedestrian involved the crash was "in Crosswalk."

43. Location of Pedestrian at Impact
- The only pedestrian involved in the crash was "Not Impacted."

44. Animal Involvement
- A collision with a deer was observed as the only animal-involved crash.

45. Was the Animal Struck
- The only animal-involved crash (with a deer) was "Struck by a Vehicle, or Involved with MC."

46. Roadway-Design Factors
- There were no roadway-design issues in 94 percent of crashes.

47. Roadway-Maintenance Factors
- There were no maintenance issues in 95 percent of crashes.

48. Traffic-Control Factors
- No traffic-control issues were reported.

49. Traffic Hazard, Including Construction and Maintenance Operations
    - There was a traffic-hazard contribution to 11 crashes.

50. Weather-Related Problems
    - The weather was a contributing factor in five cases.

51. Effect of the Visual Background of Other Vehicle Along This Operator/Rider's Line of Sight at Time of Precipitating Event
    - Negative impacts on conspicuity were overrepresented in fatal crashes.

3.1.3 Contributing-Factors Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Roadway Design–Issue Crash Contribution
    - 29 cases identified "Roadway-Design Issues" as a "Primary or Contributing Factor" in the crash.

2. Roadway Maintenance–Issue Crash Contribution
    - Five cases identified "Roadway Maintenance" as a "Primary Contributing Factor" in the crash.

3. Traffic Controls–Issue or Malfunction Crash Contribution
    - "Traffic Controls" was not identified as a primary or contributing factor in any crash.

4. Temporary Traffic Obstruction Including Construction Crash Contribution
    - "Temporary Traffic Obstruction" was underrepresented in single-vehicle crashes; no difference observed in fatal versus nonfatal crash rates.

5. Weather-Related Crash Contribution
    - Weather was cited in four cases as the primary contributing factor.

6. Visual Background of Other Vehicle Along Motorcycle Rider's Line of Sight Prior to Crash, Crash Contribution
    - A positive effect was observed 57 times; a negative effect was observed 17 times.

7. Effect of Insect Presence on the Rider Crash Contribution
    - The effect of insect presence on rider crashes was not observed.

8. MC Tire-Size Crash Contribution
    - Mismatched rim and section sizes were observed at a low frequency (8 of 351 observations for the front tire/rim and 6 of 351 observations for the rear tire/rim).

9. MC Tire Inflation Pressure
    - "Grossly Underinflated" front tires and "Grossly Underinflated" rear tires were overrepresented in single-vehicle crashes.

10. Crash Causation Related to MC Tire or Wheel Condition
    - "Gross Error of Inflation" of front and rear tires was overrepresented in single-vehicle crashes.

11. Crash Causation Related to MC Suspension Condition
    - No suspension-condition crash causation was observed.

12. Crash Causation Related to MC Frame Condition
    - One case of frame-related crash causation was observed.

13. Crash Causation Related to MC Cornering Clearance
    - Two cases had foot-peg grounding contributing to the crash; these were overrepresented in single-vehicle crashes.

14. Crash or Injury Causation Related to MC Seat
    - The effect of the MC seat related to the crash or injury was not observed.

15. Crash/Injury Causation Related to MC Gas-Tank Design/Orientation
    - There were no observations related to crash causation; however, gas-tank design affected the rider's post-crash trajectory.

16. Crash Causation Related to MC Drive-Chain, Belt, or Shaft Condition
    - Crash causation related to MC drive-chain, belt, or shaft condition was not observed.

17. Crash or Injury Causation Related to MC Exhaust-System Condition
    - Crash or injury causation related to the MC exhaust-system condition was not observed.

18. Motorcycle Vehicle Failure, Crash Causation–Related Defect
    - Crash causation-related defects were only observed in single-vehicle crashes.

19. Was MC Pre-Crash Fire Cause of Crash
    - No MC pre-crash fire caused a crash.

20. MC Cargo/Luggage Contribution to Crash
    - MC cargo or luggage did not contribute to any crash.

21. Rider Unsafe Acts in this Crash
    - The majority of crashes involved unsafe acts on behalf of the rider.
    - "Major Unsafe Act" was overrepresented in single-vehicle and fatal crashes.

22. MC Rider Attention Failure/Distraction or Stress Contribution to Crash
    - Attention failure contributed to crash causation in 32 percent of cases.
    - Attention failure was overrepresented in single-vehicle and fatal crashes.

23. Motorcyclist’s Lane Choice Contribute to Crash Causation
    - “Lane Choice Contributed to Crash Causation” was underrepresented in single-vehicle crashes.

24. Motorcyclist’s Traffic Scan Contribute to Crash Causation
    - This was significant for multiple-vehicle crashes.
    - There were no significant differences between fatal and nonfatal crashes.

25. Motorcyclist’s Visual Obstructions Contribute to Crash Causation
    - This was underrepresented in single-vehicle crashes.

26. Motorcyclist’s Hazard-Detection Failure Contribute to Crash Causation
    - This was underrepresented in single-vehicle crashes.

27. Motorcyclist’s Faulty Traffic Strategy Contribute to Crash Causation
    - This was overrepresented in multiple-vehicle crashes.

28. Motorcycle’s Speed as Compared to Surrounding Traffic Contribution to Crash Causation
    - This was present in 29 percent of crashes and overrepresented in fatal crashes.

29. Motorcycle’s Position With Respect to Other Traffic Contribution to Crash Causation
    - This was a factor in 37 percent of multiple-vehicle crashes.

30. Motorcyclist’s Loss of Control that Contributed to Crash Causation
    - This was overrepresented in single-vehicle and fatal crashes.

31. Motorcyclist’s Control Unfamiliarity Contribution to Crash Causation
    - This was overrepresented in single-vehicle crashes.

32. Motorcyclist’s Skills Deficiency Contribution to Crash Causation
    - This was overrepresented in single-vehicle and fatal crashes.

33. Motorcyclist’s Vehicle-Handling Unfamiliarity Contribution to Crash Causation
    - This was overrepresented in single-vehicle and fatal crashes.

34. Motorcyclist’s Control Operations Interference with Driving Tasks
    - No significant interference was observed.

35. Motorcyclist’s Crash Avoidance Failure Contribution to Crash Causation
    - This was overrepresented in single-vehicle and fatal crashes.

36. Validity of Evasive Action for the Situation
    - Proper evasive action was taken twice as often as the improper action in multiple-vehicle crashes (27 percent proper versus 11 percent improper), while improper evasive action was taken twice as often as the proper action in single-vehicle crashes (43 percent proper versus 22 percent improper).

- "Yes, Evasive Action Was the Proper Choice for the Situation" was unrepresented in fatal crashes.

37. Competent Execution of Evasive Action
    - Evasive action was neither taken nor properly executed in 80 percent of cases.
    - Proper execution was underrepresented in single-vehicle and fatal crashes.

38. Why Collision-Avoidance Maneuver Failed
    - "Inadequate Time Available to Complete Avoidance Action" was overrepresented in multiple-vehicle crashes and underrepresented in single-vehicle crashes.
    - "Loss of Control" when attempting to avoid collision was overrepresented in single-vehicle crashes.

39. Language Barriers or Difficulty with Sign Comprehension Contribution to Crash
    - This was not observed to be a crash contribution.

40. Motorcyclist's Traffic-Knowledge Deficiency Contribution to Crash Causation
    - This was underrepresented in single-vehicle crashes.

41. Motorcyclist's Vehicle Control–Skill Deficiency Contribution to Crash Causation
    - This contributed to the crash in 24 percent of cases.
    - This was overrepresented in single-vehicle and fatal crashes.

42. Motorcyclist's Aggressive Attitude Contribution to Crash Causation
    - This was present in 25 percent of cases.
    - This was overrepresented in single-vehicle and fatal crashes.

43. Situation Incompatibility Contribute to Crash Causation
    - This was present in 25 percent of cases.
    - This was overrepresented (at the 90-percent level) in single-vehicle crashes.

44. Motorcyclist's Compensation Failure Contribution to Crash Causation
    - This was present in 23 percent of cases.
    - This was underrepresented in single-vehicle crashes.

45. Motorcyclist's Unsafe Act Contribution to Crash Causation
    - "Unsafe Act" contributed to the crash 44 percent of the time.
    - This was overrepresented in single-vehicle and fatal crashes.

46. Motorcyclist's Alcohol/Drug Involvement Contribution to Crash Causation.
    - This was present in 13 percent of cases.
    - This was overrepresented in single-vehicle and fatal crashes.

47. Motorcyclist's Previous Recorded Violations Relationship to Current Crash
    - This was overrepresented in single-vehicle and fatal crashes.

48. Motorcyclist’s Previous Crashes Relation to Current Crash
- No significant differences were observed.

49. Upper-Extremities and Upper-Torso Coverage Injury Impact
- “Coverage/Equipment Use and Injury Prevention” was underrepresented in single-vehicle crashes.
- “Presence and Reduction or Prevention of Injury” was underrepresented in fatal crashes.

50. Lower-Extremities and Lower-Torso Coverage Injury Impact
- There was a greater presence of equipment, but no effect on injury was observed in fatal crashes.

51. Footwear’s Injury Impact
- Impact differences were observed in fatal and nonfatal crashes.

52. Gloves’ Injury Impact
- “Not Applicable, No Gloves” was overrepresented in single-vehicle and fatal crashes.

53. Eye-Coverage’s Injury Impact
- Little injury impact was observed.

54. Eye or Face-Protection Contribution to Crash Causation
- There were three cases in which the presence or absence of coverage contributed to the crash.

55. Helmet’s Impact on Injury
- Helmets were more effective in preventing injury in multiple-vehicle crashes.
- Helmets were less effective in reducing or preventing injury in fatal crashes.

56. Helmet’s Contribution to the Crash Causation
- There was one instance of contribution to a multiple-vehicle crash.

57. Crash Contribution of Helmet
- Helmets had “No Effect” in regard to crash contribution.

58. Cause of Helmet Ejection During Crash
- Helmets were ejected in two cases due to “Retention System Failure” and “Helmet Shell Failure.”

59. Conspicuity Contribution of Upper-Torso Clothing
- “Bright Color Torso Garment” enhanced conspicuity only in multiple-vehicle crashes.

60. Apparel Contribution to Comfort, Fatigue, Attention
   - “Apparel Protected Rider from Adverse Weather, Reduced Fatigue and Preserved Attention” only in multiple-vehicle crashes.

61. Apparel Contribution to Control Interference
   - Apparel did not interfere with MC controls.

62. MC Passenger’s Contribution to Crash Causation
   - “Passenger Interfered with MC Balance, Caused Rider Loss of Control” was overrepresented in single-vehicle crashes.

63. Effect of Rider/Passenger Interaction on Injury Causation
   - Interaction increased injury (five times) more often than it decreased injury (three times).

64. MC Passenger’s Upper-Extremities and Upper-Torso Coverage Impact on Injury
   - Coverage was 28 percent effective at reducing or preventing injury when the area was exposed to injury in a crash.

65. MC Passenger’s Lower-Extremities and Lower-Torso Coverage Impact on Injury
   - This was not assessable.

66. MC Passenger’s Footwear Impact on Injury
   - Footwear was 33 percent effective at reducing or preventing injury when the area was exposed to injury in a crash.

67. MC Passenger’s Gloves Impact on Injury
   - Gloves reduced or prevented injury when the area was exposed to injury in a crash.

68. Effect of MC Passenger’s Eye Coverage on Injury
   - Eyewear was present and prevented injury in one crash.

69. Effect of MC Passenger’s Helmet on Injury
   - The passenger’s helmet was 88-percent effective at reducing or preventing injury.
   - Head injuries were overrepresented in fatal crashes.

70. Other-Vehicle Number
   - 82 single-vehicle and 269 multiple-vehicle cases were in the MCCS.
   - Single-vehicle crashes were overrepresented in fatal crashes.

71. Roadway-Design-Issue Impact on Other Vehicle
   - 9 percent of multiple-vehicle crashes identified “Roadway-Design Issue” as a contributing factor.

72. Roadway Maintenance–Issue Impact on Other Vehicle

- Less than 1 percent of multiple-vehicle crashes identified “Roadway-Maintenance Issues” as a contributing factor.

73. Traffic-Controls Issue or Malfunction Crash Contribution

- One crash identified a traffic-control issue or malfunction as a contributing factor.

74. Temporary Traffic Obstruction Including Construction Impact on Other Vehicle

- This was identified as a factor in 18 of the 269 multiple-vehicle crashes.

75. Weather Related–Problem Impact on Other Vehicle

- 2 of the 269 multiple-vehicle cases identified weather-related problems as a factor.

76. Conspicuity of Motorcycle Along Other-Vehicle Driver’s Line of Sight Prior to Crash

- In 24 of the multiple-vehicle cases, the visual background made the MC more visible, and in 54, the visual background made the MC less noticeable.

77. Other Vehicle–Failure/Defect Contribution to Crash Causation

- This was present in only one crash.

78. Other Vehicle–Passenger(s) Contribution to Crash Causation

- In 7 (2.6 percent) of the cases, and nearly one-third of the time the crash involved an MC with passenger, the passengers contributed to crash causation.

79. Other Vehicle Driver’s Attention Failure/Distraction or Stress Contribution to Crash Causation

- In 43 percent of cases, “Attention Failure/Distraction/Stress” was identified as a factor in crash causation.

80. Other Vehicle Driver’s Lane-Choice Contribution to Crash Causation

- In 22 percent of multiple-vehicle crashes, the “Lane Choice Contributed to Crash Causation.”

81. Other Vehicle Driver’s Traffic-Scan Contribution to Crash Causation

- In 70 percent of multiple-vehicle crashes, the OV driver’s “Traffic Scan” contributed to the crash.

82. Other Vehicle Driver’s Visual-Obstructions Contribution to Crash Causation

- In 22 percent of multiple-vehicle crashes, “Visual Obstructions Were Present and Contributed to Crash Causation.”

83. Other Vehicle Driver’s Hazard Detection–Failure Contribution to Crash Causation

- In 5 percent of multiple-vehicle crashes, temporary traffic obstructions were present and contributed to crash causation.

84. Other Vehicle Driver's Faulty Traffic–Strategy Contribution to Crash Causation
- "Traffic Strategies Contributed to Crash Causation" in 50 percent of multiple-vehicle crashes.

85. Other Vehicle's Speed as Compared to Surrounding Traffic Contribution to Crash Causation
- "Slow or Exceedingly High Speed Difference Caused or Contributed to Crash Causation" in 21 percent of multiple-vehicle crashes.

86. Other Vehicle's Position with Respect to Other Traffic Contribution to Crash Causation
- "Position Relative to Other Traffic Contributed to Crash Causation" in 47 percent of multiple-vehicle crashes.

87. Other Vehicle Driver's Control-Unfamiliarity Contribution to Crash Causation
- Only two crashes showed "Evidence of Control Unfamiliarity as a Contributing Factor."

88. Other Vehicle Driver's Skills-Deficiency Contribution to Crash Causation
- 4.5 percent of multiple-vehicle crashes showed "Skills Deficiency Present as a Contributing Factor."

89. Other Vehicle Driver's Vehicle Handling–Unfamiliarity Contribution to Crash Causation
- Less than 1 percent of multiple-vehicle crashes showed "Vehicle Handling Unfamiliarity Present as a Contributing Factor."

90. Other Vehicle Driver's Control Operations Interference with Driving Tasks
- "Directed Attention Away from Traffic Conflict" contributed to crash causation in 13 percent of multiple-vehicle crashes.

91. Cause of Other Vehicle Driver Failure to Avoid Crash
- "Potential Hazard Detection Failure" contributed to the failure to avoid the crash in 60 percent of multiple-vehicle crashes.

92. Evasive Action Choice for the Situation
- "Evasive Action Was the Proper Choice for the Situation" in 12 percent and "Evasive Action Was Not the Proper Choice for the Situation" in 2 percent of multiple-vehicle crashes.

93. Evasive Action Execution
- "Evasive Action Was Properly Executed" in 10 percent and "Evasive Action Was Not Properly Executed" in 4 percent of multiple-vehicle crashes.

94. Other Vehicle Driver's Collision Avoidance–Failure Cause
- "Decision Failure" accounted for 2 percent of collision-avoidance failures, "Poor Execution of Evasive Action" accounted for 4 percent, and "Inadequate Time

Available to Complete Avoidance Action" accounted for 7 percent of multiple-vehicle crashes.

95. Other Vehicle Driver's Language Barriers or Difficulty with Sign Comprehension
    - There were "No Language Barriers or Sign Comprehension Problem Present" for any crash.

96. Other Vehicle Driver's Traffic Knowledge–Deficiency Contribution to Crash Causation
    - "Traffic Knowledge–Deficiency Contributed to Crash Causation" in 8 percent of multiple-vehicle crashes.

97. Other Vehicle Driver's Vehicle-Control-Skill-Deficiency Contribution to Crash Causation
    - "Inadequate Vehicle Control Skills Contributed to Crash Causation" in 4 percent of multiple-vehicle crashes.

98. Other Vehicle Driver's Aggressive-Attitude Contribution to Crash Causation
    - "Aggressive Attitude Contributed to Crash Causation" in 8 percent of multiple-vehicle crashes.

99. Situation Incompatibility Contribution to Crash Causation
    - "Situation Incompatibility Contributed to Crash Causation" in 27 percent of multiple-vehicle crashes.

100. Other Vehicle Driver's Compensation-Failure Contribution to Crash Causation
    - "Compensation Failure Did Contributed to Crash Causation" in 20 percent of multiple-vehicle crashes.

101. Other Vehicle Driver's Unsafe-Act Contribution to Crash Causation
    - "Unsafe Act Contributed to Crash Causation" in 63 percent of multiple-vehicle crashes.

102. Other Vehicle Driver's Alcohol/Drug Involvement Contribution to Crash Causation
    - "Alcohol/Drug Involvement Contributed to Crash Causation" in 3 percent of multiple-vehicle crashes.

103. Other Vehicle Driver's Previous Recorded Violations Relation to Current Crash
    - "Record of Violations for Actions Similar to Those in Crash" were related to the crash in 4 percent of multiple-vehicle crashes.

104. Other Vehicle Driver's Previous Crashes Relation to Current Crash
    - "Record of Previous Crashes Similar to This Crash" was present in 6 percent of multiple-vehicle crashes.

105. Primary Factor Contributing to Crash
- The top five primary factors that contributed to the crash were "Other Vehicle Driver Perception Failure" (30 percent), "Other Vehicle Driver Decision Failure" (17 percent), "Motorcycle Rider Decision Failure" (14 percent), "Motorcycle Rider Reaction Failure" (12 percent), and "Motorcycle Rider Perception Failure" (11 percent).

106. Crash-Contributing Factors and Investigator Confidence
- Crash investigators report a weighted average confidence in identification of the crash-contributing factors of 88 percent.

3.1.4 Motorcyclist Versus CR Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Operation of Motorcycle Immediately Prior to the Crash
   - 58 percent were coded as "moving in straight line" and 15 percent were coded as "negotiating a curve" prior to the crash.

2. Sight Line at the Start of the Crash Sequence
   - 83 percent were coded as "looking straight ahead" prior to the crash.

3. Functioning of Brakes Before the Crash
   - 99 percent were coded as "functioning" prior to the crash.

4. Hands/Fingers Positioned on the Front Brake Prior to the Crash Event
   - 61 percent of cases were coded as "fingers positioned on front brake" prior to the crash.

5. Travel Lane Just Before the Precipitating Event
   - 57 percent were coded as in "lane one" and 27 percent were coded as in "lane two" prior to the crash.

6. Travel Speed Before the Precipitating Event
   - 46 percent were coded as traveling "under 40 mph" prior to the crash; the weighted average speed was coded as "30.5 mph" prior to the crash.

7. Lateral Direction Movements of Motorcycle Immediately Before Impact
   - 64 percent were coded as "took no avoidance maneuver," 20 percent were coded as "moved to the left," and 16 percent were coded as "moved to the right" to avoid the crash.

8. Collision Avoidance Actions Taken (More Than One Coded)
   - 60 percent were coded as "braked," 42 percent were coded as "took no action," and 35 percent were coded as "steered left or right" to avoid the crash.

9. Status of Control of the Motorcycle
   - 61 percent were coded as "experienced no loss of control," 14 percent were coded as "experienced low-side slide out," 6 percent were coded as "experienced high-side slide out," 7 percent were coded as "ran wide/off the road," and 5 percent were coded as "capsized."

10. Description of Control Loss Due to Weather, Roadway, or Mechanical Problems
   - 10 percent were coded as "experienced control loss, mostly due to the roadway."

11. Travel Direction of Other Vehicle
   - 36 percent of other vehicles were coded as "from the left," 41 percent were coded as "from the right," 8 percent were coded as "from the front," 6 percent were coded as "from behind," and 4 percent were coded as "oncoming."

12. Clarity of Line of Sight to Other Vehicle
   - 87 percent were coded as "indicated no obstructions in line of sight."

13. Obscurity of the Other Vehicle
   - 97 percent were coded as "unobscured."

14. Position of Rider on the Motorcycle at the Time of Collision
   - 95 percent were coded as "in the normal seated position."

15. Motorcycle Rider's Distractions
   - 90 percent were coded as "without distractions," 4 percent were coded as "looked but did not see," and 3 percent were coded as "distracted by another person."

16. Trip Origin
   - Disparity was observed between the crash and control data. Nearly all coded origins were underrepresented or overrepresented in the crash data.

17. Safety or Maintenance Checks Completed Before Leaving for This Trip
   - "Checked Brakes" was overrepresented while "Checked Tire Pressure" and "Chain" were underrepresented in the crash data.

18. Trip Destination
   - Disparity was observed between the crash and control data. "Home," "Work," "Friend/Family," and "Bar/Pub" were overrepresented while "Recreation" and "Personal Business" were underrepresented in the crash data.

19. Trip Distance in Miles
   - Shorter trips were overrepresented and longer trips were underrepresented in the crash data.

20. Frequency of Travel This Road On/In Any Vehicle
   - "First Time" and "Daily" were overrepresented while "Weekly" and "Monthly" were underrepresented in the crash data.

21. Riding Time (Today) Prior to the Crash Interview
    - Riding time was generally underrepresented in crashes.

22. Total Miles Ridden Today Before the Crash/Interview
    - “Less than 1 Mile” ridden was overrepresented and “11–30” mi ridden was underrepresented in the crash data.

23. At the Time of Crash/Interview, Were Motorcycle Riders Wearing a Helmet
    - Riders without helmets were overrepresented in the crash data.

24. Reason for Not Wearing A Helmet
    - No reasons were provided by unhelmeted riders.

25. Does the Motorcycle Rider Ever Wear A Helmet?
    - Only one response was obtained.

26. Was the Rider’s Helmet Properly Adjusted on His/Her Head
    - In 99 percent of the crash and control data, the rider’s helmet was properly adjusted on his/her head; there were no significant differences between the crash and control data.

27. Was the Helmet Securely Fastened to the Rider’s Head
    - “No” (3 percent) was overrepresented in the crash data.

28. Type of Helmet
    - “Half Police” and “Novelty” helmets were underrepresented and “Full Face” was overrepresented in the crash data.

29. Type of Helmet Coverage
    - “Full Face” was overrepresented and “Partial Coverage” was underrepresented in the crash data.

30. Predominant Color of Helmet
    - “Green” was underrepresented in the crash data.

31. Color of the Face Shield
    - “Grey/Smoke” was overrepresented in the crash data.

32. Is the Rider the Owner of This Helmet
    - “Yes” was 99 percent for crash and control data; no significant differences were observed.

33. Helmet Fit
    - “Too Large” was underrepresented in the crash data.

34. Helmet Retained in Place During the Crash
    - Helmets were retained in 91 percent of crashes.

35. Percent of Helmet Use When Driving
    - 99 percent were wearing a helmet for the crash and control data; no significant differences were observed.

36. Conditions When Helmet Is Used by the Rider
    - "Always" was claimed by 100 percent of crash riders and 99.7 percent of control riders; no significant differences were observed.

37. Physical Impairments of Motorcycle Riders
    - "Respiratory/Cardiovascular" was overrepresented in the crash data.

38. Physiological Condition of Motorcycle Riders
    - "Fatigue" was overrepresented while "Thirst" was underrepresented in the crash data.

39. Psychological Condition of Motorcycle Riders
    - "Legal Problems" and "Reward Stress" were overrepresented while "Traffic Conflict/Road Rage" was underrepresented in the crash data.

40. Sleep in the 24 Hours Prior to the Crash/Control Interview
    - 2 and 7 h of sleep were overrepresented while 9, 10, and 12 h were underrepresented in the crash data.

41. Alcohol, Drugs, or Medications Consumption Prior to the Crash/Control Interview
    - No significant differences were observed between the crash and control data.

42. Type of Drugs Consumed Other Than Alcohol
    - "Stimulants" was overrepresented while "Blood Pressure/Thinners" and "Insulin" were underrepresented in the crash data.

43. Source of the Drugs Other Than Alcohol
    - "Illegal" was overrepresented and "Prescription Drugs" was underrepresented in the crash data.

44. Is Rider the Owner of This Motorcycle
    - "No" was overrepresented in the crash data.

45. Source of Purchase of This Motorcycle
    - "Newspaper Ad" was overrepresented in the crash data.

46. Time the Crash/Control Interview Involved Motorcycle Owned by Riders
    - "Less Than 2 Weeks" was overrepresented and "6 to 9 Years" was underrepresented in the crash data.

47. Motorcycle-Riding Experience of Riders
    - All codes less than 3 yr were overrepresented in the crash data.

48. Time the Crash/Control Interview Involved Motorcycle Operated by Rider

- "Less Than 2 Weeks" was overrepresented and "6 to 9" and "9 to 12" yr were underrepresented in the crash data.

49. Average Number of Days Per Year of Riding the Motorcycle

- "91 to 150" and "151 to 180" d per yr were underrepresented while "331 to 365" d was overrepresented in the crash data.

50. Number of Miles Per Year Riding the Motorcycle

- There were no significant differences observed between the crash and control data.

51. Type of Motorcycle Training Rider Had

- "None" was overrepresented and "Self-Taught" was underrepresented in the crash data.

52. Year of Formal Training Received

- "Years 2001 to 2005" was underrepresented in the crash data.

53. Reason for Not Taking Motorcycle Safety Training

- No statistically significant differences were observed between the crash and control data.

54. Age When Rider Began to Ride a Street Motorcycle

- "Never Ridden Before" and "Between 17 and 25 Years Old" were overrepresented and "Under Age 17" was underrepresented in the crash data.

55. Was There a Gap in Years of Riding a Motorcycle

- Approximately 40 percent of riders had a gap; no statistically significant differences were observed between the crash and control data.

56. Most Recent Hiatus in Riding a Motorcycle

- "1 Year or Less" was overrepresented and "4 to 6 Years" was underrepresented in the crash data.

57. Percent of Driving Motorcycle Versus Driving Other Vehicles

- "30–70 Percent" MC usage was underrepresented and "Greater Than 90 Percent" usage was overrepresented in the crash data.

58. Percent of Time MC Being Used for Transportation Purposes

- "Less Than 10 Percent" and "20–30 Percent" were underrepresented and "Over 80 Percent" and "Over 90 Percent" were overrepresented in the crash data.

59. Time Period of Driving Any Motor Vehicle

- "1–3," "3–5," and "5–10" yr were overrepresented and "More Than 30" yr was underrepresented in the crash data.

60. Number of Miles Per Year of Driving a Car or Truck
- "None" and "20,000–25,000" mi were overrepresented while "15,000–20,000" mi was underrepresented in the crash data.

61. Type of Training Rider Had for Driving a Car or Truck
- "No Training" and "Professional Training for Commercial License" were underrepresented while "Self-Taught" and "Official Driver Training Course" were overrepresented in the crash data.

62. Number of Traffic Convictions in Last 5 Years
- "None" was overrepresented while "One," "Two," "Three," and "More than 10" were overrepresented in the crash data.

63. Number of MC Moving Traffic Crashes in the Last 5 Years
- "Three" was overrepresented in the crash data.

64. Number of Car or Truck Crashes in the Last 5 Years
- "None" was underrepresented and "Four" was overrepresented in the crash data.

65. Experience Riding with Passengers on MC
- "Never Carry Passengers" was overrepresented and "Moderate" and "Extensive" experience were underrepresented in the crash data.

66. Experience Riding with Cargo/Luggage on MC
- "No Experience with Cargo" was overrepresented while "Always Carry Cargo" was underrepresented in the crash data.

67. Is Rider a Member of an MC Club
- "No" was overrepresented while "Yes" was underrepresented in the crash data.

68. Was the Rider Riding With Other Motorcyclists at the Time of Crash/Interview
- "No" was overrepresented while "Yes" was underrepresented in the crash data.

69. Number of MCs in the Group
- "None" was overrepresented while "One," "Two," and "Three" were underrepresented in the crash data.

70. Riding Formation of the MC Group
- "No Group" was overrepresented while "Single File" and "Staggered" were underrepresented in the crash data.

71. Position of the MC in the Formation
- "Not in Formation" was overrepresented while "Front," "Middle," and "Rear" were underrepresented in the crash data.

72. Type of Upper-Body Clothing
- “None” and “Armored Leather” were overrepresented while “Light” and “Medium” cloth garments were underrepresented in the crash data.

73. Was the Upper-Body Clothing MC Oriented
- “No” was overrepresented while “Yes” was underrepresented in the crash data.

74. Type of Lower-Body Clothing
- “None,” “Light Cloth,” and “Leather” were overrepresented while “Medium-Cloth Garment” was underrepresented in the crash data.

75. Was the Lower-Body Clothing Motorcycle Oriented
- “No” was overrepresented while “Yes” was underrepresented in the crash data.

76. Was the Rider Wearing an Inflatable Safety Vest
- Three vests were observed; no statistically significant differences were observed between the crash and control data.

77. Type of Shoes Or Boots Worn by Rider
- No statistically significant differences were observed between the crash and control data.

78. Did the Footwear Go Up Over the Rider’s Ankle
- No statistically significant differences were observed between the crash and control data.

79. Was the Footwear Motorcycle Oriented
- “No” was overrepresented while “Yes” was underrepresented in the crash data.

80. Type of Gloves Worn by Riders
- Approximately 25 percent wore gloves; no significant differences were observed between the crash and control data.

81. Were the Gloves Motorcycle Oriented
- “Yes, Full Fingered” was overrepresented while “Yes, Shorties” was underrepresented in the crash data.

82. Was the Rider’s Clothing Retroreflective
- “Retroreflective Gloves” was overrepresented and “Retroreflective Boots” was underrepresented in the crash data.

83. Clothing Color
- Upper Body: “Red” was overrepresented while “Orange” and “Brown” were underrepresented in the crash data
- Waist Down: “Multicolor” and “Blue” were underrepresented while “Yellow” and “Black” were overrepresented in the crash data.

- Color of Footwear Worn by Riders: “Red” and “Orange” were overrepresented in the crash data.
- Color of Gloves Worn by Riders: “Yellow” was overrepresented in the crash data.

84. Was Corrective Lenses Used by Riders
    - 75 percent of responses indicated that the rider did not wear corrective lenses; no statistically significant differences were observed between the crash and control data.

85. Type of Eyewear Worn by Riders
    - “None” was overrepresented while “Non-Prescription Sun Glasses,” “Prescription Sunglasses,” and “Contact Lenses” were underrepresented in the crash data.

86. Color of the Eye-Coverage Lens
    - “Clear” and “Amber/Yellow” were overrepresented while “Green” was underrepresented in the crash data.

87. Did the Rider Sustained Injuries in the Crash
    - All riders sustained some type of injury (per study inclusion protocol).

88. Type of Medical Treatment Received
    - 6 percent received no treatment, 39 percent were treated and released at a hospital, and 47 percent were admitted to a hospital.

89. Age of Rider at the Time of the Crash/Interview
    - “Under 20,” “21–25,” and “26–30”-yr-old riders were overrepresented and older riders were underrepresented in the crash data.

90. State/Country That Issued the Rider’s Current Driver’s License
    - “No License” was overrepresented in the crash data.

91. Type of Operator’s License
    - “Learner’s Permit” and “Automobile License” were overrepresented and “Commercial License” was underrepresented in the crash data.

92. Year the Rider’s Driver’s License(s) Were Issued
    - No statistically significant differences were observed between the crash and control data.

93. Number of Times a Motorcycle Learner’s Permit Was Acquired
    - “Three” was overrepresented in the crash data.

94. Number of Years a Motorcycle License Was Held by the Riders
    - “Less Than Two Weeks,” “Two Weeks to One Year,” and “One to Two Years” were overrepresented while “Thirty to Forty” and “More Than Forty” years were underrepresented in the crash data.

95. Rider's Ethnicity, Hispanic or Latino
- "Yes" was overrepresented in the crash data.

96. Race of the Rider
- "Black or African American" was overrepresented in the crash data.

97. Height of the Rider
- No statistically significant differences between heights of crash and control riders was observed.

98. Weight of the Rider
- Lighter riders ("101–150 Pounds") were overrepresented and heavier riders ("200–251 Pounds" and "251–300 Pounds") were underrepresented in the crash data.

99. Rider's Gender
- No statistically significant differences in gender were observed.

100. Level of Formal Education of the Rider
- "High School or GED" was underrepresented while "Partial College/University" was overrepresented in the crash data.

101. Current Occupation of the Rider
- "Computer and Mathematical," "Arts, Design," "Entertainment," "Sports," "Media," "Sales and Related Occupations," "Military," and "Full-Time Student" were overrepresented while "Installation, Maintenance and Repair" was underrepresented in the crash data.

102. Marital Status of the Rider
- "Single" was overrepresented while "Divorced" was underrepresented in the crash data.

103. Number of Children for the Rider
- "None" was overrepresented while "Two" and "Three" were underrepresented in the crash data.

104. Blood Alcohol Concentration (BAC)
- "Negative BAC" was underrepresented while BACs of "1–10," "11–20," "21–30," "31–40," "51–100," "151–200," and "greater than 300" mg/100 ml were overrepresented in the crash data.

105. Source of BAC Information
- The BAC source reflected that the available testing method for control riders was limited to breath testing.
- 78 percent of riders who crashed their MC were not tested for BAC.

3.1.5 MC-Passenger Versus Control-Passenger Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Location of the MC Passenger Prior to the Crash
   - All responses were "Immediately Behind the Rider" prior to the crash.

2. Riding Position of the Motorcycle Passenger at the Time of Crash
   - All responses were "Normal, Straddle-Seated Behind Rider."

3. Motorcycle Passenger Actions Contributing to the Crash
   - In one case, the passenger caused the rider to lose balance and control.

4. Was Passenger Wearing a Helmet at the Time of the Crash/Interview
   - 95 percent of crash passengers and 100 percent of control passengers wore helmets; there were no statistically significant differences in the rate of helmet wearing.

5. Reason for Not Wearing a Helmet
   - No responses were provided.

6. Does the Passenger Ever Wear a Helmet
   - No responses were provided.

7. Whether Passenger's Helmet Was Properly Adjusted on Their Head
   - The response was "Yes" for all who were wearing a helmet.

8. Whether Passenger's Helmet Was Securely Fastened to Their Head
   - The response was "Yes" for all who were wearing a helmet.

9. Type of Helmet
   - "Full-Face Motorcycle Helmet" was the most frequently observed response (67 percent for crash passengers and 46 percent for control passengers); no statistically significant differences in helmet type were observed.

10. Helmet Coverage
    - "Full-Facial Coverage with Integral Chin Bar and Face Shield" was the most frequently observed response (50 percent for crash passengers and 39 percent for control passengers); no statistically significant differences in coverage were observed.

11. Predominant Color of the Helmet
    - "Blue" was overrepresented at the 90-percent level in the crash data.

12. Color of the Face Shield
    - "Grey/Smoke" was overrepresented while "Clear" was underrepresented in the crash data.

13. Is Passenger the Owner of the Helmet
    - 67 percent of crash passengers and 92 percent of control passengers provided data owned the helmet they were wearing; no statistically significant differences were observed.

14. Fit of the Passenger's Helmet
    - One helmet was coded as "Too large, Too Loose" in the crash data; all control helmets were coded as "Acceptable Fit."

15. Whether Motorcycle Passenger's Helmet Was Retained in Place During the Crash
    - The passenger's helmet was retained in the crash 85 percent of the time.

16. Percent of Helmet Use by the Passenger
    - All helmet-wearing passengers stated that the helmet was worn 100 percent of the time; one crash passenger did not wear a helmet.

17. Condition When Helmet Is Worn by the Passenger
    - 18 percent of the crash passengers indicated they never wear a helmet; all others stated that they wear a helmet 100 percent of the time.

18. Physical Condition/Impairments of the Passengers
    - Passengers mentioned "Vision Reduction," "Hearing Reduction," "Diabetes," and "Arthritis" as physical conditions or impairments; no statistically significant differences were observed.

19. Physiological Concerns/Status of the Passengers
    - "No" was overrepresented in the crash data.

20. Psychological Concerns/Status of the Passengers
    - "Financial" and "Legal" problems were mentioned by control passengers; no statistically significant differences were observed.

21. Sleep Time of Passenger in Last 24 Hours Prior to the Crash/Interview
    - The average sleep time was 7.6 h for crash passengers and 7.9 h for control passengers; no statistically significant differences were observed.

22. Alcohol, Drugs, or Medications Consumed in 24 Hours Prior to the Crash/Interview
    - 55 percent of the crash passengers and 62 percent of the control passengers reported no alcohol or drug use in the prior 24 h; no statistically significant differences were observed.

23. Type of Drugs Consumed Other Than Alcohol
    - "No Drugs, Other than Alcohol" was overrepresented in the crash data.

24. Source of Drugs Consumed Other Than Alcohol
    - No statistically significant differences were observed.

25. Riding Experience as a Passenger on the Crash/Involved MC
    - "Less Than Two Weeks" was overrepresented in the crash data at the 90-percent level.

26. Riding Experience as a Passenger in Any Kind of Motor Vehicle
    - No statistically significant differences were observed.

27. Riding Experience as a Passenger on Any Street MC
    - "6 to 9 Years" was overrepresented in the crash data.

28. Number of Days Per Year of Riding as a Passenger on an MC
    - Average for crash passengers was 19 d and for control passengers 64 d; no statistically significant differences were observed.

29. Type of Motorcycle Training the Passenger Has Had
    - 80 percent of crash passengers had "None," while 62 percent of control passengers had "None"; no statistically significant differences were observed.

30. Percentage of Time Riding as a Passenger on the Motorcycle Versus Another Type of Vehicle
    - 18 percent for crash passengers, and 25 percent for control passengers; no statistically significant differences were observed.

31. Percent of Time Riding as a Passenger on the Motorcycle for Recreation/Transportation
    - Crash passengers ride recreationally an average of 83 percent of the time, while control passengers ride recreationally an average of 74 percent of the time; no statistically significant differences were observed.

32. Experience as a Passenger on Motorcycles
    - "Extensive" experience was underrepresented in the crash data at the 90-percent level.

33. Number of Motorcycle Traffic Crashes When a Passenger in Last 5 Years
    - No crash-involved passengers had been previously in an MC crash; three control passengers reported having been in previous MC crashes; no statistically significant differences were observed.

34. Number of Car or Truck Crashes When a Passenger in Last 5 Years
    - No statistically significant differences were observed.

35. Type of Upper-Body Clothing
    - No statistically significant differences were observed.

36. Whether the Upper-Body Clothing Was Motorcycle Oriented
- 50 percent of upper-body clothing was MC oriented for crash passengers, while 62 percent of upper-body clothing was MC oriented for control passengers; no statistically significant differences were observed.

37. Type of Lower-Body Clothing
- 78 percent of lower-body clothing was “Medium Cloth,” 7 percent was a “Leather Garment,” and 7 percent was “Kevlar” for control passengers; 38 percent of lower-body clothing was “Medium Cloth” and 5 percent was “Light Cloth” for crash passengers; no statistically significant differences were observed.

38. Whether the Lower-Body Clothing Was Motorcycle Oriented
- 0 percent of lower-body clothing was MC oriented for crash passengers, while 15 percent of lower-body clothing was MC oriented for control passengers; no statistically significant differences were observed.

39. Whether an Inflatable Safety Vest Was Worn by the Passengers
- No passengers were observed wearing this type of vest.

40. Type of Shoes/Boots Worn by the Passenger
- “Athletic, Training Shoe” was overrepresented in the crash data.

41. Whether the Footwear Goes Up Over the Passenger’s Ankle
- “No” for 64 percent of crash passengers, and “No” for 39 percent of control passengers; no statistically significant differences were observed.

42. Whether the Footwear Was Motorcycle Oriented
- “No” was overrepresented in the crash data.

43. Type of Gloves Worn
- No statistically significant differences were observed.

44. Whether the Gloves Were Motorcycle Oriented
- No statistically significant differences were observed.

45. Whether Retroreflective Clothing Was Used by Passengers
- Only one item of retroreflective clothing was observed (on a control passenger).

46. Passenger’s Clothing Color
- “White” was overrepresented for upper-body clothing in the crash data.
- “Brown” was overrepresented for shoes in the crash data.
- No statistically significant differences in lower-body clothing or glove color were observed.

47. Type of Eyewear Worn by the Motorcycle Passengers
    - No statistically significant differences were observed.

48. Color of the Eye-Coverage Lens
    - “Clear” was overrepresented in the crash data.

49. Whether Motorcycle Passenger Was Injured in the Crash
    - 100 percent of passengers sustained injury in the crashes.

50. Type of Medical Treatment Motorcycle Passenger Received
    - 12 percent of passengers were treated on scene, 50 percent were treated and released at a hospital or walk-in clinic, and 38 percent were admitted to a hospital.

51. Age of the Passenger at the Time of the Crash/Control Interview
    - The average age of a crash passenger was 30 yr, and the average age for a control passenger was 39 yr; no statistically significant differences were observed.

52. State/Country Where the Passenger’s Current Driver’s License Issued
    - “No License” was overrepresented and “California” was underrepresented in the crash data.

53. Type of Operator’s License Held by the Passenger
    - “Motorcycle License” was underrepresented in the crash data.

54. When Was the License Issued to the Passenger
    - “Years 2014–2015” were underrepresented in the crash data.

55. Hispanic or Latino Origin of Passengers
    - 36 percent of crash passengers responded “Yes,” and 23 percent of control passengers responded “Yes”; no statistically significant differences were observed.

56. Race (Ethnicity) of the Motorcycle Passengers
    - “White” was overrepresented in the crash data.

57. Height of the Motorcycle Passenger
    - 80 percent of crash passengers were under 5 ft and 6 inches, and 85 percent of control passengers were of a similar height; no statistically significant differences were observed.

58. Weight of the Motorcycle Passenger in Pounds
    - 64 percent of crash passengers were under 150 lb, as were 77 percent of control passengers; no statistically significant differences were observed.

59. Gender of the Motorcycle Passenger
- 86 percent of crash passengers were female compared to 100 percent of control passengers; no statistically significant differences were observed.

60. Level of Formal Education Completed by the Motorcycle Passenger
- "Less Than High School Diploma" was overrepresented and "Graduate Degree" was underrepresented in the crash data.

61. Motorcycle Passenger's Current Occupation
- "Full-Time Student" was overrepresented in the crash data.

62. Marital Status of the Motorcycle Passenger
- "Single" was overrepresented and "Married" was underrepresented in the crash data.

63. Number of the Motorcycle Passenger's Children
- No statistically significant differences were observed.

64. Motorcycle Passenger's Blood Alcohol Concentration (BAC) Level
- "21 to 30 mg/100 ml" was overrepresented in the crash data.

65. Source of the Passenger's Blood Alcohol Concentration (BAC) Information
- Crash passengers were generally not tested.

3.1.6 MC-Mechanical Versus Control-MC-Mechanical Data (All Percentages Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Ambient Temperature
- The average temperature was 71 °F; lower temperatures were overrepresented in the crash data versus the control data.

2. Weather Description
- "Clear" was underrepresented and "Overcast" and "Fog/Haze" were overrepresented in the crash data.

3. Wind Description
- "None, Calm" and "Variable" were overrepresented and "Light" was underrepresented in the crash data.

4. Wind Direction with Respect to Motorcycle Path
- "None, No Wind," "Headwind," "Right Crosswind," and "Tailwind" were overrepresented while "Left Crosswind" was underrepresented in the crash data.

5. Manufacturer
- Data were tabulated in a side-by-side comparison in MCCS Volume 8.

- “Buell,” “Kawasaki,” and “Yamaha” were overrepresented while “BMW” and “Harley-Davidson” were underrepresented in the crash data.

6. Model
   - Data were tabulated in a side-by-side comparison in MCCS Volume 8.

7. Year
   - Data were tabulated in a side-by-side comparison in MCCS Volume 8.
   - “2006–2010” was overrepresented and “2011–2015” was underrepresented in the crash data.

8. Motorcycle Legal Category
   - “L1” was underrepresented and “L3” was overrepresented in the crash data.

9. Motorcycle Type
   - “Sport, Race Replica” was overrepresented and “Dual Purpose (On/Off Road),” “Cruiser,” “Touring,” and “Sport-Touring” were underrepresented in the crash data.

10. Motorcycle Weight
    - Lighter MCs (“301–400 Pound” and “401–500 Pound”) were overrepresented while heavier MCs (“601–700 Pound,” “701–800 Pound,” “801–900 Pound,” and “901–1,000 Pound”) were underrepresented in the crash data.

11. Vehicle Identification Number (VIN)
    - VINs were not published.

12. Odometer Reading in Miles
    - “5,000–9,999 Miles” was overrepresented in the crash data.

13. Registered Owner Category
    - “Operated with Consent of Owner” and “Dealer” were overrepresented while “Rider as Owner” was underrepresented in the crash data.

14. Predominant Color of Motorcycle
    - “Multicolored,” “White,” “Black,” and “Silver/Grey” were overrepresented while “Yellow,” “Red,” “Green,” “Orange,” and “Gold” were underrepresented in the crash data.

15. Did the Motorcycle Have Any Retroreflective Parts, Material, or Paint?
    - “No” retroreflective parts was overrepresented while “Yes” was underrepresented in the crash data.

16. Motor Displacement
    - “200–299” and “400–499” cc displacements were overrepresented while “1,500–1,599” and “1,600–1,699” cc were underrepresented in the crash data.

17. Number of Cylinders
    - "4 Cylinders" was overrepresented while "2 Cylinders," "3 Cylinders," and "6 Cylinders" were underrepresented in the crash data.

18. Number of Passengers
    - "No passengers" was overrepresented in the crash data.

19. Motorcycle Cargo/Luggage
    - 47 percent of the crash-involved MCs carried cargo.

20. Are Control Motorcycle Tires Original Equipment
    - 26 percent "Yes," 73 percent "No, But Standard Size," and 4 percent "Modified" were recorded.

21. Mechanical or Other Problem Experienced Prior to Crash
    - 98 percent experienced no problems.

22. Source of Problem
    - Less than 1 percent was coded as "Stuck or Binding Throttle"; No other problems were found.

23. Tire-Size Measurement Units
    - 90 percent used millimeters.

24. Tire Measurement
    - Data were tabulated in MCCS Volume 8.

25. Tire Manufacturer
    - Data were tabulated in MCCS Volume 8.

26. Rim Size
    - Data were tabulated in MCCS Volume 8.

27. Rim Manufacturer
    - 99.4 percent reflected "Original Equipment Manufacturer."

28. Tire-Tread Type
    - "All Weather, Angle Groove" was overrepresented while "All Weather, Diagonal" was underrepresented in the crash data for both front and rear tires.

29. Measured Tread Depth
    - "00/32," "1/32," and "3/32" inch depths were overrepresented while "5/32" and "6/32" inch depths were underrepresented for front tires in the crash data.
    - "00/32," "1/32," "2/32," and "11/32" inch depths were overrepresented while "9/32" inch depth was underrepresented for rear tires in the crash data.

30. Inflation Pressure Code in PSI
- Front- and rear-tire-pressure distributions were similarly shaped for the crashed MCs; the average front pressure measured 23 psi, and the average rear pressure measured 29 psi.

31. Braking Evidence on Tires
- For front tires, 90 percent showed no braking evidence, 5 percent showed moderate braking, and 5 percent showed heavy braking, most with one skid patch.
- For rear tires, 82 percent showed no braking evidence, 3 percent showed moderate braking, 12 percent showed heavy braking with skid patches, and 2 percent showed heavy braking with multiple skid patches.

32. Are Wheels Original Equipment
- 92 percent "Yes" and 7 percent "No, but Standard Size" were recorded.

33. Is the Suspension Original Equipment
- 97 percent "Yes," 2 percent "Partially," and 1 percent "No" were recorded.

34. Suspension Type
- For the front suspension, "Rigid Wheel Mount" and "Telescoping Tube, Inverted Fork" were overrepresented and "Telescoping Tube, Conventional Fork" and "Telelever" were underrepresented in the crash data.
- For the rear suspension, "Rigid Wheel Mount," "Conventional Fork, Swing Arm–Mono Shock," and "One Sided Swing Arm Mono Shock" were overrepresented and "Conventional Fork Swing Arm, Double Exterior Tubular Shocks" and "One Sided Swing Arm Mono Shock" were underrepresented in the crash data.

35. Suspension Condition
- For the front suspension, 99 percent recorded "No Unusual Condition."
- For the rear suspension, 99 percent recorded "No Unusual Condition."

36. Rider Brake-Control Type
- 93 percent one-hand and one-foot break configuration was recorded in both crash and control data.

37. Motorcycle Rider Brake-Control Side
- Both brakes were on the right for 89 percent of MCs; no statistically significant differences were observed.

38. Motorcycle Brake Actuation at Lever or Pedal
- 88 percent of the brake actuation was hydraulic and 10 percent was mixed (hydraulic/mechanical/electric).

39. Brake Control–System Type
   - "Independent Front Brake" was overrepresented and "Combined Front and Rear Brakes" was underrepresented in the crash data.

40. Connection to Brakes Includes Which Valve Types
   - For the front brake, 87 percent "Both No Proportioning Valve," 7 percent "Both Fixed Proportioning Valve," and 7 percent "Mixed" were recorded.
   - For the rear brake, 92 percent "Both No Proportioning Valve," 3 percent "Both Fixed Proportioning Valve," and 5 percent "Mixed" were recorded.

41. Antilock Braking System (ABS)
   - "No" was overrepresented and "Yes" was underrepresented in the crash data for both front and rear brakes.

42. Motorcycle ABS Type
   - For the front brake, 67 percent "Electro-Hydraulic," 11 percent "Hydro Mechanical," 17 percent "All Hydraulic, Fluidic," and 6 percent "Electro-Mechanical" were recorded.
   - For the rear brake, 77 percent "Electro-Hydraulic," 8 percent "Hydro Mechanical," 8 percent "All Hydraulic, Fluidic," and 8 percent "Electro-Mechanical" were recorded.

43. Motorcycle Brake Mechanism
   - For the front brake, 53 percent "Double Disc, Multi-Piston," 32 percent "Single Disc, Multi-Piston," and 3 percent "Double Disc, Single Piston" were recorded.
   - For the rear brake, 63 percent "Single Disc, Single Piston," 23 percent "Single Disc, Multi-Piston," and 11 percent "Drum, Single Leading Shoe" were recorded.

44. Brake Mechanism Actuation
   - For the front brake, 98 percent "Hydraulic" was recorded.
   - For the rear brake, 88 percent "Hydraulic" and 12 percent "Mechanical" were recorded.

45. Were Motorcycle Brakes Operational Before Crash
   - For the front brakes, 98 percent "Yes" was recorded.
   - For the rear brakes, 99 percent "Yes" was recorded.

46. Do the Motorcycle Brakes Appear to be Defective
   - 99 percent "No" was recorded.

47. Brakes Condition/Wear
   - For the front brakes, 93 percent "No Significant Wear" and 6 percent "Minimum Wear" were recorded.
   - For the rear brakes, 93 percent "No Significant Wear" and 6 percent "Minimum Wear" were recorded.

48. Brake Adjustment
- For the front brakes, 98 percent “No Maladjustment” was recorded.
- For the rear brakes, 98 percent “No Maladjustment” was recorded.

49. Frame Type/Configuration
- “Step Through, Formed Sheet Metal” and “Perimeter Frame, Extrusion Element Type” were overrepresented and “Conventional Tube, Cradle Type with Single Down Tube,” and “Backbone Type, Motor Transmission Integral with Frame” were underrepresented in the crash data.

50. Frame Material
- 64 percent “Steel” and 35 percent “Aluminum Alloy” were recorded.

51. Reduction in Wheelbase
- 70 percent no reduction, 11 percent “1–5” inches, and 8 percent “5–10” inches were recorded.

52. Did Front Wheel Displace Against Either the Motor or the Frame
- 75 percent “No” and 25 percent “Yes” were recorded.

53. Steering-Stem Adjustment
- 100 percent “Secure, Properly Tightened” was recorded.

54. Steering Damper Installed
- 87 percent “None Installed/Not Applicable” and 10 percent “Hydraulic Tubular Damper” were recorded.

55. Is Rear Swing Arm Loose
- 100 percent “No” was recorded.

56. Is the Motorcycle Equipped with Pedals
- 0.3 percent was recorded in the crash and control data; no statistically significant differences were observed.

57. Rider Foot Pegs, Footrest Type
- 89 percent folding types, 5 percent rigid types, and 6 percent scooter were recorded.

58. Passenger Foot Pegs, Footrest Type
- 81 percent folding types, 1 percent rigid types, 3 percent scooter, and 14 percent “None” were recorded.

59. Side-Stand Type
- 93 percent “Original Equipment, Left Side, Metal End/Pad” was recorded.

60. Center-Stand Type

- 83 percent “None” and 17 percent “Original Equipment, Installed” were recorded.

61. Headlamp-Assembly Type

- “Single with Auxiliary Lights” was underrepresented and “Double with Auxiliary Lights” was overrepresented in the crash data.

62. Was Headlamp Illuminated at the Time of Crash?

- “Yes” was recorded 98 percent and above for both the crash and control data; no statistically significant differences were observed.

63. Was Motorcycle Equipped With an Airbag?

- 0.3 percent “Yes” was recorded for the both crash and control data; no statistically significant differences were observed.

64. Is Motorcycle/Control Motorcycle Equipped With or Pulling Any of the Following

- Less than 1 percent were recorded pulling a sidecar or trailer for both the crash and control data; no statistically significant differences were observed.

65. Handlebar Type/Modifications

- “Clip-on—Not Original Equipment” was overrepresented and “Original Equipment” was underrepresented in the crash data.

66. Handlebar Mounting

- 94 percent “Original Equipment, Solid,” 5 percent “Risers,” and 1 percent “Original Equipment, Rubber Bushing” were recorded.

67. Handlebar Construction/Material

- 71 percent “Steel Tube,” 16 percent “Aluminum Alloy,” and 12 percent “Cast Aluminum” were recorded.

68. Handlebar Measurements

- The average handlebar width measured was 29.4 inches; 99 percent of data fell between “10–15” and “35–40” inches.
- The average handlebar rise measured was 3.8 inches; 100 percent of data fell between “–5 to 0” and “15–20” inches.
- The average handlebar sweep measured was 6.4 inches; 99 percent of data fell between “0–2” and “14–16” inches.

69. Control Motorcycle Seat Modification

- 88 percent “No” was recorded.

70. Seat Type

- “Single Straddle Seat, Pillion Pad Behind” was overrepresented while “Conventional Straddle, One Level Seat” and “Bucket, Double Seat, Raised Passenger” were underrepresented in the crash data.

71. Seat Fastening

- 56 percent “Multiple Tab and Screw Adjustment,” 16 percent “Tank Tongue with Double Claw Latch,” and 10 percent “Bolted” were recorded.

72. Fuel Tank Type

- 80.3 percent “Saddle,” 7 percent “Submerged Frame,” 6 percent “Perimeter Mount,” and 5 percent “Under Seat” were recorded.

73. Fuel Tank Material

- 92 percent “Steel,” 4 percent “Injection Molded Plastic,” and 3 percent “Aluminum Alloy” were recorded.

74. Fuel Tank Cap Type

- 41 percent “Smooth with Tank Top Surface, No Cover,” 16 percent “External Screw Type, No Cover,” and 12 percent “Smooth with Tank Top Surface, Covered” were recorded.

75. Cap Retention

- 98 percent “Retained Securely, No Venting of Fuel Loss from Cap” was recorded.

76. Tank Retention

- 92.3 percent “Tank Completely Retained on Motorcycle” and 5 percent “Partially Separated” were recorded.

77. Tank Deformation

- 47 percent “None,” 41.1 percent “Mild Denting,” 85 percent “Moderate Denting,” and 5 percent “Severe Damage” were recorded.

78. Deformation Source

- 34 percent “Collision Contact with Other Motorcycle Components,” 22 percent “Collision Contact with Roadway Surface,” and 19 percent “Contact with Motorcyclist’s Body” were recorded.

79. Was There a Fuel Tank Failure?

- 93 percent “No” was recorded.

80. Tank Damage/Failure Type (Code Up to Four, Adds to Greater Than 100 Percent)

- 88 percent “Denting or Crushing” and 40 percent “Laceration or Puncture from Edge or Sharp Object” were recorded.

81. Was There a Fuel Spill or Leak?

- 84 percent “No,” 10 percent “Minor, Little or No Fire Hazard,” 3 percent “Moderate Leak,” and 3 percent “Large Leak, Severe Fire Hazard” were recorded.

82. Source of Fuel Spills or Leaks (Code Up to Five)
- 82 percent "Not Applicable," 7 percent "Primary Fuel Tank," 5 percent "Fuel Cap," and 4 percent "Fuel Lines" were recorded.

83. Did a Fire Occur?
- 99 percent "No" was recorded.

84. When Did a Fire Occur?
- A fire occurred once "During Crash" and once "Post-Crash."

85. The Fire Occurred How Long After a Crash?
- 100 percent "One Minute" was recorded.

86. Fuel Source for Fire
- The fuel source for the fire was once the "Primary Fuel Tank" and once the "Fuel Cap."

87. Ignition Source of Fire
- The ignition source of the fire was once recorded as "Sliding Motorcycle Causes Friction Sparks" and once recorded as "Exhaust System."

88. Driveline Type
- 57 percent "Sprocket and Exposed Chain," 29 percent "Belt," 13 percent "Shaft," and 1 percent "Sprocket and Enclosed Chain" were recorded.

89. Drive-Chain, Belt, or Shaft Condition
- 95 percent "No Unusual Condition," 3 percent "Excessively Loose/Wear," and 1 percent "Chain of Belt Derailed" were recorded.

90. When Did This Driveline Damage Occur?
- 97 percent "No Driveline Damage," 2 percent "During Crash," and 1 percent "Pre-crash" were recorded.

91. Drive-Sprocket Condition
- 99 percent "No Unusual Condition" and 1 percent "Worn but Serviceable" were recorded.

92. Does Throttle Control Work?
- 88 percent "Yes" and 12 percent "No" were recorded.

93. Drum Condition
- 88 percent "No Drum Damage" and 12 percent "Grip Interference, Binds" were recoded.

94. Condition of Cables
- 95 percent "Cables Not Damaged" and 4 percent "Bind Due to Bent Sheath" were recorded.

95. Condition of Throttle Plate/Slides
    - Greater than 99 percent “Throttle Plate/Slides Not Damaged” and less than 1 percent “Prior Damage” were recorded.

96. Return-Springs Condition
    - 92 percent “Return Springs Not Damaged” and 8 percent “External Springs Missing, Sticking Throttle” were recorded.

97. Condition of Exhaust
    - 44 percent “No Problems, Good Condition,” 27 percent “Worn or Damaged,” 16 percent “Performance Equipment, Same Noise Level as Original Equipment,” and 12 percent “High Performance Equipment, Excessive Noise” were recorded.

98. Exhaust-System Modification, Control Motorcycles
    - 56 percent “No,” 26 percent “Yes, Performance Equipment-Noise Level Same as Original Equipment,” and 20 percent “High-Performance Equipment, Excessive Noise” were recorded.

99. Has the Windshield Been Modified, Control Motorcycle
    - 89 percent “No” and 11 percent “Yes” were recorded.

100. Is MC Equipped with Crash Bars, Control Motorcycle
    - 72 percent “No” and 28 percent “Yes” were recorded.

101. Is MC Equipped with Engine Guards, Control Motorcycle
    - 78 percent “No” and 23 percent “Yes” were recorded.

3.1.7 MC Dynamics Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or “Other (Specify)” Responses)

1. Pre-Crash Motion Prior to Precipitating Event
    - “Turning Right,” “Crossing Opposing Traffic,” and “Negotiating Curves” were overrepresented in single-vehicle crashes.
    - “Crossing Opposing Lanes of Traffic” and “Negotiating Curves” were overrepresented in fatal crashes.

2. Travel Speed
    - The average travel speed was 35 mph.
    - Higher travel speeds (greater than 50 mph) were overrepresented in single-vehicle and fatal crashes.

3. Travel-Speed Confidence Interval
    - 93 percent estimated within ±5 mph, and 6 percent estimated within ±10 mph.

4. Line of Sight to OV
   - 82 percent of crashes had a line of sight between the 11 and 2 o'clock positions.

5. Pre-Crash Motion After Precipitating Event
   - Right or left departures from straight-line motions were overrepresented in single-vehicle crashes, and "Left Movement" was overrepresented in fatal crashes.

6. Crash-Avoidance Action
   - "Braking" and "Swerving" were underrepresented while "Accelerating," "Cornering," and "None" were overrepresented in single-vehicle crashes.
   - No statistically significant differences in avoidance actions were observed.

7. Braking Skid Marks on Highway
   - "Absence of Skid Marks" was overrepresented in single-vehicle crashes.
   - "Skid Marks from Both Front and Rear Tires, Front and Rear Equivalent and Overlaying" was overrepresented in fatal crashes.

8. Length of Skid Marks on Highway
   - Longer skid marks were overrepresented in fatal crashes for both front and rear tires.

9. Braking Skid Mark Striation Evidence on Highway
   - In 32 percent of cases, braking evidence was confirmed for the crashed MC.

10. Braking Tire Striation Evidence
   - The absence of evidence was underrepresented while "Front Tire Only" evidence was overrepresented in fatal crashes.

11. Swerve
   - "Swerving," whether it was a correct or incorrect decision, was underrepresented in single-vehicle crashes.

12. Acceleration Evidence on Rear Tire
   - Over 99 percent of cases showed no evidence of acceleration on the rear tire.

13. Counter-Steering
   - "Improper Counter-Steering" was overrepresented in single-vehicle crashes.

14. Cornering Skid-Mark Evidence on Roadway
   - 98 percent of cases showed no evidence of cornering skid marks on the roadway.

15. Cornering Tire-Striation Evidence
   - Cornering tire-striation was overrepresented for front and rear tires in single-vehicle crashes.

- “Left Cornering” was overrepresented in fatal crashes.

16. MC First-Collision Contact Code
    - MC sides and undercarriage were overrepresented in single-vehicle crashes.
    - “Right Front” and “Top Rear” were overrepresented (at the 90-percent level) in fatal crashes.

17. Object(s) Contacted (Code Up to Three)
    - In statistical tests, “Curbs,” “Ground,” “Walls,” “Poles,” “Roadway Surfaces,” “Fixed Objects,” “Animals,” and “Non-fixed Objects” were overrepresented at the 90-percent confidence level in single-vehicle crashes.
    - “Other Vehicles,” “Curbs,” “Walls,” and “Fixed Objects” were overrepresented in fatal crashes.

18. MC Impact Speed in Miles Per Hour
    - The weighted average impact speed was 29 mph.
    - Higher speeds were overrepresented in single-vehicle and fatal crashes.

19. Roll Attitude Angle
    - “Right-Side Down” and “Left-Side Down” were overrepresented in single-vehicle crashes.
    - “Left-Side Down” was overrepresented in fatal crashes.

20. Sideslip Angle in Degrees
    - Low angles (30–1 degrees counterclockwise and 90–360 degrees clockwise) were overrepresented in single-vehicle crashes, and higher counterclockwise angles (90–61 degrees counterclockwise) were overrepresented in fatal crashes.

21. Relative Heading Angle
    - “Zero Degrees” was overrepresented in single-vehicle and fatal crashes.

22. Principle Direction of Force
    - Nonhorizontal force was overrepresented and angles to the right of straight ahead were underrepresented in single-vehicle crashes.
    - “0 to 45 Degrees Right of Straight Ahead” was overrepresented in fatal crashes.

23. Calculated Time from Precipitating Event to Impact
    - The average time from the precipitating event to impact was 2.2 s.

24. MC Motion Code
    - “Rolling on Wheels Then Impacting Object,” “Vehicle Rollover,” and “Vaulting” were overrepresented in single-vehicle crashes.
    - “Rolling on Wheels Then Impacting Object,” “Skidding,” and “Run Over at POI” were overrepresented in fatal crashes.

25. Distance from POI to MC POR
- The average distance was 53 ft.
- Longer distances were overrepresented in single-vehicle and fatal crashes.
- Greater offset distances were seen in fatal crashes.

26. Post-Crash Scrape Marks on MC
- "Tumbling" (both end over end and side over side) and "Down on Left Side, Front End First" were overrepresented while "Down on Left Side, Sliding Low End First" was underrepresented in single-vehicle crashes.
- "Sliding on Right Side (Both Low-Side First and Rear-End First)" and "Tumbling End Over End" were overrepresented in fatal crashes.

27. Rider Motion Code
- "Tumbling and Rolling to POR" and "Skidding to POR" with and without "Impact With Object at POR" were overrepresented while "Vaulting" was underrepresented in single-vehicle crashes.
- "Skidding With Impact With Object at POR," "Vaulting With Object Impact," and "Run Over at POI" were overrepresented while "Skidding Without Object Impact" and "Not Separating from Motorcycle" were underrepresented in fatal crashes.

28. Distance from POI to Rider POR
- The average distance was 35 ft; longer distances were overrepresented in fatal crashes.

29. Passenger Motion Code
- "Point of Rest" located the same as "Point of Impact" was overrepresented in fatal crashes.

30. Distance from POI to Passenger POR
- The weighted average was 31 ft; longer distances were overrepresented in fatal crashes.

31. Post-Crash Crash Scene Scrape Marks
- No significant differences by crash type were observed.

32. Proper Tire Size
- "Oversized Rim" or "Oversized Section" were overrepresented in single-vehicle crashes.
- "Improper Rim, Too Small" on the front tire and "Proper Rim, Undersize Section" on the rear tire were overrepresented in fatal crashes.

33. Post-Crash Tire Inflation Pressure
- A grossly underinflated front tire was overrepresented in single-vehicle crashes.

34. Contributing Factor Related to Tire or Wheel
    - "Underinflation" and "Gross Inflation Errors" were overrepresented in single-vehicle crashes for both front and rear tires.

35. Contributing Factor Related to Suspension Condition
    - "Suspension Condition" was not a contributing factor.

36. Contributing Factor Related to Frame Condition
    - One instance was observed.

37. Contributing Factor Related to Cornering Clearance
    - Two instances were observed, and both showed that the foot pegs grounded out in single-vehicle crashes.

38. Contributing Factor Related to the Seat
    - "Seat" was not a contributing factor.

39. Contributing Factor Related to the Drive-Chain, Belt, or Shaft Condition
    - "Drive-Chain, Belt, or Shaft Condition" was not a contributing factor.

40. Contributing Factor Related to the Exhaust System Condition
    - One instance was observed.

41. Contributing Motorcycle Vehicle Failure
    - "Brake Failure" and "Tire and Wheel Failure," one instance each, were observed.

42. Was a Pre-Crash Fire a Contributing Factor
    - No fires were observed.

43. Was the Cargo/Luggage a Contributing Factor
    - "Cargo/Luggage" was not a contributing factor.

3.1.8 Injury Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Source of Injury Data
    - 2,662 injuries were recorded for crash motorcyclists and crash passengers, and 254 injuries were coded for OV drivers.
    - 32 percent were from "Autopsy Records," 25 percent were from "Interviews," 21 percent were from "Police," 14 percent were from "Hospital (Non-ER) Records," 6 percent were from "Coroner Reports," and 4 percent were from "ER" records.

2. Body Region
    - Most injuries were observed on the "Lower Extremity" (32 percent) or "Upper Extremity" (24 percent), with 15 percent to the "Thorax," 8 percent to the

“Head,” 8 percent to the “Abdomen,” 7 percent to the “Face,” 4 percent to the “Spine,” 2 percent to the “Neck,” and 1 percent to the “Skin.”
- Injuries to the “Thorax,” “Abdomen,” “Skin,” and “Face” were overrepresented while injuries to the “Spine” and “Lower Extremities” were underrepresented in single-vehicle crashes.
- Injuries to the “Head,” “Face,” “Neck,” “Thorax,” and “Abdomen” were overrepresented while the “Spine,” “Upper Extremities,” “Lower Extremities,” and “Skin” were underrepresented in fatal crashes.

3. Injuries by Body Region and Severity
   - 0.8 percent of all recorded injuries were “Untreatable,” 2 percent were “Critical,” 3 percent were “Severe,” 10 percent were “Serious,” 25 percent were “Moderate,” and 59 percent were “Minor.”

4. Maximum Injury Severity for Each Case
   - 4 percent of cases had one or more maximum injury recorded as “Untreatable,” 4 percent had one or more maximum injuries recorded as “Critical,” 5 percent had one or more maximum injuries recorded as “Severe,” 17 percent had one or more maximum injuries recorded as “Serious,” 32 percent had one or more maximum injuries recorded as “Moderate,” and 38 percent had one or more maximum injuries recorded as “Minor.”
   - “Untreatable” injuries were overrepresented in single-vehicle crashes.
   - “Untreatable,” “Critical,” and “Severe” injuries were overrepresented in fatal crashes.

5. Injury Severity, All Injuries
   - The number of “Untreatable,” “Critical,” and “Severe” injuries were overrepresented in single-vehicle crashes.
   - The number of “Untreatable,” “Critical,” “Severe,” and “Serious” injuries were overrepresented in fatal crashes.

6. Type of Anatomical Structure Injured
   - 52 percent of the observed injuries were to the “Skin,” 23 percent were “Skeletal,” 19 percent were to “Organs,” 3 percent were to “Joints,” 2 percent were to “Vessels,” 1 percent were to the “Head,” and 0.3 percent were to “Nerves.”

7. First Injury Source
   - 55 percent showed “Other Vehicle or Object in the Environment” as the first injury source.

8. First Injury Source Confidence Level
   - See table 8 in MCCS Volume 9 for more information.

9. Second Injury Source
   - 61 percent showed “Other Vehicle or Object in the Environment” as the second injury source.

10. Second Injury Source Confidence Level
    - See table 10 in MCCS Volume 9 for more information.

11. Occupant Direct/Indirect Injury
    - 96 percent of injuries were from “Direct Contact.”

12. Blood Alcohol Concentration
    - 66 percent of riders, 50 percent of passengers, and 83 percent of OV drivers had BACs of 0 mg/100 ml.
    - 72 percent of riders, 75 percent of passengers, and 100 percent of OV drivers had BACs of 0.08 mg/100 ml or less.

13. Alcohol/Drug Impairment
    - 89 percent of riders, 89 percent of passengers, and 100 percent of OV drivers were observed with “No” alcohol/drug impairment. (Note that impairment is determined subjectively by the police officer’s judgement.)

14. Source of BAC Information
    - 13 percent of riders, 10 percent of passengers, and 21 percent of OV drivers had blood tests to determine their BAC.

15. Time Span From Crash to BAC Collection
    - 10 percent of crash-involved individuals were tested within 4 h of the crash; they represented 90 percent of those who were tested.

16. Type of Drugs Other Than Alcohol
    - “No Drugs Other Than Alcohol” was recorded for 8 percent.
    - No drugs or alcohol (“Not Applicable”) was recorded for 86 percent.
    - 3 percent indicated “Multiple Drugs Taken,” 2 percent indicated “Depressants,” and 1 percent indicated “Stimulants.”

17. Source of Drugs Other Than Alcohol
    - “Prescription” drugs were recorded for 25 percent.
    - “Illegal” drugs were recorded for 23 percent.

18. Injury Severity Score
    - 76 percent had an Injury Severity Score of 0–10.
    - 10 percent had an Injury Severity Score of 11–20.

19. Trauma Status
    - 40 percent were “Treated at a Hospital and Released.”
    - 35 percent were “Admitted to a Hospital.”
    - 6 percent “Sought No Medical Treatment.”
    - 4 percent were “Dead on Scene.”
    - 4 percent were “Dead on Arrival at Hospital.”

20. Number of Days of Hospital Admission
  - 66 percent were "Not Hospitalized."
  - 22 percent stayed "Less Than 5 Days."
  - 6 percent stayed "6–10 Days."
  - 2 percent stayed "More Than 40 Days," with more than half of these staying "More Than 96 Days."

21. Death Within How Many Days
  - 95 percent of fatalities died within 5 d of the crash.
  - One fatality occurred 62 d after the crash.

3.1.9 OV-Driver Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Pre-Crash Motion Prior to Precipitating Event
  - The OV driver was "Stopped in Traffic" in 25 percent of fatal crashes and 24 percent of nonfatal crashes.
  - "Moving in a Straight Line" with "Foot Off Accelerator," "Accelerating," and "Backing up" as well as "Turning Left with Foot Off Accelerator" were overrepresented in fatal crashes.

2. Sight Line at the Start of the Crash Sequence
  - The most common vision direction was "Looking Straight Ahead" (48 percent) in crashes.
  - No statistically significant differences were observed between fatal and nonfatal crashes.

3. Travel Lane Just Before the Precipitating Event
  - "Right (Curb) Lane" was the travel lane in 47 percent of crashes.
  - No statistically significant differences were observed between fatal and nonfatal crashes.

4. Travel Speed Before the Precipitating Event
  - The average speed was 9 mph.
  - No statistically significant differences were observed between fatal and nonfatal crashes.

5. Collision-Avoidance Actions
  - 83 percent of OV drivers took no collision-avoidance action.
  - No statistically significant differences were observed between fatal and nonfatal crashes.

6. Description of Control Loss Due to Weather, Roadway, or Mechanical Problems
  - Only one instance of control loss was observed.

7. Number of Passengers
   - There were no passengers in 67 percent of OVs.
   - “Four Passengers” was overrepresented in fatal crashes.

8. Did Other-Vehicle Passenger Contribute to Crash
   - When present, passengers contributed to the crash in 13 percent of cases.

9. Clarity of Line of Sight to MC
   - The line of sight was “Not Clear” in 22 percent of 251 cases where these data were known.
   - No statistically significant differences were observed between fatal and nonfatal crashes.

10. Object Obstructing View
    - The frequency of objects obstructing the OV driver’s view were as follows: 7 percent “Roadside Objects,” 3 percent “Other Vehicles,” and 3 percent “Roadway Grade or Curvature”.

11. Was View to MC Obscured?
    - 94 percent of the time, the view to the MC was “Not Obscured.”
    - When views were obscured, “Sun Glare” was most frequent at 3 percent.

12. Distractions
    - 79 percent of OV drivers reported “Attentive and Not Distracted.”
    - 12 percent reported “Looked, but Didn’t See” the MC.
    - 7 percent reported being distracted by some type of device (1 percent) or an outside event/person (3 percent) or that the details were unknown (3 percent).

13. Start Point of the Trip
    - “Home” was the most common start point at 35 percent, with “Work, Business” being second most common at 19 percent.

14. Trip Destination
    - “Home” was the most common destination at 39 percent, with “Work, Business” being second most common at 15 percent.
    - Travel to “Family, Friends, Relatives” and to “Religious Activity” were overrepresented in fatal crashes.

15. Trip Distance in Miles
    - The average trip distance was 10 mi.
    - Short trips of “2–5 Miles” were overrepresented in fatal crashes.

16. Frequency of Travel on This Road on/in Any Vehicle
    - 79 percent of OV drivers travelled the road at least weekly.
    - Traveling the road “Less than Annually” was overrepresented for fatal crashes.

17. Time Driving Today Prior to the Crash (Hours)
    - The recorded time driving prior to the crash of “30 to 60 Minutes” was overrepresented for fatal crashes.

18. Total Miles Traveled Before the Crash Occurred
    - Recorded travel of 21–25 mi before the crash was overrepresented for fatal crashes.

19. Physical Impairment
    - “Vision Reduction or Loss” was underrepresented in fatal crashes.
    - “Respiratory, Cardiovascular Condition” was overrepresented in fatal crashes.

20. Physiological Status at the Time of Crash
    - 89 percent of OV drivers reported physiological issues at the time of the crash.
    - Of those who reported, 6 percent were “Hungry” and 3 percent were experiencing “Elimination Urgency” at the time of the crash.

21. Psychological Status at the Time of Crash
    - 89 percent of OV drivers reported no emotional problems at the time of the crash.
    - 5 percent reported “Conflict with Friends or Family,” and 4 percent reported “Work Related Problems.”

22. Sleep in Hours 24 Hours Prior to the Crash
    - The reported sleep for OV drivers in the 24 h prior to the crash averaged 7.5 h.
    - Sleep ranged from “None” to “11” h in the 24 h prior to the crash.

23. Alcohol or Any Drugs or Medications Consumption 24 Hours Prior to the Crash
    - 68 percent reported no use of alcohol or drugs.
    - 9 percent of OV drivers had consumed alcohol in the 24 h prior to the crash.
    - 21 percent of OV drivers had consumed drugs/medication in the 24 h prior to the crash.

24. Type of Drugs Other Than Alcohol
    - “Drugs Taken, Type Unknown” was overrepresented in fatal crashes.

25. Source of The Drugs Other Than Alcohol
    - Only one OV driver reported use of illegal drugs.

26. Time Driving Any Kind of Motor Vehicle (Years)
    - The average prior driving experience was 7 yr.

27. Time Driving the Crash-Involved MC/Motor Vehicle
    - The average experience with the crash-involved vehicle was 1.1 yr.
    - Driving experience of “3 to 4” yr with the crash-involved vehicle was overrepresented in fatal crashes.

28. Miles/Year Drive Car or Truck
- OV drivers drove an average of 13,300 mi per yr.

29. Type of Driving Training Driver Had
- "None" was overrepresented (at the 90-percent level) in fatal crashes.

30. Number of Traffic Convictions in Previous 5 Years
- On average, OV drivers had 0.6 violations in the previous 5 yr.

31. Number of MC Crashes in Past 5 Years
- Two instances were observed: one had 1 crash, and the other had 2.

32. Number of Car or Truck Traffic Crashes in the Past 5 Years
- 32 percent of OV drivers had one or more car/truck crashes in the past 5 yr.

33. Does Other-Vehicle Driver Currently Ride a Street MC
- Seven instances were observed.

34. MC Riding Experience (Years)
- Seven instances were observed with an average of over 5 yr of experience.
- 6 yr of experience was overrepresented in fatal crashes.

35. Average Number of Days/Year Driver Rides MCs
- While not statistically significant, riders in fatal crashes rode less than 30 d per yr on average.

36. Miles/Year Driver Rides MCs
- OV drivers averaged about 100 mi by MC per yr.

37. Time of Riding an MC Versus Another Type of Vehicle in Percentage
- The percentage of time MCs were ridden by OV drivers varied from less than 10 percent to more than 40 percent of the time they travel by vehicle.

38. Percentage of Time Other-Vehicle Driver Who Rides a Motorcycle Rides for Recreation (Versus Basic Transportation)
- Recreational riding dominated responses; riding less than 20 percent of the time for recreation was overrepresented in fatal crashes.

39. Age at the Time of the Crash
- OV drivers averaged 41 yr of age, ranging from less than 18 to over 85.

40. Driver Injury in This Crash
- 9 percent of OV drivers sustained injuries in the crash.

41. Type of Medical Treatment Received
- 8 percent of injured OV drivers were admitted to a hospital.

42. State/Country Where Current Driver's License Issued
- 7 percent of OV drivers did not hold a current driver's license.
- 86 percent of OV drivers held a California driver's license.

43. Type of Operator's License
- 87 percent of OV drivers held automobile licenses.
- 6.5 percent of OV drivers held MC licenses.

44. Year License Issued
- OV drivers with licenses issued in 2010 or 2011 were overrepresented in fatal crashes.

45. License Qualifies Driver to Operate Motor Vehicle
- 99 percent of OV drivers were qualified to drive the vehicle they were driving.

46. Driver's Origin, Hispanic or Latino
- 39 percent of OV drivers who responded were Hispanic or Latino.

47. Race (Code Up to Four)
- 78 percent of respondents were White.

48. Driver's Height
- OV drivers averaged 5 ft and 7 inches.

49. Driver's Weight (Pounds)
- OV drivers averaged 160 lb.

50. Gender
- 57 percent of OV drivers were male.

51. Level of Formal Education Attained
- 29 percent of OV drivers attained a high school degree or less.
- 42 percent of OV drivers were college graduates.

52. Current Occupation
- OV drivers with "Architecture and Engineering" occupations and those with "Arts, Design, Entertainment, Sports, or Media" occupations were overrepresented in fatal crashes.

53. Are You Required to Wear Corrective Lenses When Riding/Driving?
- 71 percent did not require corrective lenses when driving, and these drivers were overrepresented in fatal crashes.

54. Were Corrective Lenses in Use at the Time of the Crash?
- Those using corrective lenses at the time of the crash were underrepresented in fatal crashes.

55. Marital Status
    - Cohabiting individuals were overrepresented in fatal crashes.

56. Number of Children
    - 28 percent of OV drivers had no children.
    - OV drivers with children averaged 2.1 children.

57. Blood Alcohol Concentration (BAC)
    - 84 percent of OV drivers with a known BAC had a negative test for alcohol.

58. Source of BAC information
    - "Official Records" and "Breath Testing" were overrepresented in fatal crashes.

3.1.10 OV Data (All Percentages and Statistical Conclusions Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Vehicle Body Type
    - "Automobiles" (61 percent) were the most common OVs in crashes, followed by "Light Conventional Trucks" (10 percent), "Utility Vehicles" (9 percent), and "Automobile Derivatives" (9 percent).

2. Vehicle Manufacturer
    - Over 35 different motor-vehicle manufacturers were involved in crashes in the MCCS.

3. Vehicle Model
    - Vehicle manufacturer, model, and year are enumerated in detail in MCCS Volume 11.

4. Model Year
    - Vehicle models from 2006 to 2010 were overrepresented in fatal crashes.

5. Vehicle Identification Number
    - VINs were not published.

6. Vehicle Curb Weight
    - Vehicles with curb weights of "4,500 to 5,000" lb were overrepresented in fatal crashes.

7. Is Vehicle ABS Equipped
    - 79 percent of OVs were equipped with ABS (front and rear) and another 2 percent were ABS-equipped in the rear only.

8. Pre-Crash Mechanical Problems Experienced
    - None were observed during the MCCS.

9. Pre-Crash Motion Prior to Precipitating Event
    - "Collision Avoidance Maneuver to Avoid a Different Collision" was overrepresented in fatal crashes.

10. Travel Speed at Time of Precipitating Event
    - The Average speed was approximately 12 mph.

11. Line of Sight to MC
    - The 9 o'clock position was overrepresented in fatal crashes.

12. Pre-Crash Motion After Precipitating Event
    - "Turning Right, Constant Speed" and "Turning Right, Accelerating" were overrepresented in fatal crashes.
    - 37 percent of crashes involved left-hand-turning vehicles with no statistically significant differences observed between fatal (41 percent) and nonfatal (36 percent) crashes.

13. Collision-Avoidance Action (Code Up to Four)
    - 86 percent of OVs took no collision-avoidance action.

14. Braking Skid Marks on Roadway
    - 98 percent of OVs left no braking skid marks on the roadway.

15. Length of Skid Marks on Roadway, Each Tire (Feet)
    - No statistically significant differences in lengths of skids were observed between fatal and nonfatal crashes.

16. Braking Skid Mark Evidence on Roadway
    - All skid marks were on dry roadways; no statistically significant differences were observed between fatal and nonfatal crashes.

17. Braking Tire Striation Evidence
    - No instances were observed.

18. Acceleration Evidence on Tires
    - No instances were observed.

19. Cornering Skid Mark Evidence on Roadway
    - No instances were observed.

20. Cornering Tire Striation Evidence
    - No instances were observed.

21. Other Vehicle First-Collision Contact Code
    - First contact was coded as 58 percent to the "Vehicle Side," 25 percent to the "Vehicle Front," 15 percent to the "Vehicle Rear," 1 percent to the "Vehicle Undercarriage," and 1.5 percent to the "Motorcycle/Moped."

22. Object(s) Contacted (Code Up to Three)
   - "Other Vehicle" and "Non-Breakaway Poles Greater Than 4-Inch Diameter" were overrepresented in fatal crashes.

23. Impact Speed in Miles Per Hour
   - The impact speed averaged approximately 13 mph.

24. PDOF, Principal Direction of Force (in Degrees)
   - "181 to 225 Degrees" was overrepresented at the 90-percent level in fatal crashes.

25. Other Vehicle Post-Crash Motion Code
   - "Stopping Within 6 inches of Point of Impact" and "Skidding from POI to POR" were underrepresented at the 90-percent level in fatal crashes.
   - "Spun or Yawed, Sliding from POI to POR" and "Driver Departed Scene Immediately After Collision, but OV Still At Scene" were overrepresented at the 95-percent level in fatal crashes.

26. Distance from POI to POR (Along and Offset From Direction of Travel)
   - "40 to 60 feet" along line of travel was overrepresented in fatal crashes.
   - "40 to 60 feet" offset from line of travel was overrepresented at the 90-percent level in fatal crashes.

3.1.11 Helmet Data (All Percentages Reflect Coded Responses and Do Not Include Unknowns or "Other (Specify)" Responses)

1. Wearer of Helmet
   - 349 riders and 19 passengers were wearing helmets at the time of the crash. Two riders were involved in an MC-MC crash, and each was considered a separate case. 368 unique individuals were included in the MCCS.
   - Four riders in crashes were not wearing helmets.

2. Wearing Helmet on Head
   - 100 percent of respondents who were wearing helmets wore the helmet on their head.

3. Was Helmet Properly Adjusted on Head
   - 99 percent of those coded were properly adjusted.

4. Was Your Helmet Securely Fastened to Your Head
   - 96 percent were securely fastened.

5. Type of Helmet
   - The types observed were 74 percent "Full Face Motor Vehicle, Motorcycle Helmet," 14 percent "Half/Police Motor Vehicle, Motorcycle Helmet," 10 percent "Open Face Motor Vehicle, Motorcycle Helmet," and 3 percent "Novelty or Beanie Helmet."

6. Type of Coverage
   - 65 percent were “Full-Face with Wrap-Around Face Shield,” 17 percent were “Full Coverage,” 6 percent were “Full Facial, Retractable Chin Bar,” 5 percent were “Full Facial, Integral Chin Bar But No Face Shield,” 3 percent were “Open Face With Bubble-Type Face Shield,” 2 percent were “Open Face With Visor/Face Shield Combo,” 1 percent were “Full Facial, Removable Chin Bar,” and 1 percent were “Open-Face Helmet With Flat Wrap-Around Face Shield.”

7. Predominant Color of Helmet
   - The most common helmet colors were “Red” (61 percent), “White” (15 percent), “Yellow” (8 percent), and “Orange” (8 percent).

8. Color of Face Shield, If Present
   - The most commonly observed face-shield colors were “Clear” (58 percent) and “Grey/Smoke” (35 percent).

9. Helmet Owner by Wearer
   - 98 percent of wearers reported they were the owners of the helmet.

10. Helmet Fit
    - 97 percent of wearers indicated they had an acceptable fit.

11. Claimed Frequency of Helmet Use on Head
    - All respondents claimed 100-percent helmet usage.

12. Conditions Under Which Helmet Used on Head
    - All respondents stated they “Always Wear Helmet.”

13. Helmet Manufacturer
    - Helmet manufacturers are enumerated in MCCS Volume 13.

14. Date of Manufacture
    - Dates of manufacture are enumerated in MCCS Volume 13; months are available in the MCCS dataset.

15. Helmet Model
    - Helmet models are enumerated in MCCS Volume 13.

16. Conformity to Which Standards (Code Up to Four)
    - 60 percent conformed to FMVSS 218 (USDOT), 10 percent conformed to Snell M2005 (USA), 95 conformed to UN/ECE-22-05 (Europe), 8 percent had no standard label on their helmets, 8 percent conformed to Snell M2010 (USA), and 3 percent conformed to Snell M2000 (USA).

17. Labeled Size
    - 30 percent were labeled “Adult Medium,” 30 percent were labeled “Adult Large,” 18 percent were labeled “Adult Extra-Large,” 5 percent were labeled

“Adult Extra-Extra-Large,” 2 percent were labeled “Adult Extra Small,” and 0.5 percent were labeled “Youth Small/Medium.”

18. Helmet Mass
    - 50 percent were 50–60 oz, 22 percent were 60–70 oz, 6 percent were 40–50 oz, 5 percent were 20–30 oz, and 1 percent were 70–80 oz.

19. Condition Prior to Crash
    - 81 percent had no significant prior damage.

20. Type of Helmet Retention System
    - 95 percent had “Double D-Rings,” 4 percent were “Quick Release,” and less than 1 percent had “Lever Clamp Latches.”

21. Was Helmet Retained in Place on Head During Crash
    - 92 percent were retained on head during the crash.

22. Was There a Retention-System Failure
    - A 2-percent retention failure was observed.

23. Type of Retention-System Failure
    - 7 percent showed “Chin Strap Pulled Through D-Rings, Slide Bar, or Clamp Latch,” 1 percent showed “Webbing Tensile Failure,” less than 1 percent showed “Webbing Laceration,” and less than 1 percent showed “Quick Release Let-Go.”

24. Helmet External Damage Marks, Location, and Type
    - The location and severity of external helmet damage is relevant primarily to the individual cases. Aggregations of the responses are provided in questions 32 and 56 in section 3.1.11.

25. Type of Helmet
    - 97 percent were MC helmets, and 3 percent were novelty helmets.

26. Lens or Shield Material, If Used
    - 83 percent used a lens or shield: 42 percent were “Polycarbonates,” 28 percent were “Plastic, Cellulose Acetate or Butyrate,” and the remainder were “Acrylic, Perspex.”

27. Eye-Coverage Damage Locations (Code Up to Four)
    - 91percent showed “No Damage”; 3.6 percent “Damage to the Right Lens,” 2.7 percent “Damage to the Left Lens,” and 2.7 percent “Damage to the Frame” were identified in observations.

28. Type of Damage to Eye Coverage
    - 94 percent showed "No Damage"; 5 percent of the damage locations showed "Abrasion," 1 percent showed "Crack, Break, Chips," and 1 percent showed "Deformation."

29. Retention-System Misuse
    - Observation of improper fastening showed that 3 percent were "Fastened Too Loosely" and 2 percent were "Not Properly Fastened, End Strap or Velcro Comfort Feature."

The remaining data elements reflect the observations and testing of the 34 helmets voluntarily provided by crash victims. The helmets showed a range of damage levels, and not all could be tested based on the damage they had (or had not) sustained. Only 16 of the 34 helmets displayed impacts that could be analyzed.[1]

30. Type of Impact
    - 27 percent showed signs of "Normal and Tangential" impacts, while 20 percent showed "Essentially Tangential" impacts.

31. Impact Location
    - 15 percent of helmets showed "No Impacts."
    - 59 percent of impacts were on the "Shell, Including the Chin Bar," 9 percent were on the "Visor, Peak," 6 percent were on the "Chin Bar of Full-Face Helmet," 3 percent were on the "Edge Bead," 3 percent were on the "Shell Edge without Edge Bead," and 3 percent were on the "Helmet Liner, Crown."

32. Most Severe Impact, Clockface Location
    - 11 were on the left side, 11 were on the right side, and 6 had equally severe impacts on both sides.

33. Number of Distinct Impacts at This Location
    - 18 percent showed no impacts, 77 percent showed 1 impact, and 6 percent showed 2 impacts.

34. Most Severe Impact Location, Shell Material
    - 38 percent were "Machine Chop, Pressure Molded Glass Fiber," 27 percent were "Polycarbonate," 24 percent were "Acetyl Butadiene Styrene, ABS," 12 percent were "Hand Laminated Glass Fiber."

35. Most Severe Impact Location, Shell Thickness
    - The average shell thickness was 0.156 inch.

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[1]Interested researchers are urged to review the dataset and technical findings or MCCS Volume 13 for summary details for the following data elements.

36. Most Severe Impact Location, Liner Material
- 91 percent were “Expanded Polystyrene, Small Bead,” and 9 percent were “Expanded Polystyrene, Large Bead.”

37. Most Severe Impact Location, Liner Thickness
- 9 percent were less than 0.8 inch, 15 percent were between 0.9 and 1.1 inches, and 72 percent were between 1.2 and 1.7 inches.

38. Most Severe Impact Location, Liner Density
- 48 percent were between 3.0 and 3.5 lb/ft^3, 16 percent were between 2.5 and 3 lb/ft^3, 16 percent were between 3.5 and 4 lb/ft^3, 16 percent were between 4.5 and 5.0 lb/ft^3, and 4 percent were between 1.5 and 2.0 lb/ft^3.

39. Most Severe Impact Location, Maximum Liner Crush
- 50 percent were less than 0.5 inch, 16 percent were between 0.1 and 0.2 inch, 13 percent were between 0.2 and 0.3 inch, 13 percent were between 0.3 and 0.4 inch, 6 percent were between 0.5 and 0.6 inch, and 3 percent were between 0.9 and 1.0 inch.

40. Most Severe Impact Location, Area of Liner Crush or Signature
- This ranged from less than 10 $inches^2$ to more than 90 $inches^2$.

41. Most Severe Impact Location, Geometry of Impacting Surface
- 24 percent showed “No Impact,” 61 percent were “Flat,” 6 percent were “Complex,” 3 percent were “Spherical,” 3 percent were “Cylindrical,” and 3 percent were “Blunt Edge.”

42. Most Severe Impact Location, Material of Impacting Surface
- 69 percent impacted “Concrete,” and 31 percent impacted “Compacted Dirt.”

43. Most Severe Impact Location, Which Headform Was Used for Replication Testing
- 69 percent used “DOT Medium,” and 31 percent used “DOT Large.”

44. Mass of Replication Drop Apparatus
- 11 lb for the 16 helmets tested.

45. Equivalent Laboratory Testing Anvil
- 77 percent used “Flat Steel Anvil,” and 23 percent used “Flat Pavement.”

46. Helmet Impact Velocity from Crash Reconstruction
- Crashes were not reconstructed.

47. Impact Velocity from Laboratory Replication
- Impact velocity ranged from 5 to 17.5 mph.

48. Peak Headform Acceleration
- Acceleration ranged from 130 to 270 g.

49. Dwell Time Above 200 g
    - There were three cases: 0.6, 1.8, and 2.7 ms.

50. Head-Injury Criteria (HIC)
    - The HIC ranged from 439 to 2,587.

51. Gadd Severity Index (GSI)
    - The GSI ranged from 665 to 3,215.

52. Equivalent Specific Energy/Equivalent Drop Height From Crash Reconstruction
    - Crashes were not reconstructed.

53. Equivalent Specific Energy/Equivalent Drop Height From Laboratory Replication
    - Drop height ranged from 3 to 11.8 ft.

Only 4 of the 34 voluntarily surrendered helmets displayed second impacts that could be analyzed.[2]

54. 2nd Most Severe Impact, Type of Impact
    - 88 percent did not show a second impact. Of the four that did, two were "Both Normal and Tangential," one was "Essentially Tangential," and one was "Essentially Normal."

55. 2nd Most Severe Impact, Impact Location
    - The impact was located on shell, including the "Integral Chin Bar," "Shell Edge Without Edge Bead," and "Helmet Liner, Crown."

56. 2nd Most Severe Impact, Clockface Location
    - Of the four coded, two were to the right side and two were to the left side.

57. 2nd Most Severe Impact, Number of Distinct Impacts at This Location
    - 100 percent (all four) had one distinct impact location.

58. 2nd Most Severe Impact, Shell Material
    - The shell materials were 25 percent "Machine Chop, Pressure-Molded Glass Fiber," 25 percent "Polycarbonate," and 25 percent "Acetyl Butadiene Styrene ABS."

59. 2nd Most Severe Impact, Shell Thickness
    - The shell thicknesses were 0.08, 0.09, 0.11, and 0.20 inch.

60. 2nd Most Severe Impact, Liner Material
    - One helmet had no liner, and three had "Expanded Polystyrene, Small Bead."

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[2]Interested researchers are urged to review the dataset and technical findings or MCCS Volume 13 for summary details for the following data elements.

61. 2nd Most Severe Impact, Liner Thickness
- The liner thicknesses were 1.1, 1,54, and 1.82 inches; one was "Unknown" (no liner).

62. 2nd Most Severe Impact, Liner Density
- The liner densities were 2.33, 2.53, and 3.84 lb/ft^3; one was "Unknown" (no liner).

63. 2nd Most Severe Impact, Maximum Liner Crush
- The maximum liner crushes were 0.15, 0.15, and 0.30 inch; one was "Unknown" (no liner).

64. 2nd Most Severe Impact, Area of Liner Crush or Signature
- The area of liner crushes or signatures were 11, 12.71, and 16.57 $inches^2$; one was "Unknown" (no liner).

65. 2nd Most Severe Impact, Geometry of Impacting Surface
- One was "Complex," two were "Flat," and one was "Sharp Edge."

66. 2nd Most Severe Impact, Material of Impacting Surface
- Two were "Rolled Asphalt," one was "Wood, Post, Solid Fibers," and one was "Unknown."

67. 2nd Most Severe Impact, Which Head Form Used for Replication Testing
- Two used "DOT Medium," and one used "DOT Large."

68. 2nd Most Severe Impact, Mass of Replication Drop Apparatus
- All three helmets with liners were 11 lb.

69. 2nd Most Severe Impact, Equivalent Laboratory Testing Anvil
- One used "Flat Steel Anvil," one used "Curb Anvil," and one used "Flat Pavement."

70. 2nd Most Severe Impact, Helmet Impact Velocity from Crash Reconstruction
- Crashes were not reconstructed.

71. 2nd Most Severe Impact, Impact Velocity from Laboratory Replication
- Impact velocities were 12.1, 13.1, and 14.2 mph.

72. 2nd Most Severe Impact, Peak Headform Acceleration
- Impact velocities were 125, 151, and 231 g.

73. 2nd Most Severe Impact, Dwell Time Above 200 g
- One was above 200 g was observed at 1.8 s.

74. 2nd Most Severe Impact, Head-Injury Criteria (HIC)
- HICs were observed at 709, 960, and 1,693.

75. 2nd Most Severe Impact, Gadd Severity Index (GSI)
    - GSIs were observed at 783; 1,118; and 2,024.

76. 2nd Most Severe Impact Equivalent Specific Energy/Equivalent Drop Height from Crash Reconstruction
    - Crashes were not reconstructed.

77. 2nd Most Severe Impact, Equivalent Specific Energy/Equivalent Drop Height From Laboratory Replication
    - 4.7, 6.0, and 7.1 ft were observed in replication.

3.2 DEMOGRAPHIC DATA COMPARISON TO OTHER DATASETS

The following list provides a small sample of comparisons to other studies, and the details of the tabulated data are provided in MCCS Volume 14. All percentages and statistical conclusions reflect coded responses and do not include "Unknowns" or "Other (Specify)" responses.

1. Day of the Week Crash Occurred
    - No significant differences in "Day of the Week Crash Occurred" between the 2014 NASS/General Estimates System (GES) dataset and this study.(11,17)
    - No significant differences in "Day of the Week Crash Occurred" between the 2014 Fatality Analysis Reporting System (FARS) dataset and fatal crashes in this study.(2)
    - Monday and Tuesday were underrepresented and Saturday and Sunday were overrepresented relative to the Hurt Report.(5)

2. Time of Day the Crash Occurred
    - Statistically significant differences at the 90-percent level were seen in the "Time of Day of the Week Crash Occurred" between the 2014 NASS/GES dataset and this study, with 2:00–3:00 p.m. and 11:00 p.m.–12:00 a.m. underrepresented in this study compared to the 2014 NASS/GES data.(11,17)
    - 6:00–11:00 a.m. was overrepresented in fatal crashes in this study relative to the 2014 FARS dataset.(2)
    - The times of 7:00–8:00 a.m. and 6:00–8:00 p.m. and 10:00–11:00 p.m. were overrepresented while 12:00–3:00 p.m. was underrepresented relative to the Hurt Report.(5)

3. Number of Vehicles Involved in the Crash
    - "Single Vehicle" crashes were overrepresented while "Multiple Vehicle" crashes were underrepresented in this study relative to the 2014 NASS/GES data.(11,17)
    - "Four or More Other Vehicles" was overrepresented in fatal crashes in this study relative to the 2014 FARS dataset.(2)

4. Ambient Light Conditions
   - Nighttime crashes were overrepresented in this study relative to the 2014 NASS/GES data.(11,17)
   - "Night, Lighted" was overrepresented while "Night, Not Lighted" was underrepresented in fatal crashes in this study relative to the 2014 FARS dataset.(2)
   - "Dusk or Dawn" was underrepresented and "Night, Not Lighted" was overrepresented in this study relative to the Hurt Report.(5)

5. Weather Conditions
   - "Clear" and "Rain" were underrepresented while "Cloudy" and "Fog/Haze" were overrepresented in this study relative to the 2014 NASS/GES data.(11,17)
   - "Clear" was underrepresented while "Cloudy" and "Fog" were overrepresented in fatal crashes in this study relative to the 2014 FARS dataset.(2)
   - "Clear" and "Rain" were underrepresented while "Cloudy" and "Overcast" were overrepresented in this study relative to the Hurt Report.(5)

6. Type of Intersection
   - Intersections were overrepresented in this study relative to the 2014 NASS/GES data.(11,17)
   - No significant differences were found between fatal crashes in this study and the 2014 FARS dataset.(2)

7. Travel Speed
   - Travel speed in this study was not significantly different from the 2014 NASS/GES data for speeds below 35 mph and above 60 mph. Speeds of "36–40" and "45–50" were overrepresented and speeds of "51–55" and "55–60" were underrepresented at the 90-percent level.(11,17)
   - "Stopped" and "81–90 mph" were overrepresented in fatal crashes in this study relative to the 2014 FARS dataset.(2)
   - "0–10," "31–40," and "71–80" mph were overrepresented and "21–30 mph" was underrepresented in this study relative to the Hurt Report.(5)

8. Rider Age at the Time of the Crash
   - Younger "21–25" and "26–30"-yr-old riders were overrepresented while "50–55"-yr-old riders were underrepresented in this study relative to the 2014 NASS/GES data.(11,17)
   - Younger fatalities (18–35 yr old) were overrepresented while middle-aged (46–65 yr old) fatalities were underrepresented in this study relative to the 2014 NASS/GES data.(11,17)
   - Younger riders (17–30 yr old) were underrepresented while older riders (40–75 yr old) were overrepresented in this study relative to the Hurt Report.(5)

9. Alcohol Use
   - Alcohol use was underrepresented in this study relative to the 2014 NASS/GES data.(11,17)

- Alcohol use in fatal crashes was underrepresented in this study relative to the 2014 FARS dataset.[2]
- Alcohol use was underrepresented while drug/medication use was overrepresented in this study relative to the Hurt Report.[5]

10. Rider Gender
    - Male riders were overrepresented in this study relative to the 2014 NASS/GES dataset.[11,17]
    - Male riders were overrepresented in fatal crashes in this study relative to the 2014 FARS dataset.[2]

11. Type of MC Training Rider Has Received
    - "Self-Taught" and "Taught by Family and Friends" were underrepresented while "Motorcycle Course" and "Experienced Rider Course" were overrepresented in this study relative to the Hurt Report.[5]

12. Engine Displacement
    - Smaller engine displacements were underrepresented and larger engine displacements were overrepresented in this study relative to the Hurt Report.[5]

13. Number of Cylinders
    - "Four" and "Six"-cylinder engines were overrepresented and "One" and "Three"-cylinder engines were underrepresented in this study relative to the Hurt Report.[5]

14. Roadway Function
    - "Freeways," "Freeway Exit Ramps," "Non-arterials," and "Alleys," were underrepresented while "Arterials" was overrepresented in this study relative to the Hurt Report.[5]

15. Land Development at Scene of Crash
    - "Commercial/Business," "Urban School," and "Rural" were overrepresented and "Urban Industrial," "Single," "Family Housing," and "Rural Farming/Ranching" were underrepresented in this study relative to the Hurt Report.[5]

16. Impact Speed
    - Higher impact speeds were overrepresented in this study relative to the Hurt Report.[5]

17. Trip Origin
    - "Home" and "Bar/Pub" were overrepresented and "Shopping" and "Recreation/Social" were underrepresented in this study relative to the Hurt Report.[5]

18. Trip Destination
    - "Home" and "Bar/Pub" were overrepresented and "Shopping" was underrepresented in this study relative to the Hurt Report.(5)

19. Rider Level of Education Attained
    - Higher levels of formal education attainment were overrepresented in this study relative to the Hurt Report.(5)

20. Rider Marital Status
    - "Married" was overrepresented and "Cohabiting" was underrepresented in this study relative to the Hurt Report.(5)

21. Upper-Body Clothing
    - "Leather," and "None" were overrepresented and "Light" and "Medium Cloth" were underrepresented in this study relative to the Hurt Report.(5)

22. Lower-Body Clothing
    - "None," "Light," and "Leather" were overrepresented while "Heavy Cloth" was underrepresented in this study relative to the Hurt Report.(5)

23. Footwear
    - "Medium Street Shoes" was underrepresented and "Light Sandal, Athletic Training Shoe" was overrepresented in this study relative to the Hurt Report.(5)

24. Gloves
    - "Heavy Cloth" was overrepresented and "None," "Light," and "Medium" were underrepresented in this study relative to the Hurt Report.(5)

4.0 PROCEDURES FOR OBTAINING ELECTRONIC MCCS FILES AND DATA

Instructions for obtaining copies of the data from the MCCS or copies of the final report and corresponding Volumes are provided on the FHWA MCCS website.[18]

4.1 DATA AVAILABLE ON REQUEST

Electronic versions of the data gathered during the MCCS are available to researchers in SAS® and Excel™ formats. The complete dataset or selected subsets of the crash and control data collected during the study are available upon request to FHWA as outlined on the website.[18] Data from each of the 14 data-collection forms are available in SAS® and Excel™ formats as well as metadata files of all variables and how cases were classified for grouping and analysis in the study. MCCS Volume 2, a coding manual defining all response codes and their interpretations and meanings, is also available.[1]

APPENDIX. PROJECT WORKGROUP

A PWG was identified that provided guidance to the project team throughout the MCCS. An initial meeting was held to gather the PWG's input on study design and on research questions before the pilot study. Following this initial interaction, annual meetings were held to report progress and solicit input on the study. The PWG members represented a broad set of interests in the MC community. The individuals from the PWG are detailed in table 3.

Table 3. PWG members and affiliations.

PWG Member	Affiliation
John W. Nazemetz, Ph.D.	Oklahoma State University
Frances D. Bents	Westat
James G. Perry	Dynamic Science, Inc.
Carol H. Tan, Ph.D.	FHWA
Wayne Allard	American Motorcyclist Association
Randolph G. Atkins, Ph.D.	NHTSA
Tim Buche	Motorcycle Industry Council and Motorcycle Safety Foundation
Heidi Coleman	NHTSA, NPD-310
Eric Emery, Ph.D.	National Transportation Safety Board
Michael Fox	National Transportation Safety Board
Steve Garets	Oregon State University
Jeremy Gunderson	NHTSA
James Hedlund, Ph.D.	Highway Safety North
Jay Jackson	ABATE of Indiana
Ed Moreland	Harley-Davidson Motor Company, formerly with the American Motorcyclist Association
James V. Ouellet	Motorcycle Accident Analysis
Rick Podliska	American Motorcyclist Association
Jana Price	National Transportation Safety Board
Terry Smith, Ph.D.	Dynamic Research, Inc.
David Thom	Collision and Injury Dynamics, Inc.
Craig P. Thor, Ph.D.	FHWA
Philip Weiser	NHTSA
Kathryn Wochinger	NHTSA
Guan Xu	FHWA
Yusuf Mohamedshah	FHWA
Samir Ahmed, Ph.D.	Oklahoma State University
Al Hydeman	Al Hydeman Associates
Sherry Williams, Ph.D.	Formerly with the Motorcycle Safety Foundation
Maria E. Vegega Ph.D.	NHTSA
Paul J. Tremont, Ph.D.	NHTSA (retired)
Rebecca Crowe	FHWA
Morris Oliver, D.D.	FHWA (retired)

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- CHP, Santa Ana Division.
- CHP, Westminster Division.
- Fountain Valley Police Department.
- Huntington Beach Police Department.
- La Habra Police Department.
- Long Beach Police Department.
- National Highway Traffic Safety Administration.
- National Transportation Safety Board.
- Orange County Sheriff, Coroner.
- Orange Police Department.
- Santa Ana Police Department.
- Westminster Police Department.

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