MOTORCYCLE ACCIDENT CAUSATION AND IDENTIFICATION OF COUNTERMEASURES IN THAILAND
VOLUME I: BANGKOK STUDY

BY

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1.0 Executive Summary

A total of 723 on-scene, in-depth accident-involved motorcycles were investigated in Bangkok between December 30, 1998 and December 29, 1999. Approximately 97% of all cases were investigated at the accident location while vehicles, drivers and police were still present. The remainders were investigated within a few hours of the accident. Each investigation was conducted by a team of investigators trained in motorcycle accident investigation and analysis. After the initial investigation, the information collected was analyzed to provide a complete reconstruction of events before, during and after the collision.

One week after the accident, investigators returned to the accident scene, where they observed, counted and recorded information about motorcycles and other traffic passing accident scenes. Several months later, they returned to the accident area to conduct interviews with riders who stopped at petrol stations near the accident scene. Such "exposure data" provided a comparison of accident-involved riders to the larger population of riders who were exposed to similar accident risks (by using the same roadways under similar conditions), but who were not involved in an accident. Comparisons between accident and exposure populations helped define the differences between accident-involved riders and others.

Rider error was the most frequent primary cause in both single and multiple vehicle accidents. Two problems stand out among the rider errors. The first and most readily defined, is alcohol. Alcohol-involved accident preceded 40% of all accidents reported here. The second problem is less easily defined, but it amounts to poor driving. Half of the accidents involved improper traffic strategy such as following another vehicle too closely, unsafe speed or unsafe position.

These errors were not restricted to motorcyclists. Other vehicle drivers sometimes caused accidents by making unsafe turns across the path of a motorcycle they saw approaching but which they assumed would yield to them. Accidents also occurred when other vehicle drivers ignored traffic control signs or obvious view obstruction problems.

Mechanical problems with the motorcycle were infrequent and were usually due to poor maintenance. Vehicle problems were generally confined to absent or inoperable components (e.g. headlamp, front brake, rear brake, rear position lamp, stop lamp, rearview mirrors, etc.). No accidents occurred because of parts breaking or failing, side stands left in the down position, stuck throttles or dynamic instability.

Problems of roadway design and maintenance contributed to many of these accidents – at least one in eight. Such problems were rarely the sole cause of a motorcycle crash, but were alarmingly frequent, particularly in night accidents. The great majority of design and maintenance problems seen in this study affected all road users, not just motorcycles.

About one-eighth of the motorcycle accidents were single vehicle collisions. One-third of all accidents occurred during daylight and 62% at night, usually on unlighted roadways. The most frequent accident configuration was a motorcycle rear-ending another vehicle. Rain was an infrequent cause factor because most riders did not ride in the rain, but in the cases when rain was present it usually contributed to causing the accident.

Male motorcycle riders were over 95% of the accident population, and most riders fell into the 21 - 35 age category. The average education level was nine years. About one-third of the riders rode a motorcycle as part of their work (messengers, motorcycle taxi rider etc.) and another one-fourth were service or sales workers. Only 8% were full time students.

Alcohol-involved accidents differed markedly from non-alcohol accidents. The differences are quite distinct, and alcohol use was so frequent. Alcohol-involved accidents were three times as likely to be single vehicle crashes, three times as likely to involve loss of control, seven times as likely to involve running off the road, and twice as likely to involve violation of traffic control signals or signs when compared to non-alcohol accidents. Alcohol accidents also occurred at higher speeds (about 15 - 20 km/hr on average). Alcohol-involved riders were less likely to wear a helmet and more likely to be hospitalized or to die as a result of the crash. They were twice as likely to be the principal contributing factor in their accidents, and twice as likely to be the only cause of their accidents. Finally, even their time distributions were different: most alcohol-involved accidents occurred between 10 p.m. and 3 a.m., while most non-alcohol accidents happened between 8 a.m. and 7 p.m.

Approximately 17% of the accident-involved riders were unlicensed. Most were self-taught or learned from friends and family and only one rider had any formal training in motorcycle riding techniques and collision avoidance strategies. This lack of training, licensing and knowledge frequently appeared as rider errors in many accidents.

Among the unsafe practices that contributed to accidents was riding at night with the headlamp off. This made the motorcycle extremely difficult for other drivers to see. Night accidents in which the other vehicle violated the motorcycle right-of-way were five times as common when the headlamp was off. Modifying the motorcycle electrical system so that the headlamp operates whenever engine is running would be an effective means of preventing this problem and reducing accidents in which the other driver fails to see the approaching motorcycle. In addition, parcel racks on the front of the motorcycle should be re-designed in order to assure that carried parcels carried cannot block the headlamp from being seen by other motorists.

About one-third of the accident-involved riders who took evasive action made a proper choice, and 39% were able to carry it out effectively. This points to the need for the development and introduction of a combined braking system to maximize the braking potential for the motorcycle to avoid collisions effectively. More than 70% of the motorcycle's braking force can come from the front wheel, but too many riders used the rear brake only. Rider training might reduce the problem of poor brake utilization before an accident, but a combined braking system may be even more effective.

About two-thirds of the accident-involved riders were wearing a helmet at the time of the accident. Helmet use was much lower among passengers: only about 30%. Helmet use declined sharply at night, from 78% during the day to 60% at night. Few riders said they always wear a helmet, and many admitted that they wear one only when they think they might encounter police. Head injuries were about four times as frequent among unhelmeted riders as those who wore their helmet securely enough that it stayed on: 11% versus 2.7%.

The upper and lower extremities were injured most frequently, although these injuries were not life threatening in the majority of cases. Injuries to the spine, long bones of lower extremity, and ankle could cause significant disability and impairment. The most deadly injuries were to the chest, head and neck.

The results of this study suggest that rider training is really needed. Only one rider in 723 accidents and 2100 "exposure" interviews reported any formal motorcycle training. At present, the only formal training is offered by the Honda Safety Training Center, and most participants are police officers.

There appears to be no mechanism for disseminating this valuable knowledge into the larger population. One possibility might be to allow motorcycle riders who have completed a motorcycle safety training program to offer a rider training program. Such a program could provide instruction on traffic laws, safe riding strategies, helmet selection and use, and collision avoidance skills. Such training might be an effective co-requisite for obtaining a motorcycle license or an alternative to a fine for riders who have received a traffic citation. Clearly the present system has no mechanism to provide motorcyclists with accurate and reliable knowledge, strategies and skills needed to protect themselves from harm.

Law enforcement should focus primarily on alcohol and licensing. Alcohol-involved riders and unlicensed riders were over-represented in accidents and made up a large portion of the accident population. In addition, the excess involvement of other vehicle drivers who operated their vehicles in dangerous ways (such as violation of traffic control signals or motorcycle right-of-way) with deliberation or ignorance is a great accident contributing cause factor. Strict law enforcement and punitive action are required to impress those riders and drivers with the great hazards of unsafe vehicle operation.

Roadway design and maintenance need many improvements. The first suggestion would be better warning signs and guidance through curves, particularly at night. The second suggestion is similar: better warning signs and guidance, and fewer view obstructions, at construction sites. While many such sites are not a problem during daylight hours, they become a big problem at night due to a lack of proper warning lights and reflectors. In Bangkok, some roads were notable for problems that contributed to accidents. Crossing accidents were very frequent along Phaholyothin Road, where there are no right-turn-only signals. Raised medians separating traffic lanes that flow in the same direction on Sri Ayutthaya and Vitthayu Roads, often with view obstructions, contributed to many crashes. Also, throughout Thailand, when pavement reflectors are replaced, they should be replaced with smaller, less aggressive reflectors that do not dent motorcycle rims and cause riders to fall. Improvements in roadway design and maintenance, traffic controls and construction zone safety could reduce a substantial number of traffic accidents.

The requirement for motorcycles to ride in the curb lane should be discontinued. In urban areas, the curb-lane-only offers no benefits but exposes the riders to many hazards and risks. It was found to be a frequent contributing factor to accident causation.

One accident type stood out for its frequently fatal outcome and that was the presence of large trucks parked (abandoned) in the motorcycle lane at night with no reflectors, no warning signs, no lights or anything to alert the rider to its presence. Often these trucks were covered in dirt and dark tarpaulins so they reflected little or no light to the rear. To reduce the potential devastating effect of impacts into these unseen vehicles, the current laws for reflectorization of trucks should be made stronger so that more of the truck is fitted with reflecting materials. This will greatly increase the conspicuity of these large trucks and will greatly increase the probability that the motorcycle rider will be able to safely negotiate around the large truck.

The mandatory helmet-use law should be improved to require the *proper* use of *qualified* helmets only. Many helmets were found to fly off the wearer's head before providing any crash protection because the helmet was strapped loosely, not strapped at all or else the retention system had broken and had not been repaired. A helmet testing laboratory should be established to monitor the quality of helmets sold to the public. Enforcement authority is needed to remove sub-standard helmets from the marketplace and assure that all helmets sold to Thai consumers are capable of providing effective protection during a collision. Finally, the mandatory helmet law must be enforced to require that helmets be properly fastened. Almost no injury causes greater disability, higher social cost, or is more easily preventable, than brain injuries.

It should be noted that the lack of proper eye protection might have some implications for accident involvement. Wind blast or rain on the bare eyes can cause impairment of vision, which can delay hazard detection and collision avoidance maneuvers.

Educational program regarding protective equipment thus is essential and is an alternative communication. Accurate factual information about the benefits of helmets and other personal protective equipment should be made available to every motorcycle rider and especially to riders who have been cited for a traffic violation. Public service announcements on television and billboards should include proper helmet use, alcohol involvement in accidents, the importance of motorcycle headlamp and tail lamp visibility and other important motorcycle safety messages.

2.0 Introduction

2.1 Historical overview

Thailand is comprised of more than 200,000 kilometres of roadway. Motorcycle use in Thailand as a primary mode of transportation has increased in recent years as a result of its low initial cost, high maneuverability in congested traffic and better fuel consumption when compared to conventional automobiles. The number of motorcycle registrations in Thailand has increased from 5,521,391 in 1991 to 11,649,959 in 1997 [1].

It is unfortunate, however, that the number of motorcycle accidents and injuries to riders and passengers has also increased and has become a major public health problem. This is due to the fact that the riders and/or passengers have an increased risk of injury in traffic accidents, simply as a function of the vehicle they are using. Many motorcycle riders and/or passengers were injured or killed largely due to the fact that they have no crash protection system surrounding them, as do the occupants of conventional automobiles [2-5]. Riding a motorcycle is a very vulnerable form of motor vehicle transportation.

The most comprehensive motorcycle accident research to date was released in 1981 by the University of Southern California, *Motorcycle Accident Cause Factors and Identification of Countermeasures,* commonly known as the "Hurt Report" [6]. The fundamental purpose of the Hurt study was to collect detailed information about how and why motorcycle accidents happened, by investigating team at the scene immediately after the crash. This included investigating how injuries occurred or were prevented by the use of personal protective equipment.

Although there have been a few motorcycle research projects in Thailand, many questions regarding motorcycle accident causation remain unknown because the previous studies were solely based upon police traffic accident reports or hospital evaluations [7-8]. The data provided by each of these separate sources provide information about accident and injury rates, but cannot be used to synthesize information about accident and injury causation. Perhaps, the greatest limitation in the previous research in Thailand was in the area of accident reconstruction and analysis of motorcycle accidents, which require knowledge and skills far beyond the training of the traffic police and the medical personnel alone. Furthermore, collection of on-scene, in-depth motorcycle accident investigation also involves a tremendous amount of cooperation and coordination between many different agencies and groups such as ambulance dispatcher, traffic police, medical personnel of both private and public hospitals, and NGOS, etc. In addition, the on-scene, in-depth investigation is very expensive. As a comparison, the Hurt Report, which collected 900 on-scene, in-depth accident investigation cases during July 1975 to September 1980, cost US$501,814 at the time, a cost that would be higher now due simply to inflation.

2.2 Objectives of the research

Five specific objectives were identified at the start of this study and they are listed as follows:

1. To conduct detailed on-scene, in-depth investigation and analysis of motorcycle accidents which included a one-year investigation in the Bangkok Metropolitan Area (BMA) and a second year investigation of additional accident cases occurring in five provinces identified as representative of other regions of Thailand.

2. To identify characteristics and cause factors of motorcycle accidents in Thailand.

3. To identify motorcycle accident related injuries and the contact surfaces, which cause these injuries.

4. To compare the accident population and exposure population from the same region in order to identify the presence of risk factors which may be either over-represented or under-represented in the accident population.

5. To identify potential countermeasures capable of reducing the number of the motorcycle accidents in Thailand, and minimizing the severity of injuries when motorcycle accidents occur.

In order to complete these objectives, it was necessary to develop and perform an on-scene, in-depth investigation of motorcycle accidents in Thailand.

2.3 On-scene, in-depth investigations

On-scene, in-depth motorcycle accident investigations were conducted for 723 accidents in the study area of the BMA (Figure1). Since this was a motorcycle study, attention was directed more upon the motorcycle than the other vehicle involved in the collision. It should be noted that every motorcycle-versus-motorcycle crash generated two cases, in which each motorcycle alternated as “the motorcycle” in one case and “the other vehicle” in the second case. In this circumstance, every motorcycle was investigated and the number of case became as number of motorcycles involved. For each accident, all environmental factors, i.e. view obstruction, pavement irregularities, pre-crash paths of travel, traffic conditions, conspicuous skids of pre-crash evasive action, post-crash scrape marks, etc., were recorded and photographed. Diagrams of the accident scene were drawn to show all pertinent evidence and all skids and scrape distances, as well as all points of impact and points of rest.

In order to minimize the loss of physical evidence at the accident scene, special efforts were taken to arrive at the scene as soon as possible. This included the use of an ambulance with sirens and lights to facilitate rapid transit through the streets. This approach was found to be very successful in that the investigative team arrived on scene before vehicles or debris had been moved in 97% of the accidents.

For each accident, all environmental factors, i.e., vehicle pre-crash paths of travel, including view obstructions, pavement irregularities, traffic conditions, conspicuous skids of pre-crash evasive action, post-crash scrape marks, etc., were recorded and photographed. Diagrams of the accident scene were drawn to show pertinent evidence and all skid and scrape distances, as well as all points of impact and points of rest.

Examination of the motorcycle was usually completed at the scene. When this was not possible, it was examined wherever it was available, e.g., a tow yard, rider's home, or at the police station. All physical evidence such as collision damage, tyre skid patches, headlamp condition, fuel tank and cap, etc. were photographed and recorded.

In-depth investigation also involved interviewing motorcycle riders/passengers, other vehicle drivers, as well as eyewitnesses to the accident.

Both single and multiple vehicle collisions were included in the data sampling plan as well both suburb and urban city center Bangkok accidents. The research also included "portable" accidents, which were defined as accidents for which there was no formal notification. These accidents were investigated in the same manner as the notified accidents although these "portable" accidents tended to be less severe than the notified accidents. The "portable" accidents were included in the complete data sample in order to provide a more complete picture of the total number of accidents in the sample area as well as an indication of the general characteristics of those accidents eluding the authorities.

2.4 Helmet analysis

In 1992 the Thai Parliament adopted a law which made the use of helmets compulsory for all motorcycle riders and passengers. Enforcement of the law began on January 1, 1993. The number of helmeted riders was low particularly in the upcountry sampling regions. Throughout the collection period of the accident investigation, approximately two-thirds of the accident-involved motorcycle riders in the Bangkok data set were wearing a safety helmet, while in the upcountry data set the number of helmeted riders was about 22%. Almost all accident-involved safety helmets were examined and photographed. Many of them were acquired for further examination and analysis to determine protection performance.

2.5 Injury analysis

Medical records regarding injuries sustained by the motorcycle riders and/or passengers were collected in all cases. In most cases, the injured rider or passenger was observed directly at the accident scene or in the emergency room. All discrete injuries were coded according to the coding conventions of the Abbreviated Injury Scale (AIS 90) published by the Association for the Advancement of Automotive Medicine (1990 revision). In fatal accidents, a special in-depth autopsy procedure was performed, with a detailed analysis of the head and neck injuries.

The reconstruction of accident events included determining rider motions, as well as the sequence of body contacts and the causes of injury to the accident-involved motorcycle rider and/or passenger.

2.6 Exposure data

In order to identify risk factors in the motorcycle accident data set, it was important to collect information regarding the population of motorcycle riders who are exposed to the same risk but who were not involved in an accident. The exposure data were collected at the scene of previously investigated accidents, on the same day of the week, same time of day and similar weather conditions as the reference accident.

Gathering of exposure data began half an hour before the reference accident time and concluded an hour later. For example, if an accident occurred at 1 p.m. on Wednesday, exposure data were collected at the same location from 12:30 to 1:30 p.m. the following Wednesday.

Exposure data included the number of vehicles passing by on the motorcycle and other vehicle paths of travel, vehicle types, safety helmet use, headlamp use, number of passengers and any cargo. Video taping of the traffic flow at these accident scenes was the primary method of documenting exposure data. In addition, traffic flows were tabulated using manually operated tally counters for comparison and for assuring the maximum accuracy.

In addition to the on-scene exposure (OSE) data collections, motorcycle rider and passenger interviews were later conducted at "petrol" stations located close to the accident locations. Although the number of interviews varied at each exposure site, the overall average was three exposure interviews for each accident case. The questions in the petrol station exposure (PSE) interviews were essentially identical to those asked in the accident investigations with respect to rider training, riding experience, personal information, and trip information. The same methods of cross-verifying answers were used. The interviews were prefaced by an explanation of the research purposes and offered anonymity and privacy to the rider. The exposure interview results were analyzed as a separate data set and then used for comparison with accident-involved riders.

2.7 Accident and exposure data comparisons

A comprehensive analysis of the accident and exposure data sets was conducted to identify relationships between the different variables of the motorcycle, environment and human factors that may be either over-represented or under-represented in the accident data set. This analysis helped to identify those groups and situations that were at the greatest risk of being involved in an accident and to suggest countermeasures to reduce those accidents.

2.8 Study area

Thailand has 76 provinces divided among six general regions: northern, north eastern, eastern, central, western and southern with Bangkok as the capital. In the Bangkok Metropolitan Area (BMA), there are 50 jurisdiction districts with a total of 1,565 square kilometres. The total population of BMA is 5,604,772 (1997 official figures). This creates a dense urban population, which complicates accident accessibility and greatly extends communication requirements. Furthermore, traffic in Bangkok is often congested, making travel to the accident scene very difficult.

These complications were considered to be too great to permit coverage of the entire BMA for accident sampling. The study area was therefore reduced to cover two-thirds of the BMA sampling region so that all necessary requirements for accident notification and accessibility could be met.

In this study area, two main public emergency rescue units provided 24-hour monitoring and dispatching of ambulance services for all vehicle accidents as well as any other emergency medical treatment. One was the Narenthorn ambulance center at Rajvithi Hospital; the other was the ambulance service at Vachira Hospital. Cooperative agreements were reached with both agencies in order to support the on-scene, in-depth research activities conducted.

In addition to cooperation with the medical authorities, the Chief of the Royal Thai Police and Commissioner provided complete cooperation in terms of accessibility to the accident scenes. The Chief of the Institution of Forensic Medicine, Police Department, and Chiefs of Department of Forensic Medicine, Ramathibodi Hospital, Siriraj Hospital, Vachira Hospital and King Mongkut Hospital also provided cooperation with fatal accident cases. Cooperation and assistance from these agencies allowed the research team to collect detailed accident data within the areas of 32 jurisdiction districts of the BMA.

3.0 Development of the Research

3.1 Technical development

Training

In order to produce the required quality of accident investigation, this study used a system of training, investigation and data recording similar to that used in the previous motorcycle accident research conducted at the University of Southern California [6]. Those authors, now at the Head Protection Research Laboratory (HPRL) in Paramount, California, modified the Hurt study data forms to include information that was suitable and corresponded to the anticipated needs of motorcycle accident investigation in Thailand.

All qualified investigative team members were provided with an intensive, 12-week training course which included eight weeks of classroom training in accident investigation methodology, field relations with outside agencies, interviewing methods, on-scene photographic techniques, motorcycle systems and dynamics, human factors in accident causation, anatomy, biomechanics, rider motions, injury, accident analysis and reconstruction. The classroom training was organized and provided by HPRL staff. Part of that training included a week-long motorcycle rider training course at a safety training center.

Finally, the training course was completed with three weeks of practice at on-scene investigation skills, again under the supervision of the HPRL staff. This activity provided the investigators with an opportunity to practice their skills in motorcycle accident investigation by analyzing approximately 21 actual accidents that occurred in the Bangkok sampling region. This training approach was critical because it was very important that a detailed understanding of motorcycle accident investigation, analysis and data recording methodology be established among all of the research team members.

The training program included the following topic areas:

Vehicle systems: Motorcycle identification motorcycle type and size, electrical systems, ignition, lights, accessories, signal, suspensions, forks, dampers, seals, damage, maintenance, shocks, wear and degradation, clutch and shifter, controls, cable maintenance and failure analysis, chain and sprockets, shafts and gear housings, surge and snatch, fuel systems, carburetors, tank integrity crash fires, analysis of origins, wheels and brakes, hubs, drum and disk brakes, controls, mechanical and hydraulic, failure and malfunction analysis, tyres, tubes, characteristics, skid marks analysis, failure analysis, motorcycle defect investigation techniques. In the analysis of these vehicle factors, the emphasis was on identifying those factors that may have caused or contributed to causing an accident.

Motorcycle rider injury mechanisms: Basic human anatomy, identifying mechanisms of common injuries, biomechanics of skeletal injuries, biomechanics of head injuries including skin injuries, skull fracture, extra-axial hemorrhages, neurological injuries, anoxic injury, mechanisms of spinal injury in motorcycle accidents, distinguishing primary injuries from sequelae, understanding and using the Abbreviated Injury Scale (AIS) injury coding system.

Safety helmets: Helmets design and manufacturing techniques, relation of helmet performance standards (e.g., ANSI, ECE, JIS, SNELL) to head protection. Examination, measurement and photography of accident-involved helmets. Evaluation of retention systems, performance and determining causes of helmet ejection. Evaluating impact attenuation and penetration resistance. Determination whether helmet was worn and potential effect if a helmet had been worn.

Vehicle dynamics: Motorcycle equilibrium conditions, steady and accelerated motion, traction force requirements, anatomy of a turn, transient and steady conditions, acceleration and braking performance, wheelie, and over, lateral-directional motions, slide-out or low-side, high-side, limits of cornering; lateral-directional dynamics, capsize, weave and wobble modes, pitch-weave, load effects, application of passenger loading, physical evidence application to accident reconstruction and considerations of vehicle characteristics and vehicle defect analysis.

Environmental investigations: Type of roadway and area, ambient lighting conditions, traffic flow, lane traveled, number of through lane, type of intersection, traffic control, roadway conditions and defects, vertical and horizontal alignments, weather related accidents, etc.

Accident investigation methodology: Identification of skid marks, scrapes, human contacts on environment, and on vehicle, photography methods for skids, motorcycle and other vehicle damages, measurement and recording of accident scene evidence as well as vehicle evidence, etc.

Accident reconstruction: Case studies and reviews, collision contact conditions; injury sources, speed analysis, trajectory calculations, loss of control, collision avoidance performance of motorcycle rider and other vehicle driver, etc.

3.2 Data forms

Data reporting forms

A motorcycle accident is a very complex event and is a unique form of traffic accident. It involves interactions of many complicated human, environmental, and vehicle factors. The mechanical systems, stability, and control of single-track vehicles are very different from conventional automobiles and as a result, motorcycles can get into accidents that are very different from those of two-track vehicles. Furthermore, motorcycles leave patterns of physical evidence that differ significantly from other vehicles, thus making motorcycle accident investigations very different from other vehicle accident investigations.

Motorcycle accident investigation therefore requires specialized training in looking for and understanding the detailed physical evidence present in motorcycle accidents. Comprehensive data forms that can record this complicated information and reduce the complexity into a coherent system capable of computerized analysis are also necessary.

At the onset of this project, it was determined that detailed accident data must include all necessary elements as follows:

Accident typology and classification

Environmental factors, such as the type of area, roadway, intersection, direction of traffic flow, lane traveled, roadway condition and defect, roadway contamination, roadway alignment, traffic controls, view obstructions, animal and pedestrian involvement and weather.

Vehicle factors of the involved motorcycle and other vehicle, i.e. type, model, colour, engine displacement and type, suspension, brake systems, frame and steering, seat, fuel system type and performance, exhaust system, tyre and wheel information and evidence on the tyres, headlamp filament condition,

Vehicle dynamics, including pre-crash motion, traveling speed, lines of sight from one vehicle to the other, collision avoidance, crash motion, impact speed, relative heading angle, post-crash motion of the vehicles, rider/driver, and passengers.

Human factors of rider, passenger, and other vehicle driver including age, gender, license, education, occupation riding/driving experience, vehicle training, trip plan, alcohol involvement, physiological impairment, stress, riding attention, and recommended countermeasures, etc.

Injury analysis, including the nature and location of injuries, contact surfaces, length of hospital stay, and sources of injury information. Injuries were encoded using the Abbreviated Injury Scale (AIS, 1990 revision).

Protective clothing of upper torso, lower torso, footwear, glove, eye coverage, and helmet details.

Environmental and vehicle factors that caused or contributed to each crash.

Human errors and unsafe actions prior to the crash, collision avoidance failures, identification of risk taking tendencies, alcohol involvement, etc.

Although the development of the data form took place prior to the collection of on-scene, in-depth accident investigation, certain additional modifications of the data form were necessary to provide enough details to accurately code the complexity of a typical motorcycle accident in Thailand. For example, some motorcycle accidents involved three or more vehicles or multiple passengers.

3.3 Project schedule

The main activities of the research project took place in the following schedule:

- August 1998 through September 1998:
  Selection of research investigators, establishment of cooperative agreements with various authorities and research plans.

- October 1998 through December 1998:
  Cooperative agreement and coordination continued, team training and practice accident investigation, special in-depth head and neck examination training, and development of accident data.

- December 30, 1998 through December 29, 1999:
  Accident data collection in the Bangkok sampling area, accident data case review, quality case control, data editing, data analysis and review exposure data collection, editing, analysis and review.

- January 2000 through February 2000:
  Data review and quality control continue, upcountry site selection and establishment of cooperative agreement with local authorities.

- March 2000 through September 2000:
  Accident data collections in 5 representative provinces (Phetchburi, Trang, Saraburi, Khon Kaen and Chiang Rai) accident data case review, quality case control, data analysis and review.

- October 2000 - March 2001:
  Electronic data entry, addition exposure data regarding human factors collection (3,160 interviews), data analysis and review, quality control continued.

- March 2001 - September 2001:
  Accident and exposure data compilation, final analysis and review, final report presentation

Additionally, three other reports of these activities were prepared and submitted to the sponsor of this project:

1. Phase 1 report in March 1999.
2. Second progress report in November 1999.
3. Third progress report in February 2001.

3.4 Project personnel

The project personnel were as follows:

Principal Investigator:	Prof. Vira Kasantikul, M.D.
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4.0 Research Methodology

4.1 Cooperative agreements

The acquisition of all the necessary accident data was a complex task, requiring extensive coordination and cooperation with different agencies i.e., police, hospital personnel, NGOs, etc. There were five basic requirements identified as being necessary for the acquisition of accident information:

1. Notification of an accident from a reliable source shortly after the time the accident occurs.

2. Cooperation with the investigating police in order to gain access to all accident-involved persons and vehicles at the accident scene.

3. Follow-up of on-scene accidents, which required the cooperation of the police regarding access to the accident involved vehicles, rider, and driver information, etc.

4. Access to the injury data, which required the cooperation of emergency treating physicians from both public and private hospitals and the Coroner's office.

5. The ability to conduct a thorough examination of the accident-involved helmets by disassembly and analysis. This was accomplished by purchasing the rider's helmet or persuading the rider to donate his safety helmet to the research project.

4.2 Accident notification

Cooperative agreements were obtained so that the research team members could be stationed at the ambulance dispatch centers of two large public hospitals in Bangkok. Dispatchers at the hospitals monitored police radio communication frequencies, 24-hours a day, and dispatched ambulance service as needed and notified the team members in the event of a motorcycle accident.

Upon receiving of a notification, the research team members responded immediately in an emergency van with lights and sirens activated. A full time ambulance driver was hired specifically for the project in order to ensure the safety of team during transit to the accident scene. Generally, the team members arrived at the accident location within 5 to 15 minutes, depending on the distance and traffic density at the time of collision. Similar arrangements were made in the other provincial hospitals that were included in the upcountry portion of this research project.

A second source of accident notification was from motorcycle riders who had sustained minor injury and who had come directly to the hospital in order to seek medical attention. In these cases, notification was made upon the arrival of the motorcycle rider at the hospital.

Within each sampling region of Thailand, the use of a hospital-based notification system proved to be very successful for acquisition of motorcycle accidents. The use of the emergency vehicles with lights and sirens to get to the accident scene also greatly increased the number of successful case acquisitions. Overall, nearly 98% of all notifications in Bangkok were investigated on-scene because of the rapid response possible with the ambulance.

4.3 Access to the accident scene

The cooperative agreements with the Chief of Royal Thai Police and the Commissioner of Metropolitan Police Bureau in the Bangkok sampling region as well as the Chiefs of various regional police headquarters in the upcountry sampling areas provided an official approval for Chulalongkorn investigators to examine accident-involved vehicles and accident scenes in all instances. The cooperative agreements also permitted access to impound facilities where the accident-involved vehicles were taken. Officers also allowed Chulalongkorn personnel to interview the motorcycle rider and the other vehicle driver either at the accident scenes or police stations.

4.4 On-scene investigation

Once the notification of an accident was received, four to five team members rushed to the location in the emergency van with lights and sirens activated. On arrival at the accident scene, contact was immediately made with the investigating police officer or NGO personnel to gain access to the accident scene. The highest priority was given to collection of “perishable” data – the evidence that would disappear most quickly.

The investigation team was divided into units that completed on-scene measurements, other vehicle driver, motorcycle rider, passenger and witness interviews. The environmental evidence was photographed and later drawn to scale. All involved vehicles were photographed to define the collision damage and impact areas. The motorcycle was thoroughly examined and photographed. Information about the motorcycle, such as brake adjustment, tyre pressure, headlamp conditions, etc. was collected and recorded on scene.

4.5 Environmental evidence

Evaluation of the environmental factors included the pre-crash paths of travel of the motorcycle and other vehicle (OV), view obstructions, pavement irregularities and contamination, pre-crash lines-of-sight between vehicles, traffic flows, traffic control signals or signs, marks of pre-crash evasive action, weather conditions, etc. Following the evaluation, photographs were taken along the pre-crash paths of travel. Diagrams of the accident scene were drawn to show the locations of all pertinent evidence. The data form was then completed either at the accident scene or later during office review of scene photographs.

4.6 Vehicle evidence

The other vehicle was the first item to be photographed by the team members at the accident scene because the accident-involved automobile was usually driveable and its driver tended to leave the scene soon after the accident. They were often unwilling to be interviewed once they had left the scene. Examination of the motorcycle was often completed at the scene and, in few cases was examined wherever it was available, such as at a tow yard, the rider's home, or at the hospital where the rider sought medical attention.

4.7 Human factors

On-scene activities always involved interviewing the motorcycle rider and passenger, and other vehicle driver when they were available. Eyewitness interviews were often utilized to help locate the points of rest of both accident-involved vehicles and involved persons.

However, when physical evidence was in conflict with eyewitness statements, the latter was given less significance in favor of the more reliable physical evidence. In fatal cases or those involving severe head injury, interviews were conducted with a family member, friends, riding partner or coworker who could provide information about the injured victim. Photographs of the rider and/or passenger were taken whenever possible to verify his or her protective equipment and the injuries sustained.

4.8 Injury data

Injury data were obtained from a variety of sources. When injuries were minor and the rider did not want to seek medical treatment, injury information was taken by the on-scene investigators, based on observation and rider report. When the injured rider and/or passenger was transported to a hospital emergency room, access to the medical information of the injured rider was obtained by the cooperative agreements between the principal investigator and the treating hospitals. The nature and location of injuries were mainly obtained from the treating physicians and nurses. Radiographs were also collected and/or photographed whenever possible.

In fatal accidents, a special in-depth head/neck autopsy procedure was performed by the principal investigator. Infrequently, autopsy reports were obtained from pathologists who did the post-mortem examination when the principal investigator was unable to perform the autopsy.

4.9 Helmet acquisition

Most accident-involved helmets were obtained by buying the rider's helmet or persuading the rider to donate his or her safety helmet to the research project. In this way, many of the helmets worn by riders in upcountry accidents were obtained for a thorough examination and for further study. Failure to obtain a large quantity of the accident-involved helmets in the Bangkok series was partly due to a limited amount of money available to purchase accident-involved helmets. For a time, certain inflexible payment conditions proved to be an additional factor limiting helmet acquisition. When the payment conditions became more flexible, the number of accident-involved helmets collected increased.

4.10 Accident investigation methodology

Photography and measurement were the primary means of documenting evidence from the accident scene. Photography of the accident scene required a series of photos to be taken along the motorcycle and other vehicle paths in order to document the roadway conditions and to identify skids and scrape evidence. These photographs helped define the pre-crash evasive actions or loss of control, point of impact and point of rest of the vehicles and the rider or passengers. Extensive practice of taking pictures under variable lighting conditions was provided to each investigator to ensure that they were completely familiar with all aspects of camera operation. Flash units were used in both night and daylight photography in order to minimize the darkness of shadows cast by the sun on the motorcycle.

Photography of the accident-involved motorcycle included at least a “basic eight” view around the motorcycle (right, left, front, rear, right-front and left-front, right-rear and left-rear.) Close-up photos were taken to document specific data elements such as headlamp filament, tyre striations, scrape marks, cloth marks, areas of collision damage and any vehicle defects or damages related to accident.

Generally, the photographs of the accident-involved other vehicle documented only the area of impact with the rider or the motorcycle. Close-up photos were taken as necessary to illustrate critical data elements (e.g. contact marks). ”Match-up” photos were taken whenever possible to show the motorcycle and other vehicle side-by-side in the relative positions they had been in just a moment before impact. Such static reconstruction helped establish the collision contact conditions, which in turn helped to reconstruct the collision event.

Measurement and documentation of environmental evidence utilized measuring wheels and measuring tapes to make a simple sketch of the accident scene, which was later redrawn as a scale diagram. The sketch included all identifiable information relating to the accident, including point of impact and points of rest, skid marks, scrape marks, people marks, etc.

The motorcycle was examined in detail to identify the various systems and to determine their pre-crash maintenance conditions. Investigators also looked for design, manufacturing or pre-existing maintenance problems that might have contributed to the accident. Particular attention was given to tyres, to identify wear patterns, and skid marks and scuff marks that provided evidence about tyre usage and braking, as well as skidding or loss of control in the last few seconds before the crash. Close attention was also given to the headlamp switch and filaments in order to determine, as accurately as possible, headlamp on-off state at the time of the accident. Finally, the motorcycle examination included a search for evidence of rider/passenger contacts that might have caused injury.

During the on-scene investigation, the points of impact and rest were identified, and the path between those points was examined for evidence of rider and passenger contacts. The motorcycle and other vehicle were likewise examined to document evidence of human contact and to distinguish motorcycle impact from human impact locations. When injury information became available, the injuries were matched with contact surfaces to identify the sources and mechanisms of injury.

Helmet analysis required identification of helmet type, helmet standard certification, helmet manufacturer, and the helmet retention system. When helmet ejection occurred, methods for the logical analysis of helmet ejection were applied in order to determine why the helmet came off and when in the accident sequence it ejected.

It should be noted that the on-scene collection of data was the critical first element in the accident reconstruction effort. This was followed by the analysis of the physical evidence and synthesis of all available information in order to reconstruct the sequence of collision events. Investigators were responsible for determining vehicle speeds, collision dynamics of both motorcycle and other vehicle including collision avoidance maneuvers, rider kinematics and kinetics and injury mechanisms and protective equipment performance in preventing or reducing injuries.

4.11 Quality control

Since each accident required about 2300 data entries, which included environmental, vehicle, and human factors, a high level of quality control was essential to maintain their validity and reliability. Quality control procedures took place on virtually every level of the research effort including data collection, accident reconstruction, data coding, data entry, and statistical analysis. In this research project, the quality control was a constant ongoing process. Quite often, quality control in one level of the research led to the improvement of task performance on another level. For example, reconstruction of the accident to determine injury contact surface might find that the photos previously taken during data collection needed improvement to better illustrate characteristics of the impact. This information was therefore immediately provided to the investigators in order to improve their on-scene investigation skills.

The quality control procedures used in data collection were also applied to the reconstruction and case reviews. Since photographs were the principal means of documenting accident evidence, photographs were consulted extensively and cross-checked to verify evidence in the reconstruction for speeds, injury contact surfaces, collision dynamics, etc.

Initially, the reconstruction and review of the cases was performed by all the investigators who had worked a particular accident then it was double-checked by the principal investigator for the overall consistency. The cases were then forwarded to HPRL for the final review by at least two HPRL staff members. The results of the HPRL quality control evaluation were then returned to the Chulalongkorn investigators for continual upgrading of the quality of the investigations.

Because motorcycle accidents are highly variable events, it was impossible to foresee and anticipate how every kind of accident situation would be coded. In order to maintain consistent coding procedures, a “Coding Notebook” was developed and maintained. As new accident situations were encountered and questions arose over how to code a new situation, the issues were referred to HPRL, often on a daily basis using e-mail. After discussion between the investigation team and within HPRL, decisions were made on coding issues and placed into the “coding notebook” for reference when similar situations arose. This coding notebook was developed into digital and prints forms as an “Electronic Help File” and was used to develop and maintain consistent coding practices throughout the research project.

When quality control review of an individual case had been completed, the data were stored in a digital format on a PC-based computer. The next step of quality control was to make a series of random checks between the data entered into the computer and the data entered on the hard-copy data form. Later, when all cases had been stored digitally, simple frequency counts of the responses to each question also helped to locate incorrect entries. Many cross-tabulations of various data elements were made and unusual data entries were examined to determine the validity of the entry. Some entries required correction while other unusual entries simply reflected accident circumstances that were unusual in some way.

4.12 Data processing and analysis

Data collected in this study were encoded directly onto the field data form. When the case had been completely reviewed and approved, the data entries were transferred from the hard-copy data forms to Microsoft Excel and SPSS computer databases for analysis. Simple frequency counts were made on all variables and when an interaction of two factors was the subject of interest a cross-tabulation of all the various responses were generated.

In some cross-tabulations, data were collapsed into groups. For example, crash speed was recorded in 1 km/hr increments, but speeds of 22 and 27 km/hr could both be lumped into the 20-30 km/hr speed range. It should be noted that the data collected in each sampling region were stored as independent sets that included:

1. 723 on-scene, in-depth accident cases in the Bangkok data set
2. 359 on-scene, in-depth accident cases in the upcountry data set
3. 723 exposure site data cases in the Bangkok data set
4. 359 exposure site data cases in the upcountry data set
5. 2,100 motorcycle and rider petrol station exposure data cases in the Bangkok data set
6. 1,060 motorcycle and rider petrol station exposure data cases in the upcountry data set

While these accident and exposure data sets were independent, it was very useful to transfer data from one data set to another. For example, it was possible to make a comparison between the exposure site data and the previous on-scene, in-depth accident investigation because of the location match between the exposure site data and the accident data.

4.13 Research recommendations

This research requires a special qualification of the investigators. It was mandatory that the principal investigator be a full-time researcher. In addition to professional qualifications, the principal investigator must be capable of developing and maintaining the delicate network of co-operation and co-ordination among various authorities. The research also demands that the research team members must have extensive motorcycle experience in order to provide the perspective and sensitivity to the special problems of the motorcycle rider and motorcycle accidents. Accident Investigation is a multi-disciplinary field. Investigation teams can work best when members vary in educational background, gender, ethnicity, etc.

This research would have been immensely more difficult to carry out ten or even just five years ago without the modern communications which are now available. Mobile telephone technology made possible much more efficient use of time and resources by the investigators. For example, team members could split up during on-scene investigations, with some going to the hospital to interview the rider, some going to the police station to examine vehicles and some staying at the scene, all relaying information back and forth and then regrouping as the investigation was completed. High capacity and high speed internet communication made daily communications with the Head Protection Research Laboratory relatively simple. This was particularly important during the first year of investigation in which regular, daily communication over data coding issues took place, often including transmitting significant amounts of data in the form of scanned images.

5.0 Accident Characteristics & Environmental Factors

5.1 Investigations

A total of 723 cases in Bangkok and the surrounding area were investigated in detail in the year between December 30, 1998 and December 29, 1999. This data collection also included capturing concurrent exposure data by returning to the scene of the accident one week after the accident at exactly the same time.

One goal in the conduct of this research was to investigate, as many accidents as possible at the scene of the accident while vehicles, involved parties, witnesses, police, etc., were still present. This was not always possible, but it was achieved 97% of the time. Table 5.1.1 shows the performance of the research team regarding the collection of the motorcycle accident data. Follow-up investigations took place within 1 to 2 hours after the accident.

Table 5.1.1: Type of investigation

Type of investigation	Frequency	
On-Scene	704	
Follow-up	19	
Total	723	

5.2 General accident characteristics

Time of accident

Most accidents in Bangkok occurred at night. About 60% (429 cases) occurred in the 10 hours between 7 p.m. and 5 a.m. Accident time was recorded to the nearest minute. In Table 5.2.1 the times are summarized into three-hour blocks to illustrate the distribution of motorcycle accidents by the time of day.

Table 5.2.1: Accident time of day

Accident time	Frequency	
0:01 – 3:00	139	19.2
3:01 – 6:00	27	3.7
6:01 – 9:00	16	2.2
9:01 – 12:00	84	11.6
12:01 – 15:00	79	10.9
15:01 – 18:00	85	11.8
18:01 – 21:00	78	10.8
21:01 – 24:00	215	29.7
Total	723	

In Bangkok, the accidents occurred more often on Thursday through Sunday. The accident frequency was lower in the early part of the week, particularly on Wednesday. Table 5.2.2 reveals the accident distribution when sorted by days of the week.

Table 5.2.2: Accident day of the week

Day of week	Frequency	
Monday	80	11.1
Tuesday	89	12.3
Wednesday	68	9.4
Thursday	109	15.1
Friday	127	17.6
Saturday	125	17.3
Sunday	125	17.3
Total	723	

Table 5.2.3 shows the months of accident occurrence in Bangkok. The data appear to suggest that motorcycle accidents occurred most frequently during November and December. However, the higher concentration of accidents during these two months was probably due to better accident notification response after the team investigators became more familiar with the accident monitoring system and the accident dispatch service became more aware of the existence of the investigation team.

Table 5.2.3: Month of accident

Month	Frequency	
January	43	5.9
February	53	7.3
March	57	7.9
April	52	7.2
May	54	7.5
June	56	7.7
July	60	8.3
August	57	7.9
September	67	9.3
October	53	7.3
November	83	11.5
December	88	12.2
Total	723	

Objects involved in collision with the motorcycle

Table 5.2.4 illustrates the objects involved in collision with the accident involved motorcycles. About 79% of the 723 accident cases involved in collisions with other vehicles and 21% of all collisions were single vehicle collisions where the motorcycle did not make contact with another vehicle. In 73 cases, the other vehicle was another motorcycle.

It should be noted that every motorcycle-versus-motorcycle crash generated two cases, in which each motorcycle alternated as “the motorcycle” in one case and “the other vehicle” in the second case. The other vehicle was a motorcycle in 146 cases, suggesting there were at least 73 motorcycle-versus-motorcycle crashes. In two cases the “other motorcycle” fled the scene, so only one case was generated. Thus, 652 collisions are reported here, involving 723 motorcycles.

Table 5.2.4: Objects struck by motorcycle

Object struck by motorcycle	Frequency	
Other motor vehicle(OV)	547	75.7
Other motor vehicle, parked	25	3.5
Roadway	107	14.8
Off road environment, fixed object	15	2.1
Bicycle	1	0.1
Pedestrian	23	3.2
Animal	1	0.1
Other	4	0.6
Total	723	

In 50 of the 150 single vehicle collisions, another vehicle was involved in accident causation but no collision contact occurred. A typical accident of this type involved a motorcycle following another vehicle too closely. When the leading vehicle slowed for traffic ahead, the motorcycle rider then over-braked, causing a slide-out and subsequent fall to the roadway. In many cases another vehicle turned or changed lanes in front of the motorcycle causing motorcycle loss of control when the rider over-braked and swerved to avoid a collision.

In Bangkok, 544 accidents involved only one vehicle. Only one case involved four vehicles, when a car driver made a right turn into a petrol station and disrupted the travel of three motorcycles. Furthermore, 72 vehicles parked or abandoned at roadside were struck. Table 5.2.5 shows the number of other vehicles involved in all accidents.

Table 5.2.5: Number of other vehicles involved

Number of other vehicle	Frequency	
No other vehicle	106	14.7
One	544	75.2
Two	67	9.3
Three	5	0.7
Four	1	0.1
Total	723	

Fatal accidents

Table 5.2.6 shows a total of 54 fatal accidents, which killed 57 motorcyclists: 50 riders and seven passengers Three accidents killed both rider and passenger, while in four cases the passenger was killed but the rider survived. In addition, four pedestrians were killed after being struck by a motorcycle. Roughly, five out of every six fatal crashes occurred at night (Table 5.2.7). Later sections will detail the relationships between accident time, fatal outcomes and alcohol.

Table 5.2.6: Number of fatal accident

Fatal	Frequency	
No	669	92.5
Yes	54	7.5
Total	723	

Table 5.2.7: Ambient lighting conditions and fatal accidents.

Lighting condition	Time	Fatal accident	
		Frequency	Percent
Daylight	6.30 - 17.30	6	
Night	18.30 - 5.30	46	
Dusk-Dawn	5.30 - 6.30 and 17.30 - 18.30	2	
Total		54	

Collision configurations

"Collision configuration" was used as a very brief descriptor of how the collision occurred. It ignored many details about an accident in order to give a gross, overall description of how the collision occurred. For example, "head-on collision" made no distinction about which vehicle, if either may have been traveling the wrong way. It indicated only that the two vehicles were heading in opposite directions and collided front-to-front. Without a simple descriptor such as the "collision configuration" code, it can be complicated and time-consuming trying to figure what combination of variables will yield all accidents of a certain general type. Table 5.2.8 shows the distribution of various collision configurations in our data series.

Table 5.2.8: Accident configuration

Accident configuration	Code	Frequency	
- Head on collision	1	27	3.7
- OV into MC impact at IS, paths perpendicular	2	31	4.3
- MC into OV impact at IS, paths perpendicular	3	27	3.7
- OV turning L ahead of MC, paths perpendicular	4	8	1.1
- OV turning R ahead of MC, paths perpendicular	5	35	4.8
- MC and OV in opposite directions, OV turns crossing MC path; OV impacting MC or MC impacting OV	6,7	54	7.5
- MC turning left in front of OV, OV proceeding in either direction perpendicular to MC path	8	5	0.7
- MC turning right in front of OV, OV proceeding in either direction perpendicular to MC path	9	12	1.7
- MC overtaking OV while OV turning left	10	13	1.8
- MC overtaking OV while OV turning right	11	30	4.1
- OV impacting rear of MC	12	30	4.1
- MC impacting rear of OV	13	104	14.4
- Sideswipe, both traveling in opposite directions	14	22	3.0
- Sideswipe, both traveling in same directions	15	51	7.1
- OV making U-turn or Y-turn ahead of MC	16	53	7.3
- Other MC/OV impacts	17	64	8.9
- MC falling on roadway, no OV involvement	18	25	3.5
- MC running off roadway, no OV involvement	19	46	6.4
- MC falling on roadway in collision avoidance with OV	20	32	4.4
- MC running off roadway in collision avoidance	21	7	1.0
- MC impacting pedestrian or animal	23	25	3.5
- MC impacting environmental object	24	15	2.1
- Other	98	7	1.0
Total		723	

* IS = Intersection; OV = Other vehicle; MC = Motorcycle, L = Left ; R = Right

The configurations listed above that involve OV violation of the motorcycle right-of-way (4, 5 6, 7 and 16) accounted for 21% (151/723) of the accidents. Motorcycle-solo crashes (codes 18, 19 and 24) were 12% of the total.

The motorcycle rear-ended the other vehicle in 104 cases. Half of these crashes occurred in the curb lane (55 cases). One accident configuration stood out for its frequently fatal outcome: a night crash in which the motorcycle rear-ended a large truck abandoned in the curb lane. Eight of nine fatal crashes in which the motorcycle rear-ended an OV occurred at night in the curb lane and the majority involved a large truck left abandoned. None of the trucks had warning lights, flashers, reflectors or markers to alert other road users and guide them around the obstruction.

5.3 Accident scene

The great majority of motorcycle accidents occurred in commercial areas. This is probably due to the fact that people in Bangkok often combined their living and business accommodations. The data are shown in Table 5.3.1.

Table 5.3.1: Accident scene, type of area

Type of area	Same side of road		Opposite side of road	
	Frequency	Percent	Frequency	Percent
Urban industrial	2	0.3	2	0.3
Commercial, shopping	562	77.7	566	78.3
Housing apartments	23	3.2	24	3.3
Housing, residential	90	12.4	81	11.2
Urban school	10	1.4	13	1.8
Urban park	17	2.4	13	1.8
Undeveloped vacant land	4	0.6	6	0.8
Other	15	2.1	18	2.5
Total	723		723	

Roadway illumination

Night accidents on lighted and unlighted roads accounted for over 60% (440/723) of cases collected in Bangkok. Accidents rarely occurred at dawn, and less than 5% of accidents occurred at dusk. The distribution of the ambient lighting conditions at the time of the accident is shown in Table 5.3.2.

Table 5.3.2: Ambient lighting at accident scene

Ambient light	Frequency	
Daylight, bright	215	29.7
Daylight, not bright	26	3.6
Dusk, sundown	32	4.4
Night, lighted	207	28.6
Night, not lighted	238	32.9
Dawn, sunrise	5	0.7
Total	723	

Weather conditions

The data show that weather was consistent for the majority of the motorcycle accidents collected in Bangkok. Riding in the rain accounted for less than 2.2% of all motorcycle accident investigation in our series (Table 5.3.3). Favorable weather (i.e., clear, cloudy or overcast) was reported in almost 98% of the Bangkok cases.

Table 5.3.3: Weather conditions at the time of accident

Weather	Frequency	
Clear	505	69.8
Cloudy, partly cloudy	159	22.0
Overcast	41	5.7
Drizzle, light rain	16	2.2
Moderate or heavy rain	2	0.3
Total	723	

Motorcycle roadway characteristics

Table 5.3.4 shows that the accident-involved roadway surfaces for the motorcycle were mainly asphalt (61.7%) followed by concrete pavement (38%). Dirt or metallic surfaces were also found in only 2 cases.

Table 5.3.4: Motorcycle roadway surface

Surface material	Frequency	
Concrete	275	38.1
Asphalt	446	61.7
Dirt	1	0.1
Metallic	1	0.1
Total	723	

Type of intersection

In the Bangkok data set, over half of the accidents (378, or 52%) occurred at non-intersection areas. Of the 345 accidents that occurred at an intersection, one-third were at typical cross-intersections, another one-third at T-intersections and one-fourth at alley or driveway intersections (Table 5.3.5).

Table 5.3.5: Type of intersection

Intersection type	Frequency	
Non-intersection	378	52.3
T-intersection	117	16.2
Cross intersection	129	17.8
Angle intersection	8	1.1
Alley, driveway	85	11.8
Offset intersection	4	0.6
Other	2	0.3
Total	723	

Table 5.3.6 shows the results of a cross-tabulation of the roadway intersection and accident configurations (those listed in Table 5.2.8).

Table 5.3.6: Accident configurations at different types of intersections

Accident configuration	Type of intersection							Total
	None	T-IS	Cross	Angle	Alley	Offset	Other	
1	23	3	0	0	1	0	0	27
2	0	2	25	1	2	0	1	31
3	0	1	23	0	3	0	0	27
4	0	4	0	1	2	1	0	8
5	0	16	6	0	12	1	0	35
6	0	1	4	1	1	0	0	7
7	1	20	14	0	12	0	0	47
8	1	3	0	0	1	0	0	5
9	0	7	2	0	2	1	0	12
10	1	5	1	1	5	0	0	13
11	2	9	6	0	13	0	0	30
12	16	4	7	1	2	0	0	30
13	85	9	6	0	4	0	0	104
14	19	1	2	0	0	0	0	22
15	40	3	8	0	0	0	0	51
16	40	5	0	0	8	0	0	53
17	29	13	15	0	7	0	0	64
18	24	0	1	0	0	0	0	25
19	37	2	1	2	4	0	0	46
20	21	3	4	0	4	0	0	32
21	5	2	0	0	0	0	0	7
23	18	1	3	0	2	1	0	25
24	13	0	0	1	0	0	1	15
98	3	3	1	0	0	0	0	7
Total	378	117	129	8	85	4	2	723

At T-intersections, the most frequent collision pattern was an OV turning in front of the motorcycle while both vehicles traveled in opposite directions, or when the motorcycle path was perpendicular to the other vehicle path. Both are configurations in which the other vehicle violates the motorcycle right-of-way.

At cross intersections, the most frequent collision configuration involved the motorcycle and OV proceeding straight on perpendicular paths. At driveway or alley intersections, the most frequent collision configuration involved the motorcycle passing on the side while an OV attempted to turn into the driveway.

Type of roadway

In Bangkok, nearly 80% of accidents occurred on major roadways (at least 3-lanes, each direction) or sub-arterials (2-lanes, each direction). One fatality occurred at a tollway entrance at night when a drunk rider attempted to go past a closed toll booth and failed to notice the lowered guard arm because it had been covered by non-reflective black padding. Table 5.3.7 shows the description of the roadway that the motorcycle was traveling at the time of the accident.

Only five accidents are reported for construction detours.

Table 5.3.7: Motorcycle roadway type

Roadway type	Frequency	
Expressway entrance ramp	4	0.6
Expressway exit ramp	2	0.3
Major arterial, non-expressway	327	45.2
Non-arterial, sub-arterial	248	34.3
Temporary	2	0.3
Construction detour	5	0.7
Alley	33	4.6
Driveway	7	1.0
Minor arterial or local street	67	9.3
Other	28	3.9
Total	723	

Number of through lanes and lane traveled

Table 5.3.8 shows the number of through lanes on the pre-crash path of travel of the motorcycle. It is important to note that the number of lanes is clearly dependent upon the type of traffic way. “Through” lanes were defined as those that permitted straight, continuing travel. In non-intersection areas, this simply meant the number of lanes available. At intersections, a “through” was any lane that permitted the vehicle to continue straight through the other side of the intersection. “No through lane” was coded for driveways and for T-intersections where the roadway did not continue through the other side and the rider or driver was required to turn right or left.

Table 5.3.8: Number of through lanes, motorcycle

Number of through lanes	Frequency	
No through lane	22	3.0
One lane	128	17.7
Two lanes	227	31.4
Three lanes	255	35.3
Four lanes	65	9.0
Five lanes	22	3.0
Six lanes	2	0.3
Seven lanes	2	0.3
Total	723	

In counting lanes, lane 1 (the fast lane) was defined as the lane furthest to the right. On two-way roads, this was usually the lane closest to the center of the roadway or the center median. The “curb lane” was the lane closest to the curb, excluding roadways with only one lane each direction. About one-fourth of the accidents occurred in the curb lane, as shown in Table 5.3.9. In nearly 10% of the accidents, the motorcycle was traveling the wrong way, in opposing lanes of traffic. However in many cases, travel in opposing lanes was part of passing slower-moving traffic.

Table 5.3.9: Lane traveled by motorcycle

Lane traveled	Frequency	
No through lane	21	2.9
Lane 1	298	41.2
Lane 2	167	23.1
Lane 3	110	15.2
Lane 4	18	2.5
Lane 5	4	0.6
Lane 6	1	0.1
Lane 7	1	0.1
Right turn only	27	3.7
Left turn only	5	0.7
Wrong direction	67	9.3
U-turn only	1	0.1
Other	3	0.4
Total	723	
Curb lane	187	25.9

Roadway surface condition and defects

No significant defect of the roadway surface was reported in 90% of the cases. When a surface defect was reported, it was most often coarse patching of an old pothole or uneven pavement. Table 5.3.10 shows the number of cases where significant roadway conditions and roadway defects were noted.

Table 5.3.10: Motorcycle roadway surface defects

Surface condition	Frequency	
None	648	89.6
Surface cracking	10	1.4
Spalling	2	0.3
Holes	4	0.6
Bump	5	0.7
Ripples, ridges	1	0.1
Overbanding	1	0.1
Bitumen repair	32	4.4
Tram/train rails	5	0.7
Other	15	2.1
Total	723	100.0

Roadway surface contamination

The motorcycle roadway was dry and clean in more than 90% of accident cases (Table 5.3.11). Most of the contamination found was water or dirt. One accident occurred when the rider hit an oil spill that could not be seen because the pavement was already wet from rain. In that case, failure to detect the contamination was the sole cause factor.

Table 5.3.11: Surface contamination on motorcycle roadway

Type of contamination	Frequency	
None	674	93.2
Water	26	3.6
Oil, petroleum derivatives	2	0.3
Sand, soil, dirt	12	1.7
Temporary sign board	1	0.1
Other	8	1.1
Total	723	

Roadway alignment, horizontal and vertical

The great majority (over 90%) of the roadways on which the motorcycle accident occurred were straight and level. Bangkok is very flat, and the accidents on sloped roadways were usually related to elevated roadways such as fly-overs, expressways and bridges over the Chao Phraya River or various canals. Sometimes the short, high bridges over the canals acted as a view obstruction problem: a rider or car driver might come over a bridge and find an unexpected intersection or stopped traffic that required sudden evasive action.

About 7% of crashes occurred on curves. Usually curves were not a problem during daylight. Problems related to roadway curvature were more likely at night, due to a combination of alcohol and poor signing that failed to provide adequate warning and guidance through the curve. Tables 5.3.12 and 5.3.13 show the data for vertical and horizontal roadway alignments.

Table 5.3.12: Vertical alignment of motorcycle roadway

Slope	Frequency	
Level	674	93.2
Slope of hill	23	3.2
Crest of hill, loft	4	0.6
Slope of hill, downgrade	20	2.8
Bottom of hill	2	0.3
Total	723	

Table 5.3.13: Horizontal alignment of motorcycle roadway

Roadway curvature	Frequency	
Straight	659	91.1
Curve right	26	3.6
Curve left	28	3.9
Corner right	5	0.7
Corner left	2	0.3
Jog right	1	0.1
Jog left	2	0.3
Total	723	

5.4 Other vehicle roadway

The distribution of the other vehicle roadway type was similar to the distribution of roadway types found for the motorcycle. Nearly 80% of other vehicles were on a major arterial or sub-arterial at the time of the accident. Table 5.4.1 shows the description of the roadways that the other vehicle was traveling. As for the motorcycle, no code was available for “construction zone.” As a result, many accidents that occurred in construction zones, and were related to problems with traffic flow around the construction zone, are coded here simply as major arterials or sub-arterials.

Table 5.4.1: Other vehicle roadway type

Other vehicle roadway type	Frequency	
Expressway exit ramp	2	0.3
Major arterial	327	47.0
Non-arterial, sub-arterial	223	32.0
Temporary	1	0.1
Construction detour	5	0.7
Alley	32	4.6
Driveway	21	3.0
Minor arterial or local street	62	8.9
Other	23	3.3
Total	696	

Lane 1 was again the lane most frequently lane used by the OV. This is partly because almost all roadways have at least one lane, the exceptions are driveways and streets ending at a T-intersection, but not many have three or more. In approximately 5% of the accidents, the other vehicles traveled in the wrong direction – about half as often as the motorcycle (Table 5.4.2). Curb lane travel at the time of the accident accounted for about one-fourth of cases.

Table 5.4.2: Lane traveled by the other vehicle.

Other vehicle lane traveled	Frequency	
No through lane	45	6.5
Lane 1	309	44.4
Lane 2	154	22.1
Lane 3	94	13.5
Lane 4	18	2.6
Lane 5	2	0.3
Lane 6	1	0.1
Right turn only	23	3.3
Left turn only	6	0.9
Wrong direction	36	5.2
U-turn only	6	0.9
Other	2	0.3
Total	696	
Curb lane	166	23.9

The roadways traveled by the other vehicles were usually dry and without defect or contamination. Only two cases identified a roadway defect or roadway contamination as a contributing accident factor for the other motorcycle (Table 5.4.3 and Table 5.4.4).

Table 5.4.3: Other vehicle roadway surface defects

Surface condition	Frequency	
None	671	96.4
Surface cracking	9	1.3
Holes	2	0.3
Bump	3	0.4
Bitumen repair	1	0.1
Tram/train rails	3	0.4
Other	7	1.0
Total	696	

Table 5.4.4: Other vehicle roadway surface contamination

Surface contamination	Frequency	
None	668	96.0
Water	16	2.3
Oil, petroleum derivatives	1	0.1
Sand, soil, dirt	7	1.0
Temporary sign board	1	0.1
Other	3	0.4
Total	696	

Tables 5.4.5 and 5.4.6 show the alignment of the other vehicle roadway at the time of the accident. They were found to be level and straight in most accident cases (over 90%). As noted above for the motorcycles, the accidents that occurred on a downhill or uphill grade were most often short bridges that created view obstruction problems.

Table 5.4.5: Other vehicle roadway vertical alignment

Roadway slope	Frequency	
Level	649	93.2
Slope of hill	14	2.0
Crest of hill, loft	6	0.9
Slope of hill, downgrade	25	3.6
Bottom of hill	2	0.3
Total	696	

Table 5.4.6: Other vehicle roadway horizontal alignment

Roadway curvature	Frequency	Percent
Straight	661	95.0
Curve right	18	2.6
Curve left	12	1.7
Corner right	1	0.1
Corner left	1	0.1
Jog right	1	0.1
Jog left	2	0.3
Total	696	100.0

5.5 Traffic controls

Table 5.5.1 shows that for two-thirds of the 723 Bangkok accidents neither the motorcycle path nor the other vehicle path was controlled by any traffic sign or control signal. When a traffic control was present, it was a three-light traffic control signal about half of all cases.

Table 5.5.1: Traffic controls on motorcycle and other vehicle paths of travel

Traffic control type	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
None	490	67.8	466	67.0
Stop sign	4	0.6	7	1.0
Three-way, all-way stop	1	0.1	0	0.0
Traffic control signal	115	15.9	127	18.2
Traffic officer	4	0.6	4	0.6
Gate, toll gate	2	0.3	0	0.0
Pedestrian crossing	2	0.3	1	0.1
Traffic calming/speed bumps	4	0.6	2	0.3
Traffic advisory signs	52	7.2	45	6.5
Other	49	6.8	44	6.3
Total	723		696	

When traffic controls were present, the motorcycle rider violated it in one-third of cases. Other vehicle drivers violated traffic controls less often – approximately one-fourth of cases. (Table 5.5.2). Running through a red light, failure to stop at the stop sign and traveling in the wrong direction were the most common violations of traffic controls

The data show that 115 accidents occurred at intersections controlled by a traffic signal. In 46 of those cases (40%), the motorcycle ran the red light. The other vehicle violated the red light in 20 cases (17%). Together, 66 of 115 (57%) accidents at signal-controlled intersections involved a red light violation and two thirds of the time it was the motorcycle rider who ran the red light.

Table 5.5.2: Traffic control violation by motorcycle or other vehicle

Traffic control violation	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No	146	63.2	174	75.7
Yes	84	36.4	55	23.9
Unknown	1	0.4	1	0.4
Total	231		230	

5.6 Traffic density

The traffic density along the motorcycle and other vehicle paths was similar (Tables 5.6.1). Moderate traffic density was the most frequent situation followed by light and heavy traffic. In many cases, heavy traffic congestion could easily cause a visual obstruction between the motorcycle rider and other vehicle driver. On the other hand, light and moderate traffic conditions allowed greater speed of the accident involved vehicles.

As traffic conditions became heavier, accidents involving wrong-way travel became more frequent: they were one in every twelve crashes (51/626) in light-to-moderate conditions, but one in every six accidents (16/94) when traffic was heavy.

Table 5.6.1: Traffic density at the time of accident

Traffic density	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No other traffic	18	2.5	15	2.2
Light traffic	289	40.0	265	38.1
Moderate traffic	319	44.1	311	44.7
Heavy traffic, traffic moving	76	10.5	77	11.1
Heavy traffic, congested	18	2.5	23	3.3
Other	3	0.4	5	0.7
Total	723	100.0	696	100.0

5.7 Stationary and mobile view obstructions

Stationary view obstructions were reported in 10% of all motorcycle cases. Tables 5.7.1 lists the stationary view obstructions for motorcycle riders and other vehicle drivers at the time just prior to the collision. For many cases that occurred on straight roadways, a large pillar of an upper level expressway or sky-train, support pillars of overhead pedestrian crossings, or construction barriers, acted as stationary view obstruction.

Buildings, trees, and telephone booths, or large signboards were often found at T-intersection, alley or driveway intersections and these view obstructions often contributed to the accident.

Table 5.7.1: Stationary view obstructions

Stationary view obstruction	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No other vehicle driver	0	0.0	40	5.7
None	649	89.8	587	84.3
Building	29	4.0	29	4.2
Signs	2	0.3	2	0.3
Vegetation, trees, walls	10	1.4	11	1.6
Hill	7	1.0	6	0.9
Blind curve	1	0.1	0	0.0
Stationary or parked vehicles	8	1.1	7	1.0
Barricades	8	1.1	8	1.1
Other	9	1.2	6	0.9
Total	723		696	

Mobile view obstructions

Moving vehicles or vehicles stopped waiting in traffic often affect the rider's view of the traffic hazard. This was particularly a problem when the motorcycle rider or other vehicle driver decided to pass a slower-moving non-involved vehicle. Mobile view obstructions also adversely affected the motorcyclist's ability to see jaywalking pedestrians. Table 5.7.2 shows the number and type of mobile view obstructions that were observed during this study.

Table 5.7.2: Mobile view obstructions

Mobile view obstruction	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No other vehicle driver	0	0.0	40	5.7
None	611	84.5	553	79.5
Automobiles	69	9.5	71	10.2
Light trucks and vans	25	3.5	19	2.7
Trucks and buses	18	2.5	13	1.9
Total	723		696	

5.8 Pedestrian and animal involvement

Of the 723 on-scene, in-depth accident cases in Bangkok area, 26 cases (3.6%) involved pedestrians as shown in Table 5.8.1.

Table 5.8.1: Pedestrian involvement in accident

Pedestrian involvement	Frequency	
No pedestrian involvement	697	96.4
Yes, pedestrian involved in precipitating event	3	0.4
Yes, pedestrian involved in collision with MC	22	3.1
Other	1	0.1
Total	723	

In one case, the motorcycle rider swerved to avoid a jaywalking pedestrian but hit three other pedestrians who were on the sidewalk. All other cases involved only one pedestrian. There were 3 cases in which the pedestrian was considered to be the precipitating event but was not struck. Most pedestrians were jaywalking at the time of impact (Table 5.8.2); only four were in a designated crosswalk when struck by the motorcycle. Half of pedestrians were struck by the motorcycle at night, roughly consistent with the overall occurrence of 60% of the accidents at night.

Table 5.8.2: Location of pedestrian at impact

Pedestrian location just before impact	Frequency	
In crosswalk	4	13.3
Jaywalking	20	66.7
Pedestrian entering or leaving public transportation	1	3.3
Other	5	16.7
Total	30	

Animal involvement

Of the 723 accident investigations conducted in the Bangkok sampling region, only two cases involved dogs. However, the motorcycle struck neither dog. Rather, the riders crashed trying to avoid the dog. (Table 5.8.3).

Table 5.8.3: Accident with animal involvement

Animal involvement	Frequency	
No animal involvement	721	99.7
Small dog, less than 10kg	1	0.1
Big dog	1	0.1
Total	723	

6.0 Motorcycle and Other Vehicle Mechanical Factors

All accident-involved motorcycles and other vehicles were examined immediately following the accident to identify their basic characteristics and any mechanical factors that might be related to the pre-crash and crash events. In general, the mechanical problems found in the accident-involved motorcycles were mainly related to poor maintenance. Mechanical failures were rarely found in the other vehicle.

6.1 Motorcycle characteristics

Manufacturers

In the Bangkok data set, Honda motorcycles predominated, accounting for 42% of the accident-involved motorcycles, followed by Yamaha and Kawasaki, each with about one-fourth of the total. Table 6.1.1 shows the manufacturers of the motorcycles involved in the accident investigation.

Table 6.1.1: Motorcycle manufacturers

Motorcycle manufacturer	Frequency	
Honda	305	42.2
Yamaha	176	24.3
Kawasaki	155	21.4
Suzuki	75	10.4
Piaggio	11	1.5
Cagiva	1	0.1
Total	723	

Motorcycle type

Nearly half of the accident-involved motorcycles were step-through while another one-third were sport or race replica motorcycles. Most of the remainders were standard street motorcycles with or without minor modifications. The motorcycle type for all 723 accident-involved cases is shown in Table 6.1.2.

Table 6.1.2: Distribution of motorcycle type

Motorcycle type	Frequency	
Standard street, original equipment	95	13.1
Standard street, significant modifications	23	3.2
Sport, race replica design	246	34.0
Cruiser design	4	0.6
Scooter	12	1.7
Step-through	339	46.9
Off road, motocross, enduro, trials	4	0.6
Total	723	

Motorcycle predominating colour

The data show that darker colour motorcycles predominated in Bangkok (Table 6.1.3). Blue was the most common colour, followed by red, multi-coloured, and black.

Table 6.1.3: Motorcycle predominating colours

Motorcycle colour	Frequency	
Multi-coloured	139	19.2
White	23	3.2
Yellow	4	0.6
Black	116	16.0
Red	151	20.9
Blue	186	25.7
Green	43	5.9
Silver, grey	14	1.9
Orange	3	0.4
Brown, tan	28	3.9
Purple	14	1.9
Gold	1	0.1
Other	1	0.1
Total	723	

Motorcycle modifications

The ten most common motorcycle modifications in the 723 accident cases are listed in Table 6.1.4 (see the Appendix for a complete list of modifications).

Table 6.1.4: Motorcycle modifications

Common modifications	Frequency	
Muffler	43	5.9
Rear wheel	19	2.6
Rear fender	16	2.2
Right side rear view mirror	14	1.9
Front wheel	14	1.9
Seat	14	1.9
Handlebar	13	1.8
Left side rear view mirror	11	1.5
Rear position lamps	9	1.2
Cargo rack	8	1.1

Motorcycle engine displacement

Engine displacement in Thailand is limited by high tariffs on motorcycles over 150cc. Only eleven motorcycles in the Bangkok data exceeded the 150cc limit. Table 6.1.5 shows the motor engine displacement of the accident-involved motorcycles in Bangkok. The largest engine size was 750 cc. and the smallest was 79 cc. In Bangkok, half of the accident-involved motorcycles displaced 101 to 125 cc, followed 126 to 150 cc range. Together, the 101 to 150cc range accounted for seven out of eight motorcycles.

Table 6.1.5: Motorcycle engine displacement

Motorcycle engine displacement (cc)	Frequency	
< 100	72	10.0
101 – 125	361	49.9
126 – 150	277	38.3
> 150	11	1.5
Unknown	2	0.3
Total	723	

Table 6.1.6 shows the motorcycle engine displacement for the fatal motorcycle accidents. It should be noted that those motorcycles equipped with engines smaller than 125 cc. represent more than half of all accident cases but are involved in about 44% of the fatal accidents. In more than half of the fatal accidents, the engine was larger than 125 cc.

Table 6.1.6: Motorcycle engine size in fatal and non-fatal accidents

Engine displacement (cc)	Non-fatal		Fatal		Total	
	Freq	%	Freq	%	Freq	%
< 100	68	10	4	7	72	10
101 – 125	338	51	23	38	361	50
126 – 150	245	37	32	53	277	38
> 150	9	1	2	3	11	2
Unknown	2	0	0	0	2	0
Total	662		61		723	

Motorcycle engine cylinders

Only eight motorcycles had an engine with more than one cylinder as shown in Table 6.1.7.

Table 6.1.7: Motorcycle, number of cylinders

Number of cylinders	Frequency	
1	715	98.9
2	2	0.3
4	6	0.8
Total	723	

6.2 Motorcycle tyres and wheels

Table 6.2.1shows the tyre manufacturers, while Table 6.2.2 lists the rim manufacturers among the accident-involved motorcycles. The majority of front and rear tyres were original equipment as shown in Table 6.2.3.

Table 6.2.1: Motorcycle tyre manufacturers

Tyre manufacturers	Front		Rear	
	Frequency	Percent	Frequency	Percent
Bridgestone	19	2.4	16	2.2
Dunlop	8	1.1	8	1.1
Firestone	0	0.0	1	0.1
IRC	303	41.9	273	37.8
Kazan	1	0.1	1	0.1
Metzeler	2	0.3	2	0.3
Michelin	124	17.2	155	21.4
Pirelli	2	0.3	1	0.1
Hutchison	89	12.3	90	12.4
Other	174	24.1	176	24.3
Unknown	1	0.1	0	0.0
Total	723		778	

Table 6.2.2: Motorcycle rim manufacturers

Rim manufacturers	Front		Rear	
	Frequency	Percent	Frequency	Percent
Original equipment	31	4.3	31	4.3
Daido(DID)	107	14.8	106	14.7
Douglas	2	0.3	1	0.1
Enkai	123	17.0	127	17.6
Other	174	24.1	171	23.7
Union Cycle	258	35.7	265	36.7
Unknown	28	3.9	22	3.0
Total	723		723	

Table 6.2.3: Motorcycle tyre size

Tyre size	Front		Rear	
	Freq	%	Freq	%
Original equipment	329	45.5	290	40.1
Not original, but special size	170	23.5	190	26.3
Proper rim size, oversize section	24	3.3	23	3.2
Proper rim size, undersize section	138	19.1	151	20.9
Improper rim size, too large	26	3.6	12	1.7
Improper rim size, too small	33	4.6	54	7.5
Other	1	0.1	1	0.1
Unknown	2	0.3	2	0.3
Total	723		723	

Motorcycle tyre tread type and depth

All weather tyres with either a diagonal or an angle–groove tread pattern predominated within the data set, accounting for over 80% of front tyres and 96% of the rear tyres. A straight rib pattern was also common on front tyres. Table 6.2.4 shows the tread type of both front and rear tyres for all 723 all on-scene, in-depth accident investigation cases.

Table 6.2.4: Tread types of front and rear tyres

Tread type	Front		Rear	
	Frequency	Percent	Frequency	Percent
No tread pattern, slick	2	0.3	2	0.3
Straight rib tread pattern	103	14.2	5	0.7
Block pattern, trials type	11	1.5	17	2.4
Knobby pattern	1	0.1	1	0.1
All weather, dog-bone pattern	10	1.4	7	1.0
All weather, diagonal pattern	333	46.1	423	58.5
All weather, angle groove	263	36.4	268	37.1
Total	723		723	

Tyres were defined as being worn-out if they had 1 mm tread depth or less. About one fourth of the front tyres and one-third of the rear tyres inspected met this definition of being worn out (Table 6.2.5).

Table 6.2.5: Tread depth of front and rear tyres

Tread depth (mm)	Front		Rear	
	Frequency	Percent	Frequency	Percent
0	70	9.7	117	16.2
1	110	15.2	112	15.5
2	217	30.0	177	24.5
3	185	25.6	167	23.1
4	77	10.7	79	10.9
5	46	6.4	43	5.9
6	14	1.9	22	3.0
7	3	0.4	4	0.6
8	1	0.1	2	0.3
Total	723		723	

Motorcycle tyre pressure

Tyre pressure measurements were taken immediately following the accident and therefore the measured tyre pressure was considered to be a reliable indicator of tyre pressure at the time of the accident. Table 6.2.6 shows the tyre inflation pressure of both front and rear tyres for all accident-involved motorcycles. There were 97 cases in which the tyre deflated during the accident events, so no measurement was possible (86 cases of the front tyre and 11 cases of the rear tyre) as shown in Table 6.2.7.

About one-third of the front tyres and nearly half of the rear showed the tyre inflation pressure within 15% of the recommended pressure. Another one-third of the front and rear tyres were found to be between 16% and 39% of the normal tyre pressure. About 14% of the front and 10% of the rear tyres were grossly under inflated. In addition, 4% of the front and 7% of the rear tyres were grossly over inflated.

Table 6.2.6: Inflation pressure of front and rear tyres

Inflation Pressure (KPa)	Front		Rear	
	Frequency	Percent	Frequency	Percent
< 80	20	2.8	4	0.6
81 – 120	82	11.3	47	6.5
121 – 160	133	18.4	101	14.0
161 – 200	240	33.2	205	28.4
201 – 240	95	13.1	205	28.4
241 – 280	37	5.1	78	10.8
81 – 320	15	2.1	41	5.7
> 320	15	2.1	31	4.3
Unknown	86	11.9	11	1.5
Total	723		723	

Although tyres with excessive high or low pressure could reduce braking or cornering ability and tyres worn smooth could reduce traction, dynamic tyre failure was rarely involved as an accident contributing factor.

Table 6.2.7: Tyre inflation relative to recommended pressure

Tyre inflation	Front		Rear	
	Freq	%	Freq	%
Deflated during accident	86	11.9	11	1.5
Inflation within 15%	270	37.3	343	47.4
Inflation between 16% - 38%	238	32.9	243	33.6
Grossly underinflated, < 40%	100	13.8	75	10.4
Grossly overinflated, > 40%	29	4.0	51	7.1
Total	723		723	

Braking evidence on motorcycle tyres

Braking evidence was seen infrequently on either the front or rear tyres (Table 6.2.8). About 95% of motorcycles showed no evidence of front braking and 87% of motorcycles showed no sign of rear braking. In about 13% of all accident-involved motorcycles, skid patches were found on the rear tyre and in 4% on the front tyre alone. Braking evidence on both front and rear was about found in only about 2% of cases.

Table 6.2.8: Braking evidence on front and rear tyres

Braking evidence	Front		Rear	
	Freq	%	Freq	%
None	687	95.0	626	86.6
Heavy braking without wheel lock up	1	0.1	1	0.1
Heavy locked braking, one kid patch	31	4.3	85	11.8
Heavy locked braking, multi-skid patches	1	0.1	9	1.2
Unknown	3	0.4	2	0.3
Total	723		723	

6.3 Motorcycle brake system

About three-fourths of the accident-involved motorcycles were equipped with hydraulic front disc brakes. Rear brakes were evenly divided between mechanically operated drum brakes and hydraulic disc brakes. The different front and rear brake configurations are shown in Tables 6.3.1 and 6.3.2.

One accident-involved motorcycle had no front brake lever, while eight other motorcycles were missing parts of the braking system. The front brake was inoperable in 11 cases due to severe wear or severe deterioration of the friction surface. In these cases, the riders used only the rear brake during collision avoidance action, which contributed to accident causation by failing to slow the motorcycle enough to avoid a collision. Two accident-involved motorcycles had no rear brake and in 10 cases the rear brakes were inoperable.

Table 6.3.1: Brake mechanism configuration

Brake configuration	Front brake		Rear brake	
	Frequency	Percent	Frequency	Percent
None	9	1.2	2	0.3
Drum, single leading shoe	163	22.5	333	46.1
Single disc, single piston	118	16.3	70	9.7
Single disc, multi piston	428	59.2	318	44.0
Double disc, multi piston	5	0.7	0	0.0
Total	723		723	

Table 6.3.2: Brake mechanism actuation

Brake actuation	Front brake		Rear brake	
	Frequency	Percen t	Frequenc y	Percent
None	9	1.2	2	0.3
Hydraulic	551	76.2	388	53.7
Mechanical	163	22.5	333	46.1
Total	723		723	

6.4 Motorcycle frame and suspension

Motorcycle frame

Table 6.4.1 shows the various frame types for the accident-involved motorcycles. The step-through, tubular frame most often corresponded to the step-through motorcycle. The extrusion-element perimeter frame was usually found in the sport-bike motorcycles. The standard street motorcycles usually had a conventional cradle type tube frame with either single or double down tubes (66 of 95 or 69%) or perimeter frames (27 of 95 or 28%). Almost all motorcycle frames were steel.

Table 6.4.1: Motorcycle frame type

Frame type	Frequency	
Step-through, formed sheet metal	12	1.7
Step-through tubular frame	339	46.9
Conventional tube cradle type with single down tube	4	0.6
Conventional tube cradle type with double down tubes	86	11.9
Backbone, motor-transmission mounted independently	1	0.1
Perimeter frame, extrusion element type	280	38.7
Monocoque, shell only structure	1	0.1
Total	723	

Motorcycle steering stem adjustment

Loose or over-tightened steering stem adjustment was found in 51 cases (7%) of all accident-involved motorcycles (Table 6.4.2). Despite the control problems this can cause, there were no cases in which loose adjustment caused or contributed to a crash.

Table 6.4.2: Steering stem adjustment

Steering stem adjustment	Frequency	
Secure, properly tightened	634	87.7
Overly tightened, control interference	3	0.4
Loose, contributes to control difficulty	47	6.5
Very loose, control interference	1	0.1
Unknown	38	5.3
Total	723	

Motorcycle steering damper

Steering dampers were seen only as aftermarket items on 20 motorcycles as shown in Table 6.4.3.

Table 6.4.3: Steering damper installation

Steering damper installation	Frequency	
None installed or not applicable	703	
Hydraulic tubular damper, one side	20	
Total	723	

Front and rear suspension

About 98% of the front suspensions were found to be telescoping tube with a conventional lower fork leg (Table 6.4.4). Modifications of the front suspension were found in only 6 cases, usually raising the fork tubes through the triple clamps, to give the motorcycle a lower front profile or a more “raked” appearance.

Table 6.4.4: Front suspension type

Type of front suspension	Frequency	
Telescoping tube, conventional lower fork legs	708	97.9
Telescoping tube, inverted fork legs	2	0.3
Leading link, single or double sided	1	0.1
Trailing link, single or double sided	11	1.5
Other	1	0.1
Total	723	

Rear suspensions were almost all the typical fork type, usually with either a mono-shock or linkage articulated mono-shock spring-damper system. About one-third of motorcycles in the study had double exterior tubular shocks. Modifications were found in 8 cases. There were no cases in which the type or condition of the rear suspension contributed to accident causation. Table 6.4.5 shows the types of rear suspension.

Table 6.4.5: Rear suspension type

Type of rear suspension	Frequency	
Fork swing arm, double exterior tubular shocks	233	32.2
Conventional fork swing arm, mono-shock	456	63.1
Fork swing arm, linkage mono-shock	17	2.4
One-sided swing arm, mono-shock	3	0.4
One-sided swing arm, linkage articulated mono-shock	2	0.3
Other	12	1.7
Total	723	

Suspension contribution to accident causation

Front suspension instability was detected in 3 cases but was not considered to be a contributing factor in those cases (Table 6.4.6).

Table 6.4.6: Suspension condition related to accident causation

Condition of suspension	Front		Rear	
	Freq	Percent	Freq	Percent
No contribution	720		723	
Deteriorated, caused unstable	1		0.0	
Other	2		0.0	
Total	723		723	

Rear swing arm

A loose rear swing arm was found in about 5% of the accident-involved motorcycles (Table 6.4.7). The main source for such rear swing arm problem was a loose pivot bolt in 28 cases and worn bearings in 6 cases (Tables 6.4.8).

Table 6.4.7: Rear swing arm inspection

Swing arm inspection	Frequency	
Not loose	688	95.2
Loose	34	4.7
Unknown	1	0.1
Total	723	

Table 6.4.8: Rear swing arm pivot/bearing condition

Swing arm condition	Frequency	
Not applicable	688	95.2
Pivot bolt loose; bearings in good condition	28	3.9
Bearings loose or worn; deteriorated distinct	6	0.8
Unknown	1	0.1
Total	723	

Motorcycle wheelbase reduction

Motorcycle wheelbase reduction was measured mostly because previous research has found a relationship between crash speed and wheelbase reduction for certain collision configurations. Table 6.4.9 shows the distribution of wheelbase reduction due to impact.

About 60% of motorcycles showed no wheelbase reduction. In some cases, this was because speeds were too low to cause any deformation in a frontal impact. In other cases, it was because the impact was not in a longitudinal, front-to-rear direction, or the motorcycle may have yawed before significant wheelbase reduction occurred.

However, the most common reason for a lack of wheelbase deformation was that the small front wheels on these motorcycles often under-rode other vehicle bumpers so that in frontal motorcycle impacts most of the impact load was directed to the forks at a location above the wheel.

Table 6.4.9: Motorcycle wheelbase reduction

Wheelbase reduction (mm)	Frequency	
None	427	59.1
1 – 20	60	8.3
21 – 30	32	4.4
31 – 40	21	2.9
41 – 50	12	1.7
51 – 100	64	8.9
101 – 150	33	4.6
151 – 200	26	3.6
> 200	25	3.5
Unknown	23	3.2
Total	723	

Motorcycle front wheel displacement

The front wheel displaced against either the motor or the frame in 104 cases. This type of displacement was most consistent with a major impact against a solid, unyielding object. Front wheel displacement was about twice as common in fatal cases as in non-fatal (28% vs. 14%), probably because crash speeds (and therefore motorcycle deformation) tended to be higher in fatal cases. A comparison is shown in Table 6.4.10.

Table 6.4.10: Front wheel displacement

Front wheel displacement	Non-fatal		Fatal	
	Frequency	Percent	Frequency	Percent
No displacement	577	86.2	39	72.2
Displacement present	90	13.5	14	25.9
Unknown	2	0.3	1	1.9
Total	669		54	

6.5 Motorcycle foot pegs and side stand

About half of the rider foot-pegs were metal folding pegs with rubber covers and about 40% were rigid metal with rubber covers. The passenger foot pegs were mainly metal folding pegs with rubber covers (93%). Only the scooter models were not equipped with foot-pegs for either the rider or passenger. Tables 6.5.1 show the presence or absence of rider and passenger foot-pegs of the accident-involved motorcycles.

Table 6.5.1: Types of rider foot pegs/footrest

Type of foot pegs	Rider		Passenger	
	Freq	Percent	Freq	Percent
None	14	1.9	18	2.5
Rigid metal pegs, no covers	23	3.2	0	0.0
Rigid metal peg, rubber covers	298	41.2	6	0.8
Rigid metal folding pegs, no covers	24	3.3	25	3.5
Metal folding pegs, rubber covers	364	50.3	674	93.2
Total	723		723	

Motorcycle side stands

Most side stands were original equipment (rather than aftermarket), with a metal end or pad. Most were installed on the left (Table 6.5.2). The side stand was removed in 7 accident instances. The addition of a side stand was found in 3 cases. No cases were seen in which the side stand was in the down position, subsequently causing the rider to run wide on a turn due to the side stand limiting the amount of lean the motorcycle could do.

Table 6.5.2: Side stand inspection

Side stand type	Frequency	
None	30	4.1
Original equipment, right side, metal end or pad	1	0.1
Original equipment, right side, rubber catch pad	2	0.3
Original equipment, left side, metal end or pad	680	94.1
Accessory, installed left side	3	0.4
Other	7	1.0
Total	723	

Motorcycle center stand

The center stand was not equipped in about one-fourth of all accident-involved motorcycles. When present, the center stand was often original equipment (Table 6.5.3). The original center stand had been removed in 25 cases. There were only three cases where modifications were done to the center stand of the accident-involved motorcycles. No accident-related problems were found with center stands.

Table 6.5.3: Center stand inspection

Center stand	Frequency	
None	187	25.9
Original equipment, installed	510	70.5
Original equipment, removed	25	3.5
Ride-off stand installed	1	0.1
Total	723	

6.6 Motorcycle headlamps

The headlamp was not present in 20 cases. A single headlamp was found in about 70% of the accident-involved motorcycles. Double headlamps were found in another one-fourth of the accident group. Data are shown in Table 6.6.1.

Table 6.6.1: Headlamp assembly type

Type of headlamp	Frequency	
None	20	2.8
Single headlamp	501	69.3
Double headlamp	198	27.4
Single with auxiliary light	4	0.6
Total	723	

Motorcycle headlamp use

A common problem for motorcyclists was that OV drivers failed to see the approaching motorcycle and then made a maneuver across the motorcycle path and violated the rider's right-of-way. In many cases, the OV driver said he never saw the motorcycle coming, or saw it just an instant before the crash. Due to its small size, the motorcycle is a small "visual target" in traffic and is relatively inconspicuous. It is much more likely to be overlooked than a large bus or truck.

Headlamp usage varied with ambient light conditions, which were grouped here into three categories: 1) daytime (bright and not bright), 2) nighttime (night-lighted and not lighted) and 3) dusk and dawn categories. Table 6.6.2 shows that the headlamp was not used in about 87% of the daytime accidents, 13% of the nighttime accidents and 73% of dusk-dawn accidents.

Table 6.6.2: Headlamp use and ambient light conditions

Illumination condition	Headlamp use			Total
	On	Off	Unknown	
Daylight	29 (12.0%)	211 (87.6%)	1 (0.4%)	241 (100.0%)
Night	381 (85.6%)	59 (13.3%)	5 (1.1%)	445 (100.0%)
Dusk	7 (30.0%)	25 (70.0%)	0 (0.0%)	32 (100.0%)
Dawn	3 (60.0%)	2 (40.0%)	0 (0.0%)	5 (100.0%)
Total	420	297	6	723

6.7 Motorcycle handlebar and throttle

The handlebar was usually the original equipment supplied with the motorcycle (Table 6.7.1). Handlebars were replaced in only 13 cases. Most handlebars were made of cast steel with steel tube (70%) or steel tube (30%).

Table 6.7.1: Handlebar inspection

Handlebar	Frequency	
Original equipment	712	
Clip on	9	
Clubman or racer	2	
Total	723	

Motorcycle throttle

Throttle malfunction was found in only 12 motorcycles (1.7%) of accident population. The sources of the throttle problems are shown in Table 6.7.2.

Table 6.7.2: Throttle condition and sources of failure

Throttle condition	Drum condition	Cable condition	Throttle plate/slides condition	Return springs condition
Function properly	715 (99.0%)	715 (99.0%)	717 (99.2%)	713 (98.6%)
Not function properly	4 (0.5%)	4 (0.5%)	2 (0.2%)	6 (0.9%)
Unknown	4 (0.5%)	4 (0.5%)	4 (0.5%)	4 (0.5%)
Total	723 (100%)	723 (100%)	723 (100%)	723 (100%)

6.8 Motorcycle fuel system performance and fire hazards

The type of fuel tank depended largely upon the motorcycle type. Under-seat fuel tanks were almost always found on step-through motorcycles and a few scooters. Saddle-type tanks located between the rider's knees, were found on sport bikes and conventional street motorcycles.

Motorcycle tank retention

The vast majority of the fuel tanks (98%) were completely retained in position throughout the entire accident sequence. Eight tanks partially separated and five tanks completely separated from the motorcycle as shown in Table 6.8.1. All were the saddle-type, which attach to the frame but are not an integral part of the frame, as under-seat tanks are.

Table 6.8.1: Fuel tank retention

Fuel tank retention	Frequency	
Completely separated from motorcycle	5	
Partially separated, displaced from mounting	8	
Completely retained in mounting position	710	
Total	723	

Motorcycle tank deformation

About three-fourths of the 723 cases showed no tank deformation. Of the 195 cases that had some deformation, about seven out of eight had only mild damage. Severe deformation was found in only one case (Table 6.8.2).

The source of the gas tank deformation was mainly from contact with the motorcyclist's body or by other motorcycle components, usually the handlebars. (Table 6.8.3).

Table 6.8.2: Amount of fuel tank deformation

Tank deformation	Frequency	
None	528	73.0
Mild denting	170	23.5
Moderate denting	24	3.3
Severe damage	1	0.1
Total	723	

Table 6.8.3: Sources of tank deformation

Fuel tank deformation cause	Frequency	
No tank damage	528	73.0
Contact from motorcyclist's body	80	11.1
Collision contact from other motorcycle components	52	7.2
Collision contact with other vehicle	26	3.6
Collision contact with roadway surface	7	1.0
Collision contact with other objects in environment	4	0.6
Other	25	3.5
Unknown	1	0.1
Total	723	

Tank failure, defined as any intrusion or deformation that prevented the tank from retaining fuel, occurred in 12 cases. Five cases resulted from laceration, four from blunt impact, and one from plastic tank material embrittlement (Table 6.8.4).

Table 6.8.4: Fuel tank failure

Fuel tank failure	Frequency	
No failure	711	98.3
Denting or crushing from blunt impact	4	0.6
Laceration or puncture from edge or sharp object	5	0.7
Plastic tank material embrittlement	1	0.1
Other	1	0.1
Unknown	1	0.1
Total	723	

Motorcycle fuel cap type

The type of fuel caps found on the inspected motorcycles appears in Table 6.8.5. Approximately half of the fuel caps were covered, guarded or recessed bayonet type – usually on motorcycles with a step-through frame and under-seat fuel tank. One-third of the fuel caps were smooth with tank top surface (typical of sport bikes, which were one-third of the accident population) and 12% were Monza, flip-up.

Only one accident-involved motorcycle did not have fuel cap. About 98% of the fuel caps were retained securely throughout the entire accident sequence Seven caps displaced enough to allow some fuel lost and four fuel caps were lost completely (Table 6.8.6).

The cross-tabulation between fuel cap release and fuel cap type showed that the majority of those tank caps opening from collision were covered, guarded, or recessed bayonet followed by Monza type.

Table 6.8.5: Fuel tank cap types

Type of fuel cap	Frequency	
No tank cap, cap missing	1	0.1
External screw type, no cover	3	0.4
Internal screw type, no ratchet, no cover	4	0.6
Internal screw type, ratchet, covered, or recessed	2	0.3
Exposed bayonet type, no cover, no guard	10	1.4
Covered, guarded, or recessed bayonet type	362	50.1
Smooth with tank top surface, covered	1	0.1
Smooth with tank top surface, no cover	253	35.0
Monza, flip-up	87	12.0
Total	723	

Table 6.8.6: Fuel tank cap retention

Cap retention	Frequency	
No fuel cap	1	0.1
Retained securely, no venting or fuel loss from cap	710	98.2
Not retained, ejected completely from tank body	4	0.6
Displaced sufficiently to allow fuel loss	7	1.0
Other	1	0.1
Total	723	

Motorcycle fuel spills

The majority of fuel spills occurred after collision and were usually due to the post-crash position of the motorcycles, which was almost always lying down on one side. The source of fuel leak is shown in Table 6.8.7. The carburetor vents were the primary source of the fuel leaks, accounting for 85% of the 329 cases in which a leak occurred.

Table 6.8.7: Source of fuel spills or leaks

Source of fuel spills	Frequency	
No fuel spills or leaks	336	46.5
Primary fuel tank	15	2.1
Fuel lines and fitting	23	3.2
Carburetor	329	45.5
Fuel cap	6	0.8
Fuel tank vent	3	0.4
Other	11	1.5
Total	723	

Motorcycle fires

No crash and post-crash fires occurred in any of the 723 accident cases, although moderate fuel spills and large quantities of fuel leaks were found in about 5.6% of all accident cases (Table 6.8.8). Minor leaks of the fuel system occurred in nearly half the cases but represent little hazard because the leaks occur at point of rest, where the ignition source (e.g., friction sparks from the motorcycle sliding on pavement) has disappeared.

Table 6.8.8: Fuel spill size and fire hazard

Amount of fuel spills	Frequency	
None	336	
Minor leaks, little or no fire hazard	347	
Moderate leak or spill, some fire hazard	33	
Large quantity of fuel lost with severe fire hazard	7	
Total	723	

6.9 Motorcycle exhaust systems

The vast majority of the exhaust systems inspected were original equipment or original equipment replacements (93%). Aftermarket exhaust systems and modifications were found in about 7% (Table 6.9.1). Most mufflers were found to be in good condition (Table 6.9.2.)

Table 6.9.1: Exhaust system type

Type of exhaust system	Frequency	
Original equipment	644	89.1
Original equipment replacement or equivalent	27	3.7
After-market accessory	36	5.0
After-market accessory, modified	15	2.1
Other	1	0.1
Total	723	

Table 6.9.2: Exhaust system condition

Condition	Frequency	
Good condition	671	92.8
Worn or damaged	50	6.9
Worn or damaged; excessive noise	1	0.1
Unknown	1	0.1
Total	723	

6.10 Motorcycle mechanical problems

The major mechanical problems of the accident-involved motorcycles reported in this study were the result of pre-existing maintenance-related problems as listed in Table 6.10.1.

Only one factor about the motorcycle itself stood out as a significant accident cause factor: the absence of a headlamp at night. Most often this was the result of rider failure to turn on the headlamp, but in twenty cases the headlamp was missing.

Lack of the front or rear brake may cause loss of control or limited braking performance when the rider was forced to apply either the front or rear brake. Brake problems were all found to be a pre-existing maintenance condition of the motorcycle.

Table 6.10.1: Motorcycle mechanical problems

Mechanical problem	Frequency	
Headlamp		
not equipped	20	2.8
Front brake		
Not equipped	9	1.2
Equipped, but inoperable	8	1.1
Brake lever		
Not equipped	2	0.3
Equipped, but inoperable	15	2.1
Rear brake		
Not equipped	2	0.3
Equipped, but inoperable	10	1.4
Rear brake pedal		
Not equipped	1	0.1
Equipped, but inoperable	11	1.5
Rear position lamp		
Not equipped	20	2.8
Equipped, but inoperable	11	1.5
Stop lamp		
Not equipped	17	2.4
Equipped, but inoperable	12	1.7
Rear view mirror right		
Not equipped	283	39.1
Equipped, but inoperable	9	1.2
Rear view mirror left		
Not equipped	317	43.8
Equipped, but inoperable	8	1.1

6.11 Other vehicle characteristics

Other vehicle type

In the 696 multiple vehicle accidents, two-thirds of the other vehicles were some variety of passenger vehicle (all sizes of passenger car plus pick-up trucks, sport utility vehicles and vans). About 21% of the other vehicles in this study were another motorcycle (Table 6.11.1). When a motorcycle versus motorcycle crash occurred, two cases were generated – one for each motorcycle (except when one motorcycle fled the scene, which occurred in at least two cases.) For example, if a Yamaha and a Honda collided, in one case the Honda was “the motorcycle” and the Yamaha was “the other vehicle.” In the second case, the roles were reversed.

Table 6.11.1: Vehicle types, other vehicle

Vehicle types	Frequency	
Saloon/sedan passenger car	3	0.4
Station wagon	1	0.1
Intermediate automobile	22	3.2
Compact automobile	283	40.7
Sub-compact automobile	17	2.4
Bus	32	4.6
Minibus	4	0.6
Long distance coach	1	0.1
Step-through motorcycle	65	9.3
Conventional motorcycle	81	11.6
Special or other bus	1	0.1
Mini light truck, cargo rating of < 454 kg/1000 lbs	93	13.4
Full size light truck, cargo rating of ≥ 454 kg/1000 lbs	7	1.0
Sport utility vehicle	7	1.0
Commercial truck	13	1.9
Trailer towing vehicle/truck	4	0.6
Semi-trailer-towing vehicle/truck	2	0.3
Special or other truck	5	0.7
Tuk Tuk	22	3.2
Full size van with less than 9 seats	3	0.4
Minivan	8	1.1
Special	1	0.1
Other	1	0.1
Unknown	20	2.9
Total	696	

Table 6.11.2 shows the manufacturers of the non-motorcycle other vehicles including automobiles, truck, buses, etc.

Table 6.11.2: Manufacturers of other vehicle

Manufacturers	Frequency	
Alfa Romeo	1	0.2
Audi	1	0.2
BMW	10	1.8
Chrysler	1	0.2
Citoen	2	0.4
Daewoo	5	0.9
Daihatsu	4	0.7
Datsun	1	0.2
Fiat	1	0.2
Ford	7	1.3
Honda	25	4.5
Hino	16	2.9
Hyundai	4	0.7
Isuzu	49	8.9
Mazda	11	2.0
Mercedes Benz	32	5.8
Mitsubishi	52	9.5
Nissan	60	10.9
Porshe	1	0.2
Suzuki	2	0.4
Toyota	159	28.9
Volvo	12	2.2
Volkswagen	9	1.6
Other	22	4.0
Unknown	63	11.5
Total	550	

The manufacturers of motorcycles that were the other vehicle are listed in Table 6.11.3. Again, Honda motorcycles predominated followed by Yamaha, Kawasaki and Suzuki.

Table 6.11.3: Manufacturers of motorcycle as other vehicle

Manufacturers	Frequency	
Honda	69	47.3
Kawasaki	23	15.8
Piaggio	1	0.7
Suzuki	10	6.8
Yamaha	39	26.7
Unknown	4	2.7
Total	146	

Table 6.11.4 shows the distribution of the other vehicle kerb mass. The distribution of vehicle curb mass ranged from 10 kilograms (a bicycle) to 25,000 kilograms (a heavy truck).

Table 6.11.4: Distribution of other vehicle curb mass

Curb mass (Kg)	Frequency	
0 – 50	1	0.1
51 – 250	143	20.5
251 – 400	22	3.2
401 – 1200	203	29.2
1201 – 1500	139	20.0
1501 – 2000	58	8.3
2001 – 10000	7	1.0
10001 – 15000	39	5.6
> 15000	12	1.7
Unknown	72	10.3
Total	696	

Table 6.11.5 shows the distribution of mechanical problems found for the other vehicles involved in collision. A pre-existing maintenance problem was found in 10 "other motorcycles." Failure of the brake system or the power transmission was found in only 7 cases and 4 cases, respectively.

Table 6.11.5: Other vehicle mechanical problems

Mechanical problems	Frequency	
None	612	87.9
Tyre or wheel failure	2	0.3
Braking failure	7	1.0
Power transmission failure	4	0.6
Electrical failure	2	0.3
Structural failure, not suspension, tyre, or wheel	2	0.3
Other	10	1.4
Unknown	57	8.2
Total	696	

7.0 Motorcycle and Other Vehicle Collision Kinematics

This section summarizes data from the reconstruction of 723 Bangkok accident investigation cases. A complete description of the crash dynamics includes a description of what happens during the pre-crash, crash and post-crash phases of the accident. Such an analysis describes what the vehicles were doing just before the start of the crash event as well as the change in motion that turned a normal traffic flow into an imminent collision situation. In some cases, such as when the motorcycle rear-ends a stopped OV or runs off the road instead of going around a curve, it is a continuation of motion, or a failure to act, that set the rider on a collision course. The speeds before impact and at the moment of impact were determined, along with actions taken to avoid the collision. The orientation of the motorcycle (upright, leaning, down sliding, yawing, etc.) and the orientation of the vehicles to each other at impact was recorded. Finally, the post-crash motions of rider, passenger, driver, motorcycle and other vehicle were noted.

7.1 Motorcycle pre-crash motions

Most driving involves frequent small adjustments for changing conditions such as roadway changes, traffic controls, the movements of other vehicles in the traffic flow, and even unseen factors such as strong wind. The great majority of the time, drivers make these small adjustments and traffic flows without serious incident. However, accidents occur when some event occurs and the accident-involved driver does not, or cannot, take evasive action that can prevent a crash.

For this study, that event was defined as the precipitating event (PE), and was defined as the maneuver (or failure to act) that immediately led to the accident. Some examples are as follows:

1. A car driver stopped waiting to make a right turn across opposing lanes sees the approaching motorcycle but believes the motorcycle rider should stop for his car. Driver turns right across motorcycle path, rider skids and collides with car. In this case, the PE is the beginning of the OV right turn.

2. A motorcycle rider violates a red light and collides with a bus crossing its path perpendicularly in the intersection on a green light. In this case, the PE is the motorcycle failure to begin braking at a place where it can still stop before entering the intersection.

3. A motorcycle following an OV too closely when the other vehicle suddenly brakes. The motorcycle rider skids and hits the rear of the other vehicle. The PE is the other vehicle braking. Prior to that, the rider was engaging in an unsafe act – following too closely.

The motion prior to the PE describes the typical or normal traffic flow conditions just before the accident occurs. Motion after the PE sometimes described the change in action that was the PE, and sometimes described the reactions that occurred after the PE. For example, in the first example above, the other vehicle motion before PE would be, “stopped in traffic, speed is zero;” the motion after PE would be “turning right, accelerating.” In the second example above, the PE is the motorcycle failure to brake in time to stop before entering the intersection, but the motorcycle motion before and after PE would be coded as “going straight, constant speed.”

Table 7.1.1 shows the distribution of pre-crash motions of the accident-involved motorcycles in our study. The majority of accident-involved motorcycles were found to be moving in a straight line at constant speed. The next most common maneuvers were found to be "traveling in opposing lanes," "stripe riding," and "stopped in traffic," all of which were found to be present in 3 to 5% of all accidents. It should be noted that "turning right" or "turning left" could refer to either following a curving roadway or to turning from one straight roadway onto another.

Table 7.1.1: Motorcycle pre-crash motions before and after PE

Motorcycle pre-crash motions	Before PE		After PE	
	Frequency	%	Frequency	%
Stopped in traffic, speed is zero	25	3.5	9	1.2
Moving straight, constant speed	480	66.4	240	33.2
Moving straight, throttle off	15	2.1	16	2.2
Moving straight, braking	15	2.1	180	24.9
Moving straight, accelerating	19	2.6	22	3.0
Turning right, constant speed	21	2.9	28	3.9
Turning right, throttle off	0	0.0	1	0.1
Turning right, braking	0	0.0	10	1.4
Turning right, accelerating	5	0.7	10	1.4
Turning left, constant speed	11	1.5	8	1.1
Turning left, throttle off	0	0.0	2	0.3
Turning left, braking	1	0.1	8	1.1
Turning left, accelerating	6	0.8	0	0.0
Stopped at roadside, or parked	2	0.3	0	0.0
U-turn or Y-turn to right	2	0.3	7	1.0
Changing lanes to left	3	0.4	11	1.5
Changing lanes to right	4	0.6	15	2.1
Entering from left curb, shoulder	1	0.1	1	0.1
Passing on right	22	3.0	10	1.4
Passing on left.	4	0.6	10	1.4
Wrong way, opposite traffic	38	5.3	69	9.5
Lane-splitting, longitudinal only	38		23	3.2
Lane-splitting, lateral only	2	0.3	3	0.4
Lane-splitting, longitudinal & lateral	7	1.0	3	0.4
Other	2	0.3	35	4.8
Total	723		723	

Pre-crash control operations

Approximately 75% of the accident-involved motorcycle riders were not performing any particular pre-crash control operation; they were simply riding straight ahead at steady speed. Approximately 10% of the riders were steering or turning, and 6% were accelerating prior to the collision. Table 7.1.2 shows the pre-crash control operation just before the precipitating event for the 723 accident investigation cases. There were only 6 cases in which the pre-crash control operations interfered with riding tasks of the accident-involved motorcycle riders (Table 7.1.3.)

Table 7.1.2: Motorcycle control operations before precipitating event

Pre-crash control operation	Frequency	
None	545	75.4
Accelerating, upshifting	43	5.9
Decelerating, downshifting	7	1.0
Decelerating, braking	2	0.3
Throttle change	5	0.7
Mirror adjustment	1	0.1
Operating headlamps or turn signals	1	0.1
Steering, turning	72	10.0
Other	10	1.4
Unknown	37	5.1
Total	723	

Table 7.1.3: Interference of control operation with driving task

Interference with driving	Frequency	
Not applicable	526	72.8
No interference	152	21.0
Yes, directed attention away from traffic conflict	4	0.6
Yes, directed attention away from traffic hazard	1	0.1
Other	1	0.1
Unknown	39	5.4
Total	723	

Approximately 43% of the accident-involved motorcycle riders said that they had their fingers on the front brake lever while riding in traffic. This information was based solely upon the rider interview and was only as valid as the riders were truthful.

In general, if the fingers are extended to the brake lever, the reaction time is reduced and the contraction of the finger muscles is a natural and typical reaction to a pending collision. However, the data related to the braking for collision avoidance action showed that the majority of the accident-involved riders used rear braking as a collision avoidance maneuver more often than front wheel braking.

7.2 Motorcycle pre-crash and crash speeds

Each of the 723 on-scene, in-depth investigation accidents was reconstructed analytically to determine the pre-crash and crash speeds of all involved vehicles. The crash speed calculations were mainly based on vehicle damage analysis, skid and scuff mark analysis, post-crash trajectories, etc. Occasionally, there was insufficient physical evidence for the speed analysis and the pre-crash speed was estimated based upon on the rider's interview and motorcycle damage.

Table 7.2.1 shows the distribution of the pre-crash speeds for the accident-involved motorcycle. The median pre-crash speed for all 723 cases was 39 kilometres per hour. . The median speed at impact was 31 kilometres per hour. The highest crash speed found in the study was 110 kilometres per hour. The relationship between the pre-crash and crash speeds is illustrated in Figure 7.2.1.

Table 7.2.1: Motorcycle pre-crash and crash speeds

Motorcycle speed (km/hr)	Pre-crash speed		Crash speed	
	Frequency	Percent	Frequency	Percent
Stop	26	3.6	12	1.7
1 – 10	10	1.4	34	4.7
11 – 20	58	8.0	123	17.0
21 – 30	142	19.6	187	25.9
31 – 40	173	23.9	158	21.9
41 – 50	109	15.1	94	13.0
51 – 60	93	12.9	58	8.0
61 – 70	38	5.3	32	4.4
71 – 80	20	2.8	9	1.2
81 – 90	9	1.2	6	0.8
91 – 100	3	0.4	1	0.1
> 100	4	0.6	3	0.4
Unknown	38	5.3	6	0.8
Total	723		723	

Motorcycle precrash and crash speed

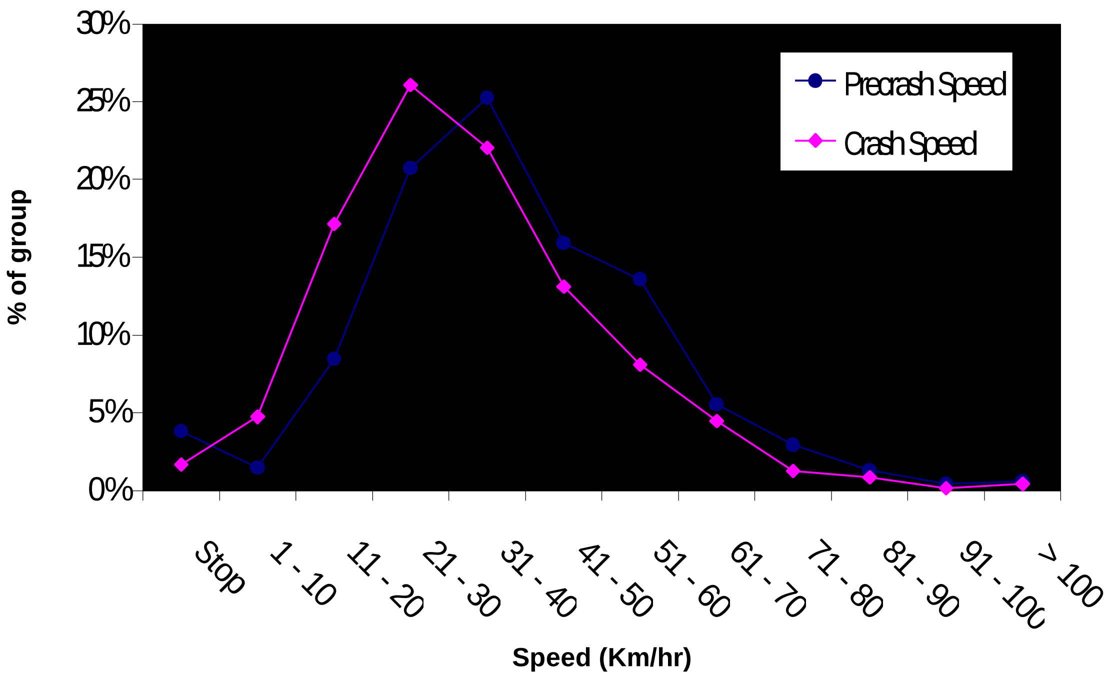

Figure 7.2.1: Percent distribution of motorcycle pre-crash and crash speeds.

Table 7.2.2: Pre-crash and crash speed in fatal and non-fatal accidents

Motorcycle speed (km/hr)	Pre-crash speed		Crash speed	
	Fatal injuries involved		Fatal injuries involved	
	No	Yes	No	Yes
Stop	24	2	12	0
1 – 10	10	0	33	1
11 – 20	56	2	120	3
21 – 30	138	4	180	7
31 – 40	169	4	151	7
41 – 50	98	11	83	11
51 – 60	85	8	49	9
61 – 70	29	9	22	10
71 – 80	16	4	6	3
81 – 90	8	1	6	0
91 – 100	3	0	1	0
> 100	4	0	3	0
Unknown	29	9	3	3
Total	669	54	669	54

Table 7.2.2 presents the pre-crash and crash speeds for the fatal and non-fatal accident cases. Speeds were generally higher in fatal accidents than in non-fatal crashes as shown in Figures 7.22 and 7.2.3. The median pre-crash speed in fatal cases was 50 km/hr, compared to 38 km/hr in non-fatal accidents. The difference in median crash speeds was greater (48 vs. 30 km/hr) because crash speeds dropped much more in non-fatal crashes than they did in fatal cases. That is, in non-fatal cases the median crash speed was 8 km/hr less than the pre-crash speed. In fatal cases the median crash was only 2 km/hr slower than the pre-crash speed.

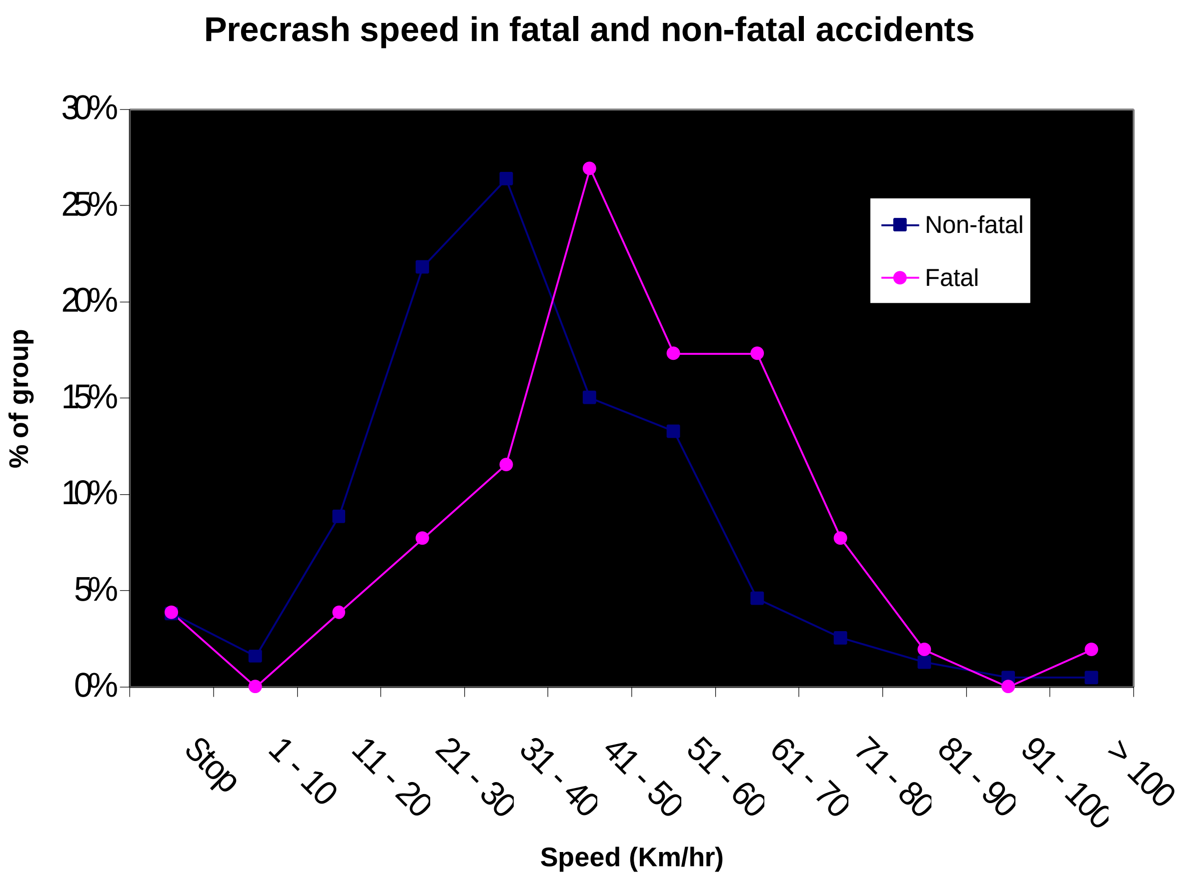

Figure 7.2.2: Percent distribution of pre-crash speed in fatal and non-fatal crashes.

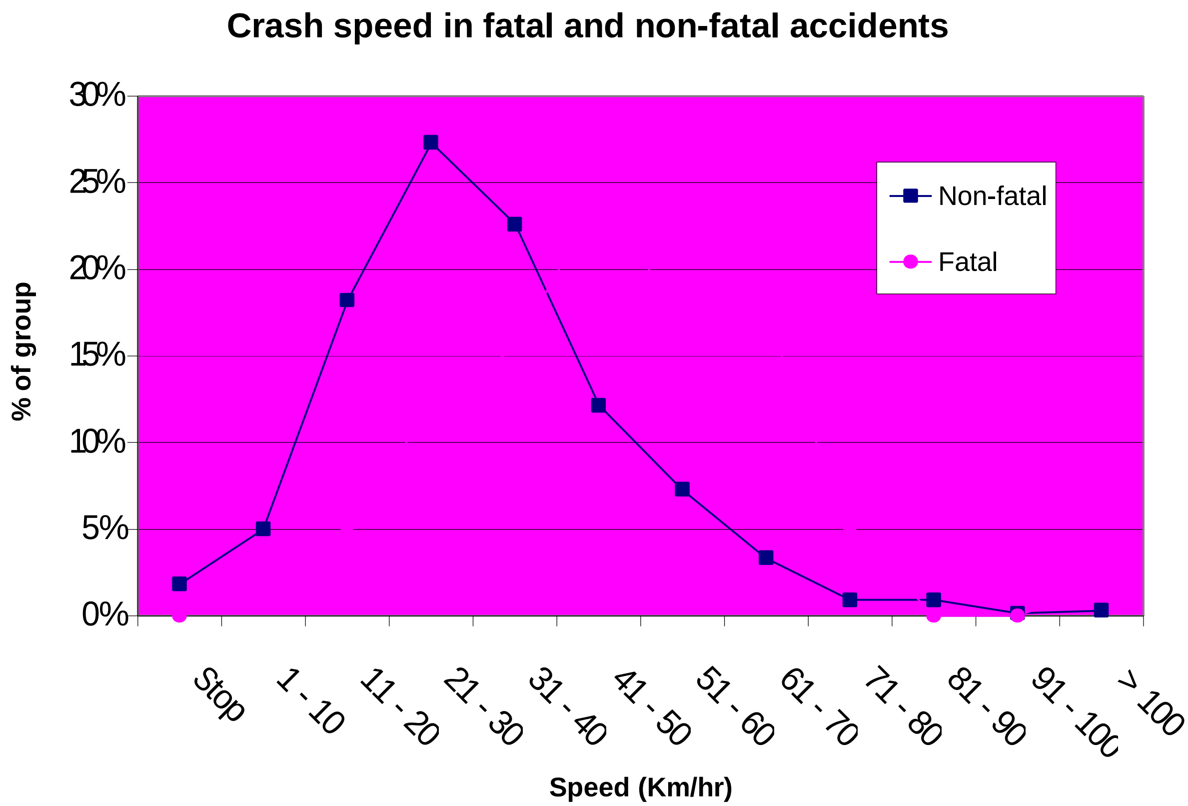

Figure 7.2.3: Percent distribution of crash speeds in fatal and non-fatal crashes.

7.3 Pre-crash line-of-sight from motorcycle to other vehicle

In order to understand the accident dynamics, it was essential to determine the pre-crash line-of-sight between the motorcycle and other vehicle involved in the accident. The line-of-sight from the motorcycle to the other vehicle was coded as a "clock face" direction with the vehicle facing towards the 12:00 position.

For example, in those cases where the motorcycle was approaching and struck an automobile from behind, the pre-crash line-of-sight from the motorcycle to the automobile would be coded as 12 o'clock and from the automobile to the motorcycle, the line of sight would be coded as 6 o'clock. Another example would be a motorcycle proceeding along a straight roadway and the other vehicle moving in opposing traffic and just beginning to turn right in front of the motorcycle. In this example, the typical pre-crash line-of-sight from the motorcycle to the other vehicle would be "1 o'clock" or 2 o'clock depending upon the location and orientation of the vehicles immediately prior to the collision.

The pre-crash line of sight relates several factors important for developing a strategy for accident prevention. The primary application would be for the detection of hazards by the motorcycle rider. The opposite line-of-sight, from other vehicle to the motorcycle, provides information regarding the part of the motorcycle exposed to the view of the other vehicle driver.

Figure 7.3.1 shows the distribution for the pre-crash line-of-sight for the 723 on-scene, in-depth accident cases. There were 616 cases in which there was another vehicle present. No data regarding line-of-sight were coded for any of the single vehicle collisions or for any cases where the motorcycle impacted a pedestrian, an animal or any other fixed objects.

The highest concentration of line-of-sight orientations was at 1 o'clock followed by 11 and 12 o'clock, with about 70% of the other vehicles being located between 11 o'clock and 1 o'clock. When the line-of-sight from MC to OV is in the 11-12-1 o' clock, the OV driver is seeing mainly the front end of the motorcycle.

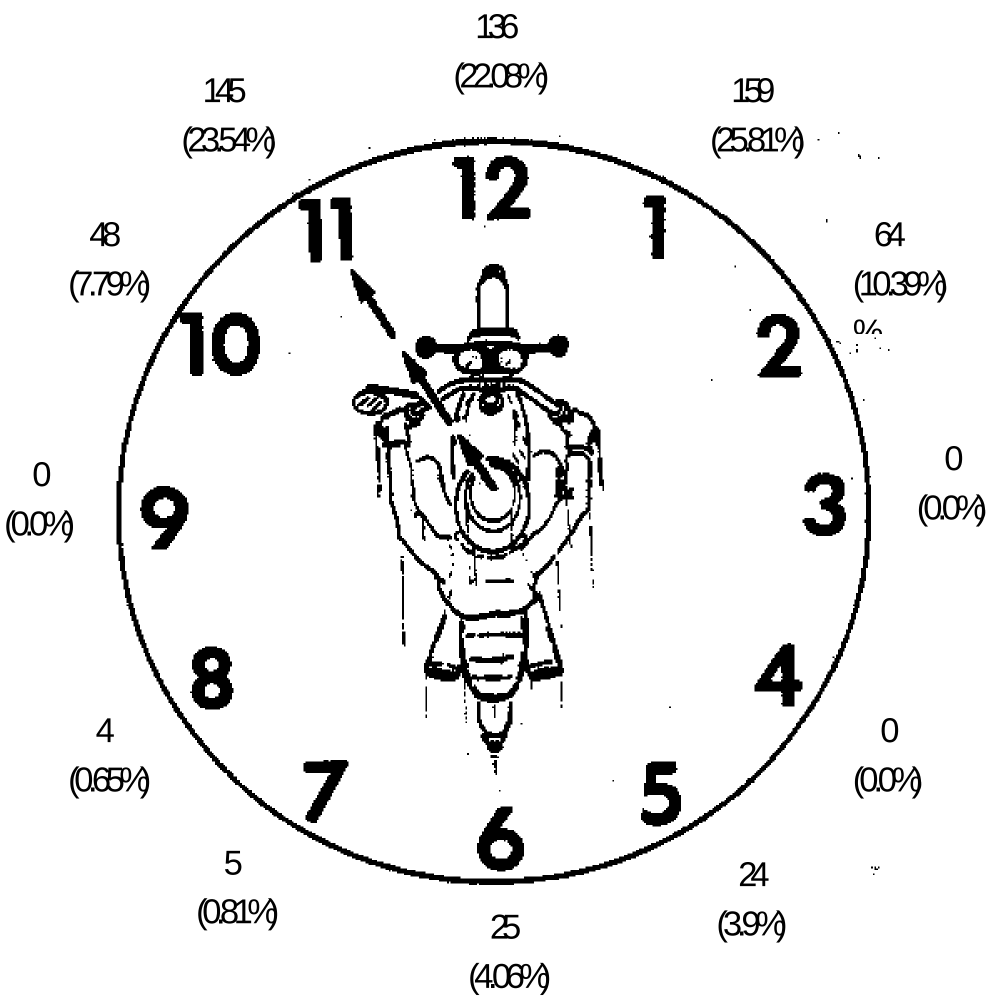

Figure 7.3.1: Motorcycle pre-crash line-of-sight to other vehicle

The 10,11,12,1 and 2 o'clock pre-crash line-of-sight to other vehicle accounted for about 76% (552 of 723) of the multiple vehicle crashes. If one excludes 104 cases in which motorcycles rear-ended the other vehicle, then the motorcycle was approaching the other vehicle in about 62% (448 of 723) of all multiple vehicle crashes. In other words, the other vehicle driver would see the front of the motorcycle in those cases.

The results indicated the existence of a potential conspicuity problem for the motorcycle. Given this high percentage of accidents, future countermeasures designed to improve motorcycle conspicuity should focus upon this frontal region of the motorcycle and the rider because this is the part most often presented to the driver of the other vehicle. Table 7.3.1 shows the distribution of pre-crash lines of sight by time of day.

Table 7.3.1: Motorcycle line-of-sight to OV and ambient lighting conditions

Line-of-sight	Ambient lighting condition						Total
	Daylight		Night		Dusk-Dawn		
	Freq	%	Freq	%	Freq	%	
1 o'clock	49	22.8	97	26.4	13	39.4	159
2 o'clock	22	10.2	39	10.6	3	9.1	64
3 o'clock	0	0.0	0	0.0	0	0.0	0
4 o'clock	3	1.4	1	0.3	2	6.1	6
5 o'clock	10	4.7	13	3.5	1	3.0	24
6 o'clock	11	5.1	13	3.5	1	3.0	25
7 o'clock	2	0.9	3	0.8	0	0.0	5
8 o'clock	1	0.5	3	0.8	0	0.0	4
9 o'clock	0	0.0	0	0.0	0	0.0	0
10 o'clock	18	8.4	27	7.3	3	9.1	48
11 o'clock	60	27.9	79	21.5	6	18.2	145
12 o'clock	39	18.1	93	25.3	4	12.1	136
Total	215		368		33		616

Nearly 60% of the multiple vehicle accidents occurred during the night. When the motorcycle headlamp was off at night, the rider's risk of getting into an accident in which the other vehicle violated the motorcycle right-of-way nearly doubled when compared to a daylight situation.

Table 7.3.2 focuses on night accidents involving five configurations where the other vehicle was crossing the path of an approaching motorcycle. For motorcycles with the headlamp off at night, the frequency of a crash involving one of those five configurations nearly doubled, from 22% for motorcycles with the headlamp on, to nearly 40% for motorcycles without a headlamp illuminated.

The data suggest that motorcycle headlamps should be on, particularly at the night and dusk-dawn, in order to maximize the visibility of the motorcycle along the 11, 12 and 1 o'clock lines-of-sight and to decrease the number of accidents that are caused by conspicuity problems.

Table 7.3.2: Headlamp on-off by accident configuration at night

Accident configuration	Code	Headlamp use at night			
		Off		On	
		Freq	%	Freq	%
OV turning left ahead of MC, paths perpendicular	4	0		3	
OV turning right ahead of MC, paths perpendicular	5	2		19	
MC and OV in opposite directions, OV turns across MC path	6,7	10		25	
OV U-turn or Y-turn ahead of MC	16	8		22	
All other MC – OV configurations		31		242	
Total		51		311	

7.4 Collision avoidance

Each one of the 723 on-scene, in-depth accident investigation cases was completely reconstructed and evaluated in order to determine the collision avoidance actions of the motorcycle rider and the other vehicle driver. Table 7.4.1 shows the evasive actions taken by the accident-involved motorcyclists.

In an accident-involved motorcycle, it was expected that this type of analysis would show collision avoidance problems that could be related to detection, decision or reaction failures. The most frequent collision avoidance actions taken were rear braking and swerving.

Table 7.4.1: Evasive action performed by rider

Evasive action taken	Motorcycle rider	
	Frequency	Percent
No evasive action	339	36.7
Use of horn	16	1.7
Flashing headlamp high beams	4	0.4
Rear braking	215	23.3
Front braking	116	12.6
Lane change	1	0.1
Swerve around hazard or obstacle	191	20.7
Lay-down, low side and slide	3	0.3
Jump or bail out	5	0.5
Braking, unknown which wheel(s)	32	3.5
Other	1	0.1
Unknown	1	0.1
Total	924	

Table 7.4.1 also shows that over one-third (37%) of the accident-involved motorcycle riders did not take any evasive action. There can be a variety of reasons that no evasive action was taken. One is that the accident occurs so fast that the rider has no time to take action. Alternatively, the rider may fail to detect a problem, or he may detect a problem too late to take any action, or he may decide to take no action. Some examples are as follows:

1. A rider stopped in traffic is rear-ended by an OV.

2. Another collision occurs immediately in front of the rider, shoving a vehicle into the motorcycle's path.

3. The motorcycle rider fails to notice oil spilled on a rain-slick roadway.

4. An OV runs a red light at an intersection, striking the motorcycle. Buildings obstruct the rider's view of the hazard until less than one second before impact.

5. A car coming from the opposite direction turns right slowly across the rider's path. The rider honks his horn and expects the other vehicle to stop, but it continues, striking the right side of the motorcycle.

6. A drunk rider runs off a right-hand curve without any apparent evasive action.

7. A rider changes lanes into the path of a faster-moving OV approaching from the rear.

Based on our analysis of each accident case, detection failures were the most frequent cause for a lack of evasive action. In some cases the rider failed to detect a plainly visible hazard (example 7 above), while in other cases (examples 3 & 4 above) it was impossible to detect the hazard. Decision failures (example 5) and reaction failures (example 6) were found to occur less frequently. There were 117 cases (31%) similar to examples 1 & 2 in which the riders took no collision avoidance action because of inadequate time. In other cases, a combination of decision and detection or reaction failures occurred. For example, if a rider decided to run a red light and failed to take evasive action before being struck by an OV, the decision to run the red light was coded as a decision failure, while the failure to see the other vehicle approaching from the left or right side was coded as a detection failure.

Reaction failures were usually coded for situations similar to example 6 above where the rider took no action before running off the road.

In Table 7.4.2, failures are listed as "strategic" or "impairment." "Impairment" failures were coded when the rider had been drinking, while "strategic" failures were coded for accident situations where no alcohol or drugs were involved. "Other" was usually coded when a rider had no chance to take any evasive action.

Table 7.4.2: Reason motorcycle rider took no collision avoidance action

Reason for no MC evasive action	Frequency	Percent
Strategic detection failure	110	25.5
Impairment detection failure	108	25.1
Strategic decision failure	48	11.1
Impairment decision failure	45	10.4
Strategic reaction failure	14	3.2
Impairment reaction failure	38	8.8
Other	64	14.8
Unknown	4	0.9
Total	431	

Evasive action evaluation

If the rider does take evasive action, his *choice* of evasive action may be correct or incorrect, and his *execution* of the evasive action may be correct or incorrect.

In this study, the standard of "correct" was set very high. One could call an evasive action the correct choice if it was an "appropriate" response to the situation, or one could say that the "correct" choice is the "best" response to the situation. For example, if a car pulls out of a driveway into the path of a motorcycle, rear-only braking could be considered an "appropriate" evasive response, but it was not considered the "best" response, as front-and-rear braking most often would be.

In a similar manner, "proper execution" was coded "yes" only if the rider showed highly skilled execution of whatever avoidance maneuver he or she chose. In other words, the rider could choose the wrong evasive action (such as swerving left when a swerve to the right would have been better), but if the rider executed the evasive action skillfully it would be coded as "proper execution." Also, if the rider executed the proper evasive action but waited too long before beginning evasive action, this was coded as improper action. An example would be a rider (or car driver) who saw a collision threat ahead, honked his horn and finally braked skillfully but too late to avoid a collision.

Of course, there were cases in which the rider took evasive action but so little time was available that no evasive action could possibly avoid a collision. Table 7.4.3 shows a cross-tabulation of the 379 cases in which both proper choice and proper execution of the evasive action were evaluated. Only one-third of riders who took evasive action (19% of the 723 cases) made the proper choice. About 39% of those who took evasive action (20% of the 723 cases) executed their chosen evasive action properly. Only 12% of those who took evasive action (6% of the 723 cases) chose the proper evasive action and executed it properly.

Table 7.4.3: Rider evasive action, proper choice by proper execution

Proper choice	Proper execution				Total	
	No		Yes			
	Frequency	%	Frequency	%	Frequency	%
No	143		102		245	
Yes	88		46		134	
Total	231		148		379	

The reason that each collision avoidance maneuver failed to prevent a collision was examined and the results are reported in Table 7.4.4.

Table 7.4.4: Reason collision avoidance did not prevent collision

Reason collision avoidance failed	Frequency	
Decision failure	148	38.7
Reaction failure	50	13.1
Inadequate time available	117	30.6
Loss of control	54	14.1
Other	12	3.1
Unknown	1	0.3
Total	382	

Evasive actions and time available for action

The most common reasons for unsuccessful avoidance were inadequate time and decision failures. In addition, most riders took no evasive action at all. In order to explore the relationship between time and avoidance failure in more detail, a cross-tabulation of the time from PE to impact compared to the type of avoidance failure was generated. The analysis shows that different failures clustered in different time distributions.

Two- thirds of the accidents (231 of 341) in which the rider took no evasive action fell in to the 0 - 2.0 second range of times from PE to impact. By comparison, the largest group of decision failures (88 of 148, or 60%) fell into the 1.0 - 3.0 time range (Table 7.4.5). Two-thirds of the accidents involving reaction failures (34 of 50) had times from PE to impact of 1.6 - 3.5 seconds. Over 80% of crashes that were coded "inadequate time to avoid" fell into the 0.5 - 2.5 second range. Finally, most crashes due to slide-out loss of control ranged 1.0 - 3.0 seconds from PE to impact.

Table 7.4.5: Evasive actions and time available for action

Time from PE to impact (seconds)	Reason motorcycle evasive action did not succeed				
	No evasive action	Decision failure	Reaction failure	Inadequate time	Loss of control
0.1- 1.0	111	11	2	19	5
1.1 – 1.5	68	28	3	36	9
1.6 – 2.0	52	26	9	30	8
2.1 – 2.5	27	18	7	13	5
2.6 – 3.0	28	16	11	5	9
3.1 – 3.5	13	8	7	2	1
3.6 – 4.0	10	13	2	4	2
> 4.0	5	16	5	5	2

Loss of control

About 20% of the accidents involved some form of motorcycle loss of control (Table 7.4.6). Sometimes the loss of control was the accident, other times the rider lost control while trying to avoid a collision.

Slide-outs and high-sides represented 40% of the loss of control situations identified in this study. They were usually due to errors of braking, most often skidding the rear wheel while trying to swerve. However, at least one case involved dangerously slippery pavement, with an oil spill on rain-wet asphalt. Over-braking of the front brakes typically caused the front wheel to lock up and this resulted in extremely fast fall to the pavement.

“Capsize” was defined as simply falling over the pavement. It usually occurred when the rider was too drunk and unable to control the motorcycle. There were also cases in which the rider fell asleep while riding and capsized. The motorcycle capsized in about 3.7% of all cases.

Running wide on a turn or running off the roadway accounted for over one-third of the loss of control accidents. It was commonly associated with alcohol. In fact, half of those cases in which an alcohol-involved rider lost control, it was by running off the road, compared to only 14% of non-drinkers who lost control. (Table 7.4.7).

The typical outcome of going off the road was a collision with some part of the environment, i.e. post, curb, trees, etc. Occasionally a motorcycle “ran off the road” by drifting into the other vehicle path and collide with an oncoming vehicle. The many fixed objects along the roadside – poles, trees, mailboxes, phone booths, planters, etc., were found to stop a tumbling rider immediately and cause severe injury.

Table 7.4.6: Motorcycle loss of control mode

Loss of control mode	Motorcycle rider	
	Frequency	Percent
No loss of control	581	80.4
Capsize/ fall over	27	3.7
Braking slide-out, low-side	53	7.3
Braking slide-out, high-side	4	0.6
Cornering slide-out high-side	1	0.1
Ran wide on turn, ran off road	51	7.1
Lost wheelie	1	0.1
End-over, reverse wheelie	1	0.1
Continuation	1	0.1
Other	1	0.1
Unknown	2	0.3
Total	723	

Table 7.4.7: Alcohol impairment and loss of control mode

Loss of control mode	No alcohol	Alcohol impairment			Total
		No	Yes	Unknown	
No loss of control	373	30	175	3	581
Capsize, fall over	14	2	11	0	27
Braking slide-out, low-side	29	5	19	0	53
Braking slide-out, high-side	3	0	1	0	4
Cornering slide-out high-side	0	0	1	0	1
Ran wide on turn	8	0	41	2	51
Loss wheelie	1	0	0	0	1
End-over, reverse wheelie	0	0	1	0	1
Continuation	0	0	1	0	1
Other	1	0	0	0	1
Unknown	1	0	1	0	2
Total	430	37	251	5	723

Rider position on motorcycle just before impact

All but four riders were in the normal riding position. In one case a rider was lying on the seat with both feet extended to the rear of the motorcycle just before impact (Table 7.4.8). In two cases the riders attempted to "jump or bail out" from the imminent collision. Occasionally, riders commented that they lifted their leg to avoid the impact with the other vehicle, but there was no clear documentation to support this comment.

Table 7.4.8: Riding position on motorcycle

Riding position at time of crash	Frequency	
Normal seating position	719	99.4
Dismounting, jumping to side	2	0.3
Abnormal seating position	1	0.1
Other	1	0.1
Total	723	

Passenger position on motorcycle just before impact

The majority of the accident-involved passengers (95%) were in the normal riding position behind the motorcycle rider at the time of the collision. In three cases the passenger was seated in front of the rider. There were 13 cases in which the passenger was riding with both legs on the left side of the motorcycle and one case in which the passenger was riding with both legs on the right side of the motorcycle. In cases that the motorcycle held more than 1 passenger, the second passengers were either in front of the rider (3 cases) or behind the first passenger (8 cases) as shown in Table 7.4.9.

Table 7.4.9: Passenger riding position on motorcycle

Passenger position at time of crash	Frequency	
Immediately behind motorcycle rider	226	
Immediately in front of motorcycle rider	3	
Behind passenger in location number 1	8	
Total	237	

Calculated time from precipitating event (PE) to impact

The time available to the motorcycle rider for collision avoidance usually begins with the initiation of the PE and terminates with the impact.

Table 7.4.10 shows the distribution of the time from the precipitating event to impact for all 723 on-scene, in-depth accident investigation cases. The median time was found to be 1.9 seconds and the mean value was 2.1 seconds. As shown in Table 7.4.4, about 30% of failed collision avoidance was simply due to a lack of time for successful evasive action.

The very short times from PE to impact (i.e., less than 1 second) often occurred when the rider ran off the road, failing to make a last-second steering input that might have avoided running off the road.

Table 7.4.10: Time from precipitating event to impact

Time (sec)	Frequency	
0 - 0.5	71	9.8
0.6 – 1.0	79	10.9
1.1 – 1.5	148	20.5
1.6 – 2.0	126	17.4
2.1 – 2.5	71	9.8
2.6 – 3.0	69	9.5
3.1 – 3.5	31	4.3
3.6 – 4.0	32	4.4
4.1 – 4.5	22	3.0
4.6 – 5.0	5	0.7
> 5.0	7	1.0
Unknown	62	8.6
Total	723	

Collision contact on the motorcycle

In about 30% of cases, the collision contact was located at the center front of the motorcycle, which includes the front tyre and wheel, fender and forks (Table 7.4.11). Another 22% and 19% first collision contacts were at the left and right front of the accident-involved motorcycle. When these three configurations are collapsed, a total of about 70% of the motorcycle collision contacts were predominately frontal impact.

Table 7.4.11: Motorcycle first collision contact

First collision contact on MC	Frequency	
Center front	208	28.8
Center rear	18	2.5
Left center	71	9.8
Left front	160	22.1
Left rear	15	2.1
Right center	62	8.6
Right front	140	19.4
Right rear	25	3.5
Top center	1	0.1
Top front	7	1.0
Undercarriage center	5	0.7
Undercarriage front	4	0.6
Undercarriage right	2	0.3
Unknown	5	0.7
Total	723	

Figure 7.4.1 shows the distribution of first collision contacts for the 723 on-scene, in-depth accident investigation cases.

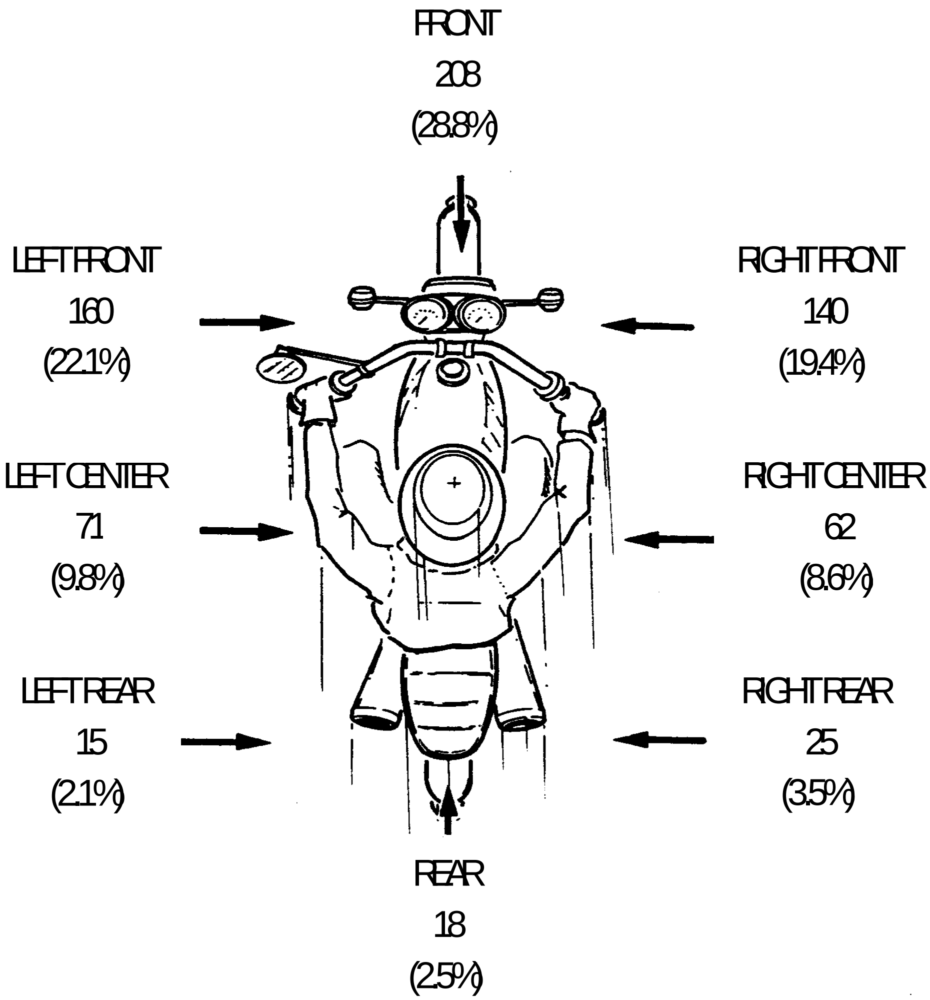

Figure 7.4.1: First collision contact on the motorcycle

7.5 Post-crash motion of the motorcycle

The majority of these accident-involved motorcycles skidded and slid from point-of impact (POI) to point of rest (POR) accounting for 46% of all accidents investigated. Table 7.5.1 shows the post-crash motion of the motorcycle for 723 on-scene, in-depth accident cases.

Table 7.5.1: Motorcycle post-crash motions

Motorcycle post-crash motions	Frequency	
Stopped at point of impact (POI)	60	8.3
Stopped within 2 m of POI	101	14.0
Rolled on wheels from POI to POR	17	2.4
Rolled from POI, impacted object at POR	25	3.5
Vehicle rollover from POI to POR	1	0.1
Skidded, slid from POI to POR	330	45.6
Skidded, slid from POI, impacted object at POR	66	9.1
Vaulted above ride height from POI, rolled to POR	1	0.1
Vaulted above ride height, impacted object at POR	2	0.3
Run over at POI	3	0.4
Run over, dragged from POI to POR	12	1.7
Landed on the vehicle; carried to POR	3	0.4
Engaged with OV, POR same as OV POR	16	2.2
Vehicles did not separate	7	1.0
Spun or yawed, sliding from POI to POR	48	6.6
Other	31	4.3
Total	723	

Post-crash motion of motorcycle rider and passenger

About one-third (35%) of riders and 20% of passengers did not separate from the motorcycle after the crash (Table 7.5.2). About 18% of them slid to the point of rest. A similar proportion (18%) stopped at or very close to the point of impact, which can create very dangerous decelerations when crash speeds are high. Eight riders, but no passengers, were run over.

Table 7.5.2: Rider and passenger post-crash motions

Rider or passenger post-crash motions	Rider		Passengers	
	Frequency	%	Frequency	%
Stopped at point of impact(POI)	47	6.5	7	3.0
Stopped within 2 m of POI	81	11.2	37	15.6
Tumbled and rolled from POI to POR	75	10.4	27	11.4
Tumbled from POI, hit object at POR	9	1.2	2	0.8
Skidded, slid from POI to POR	120	16.6	52	21.9
Slid from POI, hit other object at POR	18	2.5	4	1.7
Vaulted above ride height, rolled to POR	15	2.1	4	1.7
Vault above ride height, then slid to POR	29	4.0	14	5.9
Vault above ride height, hit object at POR	15	2.1	7	3.0
Run over at POI	4	0.6	0	0.0
Run over, dragged from POI to POR	4	0.6	0	0.0
Landed on the vehicle; carried to POR	22	3.0	6	2.5
Entrapped with OV, POR same as OV	5	0.7	0	0.0
Did not separate from motorcycle	255	35.3	49	20.7
Departed scene, hit-and-run	2	0.3	15	6.3
Other	21	2.9	12	5.1
Unknown	1	0.1	1	0.4
Total	723		237	

Distance from point of impact to rider/passenger point of rest

Table 7.5.3 shows the distance between POI and POR of the accident-involved riders and passenger. About one-fourth of the riders and passengers came to rest 2 metres or less from the POI. The median distance was 4.6 metres for the riders and 4.2 metres for the passengers.

Table 7.5.3: Rider and passenger distance from POI to point of rest

Distance from POI to POR (m.)	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Stopped at POI	55	7.6	11	4.6
0.6 - 2.0	145	20.1	51	21.5
2.1 - 4.0	130	18.0	41	17.3
4.1 - 6.0	93	12.9	35	14.8
6.1 - 8.0	59	8.2	18	7.6
8.1 - 10.0	53	7.3	11	4.6
10.1 - 15.0	73	10.1	23	9.7
15.1 - 20.0	41	5.7	7	3.0
> 20.0	54	7.5	12	5.1
Unknown	20	2.8	28	11.8
Total	723		237	

7.6 Other vehicle kinematics

About two-thirds of the accident-involved other vehicles were moving in a straight line before the precipitating event. About one in seven were stopped in traffic, and another 7% were parked at the roadside. Only about 2% of other vehicles were traveling the wrong way just prior to the precipitating event – about half as often as motorcycles. Table 7.6.1 shows the other vehicle pre-crash motions before and after the precipitating event.

Table 7.6.1: OV pre-crash motion before and after precipitating event

Other vehicle pre-crash motion	Before PE		After PE	
	Frequency	%	Frequency	%
Stopped in traffic, speed is zero	104	14.9	60	8.6
Moving straight, constant speed	267	38.4	120	17.2
Moving straight, throttle off	94	13.5	6	0.9
Moving straight, braking	61	8.8	103	14.8
Moving straight, accelerating	23	3.3	20	2.9
Turning right, constant speed	5	0.7	58	8.3
Turning right, throttle off	1	0.1	4	0.6
Turning right, braking	4	0.6	16	2.3
Turning right, accelerating	8	1.1	50	7.2
Turning left, constant speed	5	0.7	11	1.6
Turning left, throttle off	1	0.1	3	0.4
Turning left, braking	1	0.1	13	1.9
Turning left, accelerating	5	0.7	2	0.3
Stopped at roadside, or parked	49	7.3	42	6.3
Backing up, in a straight line	1	0.1	52	7.5
Making U-turn right	3	0.4	1	0.1
Changing lanes to left	4	0.6	30	4.3
Changing lanes to right	6	0.9	27	3.9
Entering traffic from left shoulder, curb	4	0.6	3	0.4
Passing on right	9	1.3	3	0.4
Passing on left	1	0.1	1	0.1
Crossing opposing lanes of traffic	0	0.0	1	0.1
Wrong way, against opposing traffic	14	2.0	27	3.9
Lane splitting, longitudinal motion only	9	1.3	7	1.0
Lane-splitting, lateral motion only	1	0.1	2	0.3
Lane-splitting, longitudinal and lateral	4	0.6	3	0.4
Other	11	1.3	30	4.0
Unknown	1	0.1	0	0.0
Total	696		696	

7.7 Other vehicle speed

Table 7.7.1 shows the distribution of OV pre-crash and crash speeds. The median pre-crash speed was 27 km/hr and the median impact speed was 21 km/hr. The pre-crash speed was not known in 75 cases (10.8%) due to insufficient physical evidence, or because of a hit-and-run situation. The relationship between the pre-crash and crash speeds is illustrated in Figure 7.7.1.

About 7% of accident-involved vehicles showed no collision contact and approximately one-fifth of the cases occurred when the other vehicle was either stopped waiting in traffic or parked at the roadside.

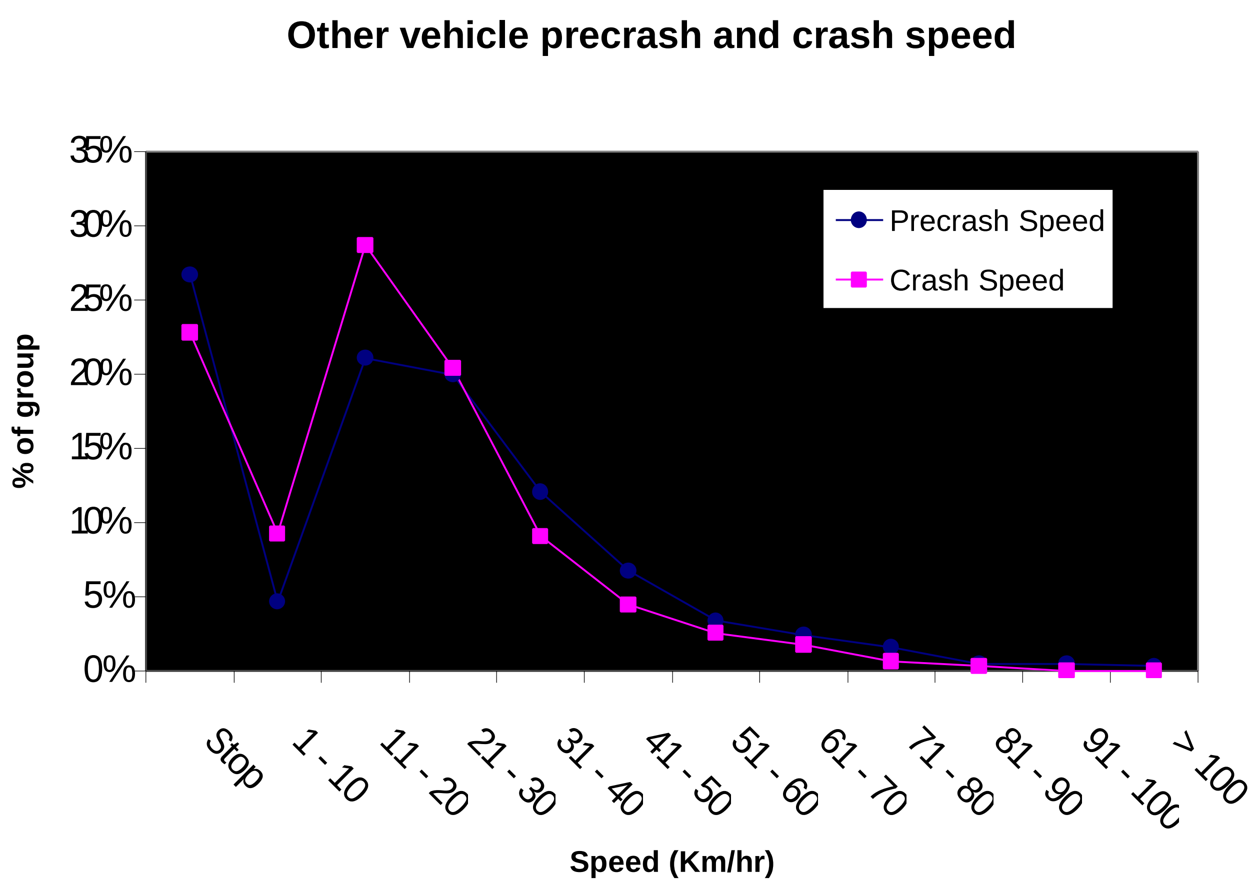

Figure 7.7.1: Percent distribution of OV pre-crash and crash speeds.

Table 7.7.1: Other vehicle pre-crash and crash speeds

Speed (km/hr)	OV pre-crash speed		OV crash speed	
	Frequency	Percent	Frequency	Percent
0	166	23.9	143	20.5
1 - 10	29	4.2	58	8.3
11 – 20	131	18.8	180	25.9
21 – 30	124	17.8	128	18.4
31 – 40	75	10.8	57	8.2
41 – 50	42	6.0	28	4.0
51 – 60	21	3.0	16	2.3
61 – 70	15	2.2	11	1.6
71 – 80	10	1.4	4	0.6
81 – 90	3	0.4	2	0.3
91 – 100	3	0.4	0	0.0
> 100	2	0.3	0	0.0
No collision contact	-	-	50	7.2
Unknown	75	10.8	19	2.7
Total	696		696	

7.8 Pre-crash line-of-sight from the other vehicle to the motorcycle

The distribution of the pre-crash lines-of-sight from the other vehicle driver to the accident-involved motorcycle is shown in Table 7.8.1. Pre-crash line-of-sight between 10 and 2 o'clock from the other vehicle to the motorcycle accounted for 57% of multiple vehicle crashes. Once again, the data suggest that the motorcycle frontal conspicuity is an important issue in motorcycle accidents. The cross-tabulation of accident configuration and pre-crash line of sight where OV must cross the path of MC suggests that, at night, about one-third of accident-involved motorcycles did not operate the headlamp.

Table 7.8.1: Pre-crash line-of-sight from other vehicle to motorcycle

Line-of-sight from OV to motorcycle	Frequency	
1 o'clock	133	19.1
2 o'clock	85	12.2
3 o'clock	1	0.1
4 o'clock	14	2.0
5 o'clock	100	14.4
6 o'clock	128	18.4
7 o'clock	55	7.9
8 o'clock	3	0.4
10 o'clock	47	6.8
11 o'clock	80	11.5
12 o'clock	50	7.2
Total	696	

7.9 Other vehicle collision avoidance

Table 7.9.1 shows the collision avoidance action taken by the other vehicle driver. Approximately two-thirds of the drivers did nothing to avoid the collision, which may reflect the fact that nearly half of these drivers failed to detect the motorcycle as shown in Table 7.9.2. Of course, no evasive action occurred in 40 cases when the other vehicle was parked or abandoned. About one-fourth of the drivers used braking with or without steering as the collision avoidance action.

Table 7.9.1: Collision avoidance performed by other vehicle operators

Evasive action taken	Frequency	
No driver	40	5.6
No evasive action, continuation	466	65.3
Braking	117	16.4
Steering	29	4.1
Braking and steering	30	4.2
Honk horn or flash high beams	12	1.7
Other	1	0.1
Unknown	19	2.7
Total	714	

Table 7.9.2: Other vehicle, reason for lack of collision avoidance

Reasons for no evasive action	Frequency	
Strategic detection failure	227	43.2
Impairment detection failure	24	4.6
Strategic decision failure	53	10.1
Impairment decision failure	11	2.1
Strategic reaction failure	2	0.4
Impairment reaction failure	2	0.4
Other	181	34.5
Unknown	25	4.8
Total	525	

The other vehicle driver failure to avoid the collision was largely due to inadequate time available (see Table 7.9.3). When evasive action was taken, the other vehicle drivers chose the proper actions much more often than motorcyclists (70% compared to 35%) and they were more likely to execute it properly (59% compared to 39%.)

Table 7.9.3: Evaluation of other vehicle driver collision avoidance

Driver collision avoidance performance	Frequency	
Evasive action proper for situation		
Not applicable	523	72.3
No	51	7.1
Yes	119	16.5
Unknown	3	0.4
Evasive action properly executed		
Not applicable	523	72.3
No	68	9.4
Yes	102	14.1
Unknown	3	0.4
Failed collision avoidance due to		
Not applicable	523	72.3
Decision failure	37	5.1
Reaction failure	25	3.5
Inadequate time available	88	12.2
Loss of control	2	0.3
Other	18	2.5
Unknown	3	0.4
Total	723	

The reasons for this are possibly related to the relatively complexity of motorcycle controls or to the level of training and experience of automobile drivers. In a car, the driver can quickly perform two very simple collision avoidance maneuvers: turning the wheel to swerve or pressing on the single brake pedal in order to cause high level of braking force at all wheels. Neither swerving nor braking a car requires great skill or sophistication, and even if the tyres skid, the car will not fall over on its side, as a motorcycle is likely to do. In addition, cars are so big that swerving, in many cases, does not strongly affect their location in the roadway.

In contrast, motorcycles have separate controls for front and rear brakes, which must be applied vigorously, but not too hard, to avoid lock-up and a possible fall. Swerving to one side requires counter-steering, which adds yet another level of complexity to the emergency avoidance action.

First collision contact on other vehicle

Table 7.9.4 shows the common frontal collision contact area with the motorcycle. (See Appendix for complete details on collision contact.)

Table 7.9.4: Points of first collision contact on the other vehicle

Collision contact	Code	Frequency	
Automobile, Van, Bus, Truck			
Front bumper	F01X	97	13.9
Front corner	F04X	21	3.0
Side of front bumper	S01X	30	4.3
Side corner	S02X	12	1.7
Front mudguard fender	S03X	24	3.4
Front mudguard, wheel house	S04X	9	1.3
Front tyre	S05X	20	2.9
Front door, front	S10X	25	3.6
Front door, rear	S11X	14	2.0
Motorcycle as an OV			
Left front	MCLF	22	3.2
Right front	MCRF	27	3.9
Center front	MCCF	41	5.9
Tuk-Tuk			
Right front	TTFR	2	0.3
Left front	TTFL	2	0.3

7.10 Other vehicle post-crash motion

The OV most often stopped very close to the point of impact: about one-third stopped at or within 2 metres of POI. Table 7.10.1 shows the OV post-crash motion. OV drivers fled the scene in nearly one of every fourteen accidents, sometimes leaving the OV behind. There were 48 drivers who were coded as having left scene immediately because there was no collision contact.

Table 7.10.1: Other vehicle post-crash motion

Other vehicle post-crash motion	Frequency	
Stopped at point of impact (POI)	140	20.1
Stopped within 2 m of POI	107	15.4
Rolled on wheels from POI to POR	178	25.6
Rolled on wheel s from POI, impacted object at POR	14	2.0
Vehicle rollover from POI to POR	3	0.4
Skidded, slid from POI to POR	114	16.4
Skidded, slid from POI, impacted object at POR	14	2.0
Vehicles did not separate	16	2.3
Spun or yawed, sliding from POI to POR	6	0.9
Hit and run	34	4.9
Driver departed scene but other vehicle still at scene	13	1.9
Other	56	8.0
Unknown	1	0.1
Total	696	

Distance from point of impact to other vehicle point of rest

About 40% of the cases investigated found that the distance from POI to POR was 2 metres or less. The median distance of the other vehicle POI to POR was 1.7 m. Table 7.10.2 shows the distribution of distance between the POI and other vehicle POR.

Table 7.10.2: Distance point of impact to other vehicle point of rest

Distance from POI to OV POR (m.)	Frequency	
Stop at POI	160	23.0
0.6 - 2.0	125	18.0
2.1 - 4.0	72	10.3
4.1 - 6.0	39	5.6
6.1 - 8.0	20	2.9
8.1 - 10.0	17	2.4
10.1 - 15.0	38	5.5
15.1 - 20.0	17	2.4
> 20.0	26	3.7
OV no collision contact	48	6.9
Unknown	134	19.3
Total	696	

8.0 Human Factors

The data presented in this chapter describe the general characteristics of the motorcycle rider, passenger and the other vehicle driver in the Bangkok accident population. Such variables as age, gender, riding or driving license, training, education, occupation, height, weight, riding or driving experience, previous traffic violation, previous traffic accident trip plan, frequency of the road use are presented. Certain data that relate specifically to the collision are also included, such as alcohol involvement, stress, attention to riding and driving, rider unsafe act, rider position, passenger location on motorcycle, and recommended countermeasures.

8.1 Rider, passenger and other vehicle driver general characteristics

Age

The youngest motorcycle rider was 12 years old; the oldest was 58. The median age was 27 years. About half of all riders were 21 to 30 years and 20% were under the age of 21 years.

Passengers generally tended to be younger than riders. The youngest passenger was 4 years old; the oldest was 67 and the median age was 22 years. Five passengers were below the age of 10 years. About one-third of passengers were 11 to 20 years old.

By comparison, the other vehicle drivers tended to be older than both riders and passengers. Their median age was 34 years (seven years older than riders, and 12 years older than passengers). About half of the other vehicle drivers were 21 to 40 years. The youngest was 14 years old and the oldest was 78 years.

The age distribution for all three groups is shown in Table 8.1.1.

Table 8.1.1: Age of motorcycle rider, passengers and other vehicle driver

Age (years)	MC riders		MC passengers		OV drivers	
	Frequency	%	Frequency	%	Frequency	%
0 - 10	0	0.0	5	2.1	0	0.0
11 – 20	142	19.6	84	35.4	40	6.1
21 – 30	355	49.1	98	41.4	204	31.1
31 – 40	170	23.5	29	12.2	166	25.3
41 – 50	51	7.1	13	5.5	110	16.8
51 – 60	3	0.4	2	0.8	24	3.7
> 60	0	0.0	0	0.0	5	0.8
Unknown	2	0.3	6	2.5	107	16.3
Total	723		237		656	

Table 8.1.2 shows the distribution of motorcycle rider age in fatal and non-fatal accidents. The median age of the fatally injured riders was 26 years. The youngest rider in a fatal accident was 14 years and the oldest was 46 years. About half of fatal cases were 21 to 30 years old.

Table 8.1.2: Rider's age in fatal and non-fatal accidents

Rider's age (years)	Fatal injuries involved		Total
	No	Yes	
11 – 20	135	7	142
21 – 30	329	26	355
31 – 40	156	14	170
41 – 50	49	2	51
51 – 60	3	0	3
Unknown	1	1	2
Total	727	50	723

Gender

Male motorcycle riders accounted for 96% of all cases investigated and out-numbered females by a ratio of 23-to-1. By contrast, other vehicle drivers were mostly male (88%), but they out-numbered females by only 7 to 1. Motorcycle passengers were much more evenly divided. Table 8.1.3 shows the gender distribution of motorcycle riders and passengers and the other vehicle drivers for 723 cases in the Bangkok sampling region.

Table 8.1.3: Rider, passenger and other vehicle driver gender distribution

Gender	MC rider		MC passengers		OV driver	
	Frequency	%	Frequency	%	Frequency	%
Male	693		141		500	
Female	30		96		71	
Unknown	0		0		85	
Total	723		237		656	

Height and weight

Table 8.1.4 shows the height distribution for the accident-involved motorcycle riders for all 723 on-scene, in-depth accident investigation cases collected in Bangkok. Rider height varied from 140 cm to 194 cm with a median height of 169 cm. Passenger height varied from 94 to 180 cm with a median height of 165 cm. The shorter passengers were predominantly children. Other vehicle driver heights were essentially identical to the motorcycle riders, with a range from 140 cm. to 195 cm. and a median height of 167 cm. The data are also shown in Table 8.1.4.

Table 8.1.4: Rider, passenger and other vehicle driver height distribution

Height (cm)	MC rider		MC passengers		OV drivers	
	Frequency	%	Frequency	%	Frequency	%
0 - 140	0	0.0	2	0.8	0	0.0
0 – 145	1	0.1	1	0.4	1	0.2
146 – 150	2	0.3	7	3.0	5	0.8
151 – 155	12	1.7	21	8.9	22	3.4
156 – 160	67	9.3	62	26.2	60	9.1
161 – 165	172	23.8	66	27.8	146	22.3
166 – 170	269	37.2	57	24.1	194	29.6
171 – 175	163	22.5	15	6.3	91	13.9
176 – 180	29	4.0	1	0.4	18	2.7
> 180	3	0.4	0	0.0	3	0.5
Unknown	5	0.7	5	2.1	116	17.7
Total	723		237		656	

Motorcycle rider weight ranged from 40 to 95 kilograms with a median weight of 60 kilograms. The median weight for the male riders was also 60 kilograms (because males represented 96% of the total number of motorcycle riders) and the median weight for the female riders was 50 kilograms. Passenger weights ranged from 20 to 80 kilograms, with a median weight of 55 kilograms. It is important to note that about 40% of passengers were female. Other vehicle driver weights were nearly identical to those of motorcycle riders, varying from 42 to 95 kilograms with a median weight of 60 kilograms. Table 8.1.5 shows the weight distribution for accident-involved riders, passengers and OV drivers.

Table 8.1.5: Rider, passenger and other vehicle driver weight distribution

Weight (kg)	MC rider		MC passenger		OV driver	
	Frequency	%	Frequency	%	Frequency	%
11 – 20	0	0.0	1	0.4	0	0.0
21 - 30	0	0.0	0	0.0	0	0.0
31 – 40	1	0.1	11	4.6	0	0.0
41 – 50	93	12.9	84	35.4	90	13.7
51 – 60	273	37.8	87	36.7	220	33.5
61 – 70	241	33.3	43	18.1	179	27.3
71 – 80	96	13.3	5	2.1	42	6.4
> 80	14	1.9	0	0.0	8	1.2
Unknown	5	0.7	6	2.5	117	17.8
Total	723	100.0	237	100.0	656	100.0

Occupations

Messengers and motorcycle taxi riders were the largest group of accident-involved riders (33.2%), followed by service workers (26%) and unskilled workers (15.4%).

Motorcycle passengers tended to cluster in the same few occupational categories as riders, although their distribution was somewhat different. Passengers were twice as likely as riders to be full-time students (18% vs. 8%).

Other vehicle drivers were more widely spread in occupations. Those who were drivers were often taxi or bus drivers. The distribution of occupations is shown in Table 8.1.6.

Table 8.1.6: Occupations of rider, passenger and other vehicle driver

Rider occupation	MC rider		MC passenger		OV driver	
	Freq	%	Freq	%	Freq	%
Unemployed > 1 month	36	5.0	13	5.5	7	1.1
Senior officials, managers	6	0.8	1	0.4	36	5.5
Professionals	3	0.4	0	0.0	13	2.0
Technicians	0	0.0	0	0.0	9	1.4
Clerical, office workers	38	5.3	20	8.4	71	10.8
Service, shop and sales	188	26.0	71	30.0	92	14.0
Craft and related worker	8	1.1	4	1.7	2	0.3
Transport eqpt driver	240	33.2	15	6.3	237	36.1
Factory workers	2	0.3	0	0.0	1	0.2
Unskilled laborers	111	15.4	54	22.8	21	3.2
Housewife, homemaker	0	0.0	5	2.1	4	0.6
Military, active duty	21	2.9	2	0.8	18	2.7
Student, full time	58	8.0	42	17.7	45	6.9
Retired, gov't or military	0	0.0	0	0.0	3	0.5
Other	1	0.1	0	0.0	1	0.2
Unknown	11	1.5	10	4.2	96	14.6
Total	723		237		656	

Education

The great majority of motorcycle riders in these accidents had a high school degree or less. In fact, nine years was the median number of years of formal schooling reported by riders and passengers. Other vehicle drivers had, on average, more education. Two-thirds of other vehicle drivers whose education was known had a high school education or less, but more than one-fourth had graduated from college. Other vehicle drivers had an average of 12 years formal schooling. The education background of the accident-involved riders, passengers and other vehicle drivers is shown in Table 8.1.7.

Table 8.1.7: Educational status of rider, passenger and other vehicle driver

Educational status	MC rider		MC passenger		OV driver	
	Freq	%	Freq	%	Freq	%
No formal schooling	0	0.0	2	0.8	0	0.0
High school or less	603	83.4	190	80.2	334	50.9
Partial college	24	3.3	14	5.9	31	4.7
Technical school graduate	24	3.3	5	2.1	11	1.7
College/university graduate	23	3.2	5	2.1	128	19.5
Advanced degree	1	0.1	0	0.0	9	1.4
Unknown	48	6.6	21	8.9	143	21.8
Total	723		237		656	

8.2 Rider licensing and training

License qualification

Over three-fourths of motorcycle riders had a motorcycle license. Only about one in six riders had no license at all. Table 8.2.1 shows the type of licenses held by the accident-involved motorcycle riders.

Table 8.2.1: Rider's license qualification

License type	Frequency	
No license held	126	17.4
Learner's permit, only	19	2.6
Motorcycle license	565	78.1
Automobile license	1	0.1
License to transport people	1	0.1
Unknown	11	1.5
Total	723	

Rider training

Approximately 90% of accident-involved riders were self-taught (Table 8.2.2). Most of the other riders were taught by family or friends. Only one single rider reported having any formal motorcycle training.

The lack of training means that most riders are operating a motorcycle in traffic with no clear idea or knowledge of the defensive driving strategies and collision avoidance skills that could save their lives.

Table 8.2.2: Rider motorcycle training

Rider training	Frequency	
Self taught	635	87.8
Taught by friends or family	56	7.7
Special mandatory motorcycle training	1	0.1
Unknown	31	4.3
Total	723	

8.3 Rider motorcycling experience

Overall riding experience

Most motorcycle riders claimed to have over seven years of riding experience on various motorcycles. In fact, the median reported experience was 8 years. Only about one in 40 said they had less than one year or riding experience, and one in 25 riders said they had less than two years of riding experience. The data are shown in Table 8.3.1.

Experience on the accident-involved motorcycle was usually less than experience on all motorcycles. Only 6% of the riders had less than two weeks experience, although about one-fourth had less than six month's of riding on the accident motorcycle. About half of the riders claimed to have experience in the 1 to 3 year range.

Table 8.3.1: Motorcycle riding experience

Riding experience (months)	All motorcycles		Accident motorcycle	
	Frequency	Percent	Frequency	Percent
< 1	0	0.0	43	5.9
1 – 6	2	0.3	131	18.1
7 – 12	15	2.1	98	13.6
13 – 24	40	5.5	148	20.5
25 – 36	39	5.4	107	14.8
37 – 48	37	5.1	62	8.6
49 – 60	84	11.6	53	7.3
61 – 72	42	5.8	14	1.9
73 – 84	40	5.5	17	2.4
> 84	395	54.6	18	2.5
Unknown	29	4.0	32	4.4
Total	723		723	

Ownership of the accident motorcycle

Most accident-involved riders were the registered owner of the motorcycle they crashed. Approximately one-fourth of the accident-involved motorcycles were operated with consent of the owner. The "consenting owner" was usually a parent, friend or employer of the rider. The data are shown in Table 8.3.2.

Table 8.3.2: Owner of the accident motorcycle

Registered owner	Frequency	
Motorcycle rider	518	71.6
Motorcycle passenger	8	1.1
Operated with consent of owner	189	26.1
Stolen	1	0.1
Other	1	0.1
Unknown	6	0.8
Total	723	

Motorcycle use patterns

Approximately 80% of the riders claimed to ride daily, implying frequent use of the motorcycle. Many riders indicated that they depend upon the motorcycle as their major means of transportation. Table 8.3.3 shows the distribution of the number of days per year that the accident-involved rider used his or her motorcycle.

Table 8.3.3: Days per year riding motorcycle

Days riding per year	Frequency	
0 – 50	5	0.7
51 – 100	16	2.2
101 – 150	26	3.6
151 – 200	19	2.6
201 – 250	6	0.8
251 – 300	32	4.4
301 – 365	589	81.5
Unknown	30	4.1
Total	723	

The median distance traveled was 10,000 kilometres per year. About 60% of riders said they rode 3,000 to 12,000 kilometres each year. Table 8.3.4 shows the distance traveled annually by the accident-involved riders.

Table 8.3.4: Distance rider rides a motorcycle per year

Distance ridden per year (km)	Frequency	
1 – 3000	58	8.0
3001 – 6000	112	15.5
6001 – 9000	93	12.9
9001 – 12000	161	22.3
12001 – 15000	53	7.3
15001 – 18000	26	3.6
18001 – 21000	39	5.4
> 21000	62	8.6
Unknown	119	16.5
Total	723	

Riders were asked to estimate what proportion of their total vehicle operation was divided between driving a vehicle other than a motorcycle and motorcycle-recreational and motorcycle-basic transportation uses. In other words, if a rider said he drove a car 10% of the time and his motorcycle use was evenly divided between basic transportation (going to work, market, visiting friends) and recreational use (riding for enjoyment, going to recreational activities, etc.), then his non-motorcycle usage was coded as 10%, basic transportation 45% and recreation 45%, for a total of 100%.

Table 8.3.5 shows the average of estimates of motorcycle on non-motorcycle percent use as reported by the accident-involved riders. Basic transportation accounted for 86% of all motorcycle use, recreational use of the motorcycle accounted for 13.7% of all motorcycle use and only 0.3% did not use. Younger riders tended to use the motorcycle for both recreation and basic transportation.

Table 8.3.5: Vehicle use patterns

Vehicle use	Average percent of total time
Non-motorcycle	0.3
Recreation	13.7
Basic transportation	86.0
Total	100.0

8.4 Experience carrying passengers and cargo

Approximately two-thirds of the accident investigation cases involved only a rider without passengers. Of those 227 cases where a passenger was involved, nearly half the riders said they had a moderate amount of passenger-carrying experience. About 20% said they had very little experience. Most of those with extensive experience were motorcycle taxi riders (58%). Table 8.4.1 shows the rider's experience carrying passengers on the motorcycle.

Table 8.4.1: Experience carrying passengers

Passenger carrying experience	Frequency	
Not applicable, no passenger	496	68.6
Never before carried passengers	1	0.1
Very little experience	44	6.1
Moderate experience	104	14.4
Extensive experience	67	9.3
Unknown	11	1.5
Total	723	

Riding experience with similar cargo

Riders who were carrying some sort of luggage or cargo were asked about their previous experience carrying similar loads. Of the 76 riders who carried cargo when they crashed, only 13 (17%) said they seldom carried such a load. Most who carried a cargo were very experienced at it, as shown in Table 8.4.2.

Table 8.4.2: Rider experience with similar cargo/luggage

Experience with similar cargo	Frequency	
Not applicable, no cargo/luggage	647	
Seldom carries similar cargo/luggage	13	
Frequently carries similar cargo/luggage	24	
Always carries similar cargo/luggage	39	
Total	723	

Eight cases were reported in which the cargo/luggage either directly impacted another vehicle or interfered with control and therefore contributed to the accident causation (Table 8.4.3).

Table 8.4.3: Cargo/luggage contribution to accident causation

Contribution of cargo/luggage	Frequency	
Not applicable, no cargo/luggage	647	
No contribution	68	
Interfered with controls, prevented evasive action	5	
Other	3	
Total	723	

8.5 Rider's prior violation and accident experience

Approximately 90% of the accident-involved riders claimed to have no traffic citations in the previous five years. Because law enforcement records were not centralized, rider statements could not be verified. Table 8.5.1 reports what motorcycle riders said in their interviews.

Tables 8.5.1 also shows the previous motorcycle and non-motorcycle accident experience reported by riders for the five years prior to the subject accident. Their statements suggest that the riders have had more accidents than traffic citations: 210 riders reported at least one previous motorcycle traffic accident. Only 13 riders said they had had a previous non-motorcycle traffic accident. Among the fatal cases, the previous accident experience was unknown in 26 cases and 15 of the 50 (30%) had had at least one previous accident.

Table 8.5.1: Rider traffic violations in the last five years

Prior citations & accidents	Traffic citations		Motorcycle accidents		Non-motorcycle accidents	
	Freq		Freq		Freq	
None	638	88.2	478	66.1	674	93.2
One	20	2.8	109	15.1	6	0.8
Two	9	1.2	64	8.9	2	0.3
Three	10	1.4	19	2.6	4	0.6
Four	3	0.4	9	1.2	1	0.1
Five	3	0.4	4	0.6	36	5.0
Six	0	0.0	1	0.1	0	0.0
Eight	0	0.0	1	0.1	0	0.0
Ten	2	0.3	2	0.3	0	0.0
Fourteen	0	0.0	1	0.1	0	0.0
Unknown	38	5.3	35	4.8	0	0.0
Total	723		723		723	

8.6 Rider trip

Rider familiarity with roadway

Approximately 90% of the accident-involved riders claimed daily or weekly use of the roadway where the accident occurred, which indicates that most riders were familiar with the accident location. Only 12 riders (1.7%) had never traveled that roadway before. Table 8.6.1 shows the distribution of rider familiarity with the accident roadway.

Table 8.6.1: Rider familiarity with accident roadway

Roadway familiarity	Frequency	
Daily use	514	71.1
Weekly use	115	15.9
Monthly use	37	5.1
Quarterly use	5	0.7
Annually use	3	0.4
Less than annually	2	0.3
Never used this roadway before	12	1.7
Unknown	35	4.8
Total	723	

Rider trip plan

Work was, by far, the most common trip origin, while home and work predominated as the most frequent trip destinations. Only one rider in eight said his trip had started at a bar or restaurant. If a rider was on the job at the time of his accident, both origin and destination were coded as "work". The origins and destinations of the trip that the rider was taking at the time of the accident are shown in Table 8.6.2.

Table 8.6.2: Rider trip origin and destination

Location	Trip origin		Trip destination	
	Frequency	Percent	Frequency	Percent
Home	117	16.2	336	46.5
Work, business	288	39.8	210	29.0
Recreation	63	8.7	19	2.6
School, university	10	1.4	8	1.1
Errand, shopping	37	5.1	38	5.3
Friends, relatives	92	12.7	81	11.2
Bar, restaurant	91	12.6	4	0.6
Others	0	0.0	1	0.1
Unknown	25	3.5	26	3.6
Total	723		723	

The great majority of accidents occurred on short trips. Riders were asked to estimate the distance from origin to destination of the trip on which the accident occurred. Their answers are summarized in Table 8.6.3. The median distance between the point of origin and the accident scene was 5 kilometres. About five out of six riders were going less than 10 kilometres.

Table 8.6.3: Distance of rider's intended trip plan

Trip length (km)	Frequency	
< 0.1	11	1.5
0 – 1.0	93	12.9
1.1 – 2.0	90	12.4
2.1 – 3.0	52	7.2
3.1 – 5.0	124	17.2
5.1 – 10.0	160	22.1
> 10.0	116	16.0
Unknown	77	10.7
Total	723	

The length of time riding from origin to the point where the accident occurred is shown in Table 8.6.4. The median value of the riding time was 0.1 hour or 6 minutes.

Table 8.6.4: Length of time since departure to the time of accident

Time riding before crash (hours)	Frequency	
0.0	65	9.0
0.1	257	35.5
0.2	151	20.9
0.3	104	14.4
0.4	1	0.1
0.5	45	6.2
0.6 - 0.7	4	0.6
0.8 - 1.0	4	0.6
> 1.0	1	0.1
Unknown	91	12.6
Total	723	

About 9 % of the accident-involved riders said they had been riding less than 3 minutes; half of the riders had been riding for less than ten minutes. Only 1% had been riding longer than half an hour. Fatigue due to long riding does not appear to be a factor in these crashes.

8.7 Physiological impairment

Rider permanent impairments

The majority of riders were found to be normal, without any permanent physiological impairment. About 2.5% of the riders suffered from vision impairment that required glasses to be worn. Two riders crashed when they had seizures due to untreated epilepsy. For one of those riders, it was his third such accident due to seizures. One rider had a leg prosthesis as the result of a previous motorcycle accident. Another rider had only one arm and was riding with a motorcycle which was modified by moving the clutch lever to the right handlebar, replacing the front brake lever, and operating the motorcycle without a front brake. Table 8.7.1 shows the frequency of permanent physiological impairment of the accident-involved motorcycle riders.

Table 8.7.1: Rider permanent impairments

Permanent impairment	Frequency	
None	660	91.3
Vision	18	2.5
Respiratory, cardiovascular	5	0.7
Amputee	2	0.3
Neurological, epilepsy, stroke	2	0.3
Endocrine system, diabetes, digestive system	1	0.1
Other	3	0.4
Unknown	32	4.4
Total	723	

Rider temporary impairments

Fatigue was the most commonly reported temporary physiological condition. In some cases fatigue appeared to be a contributing factor in accident causation because the riders tended to fall asleep while riding. The frequency and distribution of temporary physiological impairments for the accident-involved motorcycle riders is shown in Table 8.7.2.

Table 8.7.2: Rider temporary physiological impairments

Temporary impairment	Frequency	
None	632	87.4
Fatigue	31	4.3
Hunger	3	0.4
Thirst	1	0.1
Unknown	56	7.7
Total	723	

Rider stress on the day of the accident

Riders were asked if there were any unusual problems or stress on the day of the accident, prior to the accident. The most frequent stress reported by riders was financial distress, followed by conflicts with friends or relatives, and work-related problems.

"Road rage" was found in two instances and was clearly a significant contributing factor to both accidents. In one case, the rider lost his temper with another driver and swerved sharply to the left across the curb lane of traffic. His motorcycle hit the left curb and fell down sliding. The frequency distribution of stresses that were admitted by the accident-involved motorcycle rider is shown in Table 8.7.3.

Table 8.7.3: Rider stress on the day of accident

Type of stress	Frequency	
None observed or noted	642	88.8
Conflict with friends, relatives, divorce, separation	6	0.8
Work related problems	4	0.6
Financial distress	9	1.2
Legal, police problems	1	0.1
Traffic conflict, road rage	2	0.3
Other	3	0.4
Unknown	56	7.7
Total	723	

8.8 Alcohol

Rider alcohol involvement

One of the most remarkable findings of this study is the high level of alcohol involvement in these accidents: 40% of riders had been consuming alcohol. Table 8.8.1 shows the number of riders who had been drinking alcohol in the 723 Bangkok accident investigation cases.

Of 289 riders who had consumed alcohol before they crashed, about 86% appeared to be significantly impaired (Table 8.8.2).

A cross-tabulation showed that 52% of unskilled workers and 27% of motorcycle taxi riders were impaired when they crashed. By comparison, only 9% of the students had been drinking before they got into an accident.

Table 8.8.1: Rider alcohol use

Rider alcohol use	Frequency	
None	430	
Had been drinking	289	
Unknown	4	
Total	723	

Table 8.8.2: Rider alcohol impairment

Alcohol impairment	Frequency	
Not significantly impaired	37	
Significantly impaired	251	
Unknown	5	
Total	293	

Alcohol-involved riders were far more likely to die in a crash than non-alcohol-involved riders. Approximately three-fourths of the fatally injured riders -- 37 of 50 -- had been drinking alcohol. Only 11 fatally injured riders had not been drinking. Alcohol involvement was unknown in two fatal cases. Table 8.8.3 shows the frequency of alcohol involvement in the fatal accidents.

There were 37 fatalities among the 289 alcohol-involved accidents (12.8%) or about one death for every eight crashes. Among non-alcohol-involved riders, 11 crashes in 430 accidents (2.6%) amounted to one death in every 39 accidents.

Table 8.8.3: Alcohol in fatal and non-fatal accidents

Alcohol impairment	Fatal injury involvement		Total	Deaths per accident
	No	Yes		
No	419	11	430	1 : 39
Yes	252	37	289	1 : 7
Unknown	2	2	4	1: 2
Total	673	50	723	1 : 14

Nearly 40% of riders (275) were tested for blood alcohol concentration (BAC), often whether they appeared to have been drinking or not. Of these, 111 (40%) showed no detectable alcohol, but 60% had been drinking before they crashed. Half of those tested had a BAC over the legal limit of 50 mg/100ml of blood (mg%). Among alcohol-involved riders, the median BAC was 107 mg%. It should be noted that riders who were either police or military personnel usually refused to allow alcohol testing, although observation by the investigators suggested they were drunk and sometimes very drunk.

A number of riders with minor injuries were tested for BAC by breath testing analysis or urine tests. Of the 275 riders tested, two-thirds were blood tests, and one-third had a breath test. BAC values that were derived from blood drawn samples were not corrected to estimate the BAC at the time of the accident. This was due to the fact that in most cases there was little time lapse between the crash and the time the blood was drawn. In the majority of fatal cases, blood was obtained at time of autopsy for later toxicological analysis. In the non-fatal cases, BAC was frequently obtained by taking a blood sample during the transportation to the emergency room or at the emergency room.

Table 8.8.4 shows the distribution of rider blood alcohol concentration (BAC) at the time of the accident. The source of BAC is shown in Table 8.8.5.

Table 8.8.4: Rider blood alcohol concentration level

Blood alcohol (mg%)	Frequency		Percent of 275 tested cases
Not tested	447	61.8	-
Test results negative	111	15.4	40.4
1 – 50	28	3.9	10.2
51 – 100	42	5.8	15.3
101 – 200	62	8.6	22.5
201 – 300	28	3.9	10.2
> 300	5	0.7	0.8
Total	723		

Table 8.8.5: Rider blood alcohol concentration testing method

Blood alcohol concentration test method	Frequency	
Not applicable, no test	448	61.9
Breath testing	91	12.6
Blood testing	182	25.2
Urine testing	2	0.3
Total	723	

The high frequency of alcohol involvement represents a major contributing factor in these Bangkok accidents, particularly in the fatal cases. The role of alcohol in motorcycle accident causation is elaborated in Section 11.3 of this report.

8.9 Rider attention to driving task

Inattention or daydreaming was found to occur in about 20% of the accident-involved riders, particularly in the drunk riders (nearly half appeared to have been completely inattentive to the driving task before they crashed) or those riders who were fatigued due to a long work period. In this current study, six riders fell asleep while riding.

Adjacent traffic and non-traffic items held the attention of motorcycle accident involved riders in about 6.5% of the 723 accident cases. Table 8.9.1 shows the motorcycle rider attention to the riding task during the pre-crash phase of the accident.

Table 8.9.1: Rider attention to driving tasks

Rider attention	Frequency	
Inattentive mode, no attention to driving tasks	150	20.7
Attention to driving/passenger tasks not a factor	459	63.5
Attention diverted to surrounding traffic	38	5.3
Attention diverted to motorcycle normal operation	1	0.1
Attention diverted to motorcycle operating problem	1	0.1
Attention diverted to non-traffic item	9	1.2
Attention diverted to passenger activities	9	1.2
Other	6	0.8
Unknown	50	6.9
Total	723	

8.10 Countermeasures recommended by rider

Two-thirds of the accident-involved motorcycle riders provided no suggestions for accident countermeasures (Table 8.10.1). Of 179 riders who suggested some countermeasure, two-thirds recommended better driver training courses. About 12% of the suggestions were for improved motorcycle rider training courses. A few riders requested more rigorous traffic laws or more rigorous drunk driving law enforcement. Generally, suggestions offered by both motorcycle riders and OV drivers tended to focus on improving the opposing collision partner's driving skills.

Table 8.10.1: Rider recommendations for accident countermeasures

Recommended countermeasures	Frequency	
None	478	66.1
Improved motorcycle licensing procedures	1	0.1
Improved motorcycle procedures for other drivers	1	0.1
Improved motorcycle rider training courses	21	2.9
Improved driver training courses	123	17.0
More rigorous traffic law enforcement	4	0.6
More rigorous drunk driving law enforcement	4	0.6
More effective personal protective equipment	3	0.4
Mandatory helmet use law enforcement	8	1.1
Other	14	1.9
Unknown	66	9.1
Total	723	

8.11 Motorcycle passengers

Number of passengers

No passenger was present on two-thirds of the accident-involved motorcycles. Only 10 accident-involved motorcycles carried two passengers, as shown in Table 8.11.1.

Table 8.11.1: Number of passengers on the accident motorcycle

Number of motorcycle passengers	Frequency	
No passengers	496	
One	217	
Two	10	
Total	723	

8.12 Passenger licensing and experience

Passenger license qualification

Passengers are not required to have any sort of license in order to ride as a passenger. However, passengers were asked about their license status. About three-quarters reported having no license. By comparison, about 17% of riders reported having no license. Table 8.12.1 shows the license held by the motorcycle passengers at the time of the accident.

Table 8.12.1: Passenger driver's license qualification

License type	Frequency	
No license held	173	73.0
Learner's permit	5	2.1
Motorcycle license	43	18.1
Automobile license	5	2.1
License to transport people	1	0.4
Unknown	10	4.2
Total	237	

Passenger experience

The passenger's experience as a passenger in all vehicle types is shown in Table 8.12.2. About 13.5% of passengers had experience on all vehicles less than 1 year.

Table 8.12.2: Passenger experience on all vehicles

Experience on all vehicles (years)	Frequency	
0 – 1	32	13.5
2 – 3	48	20.3
4 – 5	56	23.6
5 – 7	19	8.0
8 – 10	34	14.3
11 – 15	12	5.1
16 – 20	8	3.4
21 – 30	6	2.5
> 30	1	0.4
Unknown	21	8.9
Total	237	

About 21% of passengers had less than 12 months riding experience on motorcycles and 71% had less than twelve months experience as a passenger on the accident motorcycle. Table 8.12.3 shows the previous experience of riding as a passenger on any street motorcycle and on the accident motorcycle.

Table 8.12.3: Passenger's motorcycle experience

Passenger's experience (months)	All motorcycles		Accident motorcycle	
	Frequency	Percent	Frequency	Percent
< 1	21	8.9	74	31.2
1 – 6	11	4.6	69	29.1
7 – 12	17	7.2	27	11.4
13 – 24	28	11.8	17	7.2
25 – 36	26	11.0	13	5.5
37 – 48	15	6.3	7	3.0
49 – 60	34	14.3	6	2.5
61 – 72	12	5.1	2	0.8
73 – 84	4	1.7	1	0.4
> 84	48	20.3	0	0.0
Unknown	21	8.9	21	8.9
Total	237		237	

Passengers were asked to characterize the amount of their previous riding experience. Their answers are shown in Table 8.12.4. About half of these accident-involved passengers described their prior experience as "moderate."

Table 8.12.4: Experience on motorcycle

Experience on motorcycle	Frequency	
Never before rode as passenger	14	5.9
Very little experience	55	23.2
Moderate experience	117	49.4
Extensive experience	33	13.9
Unknown	18	7.6
Total	237	

Passenger days per year riding motorcycle

Table 8.12.5 shows the number of days per year that the passenger rides a motorcycle (as a motorcycle passenger.) About half of the passengers claimed that they rode 5 to 7 days a week, which suggests a relatively high use of the motorcycle as a basic source of transportation.

Table 8.12.5: Passenger days per year on motorcycle

Days riding per year	Frequency	
0 – 50	29	12.2
51 – 100	30	12.7
101 – 150	17	7.2
151 – 200	15	6.3
201 – 250	3	1.3
251 – 300	14	5.9
301 – 365	109	46.0
Unknown	20	8.4
Total	237	

Passenger motorcycle training

Passengers had, in effect, no training in motorcycle safety. About 47% of passengers were self-taught and 43% of the passengers said they had no training as the motorcycle rider as shown in Table 8.12.6.

Table 8.12.6: Passenger training

Passenger training	Frequency	
No training	102	43.0
Self-taught	111	46.8
Taught by friends or family	6	2.5
Unknown	18	7.6
Total	237	

Passenger motorcycle use patterns

As with riders and other vehicle drivers, passengers were asked how their transportation use was divided among non-motorcycle travel and motorcycle use, either for basic transportation or for recreation. Their reports about percentage use in each category were averaged and appear in Table 8.12.7. About 72% of the passengers in the Bangkok said they used the motorcycle as basic transportation and 14% as recreation.

Table 8.12.7: Passenger vehicle use distribution

Vehicle use	Average percent of total time
Non-motorcycle	13.5
Recreation	14.2
Basic transportation	72.3
Total	100.0

8.13 Passenger physiological impairments

The majority of the passengers did not have any permanent or transient physiological impairment. Only 2 passengers had vision problems and 11 were coded as being fatigued. One passenger complained of being hungry at the time of collision and one was described as being thirsty at the time of collision. A cross-tabulation shows that none of these complaints contributed to accident causation.

8.14 Passenger alcohol

Of the 237 passengers in this study, 64 (27%) had been consuming alcohol. However, the exact level of intoxication in terms of BAC was difficult to determine because the passengers often refused to be tested. The investigators' estimates of the level of impairment are shown in Table 8.14.1. Of those 64 passengers who used alcohol, about 47 cases (73%) were determined to be significantly impaired, a percentage roughly comparable to the 86% of alcohol-involved riders who appeared to be significantly impaired.

Table 8.14.1: Passenger alcohol impairment

Passenger alcohol impairment	Frequency	
No alcohol use	163	
Not significantly impaired	17	
Significantly impaired	47	
Unknown	10	
Total	237	

Table 8.14.2 shows the distribution of passenger blood alcohol concentration (BAC) at the time of the accident investigation. Eleven of 19 alcohol-involved passengers (58%) whose BAC was measured were above the legal limit of 50 mg%.

Table 8.14.2: Passenger blood alcohol concentration

Blood alcohol concentration (mg%)	Frequency	
Not tested or tested negative	163	68.8
1 – 50	8	3.4
51 – 100	3	1.3
101 – 200	7	3.0
201 – 300	0	0.0
> 300	1	0.4
Unknown	55	23.2
Total	237	

Passenger attention to riding task

About 51 of 237 (21.5%) passengers were inattentive at the time of the collision, usually due to alcohol. Two passengers fell asleep while riding on the motorcycle. However, there were no cases in which passenger inattention, or even sleeping, contributed to accident causation. Table 8.14.3 shows the passenger's attention to riding at the time of the collision.

Table 8.14.3: Passenger attention to riding tasks

Passenger attention	Frequency	
Inattentive mode, no attention to driving tasks	51	21.5
Attention to driving tasks not a factor	155	65.4
Attention diverted to surrounding traffic	6	2.5
Attention diverted to motorcycle normal operation	1	0.4
Other	2	0.8
Unknown	22	9.3
Total	237	

8.15 Passenger recommended countermeasures

The majority of the accident-involved passengers did not provide any recommended countermeasures to the investigators. About 7% of all passengers suggested improvement of driver training programs. Of those who responded, 4% requested motorcycle rider training courses, and 3% recommended stronger enforcement of the helmet use law.

8.16 Other vehicle driver licensing and training

License qualification

About half of the accident-involved drivers held only an automobile license, 10% had a license to transport people and 16% held a motorcycle license. Only 5% had no license, about one-third as many as motorcycle riders. Table 8.16.1 shows the type of driver's licenses held by the driver of the accident-involved other vehicle.

Table 8.16.1: Other vehicle driver license qualification

Type of license	Frequency	
No license held	35	5.3
Learner's permit, only	5	0.8
Motorcycle license	105	16.0
Automobile license	330	50.3
Commercial license	1	0.2
License to transport people	64	9.8
Heavy truck license	6	0.9
Unknown	110	16.8
Total	656	

Driving training

About 60% of the accident-involved drivers in this series were self-taught and 20% were taught by friends or family (Table 8.16.2). None reported any formal training.

This suggests that there may be a problem due to poor driver training and the development of the many poor driving habits seen in these accidents, such as failure to yield right of way and a general lack of any defensive driving or collision avoidance strategy.

For example, some accident-involved other vehicle drivers used the horn or flashed their headlamps rather than apply the brakes to avoid a collision, even while failing to provide a turn signal. Many other vehicle drivers stated in interviews that they thought the motorcycle would stop for them to make a U-turn or right turn, even in cases where the motorcycle was so close that it was physically impossible for the motorcycle to stop.

The effects of the lack of driver training (and rider training) appeared over and over in accident situations and in the interviews that followed the accidents.

Table 8.16.2: Other vehicle driver training

Other vehicle driver training	Frequency	
No training	5	0.8
Self taught	393	59.9
Taught by friends or family	133	20.3
Other	5	0.8
Unknown	120	18.3
Total	656	

8.17 Driving experience

The median driving experience for other vehicle drivers was 10 years. Only 2% of the other vehicle drivers claimed less than one year of driving experience. Table 8.17.1 shows the vehicle driving experience of the other vehicle drivers.

Table 8.17.1: Other vehicle driver's driving experience

Driving experience (years)	Frequency	
0 – 1	13	2.0
2 – 3	49	7.5
4 – 5	74	11.3
5 – 7	47	7.2
8 – 10	134	20.4
11 – 15	85	13.0
16 – 20	63	9.6
21 – 30	60	9.1
> 30	15	2.3
Unknown	116	17.7
Total	656	

Drivers reported a median driving experience in the accident-involved other vehicle of 24 months. In about 17 cases the other vehicle driver had less than one month of experience with that vehicle. The data for driving experience in the accident-involved other vehicles are shown in Table 8.17.2.

Table 8.17.2: Driving experience on the accident vehicle

Experience on accident vehicle (months)	Frequency	
< 1	17	2.6
1 – 6	66	10.1
7 – 12	70	10.7
13 – 24	132	20.1
25 – 36	92	14.0
37 – 48	57	8.7
49 – 60	50	7.6
61 – 72	25	3.8
73 – 84	14	2.1
> 84	12	1.8
Unknown	121	18.4
Total	656	

Table 8.17.3 shows the distribution of motorcycle riding experiences for the accident-involved other vehicle drivers. Over half of drivers said they never ride a motorcycle. The majority of other vehicle drivers with any motorcycle riding experience often held a motorcycle license. About one-fourth of the other vehicle drivers were actually the riders of a motorcycles involved in a collision with another motorcycle.

Table 8.17.3: Riding experience on any street motorcycle

Experience on any motorcycle (months)	Frequency	
< 1	365	55.6
1 – 6	2	0.3
7 – 12	7	1.1
13 – 24	11	1.7
25 – 36	14	2.1
37 – 48	6	0.9
49 – 60	22	3.4
61 – 72	10	1.5
73 – 84	10	1.5
> 84	96	14.6
Unknown	113	17.2
Total	656	

8.18 Other vehicle use pattern

Two-thirds of the accident-involved other vehicle drivers said they did not ride a motorcycle at all. Riders of the other motorcycles involved in collision also tended to ride the motorcycle as basic transportation for 25% of the time followed by recreation 5% of the time, as shown in Table 8.18.1.

Table 8.18.1: Other vehicle driver vehicle use patterns

Vehicle use	Average percent
Non-motorcycle	71.2
Recreation	5.0
Basic transportation	24.8
Total	100.0

8.19 Driver's prior traffic violation and accident experience

A total of 83 other vehicle drivers (12.6%) reported at least one previous traffic violation within the past five years. As with motorcycle riders, official driving records were not available for verification, so the data reported here rely on the truthfulness of the drivers. Table 8.19.1 shows the traffic violations reported by the accident-involved driver during the past 5 years, as well as previous accidents, both motorcycle and non-motorcycle. About one-fourth of the other vehicle drivers who were interviewed (127 of 537) said they had had a non-motorcycle traffic accident in the previous five years. When the other vehicle was a motorcycle, 49 riders (7.6 %) said they had had at least one reportable traffic accident with the motorcycle in the last five years.

Table 8.19.1: Driver traffic violation and accidents in previous 5 years

Prior violations & accidents	Traffic citations		Non-MC accidents		MC accidents	
	Freq	%	Freq	%	Freq	%
None	452	68.9	410	62.5	488	74.4
One	58	8.8	74	11.3	27	4.1
Two	19	2.9	31	4.7	17	2.6
Three	3	0.5	15	2.3	3	0.5
Four	0	0.0	3	0.5	1	0.2
Five	2	0.3	2	0.3	0	0.0
Eight	0	0.0	1	0.2	0	0.0
Ten	1	0.2	1	0.2	1	0.2
Unknown	121	18.4	119	18.1	119	18.1
Total	656		656		656	

8.20 Driver trip

Driver familiarity with roadway

About 90% of OV drivers interviewed (487 of 537) were very familiar with the roadway that they were traveling on when the accident happened, using it at least once of week. Only seven other vehicle drivers said they had never used that roadway before. Table 8.20.1 shows the frequency that the accident-involved other vehicle driver traveled upon the roadway involved in the accident.

Table 8.20.1: Driver familiarity with roadway

Roadway familiarity	Frequency	
Daily use, i.e., once per day	372	56.7
Weekly use, i.e. once per week	115	17.5
Monthly use, i.e., once per month	32	4.9
Quarterly, i.e., once per quarter	6	0.9
Annually, i.e., once per year	4	0.6
Less than annually	1	0.2
Never used this roadway before	7	1.1
Unknown	119	
Total	656	

Driver trip plan

The distribution of the origin and destinations for the other vehicle driver is shown in Table 8.20.2. In each of those categories, work predominated as the most frequent point of origin or destination. Home and work combined accounted for 61% of the origin points and 69% of the destinations in the other vehicle driver trip plans. Only about 7% of the other vehicle drivers said their trip had originated at a bar or restaurant; however, it is important to note there were many cases in which alcohol was consumed at home or during a recreational activity.

Table 8.20.2: Other vehicle driver origin and destination

Location	Trip origin		Trip destination	
	Frequency	Percent	Frequency	Percent
Home	94	14.3	199	30.3
Work, business	306	46.6	254	38.7
Recreation	22	3.4	5	0.8
School, university	13	2.0	5	0.8
Errand, shopping	27	4.1	30	4.6
Friends, relatives	45	6.9	40	6.1
Bar, pub, restaurant	37	5.6	9	1.4
Unknown	112	17.1	114	17.4
Total	656		656	

Trip distance

On average, other vehicle drivers estimated they were going 7 kilometres from origin to their intended destination. Table 8.20.3 shows the frequency distribution of the distance of the intended trip.

. The median time of driving prior to the accident was 0.2 hour or 12 minutes. The distribution of time driving from trip origin to the accident location is shown in Table 8.20.4

By comparison with the accident-involved motorcycle riders, the other vehicle drivers reported longer trip distances (i.e., 7 versus 5 kilometres) and longer times between starting a trip and the accident event (0.1 hour for motorcycle versus 0.2 hour for other vehicle). The data suggest 26% of other vehicles had an accident six minutes or less after the departure and 29% of them had traveled 5 kilometres or less at the time of the accident – the median time and distance for motorcycles.

Table 8.20.3: Distance of other vehicle driver's intended trip

Trip length (km)	Frequency	
< 0.1	4	0.6
0.1 - 1.0	39	5.9
1.1 - 2.0	39	5.9
2.1 - 3.0	21	3.2
3.1 - 5.0	86	13.1
5.1 - 10.0	146	22.3
> 10.0	136	20.7
Unknown	185	28.2
Total	656	

Table 8.20.4: Length of time between departure and time of accident

Time driving before crash (hrs)	Frequency	
0.0	46	7.0
0.1	123	18.8
0.2	99	15.1
0.3	95	14.5
0.4	14	2.1
0.5	58	8.8
0.6 - 0.7	6	0.9
0.8 - 1.0	24	3.7
> 1.0	7	1.1
Unknown	184	28.0
Total	656	

8.21 Alcohol

Driver alcohol involvement

Table 8.21.1 shows the frequency of alcohol involvement for the accident-involved drivers. Only 54 other vehicle drivers had been consuming alcohol and 76% of those alcohol-involved drivers were found to be impaired. Most drivers refused to have blood or breath tests for BAC. The distribution of the BAC level for those other vehicle drivers who were tested is shown in Table 8.21.2.

Table 8.21.1: Other vehicle driver alcohol use

Alcohol use	Frequency	
No alcohol consumption	491	
Alcohol use, only	54	
Unknown	111	
Total	656	

Table 8.21.2: Other vehicle driver blood alcohol concentration (BAC)

Blood alcohol concentration(mg%)	Frequency	
Not tested or tested negative	491	74.8
1 – 50	5	0.8
51 – 100	6	0.9
101 – 200	6	0.9
201 – 300	1	0.2
Unknown	147	22.4
Total	656	

The number of other vehicle drivers who had been consuming alcohol differed greatly from the number of drunk motorcycle riders (8% versus 18%). However, it is important to note that the alcohol status of about one-fourth of other vehicle drivers was unknown because many other vehicle drivers left the scene. In other cases, the other vehicle was parked and unoccupied; it had no driver. Therefore, it is difficult to make comparisons between the two groups.

8.22 Driver physiological impairments

Most other vehicle drivers who were involved in the collision with the motorcycle appeared to be physiologically normal. Only 6% of the other vehicle drivers reported some vision problem (Table 8.22.1). Transient physiological impairment was reported in seven cases. Only 1% of the other vehicle drivers reported that they were fatigued -- usually the riders of other motorcycles who were involved in the collision.

Table 8.22.1: Other vehicle driver physiological impairment

Physiological impairments	Frequency	
<u>Permanent impairment</u>		
None	495	75.5
Vision	41	6.3
Respiratory, cardiovascular	2	0.3
Other	1	0.2
Unknown	117	17.8
Total	656	
<u>Transient impairment</u>		
None	526	80.2
Fatigue	6	0.9
Hunger	1	0.2
Thirst	1	0.2
Unknown	122	18.6
Total	656	

Driver stress on the day of the accident

Only seven drivers (1.3% of those interviewed) reported some kind of stress on the day of accident. The data is reported in Table 8.22.2. Other vehicle drivers reported stress roughly one-third as often as the 3.7% of motorcycle riders who reported some stress. It is interesting to note that the most frequent stress that riders reported – financial problems – was not mentioned by any of the other vehicle drivers.

Table 8.22.2: Other vehicle driver stress on day of accident

Type of stress	Frequency	
None observed or noted	530	80.8
Conflict with friends and family	1	0.2
Work related problems	2	0.3
Traffic conflict, road rage	1	0.2
Death of family, friend	2	0.3
Other	1	0.2
Unknown	119	18.1
Total	656	

Driver attention to driving task

Table 8.22.3 shows the attention of the drivers of the other vehicle who were involved in the collision with the motorcycle. A lack of attention was identified in about 5% of reported cases and attention was diverted to surrounding traffic or non-traffic items in about 7% of reported cases. Table 8.22.4 shows that poor attention contributed to the accidents in 45 of 94 drivers who had attention failure.

Table 8.22.3: Other vehicle driver attention to driving tasks

Driver attention	Frequency	
Inattentive mode, no attention to driving tasks	31	4.7
Attention to driving/passenger tasks no a factor	456	69.5
Attention diverted to surrounding traffic	30	4.6
Attention diverted to non-traffic item	16	2.4
Attention diverted to passenger activities	2	0.3
Attention diverted to use mobile phone	1	0.2
Other	1	0.2
Unknown	119	18.1
Total	656	

Table 8.22.4: Contribution of attention failure to driving task

Contribution of attention	Frequency	
Not applicable, no attention failure	501	72.0
Attention failure, no contribution to accident	48	6.9
Attention failure contributed to the accident	46	6.6
Unknown	101	14.5
Total	696	

8.23 Driver recommended countermeasure

Two-thirds of the other vehicle drivers who were interviewed after a collision with a motorcycle (363 of 538 cases) made no recommendation for countermeasures. Of the 175 drivers who made some suggestion, 134 (about 75%) recommended better training for motorcyclists. The suggestions tended to focus on whatever the other vehicle drivers saw as the major cause in the accident they had just been in – which was quite often in their view, the motorcycle rider, or the rider's drunkenness or failure to use a helmet when head injuries occurred. Only 15 other vehicle drivers (3% of those interviewed) suggested countermeasures aimed at car drivers while most reported that motorcycle riders needed to improve their driving skills (see Table 8.23.1).

Table 8.23.1: Other vehicle driver recommended countermeasures

Other vehicle driver countermeasures	Frequency	
None	363	55.3
Improved motorcycle licensing procedures	49	7.5
Improved licensing procedures for other vehicles	3	0.5
Improved motorcycle rider training courses	85	13.0
Improved driver training courses	12	1.8
More rigorous traffic law enforcement	8	1.2
More rigorous drunk driving law enforcement	6	0.9
More effective personal protective equipment	2	0.3
Mandatory helmet use law enforcement	4	0.6
Other	6	0.9
Unknown	118	18.0
Total	656	

9.0 Injuries

This chapter surveys the injuries sustained by motorcycle riders in accidents. Generally, most motorcycle accidents are relatively minor, and involve mostly scrapes and bruises. Two-thirds required no more than a visit to the emergency room. Nonetheless, the injury and fatality rates were far higher than for cars: one fourth of the riders suffered significant injuries.

The injuries reported here were reported or collected for the motorcycle riders and passengers from the 723 on-scene, in-depth accident investigation cases. The injuries were either observed directly by the investigators or obtained from the treating paramedics, nurses, and physicians. Frequently, the injured riders and passengers were photographed at the accident scene as well as during hospital follow-up. X-ray findings were also recorded and photographed whenever possible. In most fatal accidents, a special in-depth autopsy procedure was performed by the principal investigator, which included a special detailed analysis of the head and neck injuries. All injuries were analyzed and coded for injury severity based on the Abbreviated Injury Scale (AIS, 1990 revision).

9.1 Trauma status

"Trauma status" refers to the level of medical treatment needed after the accident. One fourth of the riders required only first aid at the scene, while 45% were treated at the clinic or hospital and released (i.e., were hospitalized for less than 24 hours).

However, nearly 20% of the accident-involved riders were hospitalized longer than 24 hours and 2 riders became permanently disabled as a result of the accident. One in every fourteen riders who crashed was killed. Table 9.1.1 shows the trauma status of the riders and passengers involved in the accident investigation cases.

Table 9.1.1 Trauma status of motorcycle rider and passenger

Trauma status	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
No Injury	18	2.5	29	12.2
First aid at scene	193	26.7	62	26.2
Treat at hospital, clinic	267	36.9	95	40.1
Hospitalized for less than 1 day	55	7.6	17	7.2
Hospitalized for longer than 1 day	137	18.9	26	11.0
Disabled, institutionalized	2	0.3	0	0.0
Fatal, dead on scene	29	4.0	2	0.8
Fatal, dead upon hospital arrival	14	1.9	4	1.7
Fatal after hospitalization	7	1.0	1	0.4
Unknown	1	0.1	1	0.4
Total	723		237	

Passengers generally were less severely injured than riders. They were five times as likely to come through the accident without injury. They were hospitalized 58% as often as riders, and their fatality rate (one in 34) was roughly half of the rider fatality rate. This suggests that the rider's body may act to shield the passenger, particularly in frontal impacts.

As a general summary, about 75% of riders had mild injuries, which did not require hospital admission, and 25% sustained serious-to-fatal injuries. For passengers, 85% of the injuries were minor and only 15% were serious-to-fatal.

Of the 175 riders and passengers who were hospitalized, half required more than one a week stay, while another one-third stayed three days or less. Table 9.1.2 shows the length of hospital stay for the injured riders and passengers. Occasionally, the length of hospital stay was unknown because some riders and passengers decided to go for treatment at another hospital and could not be located.

With respect to the 57 fatalities, 29 riders and four passengers died at the scene, while 14 riders and two passengers were declared dead on arrival at the hospital. Seven riders and one passenger died after some hospitalization.

Table 9.1.2: Length of hospital stay, rider and passenger

Hospital stay (days)	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
0	574	79.4	204	86.1
1	13	1.8	3	1.3
2 – 3	39	5.4	7	3.0
4 – 7	26	3.6	2	0.8
> 7	65	9.0	20	8.4
Unknown	6	0.8	1	0.4
Total	723		237	

9.2 Injury severity and region

As noted in the Methodology section, injuries were coded using the AIS -- the Abbreviated Injury Scale (1990 revision) An AIS code is a seven-digit numeric code that specifies a region (first digit), the type of structure injured (2nd digit) the specific organ injured (3rd & 4th digits), details of the injury (such as open vs. closed fracture -- 5th and 6th digits) and a severity score (7th digit). The AIS has been widely used by trauma researchers around the world for nearly three decades. Injuries are classified on a 6 point ordinal scale ranging from 1 (minor) to 6 (currently untreatable). The AIS does not assess the combine effects of multiple injuries to one or more locations.

The 723 riders had a total of 3192 injuries (an average of 4.4injuries per rider). The 237 passengers recorded 706 injuries (3 injuries per passenger). For both riders and passengers, the most frequently injured regions were in order, legs, arms and face. Tables 9.2.1 and 9.2.2 show the distribution of bodily injuries to the riders and passengers involved in the Bangkok accident series.

Although the injuries to the extremities were the most frequent, they were rarely life threatening. The most frequent cause of fatal injuries in the data was injuries to the head, neck, chest and abdomen. Severe facial injuries were not fatal by themselves, but blows to the face sometimes transmitted lethal impact loads to the skull, brain and neck.

Table 9.2.1: Rider injury region and severity

Body region	Rider injury severity						
	Minor	Moderate	Severe	Serious	Critical	Fatal	Total
Head	51	37	17	66	85	5	261
Face	233	209	23	3	0	0	468
Neck	70	5	0	5	29	0	109
Thorax	73	3	17	36	61	13	203
Abdomen	58	1	22	4	24	4	113
Spine	8	35	10	0	4	3	60
Upper extremities	682	131	22	0	0	0	835
Lower extremities	798	243	85	0	0	0	1126
Pelvis	4	7	4	0	3	0	18
Total	1977	635	189	114	248	29	3192

Table 9.2.2: Passenger injury region and severity

Body region	Passenger injury severity						
	Minor	Moderate	Severe	Serious	Critical	Fatal	Total
Head	10	15	4	11	13	0	53
Face	56	43	6	0	0	0	105
Neck	14	0	0	1	4	0	19
Thorax	9	0	3	4	1	0	17
Abdomen	10	0	3	3	1	0	17
Spine	0	4	0	0	0	0	4
Upper extremities	175	21	4	0	0	0	200
Lower extremities	221	53	17	0	0	0	291
Total	495	132	37	19	23	0	706

9.3 Rider head injuries

Almost regardless of region, minor abrasions and lacerations and bruise make up the great majority of injuries motorcycle riders and passengers suffer. The discussions that follow will therefore skip over the high-frequency, low-severity items to focus on the less frequent and more serious injuries.

Skull fractures accounted for 26% of all head injuries. Discrete injuries of the brain were reported 94 times; additional brain injuries can be inferred from the "loss of consciousness" and “amnesia” cases. The most frequent head injuries were superficial abrasions, contusions and lacerations, which made up 34% of the total.

We found a deadly interaction between facial injuries and the life-threatening injuries to the central nervous system. There were several cases in which the motorcycle rider suffered a severe facial impact, which caused a displaced fracture of the mandible. The transmission of impact forces often went through the condyles of the mandible to produce a basilar skull fracture with laceration of the adjacent brainstem. These unfortunate victims with brain laceration often died at scene or shortly after arrival at the hospital.

Table 9.3.1: Rider head injuries

Head injury lesion	Frequency	
Scalp abrasion or contusion	51	19.5
Scalp laceration	37	14.2
Fracture, base of skull	17	6.5
Fracture, vault	29	11.1
Fracture skull with brain loss	22	8.4
Subdural hematoma	8	3.1
Epidural hematoma	3	1.1
Subarachnoid hemorrhage	25	9.6
Brain contusion	27	10.3
Brain concussion	2	0.8
Brain laceration	23	8.8
Brain hemorrhage	3	1.1
Unconscious	6	2.3
Amnesia	5	1.9
Crush, massive destruction	3	1.1
Total	261	

9.4 Rider face injuries

Fracture of the facial bones -- mandible, maxilla, nose, orbit, teeth and zygoma -- accounted for 5% of the facial injuries. Facial fractures are rarely as life threatening as skull fractures (despite the disfigurement they may cause), but they often indicate a significant transmission of impact energy to the head. That is, when serious facial injuries occurred, they were often found along with subdural, epidural, subarachnoid as well as intracerebral hemorrhages and brain contusions. Table 9.4.1 shows the type of lesions affecting the head and face of the injured riders.

Table 9.4.1: Rider facial injuries

Facial injury type	Frequency	
Abrasion and contusion	190	40.6
Laceration, skin	195	41.7
Avulsion	1	0.2
Eye cornea, laceration	1	0.2
Mouth NFS	27	5.8
Gingiva laceration	1	0.2
Tongue laceration	1	0.2
Teeth loosened	4	0.9
Teeth fracture	10	2.1
Facial fracture NFS	3	0.6
Mandible fracture	17	3.6
Maxilla fracture	6	1.3
Nose fracture	4	0.9
Orbit fracture	3	0.6
Zygoma fracture	5	1.1
Total	468	

9.5 Rider soft tissue neck injuries

With the exception of superficial and obvious injuries such as abrasions, minor lacerations and neck strain, neck injuries were rarely recorded by the treating physician, particularly in non-fatal cases. It appears that the lack of external physical evidence of trauma often led the treating physicians to overlook internal neck injuries. Table 9.5.1 shows the type of lesions found in the neck region. This section reports neck soft tissue injuries. Injuries of the spinal column, including cervical spine, are reported in section 9.10.

Carotid sheath hematoma, and soft tissue and neck muscle hemorrhage diagnoses were obtained only from the special in-depth autopsy examination. They were never diagnosed during emergency medical treatment and never in a standard autopsy procedure. In general, pathologists tend to stress the autopsy findings of the head, chest, abdomen and limbs. This was seen in the four fatal cases in which the autopsy was done by a pathologist other than the principal investigator. In these cases, the neck examination was not included in the routine autopsy and no information was provided as to whether soft tissue neck injuries had occurred or not. In other words, if soft tissue neck injuries are not actively sought, they probably will not be found.

The deep injuries to the neck had great potential for critical and fatal outcome. It is important to note that the injuries to the deeper structures such as hemorrhages in the carotid sheath, around the phrenic nerve, brachial and cervical plexus, fractures of the cervical spine, etc. were found only during the detailed autopsy of the fatal cases.

Table 9.5.1: Rider soft tissue neck injury

Soft tissue neck injury type	Frequency	
Superficial abrasion and contusion	16	14.7
Superficial laceration	5	4.6
Carotid sheath hematoma	29	26.6
Phrenic nerve injury	3	2.8
Verterbral artery tear	1	0.9
Pharynx contusion	1	0.9
Neck hemorrhage	54	49.5
Total	109	

In addition to the fractures of cervical spine, subluxation of the atlanto-axial ligament or atlanto-occipital ligament clearly represents a life-threatening injury (see section 9.10). Stretching of these ligaments provided a separation between the occiput and the atlas and axis which in turn could cause laceration of the vertebral vessels.

9.6 Rider thorax injuries

Significant chest injuries were infrequent, but when they occurred there was a very high potential for critical or fatal outcome. Typical life-threatening injuries to the chest included rib fractures associated with a laceration to the lungs, rupture of the aorta or major blood vessels. Rupture of the heart was observed in nine fatal cases and often resulted from direct impact loading to the thorax. Table 9.6.1 lists the thoracic injuries seen in this study.

Table 9.6.1: Rider thorax injury

Thoracic injury type	Frequency	
Abrasion and contusion	68	33.5
Laceration, skin	2	1.0
Blunt chest injury	1	0.5
Artery laceration (aorta, pulmonary, etc.)	5	2.5
Esophagus laceration	1	0.5
Trachea laceration	1	0.5
Heart contusion	6	3.0
Heart laceration	8	3.9
Lung contusion	34	16.7
Lung laceration	17	8.4
Pericardium injury	3	1.5
Hemothorax – pneumothorax	3	1.5
Rib and sternum contusion	3	1.5
Rib fracture	41	20.2
Sternum fracture	10	4.9
Total	203	

9.7 Rider upper extremity injuries

Fractures and dislocation accounted for 12% of all injuries to the upper extremities. The lesions of the upper extremities were generally not considered to be a threat to life. About one-fourth of the fractures were open fractures, which carry a substantial threat of infection that can require prolonged treatment. Open fractures are also more likely than closed fractures to be disabling, particularly to riders in jobs that require considerable manual labor. Table 9.7.1 illustrates the type of lesions affecting the upper extremities.

Table 9.7.1: Rider upper extremity injuries

Upper extremity injury type	Frequency	
Abrasion and contusion	646	77.4
Laceration, skin	54	6.5
Avulsion	2	0.2
Joint contusion, sprain	29	3.5
Joint dislocation	5	0.6
Humerus, closed fracture	6	0.7
Humerus, open fracture	11	1.3
Radius, closed fracture	19	2.3
Radius, open fracture,	6	0.7
Ulna, closed fracture	10	1.2
Ulna, open fracture	5	0.6
Fractured clavicle	24	2.9
Fractured scapula	1	0.1
Fractured finger	7	0.8
Fractured arm-forearm-hand	1	0.1
Fracture metacarpus	6	0.7
Finger amputation	3	0.4
Total	835	

One rider suffered traumatic amputation of his finger when his motorcycle hit the black, unmarked stabilizer leg of a large crane that was parked too close to traffic flow at a construction zone at night. Actually, the finger amputation was minor compared to the debilitating multiple fractures of his leg.

9.8 Rider abdominal injuries

Abdominal injuries were not a common injury found in this data set, they were only 4% of all injuries. However, when internal abdominal injuries occurred, the risk of death was considerably higher. Lacerations or ruptures of the kidneys, spleen and liver were often found in fatal cases. Table 9.8.1 illustrates the distribution of the different types of lesions to the abdomen.

Table 9.8.1: Rider abdomen injury

Abdominal injury type	Frequency	
Abrasion and contusion	58	
Laceration, skin	1	
Laceration, blood vessel	1	
Contusion, internal organs	7	
Liver laceration	16	
Spleen laceration	10	
Kidney laceration	6	
Retroperitoneal hemorrhage	14	
Total	113	

9.9 Rider pelvic region injuries

Only 18 injuries in the pelvic region were documented in this data set. Pelvic injuries were even less common among the passengers involved in the accidents. Table 9.9.1 shows the type of lesions occurring to the pelvic region.

Seven cases involved injury to the male genitalia and 11 cases involved fractured pelvis. It should be noted that the lack of external trauma often led treating physicians to overlook the pelvic injuries except when riders complained specifically of pain in the pelvic region. In this data set, it is important to note that riders rarely complained of pain due to groin injury even when the motorcycle fuel tank showed unmistakable evidence of significant pelvic impact.

Two riders died from massive hemorrhages due to comminuted fractures of the pelvic bone in which bone fragments lacerated major blood vessels of the pelvic region.

Table 9.9.1: Rider pelvic region injuries

Pelvic injury type	Frequency	
Penis contusion	1	
Scrotum or testes contusion	3	
Scrotum laceration	2	
Urethra laceration	1	
Pelvis, closed fracture	7	
Pelvis, open fracture	1	
Pelvis deformation with vascular disruption	1	
Pubic symphysis separation	2	
Total	18	

9.10 Rider spinal column injuries

Spine injuries accounted for only 1.9% of all injuries to the accident-involved riders. As shown in Table 9.10.1, the cervical spine was the most frequently injured region (70%) followed by the lumbar spine (18%) and the thoracic spines (12%).

Although spine injuries were infrequent in this data set, they represent serious and significant injuries, which often had a great potential for a fatal outcome. All except one rider (i.e., 41 of 42 riders) with cervical spine fracture or dislocation died. The sole survivor was disabled due to paralysis of both legs. Riders with thoracic spine fracture and cord laceration also died. The other two riders with simple thoracic spine fracture survived. There was only one fatally injured rider among the five riders who showed evidence of lumbar spine fracture with or without cord contusion. At the very least, injuries to the spine except acute strain could cause a long period of recovery and/or disability if the victims should survive.

Table 9.10.1: Rider spinal column injuries

Spinal injury type	Frequency	
Cervical spine fracture with cord injury	4	6.7
Cervical spine fracture	21	35.0
Cervical spine dislocation (subluxation)	17	28.3
Thoracic spine fracture with cord injury	2	3.3
Thoracic spine fracture	2	3.3
Thoracic spine dislocation with cord injury	1	1.7
Thoracic spine strain, acute	2	3.3
Lumbosacral fracture/dislocation with cord injury	3	5.0
Lumbosacral spine fracture	2	3.3
Lumbosacral spine strain, acute	6	10.0
Total	60	

9.11 Rider lower extremity injuries

Lower extremity injuries were the most common, accounting for over one-third of the rider injuries reported here. Some were serious or severe, but in no case were they ever considered to be a threat to life. While threat-to-life is not the problem with significant leg injuries, physical impairment and long-term disability represent a significant primary threat posed by serious and severe injuries to the knee, ankle and long bones. Riders with a minimum education who make a living by doing manual labor (i.e. a description that fits most of the riders involved in these accidents) are at serious risk of losing their ability to earn a living. Even after prolonged recovery, riders who have sustained open or comminuted fractures of the femur or tibia-fibula are more likely to be disabling. They may have difficulty standing or walking for longer than an hour. Table

9.11.1 shows the type of lower extremity injuries sustained by the motorcycle riders.

Table 9.11.1: Rider lower extremity injuries

Lower extremity injury type	Frequency	
Abrasion and contusion	780	69.2
Burn	1	0.1
Laceration	151	13.4
Avulsion	10	0.9
Degloving	1	0.1
Penetrating wound	3	0.3
Ankle collateral or cruciate ligament laceration	1	0.1
Knee collateral or cruciate ligament laceration	1	0.1
Muscle laceration	2	0.2
Tendon laceration	5	0.4
Ankle contusion and sprain	4	0.4
Ankle dislocation involving articular cartilage	1	0.1
Ankle laceration into joint	1	0.1
Hip contusion	2	0.2
Hip dislocation	3	0.3
Knee contusion and sprain	9	0.8
Knee laceration into joint	3	0.3
Fracture femur	39	3.5
Patella Fracture	9	0.8
Fibula, closed fracture	21	1.9
Fibula, open fracture	12	1.1
Tibia, closed fracture	23	2.0
Tibia, opened fracture	29	2.6
Foot fractures	16	1.4
Total	1127	

9.12 Injury contact surfaces

The most important factor to assist in the determination of a specific injury mechanism was the identification of the impact contact surfaces. These contact surfaces were identified as part of the analysis of each of the discrete injuries for the 723 on-scene, in-depth accident investigation cases. A typical example would be as follows: A vehicle turns right in front of an oncoming motorcycle and the rider's lower right leg strikes the front bumper of the car. The injury on the right lower leg was then analyzed with the purpose of identification of mechanism of injury. The contact surface responsible for the right leg injury was documented as being the front bumper.

By coding each injury in this way, it was possible to identify one or two collision contact surfaces that were associated with each discrete injury. In this series, 3,192 motorcycle rider injuries and 4,030 contact surfaces were identified.

The frequency of the various contact surfaces causing the motorcycle rider somatic injuries is summarized in Table 9.12.1. The helmet is uncommon as a contact surface. In most instances the helmet was simply “sandwiched” in between the pavement and rider’s head and caused the injury. In about 49 cases, injury to the rider was from contact with the helmet worn by the rider on the other motorcycle involved in collision.

Table 9.12.1: Rider injury contact surfaces

Object contacted	Frequency	
Motorcycles	594	14.74
Other vehicles	1334	33.10
Environment	2053	50.94
Helmet	49	1.22
Total	4030	

Injury contact surfaces on the motorcycle

The 10 most common motorcycle contact surfaces related to rider injuries are listed in Table 9.12.2 (see Appendix for complete listing). These injury contact surfaces were often immediately adjacent to injured body region. There were cases in which the actual injury location was remote from the contact surface or the point of force application. These were usually inertial or indirect injuries. For example, a bending load applied to the femur could cause a bending fracture near the contact area, or it might cause disruption of the medial collateral ligament of the knee, a remote injury.

Among the various motorcycle parts that acted as contact collision codes, the handlebar was the most frequent: 126 times, or 21% of all the documented rider somatic injuries. Most often, handlebar impact caused contusions of the thighs as the rider vaulted forward in a frontal impact. Occasionally, the handlebars made direct contact with the chest wall and were suspected of causing serious thoracic injury.

Motorcycle foot pegs, brake pedal and shifters often acted as the contact surface against the rider’s foot. The fuel tank was often identified as a contact surface for the rider’s pelvis, although a remarkable number of riders said nothing about groin injury despite considerable pelvic deformation of the fuel tank (complete with cloth marks of the rider’s pants). No explanation for the few complaints of groin injury is offered at this time.

The motorcycle fairing acted as a somatic injury contact surface in 69 cases. There were 20 cases in which a motorcycle rider or passenger was identified as the injury surface. Most injuries from contact with another motorcyclist involved only laceration or contusion of the head or face. Usually the person-to-person contact involved somebody on another motorcycle, but no coding distinction was made between those on the same motorcycle as opposed to somebody on a different motorcycle.

Table 9.12.2: Most common motorcycle injury contact surfaces

Motorcycle contact surface	Code	Frequency	
Brake lever, Clutch lever	MC01	22	3.7
Handlebars	MC02	126	21.2
Instruments	MC06	24	4.0
Fairing	MC09	69	11.6
Fuel tank	MC14	49	8.3
Frame tube, Frame element	MC23	49	8.3
Engine/transmission cases	MC25	28	4.7
Shifter	MC29	35	5.9
Rear brake pedal	MC31	20	3.4
Rider foot pegs, foot rests	MC37	67	11.3
Other	MC98	105	17.7

Table 9.12.3 shows the most common other vehicle contact surfaces as related to the motorcycle somatic injuries (see Appendix for complete listing). The data collected in this study found that the front surface and front side of the cars forward of the front wheel accounted for about one-fourth of all somatic injury contact surfaces. The rear section and rear corners of the other vehicles accounted for 15% of all somatic injury contact surfaces.

Table 9.12.3: Injury contact surfaces on the other vehicle

Injury contact surface on other vehicle	Code	Frequency	
Vehicle Front and Front Corner			
Front bumper	F01X	87	6.68
Front corner, headlamp nacelle	F04X	83	6.37
Side of front bumper	S01X	27	2.07
Vehicle Side Front			
Front mudguard (fender)	S03X	62	4.76
Front door, front	S10X	26	2.00
Vehicle Side Rear			
Rear tyres	S29X	34	2.61
Rear mudguard (fender), rear panel	S30X	28	2.15
Side unknown parts	S99X	26	2.00
Vehicle Rear and Rear Corner			
Rear bumper	R01X	65	4.99
Rear lamp, sub-boot (sub trunk) panel	R06X	37	2.84
Rear corner, truck bed	R13X	34	2.61
Lower rear corner, van	R16X	35	2.69
Vehicle Top Surface			
Top of bonnet, front	F06X	23	1.77
Front cowl	F08X	13	1.00
Windshield surface	F10X	13	1.00

Pavement was the number one injury contact surface in this study. It was identified as the contact surface over 1,600 times and accounted for half the injuries and 40% of the 4030 injury contact surfaces. Table 9.12.4 shows the 10 most common environmental somatic injury contact surfaces (see Appendix for complete listing).

Table 9.12.4: Injury contact surfaces in the environment

Environment contact surface	Code	Frequency	
Asphalt pavement	EA01	933	45.5
Concrete pavement	EC01	669	32.6
Concrete pole or post	EC02	77	3.8
Concrete barrier, guard rail	EC04	21	1.0
Concrete curb	EC06	108	5.3
Metal, yielding pole or post	EM02	23	1.1
Metal, yielding barrier, guard rail	EM04	32	1.6
Metal, yielding blunt surface	EM14	21	1.0
Gravel, soil pavement	ES01	25	1.2
Wood pole or post	EW02	44	2.1
Other	EY98	100	4.9

Motorcycle helmet parts were the least frequent injury contact surface and was coded only 49 times. The helmet shell was the most frequent contact surface followed by face shield. In cases where the helmet was simply "sandwiched" in between the two surfaces (for example, between the head and the pavement), the helmet was not included as a contact surface. About 20 riders suffered facial injury or head contusions from contact with somebody else’s helmet. In other cases riders were injured by parts of their own helmet. Table 9.12.5 shows the helmet parts as related to the rider head and face injuries.

Table 9.12.5: Injury contact surfaces on safety helmets

Helmet contact surface	Code	Frequency	
Shell	SH01	14	28.6
Edge bead	SH02	2	4.1
Strap or strap covering	SH03	3	6.1
Strap, metal plate	SH04	1	2.0
Energy-absorbing liner	SH06	4	8.2
Comfort padding	SH07	7	14.3
Face guard, chin piece, mouth protector	SH10	7	14.3
Face shield	SH11	9	18.4
Eyeglasses worn on face	SH13	1	2.0
Visor or peak	SH14	1	2.0
Total		49	

10.0 Helmets and Clothing

It is generally understood motorcycle riders and passengers are vulnerable to injuries due to their exposed position on the motorcycle. The evaluation of the effect of protective clothing and equipment was, therefore, considered essential to better understand means of reducing injuries.

In order to determine the effect of the protective clothing, it was first necessary to evaluate the injuries sustained and potential for injury reduction, given the clothing that was worn. For example, if the rider wore "shorts" and received no injury of the lower extremities then it is likely that there was "no contact" in that region. However, if the rider suffers from shin laceration, the short pants have "no effect" in injury prevention. If the rider was wearing trousers and there was evidence of significant abrasions on the pants, the trousers reduced the injury that would have been sustained by the rider.

10.1 Helmets

A large quantity of data was collected to describe the use and performance of the helmets involved in the motorcycle accidents. The analysis included an investigation of the helmet performance and an analysis of the detailed information on injuries. The results of this analysis then provided an adequate measurement of helmet effectiveness in preventing or reducing head injuries.

Helmet use and performance

Table 10.1.1 shows the distribution of helmeted and unhelmeted riders and passengers. A mandatory helmet use law was in effect in Thailand at the time this study was conducted. Helmets were worn by two-thirds of the riders but only 29% of passengers in the Bangkok accident population. Of the 475 helmets worn by accident-involved motorcycle riders, 128 (27%) were acquired for further examination. In addition, 17 of the 69 accident-involved passenger helmets were also obtained for further analysis.

Table 10.1.1: Helmet use by motorcycle riders and passengers

Helmet use	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
No	248		168	
Yes	475		69	
Total	723		237	

Head injuries were far less frequent among helmeted riders, particularly if the helmet remained in place on the rider's head. Less than 4% of riders whose helmets remained on had any kind of head injury, and only 10 (one in 36) suffered a brain injury. By comparison, unhelmeted riders were nearly five times as likely to sustain head injury (17.7% versus 3.6%). Head injuries above the "Minor" level were almost all brain injuries, and unhelmeted riders were almost 4 times as likely to suffer head injury in the "Moderate-to-Fatal" range: 10.9% versus 2.8%, and 6 times as likely to sustain life-threatening head injuries in the "Severe-to-Fatal" range: 6.9% versus 1.1%.

Riders whose helmets ejected seemed to come out the worst of all, even worse than unhelmeted riders. This is partly due to the fact that riders whose helmets ejected were more likely to sustain impacts to the head or face than unhelmeted riders, and the impact – sometimes very severe – may have caused the helmet to come off. In other words, head impact and helmet ejection are mixed together as cause and effect. If head or face impact occurs, head injury and helmet ejection may result, and helmet ejection then allows additional head injuries. Helmet ejection is discussed in greater detail in section 10.4.

Table 10.1.2 shows a cross-tabulation of helmet use and head injury severity. Approximately 47% (118/248) unhelmeted riders had no head injury compared to 64% of helmeted riders (305/475). Also 12% (30/248) of unhelmeted rider had AIS over 1, compared to 7% (34/475) for helmeted riders. For life threatening injuries (severe to fatal) approximately 10% (24/248) of unhelmeted versus 5% (24/475) of helmeted. Table 10.1.2 omits one helmeted rider who suffered brain injuries at the "critical" level, but whose helmet status (ejected or retained) was unknown.

Table 10.1.2: Rider helmet use and severity of most severe head injury

Most severe head injury	No helmet		Helmet worn				Total	
			Ejected		Retained			
	Freq	%	Freq	%	Freq	%	Freq	%
None	204	82	70	63	351	96	625	86
Minor	17	7	21	19	3	1	41	6
Moderate	3	1	3	3	4	1	10	1
Serious	7	3	2	2	2	1	11	1
Severe	12	5	13	12	4	1	30	4
Critical	3	1	1	1	0	0	4	1
Fatal	2	1	0	0	0	0	2	0
Total	248		110		364		722	

A separate analysis was done on a case-by-case basis, relying on the investigator's subjective evaluation of helmet performance. This is because the relationship between helmet use and head injury can vary from accident to accident. For example, in one accident a rider might have no head injury because there was no impact to the helmet or the head. In another case, a rider might have serious head injury, yet extensive damage to the helmet might show that it prevented far more severe (or even fatal) head injuries. In a third case, a helmet might be worn, but brain injuries might occur due to impact to the unprotected face -- in which case the helmet would be judged to have had no effect on head injury. Other possibilities include situations in which a helmet flies off the rider's head, performs very badly or is completely overwhelmed by impact loads. In these cases, the helmet performance might be judged as having "no effect" on head injury.

The results of this analysis are shown in Table 10.1.3. One third of the helmets showed no sign of contact. Of the 330 helmets that showed evidence of collision damage, the helmet was judged to have prevented head injuries completely in half those cases. The helmet reduced head injury in another one-third (103 cases) in which it sustained collision contact.

Table 10.1.3: Helmet effectiveness evaluation

Helmet effect	Frequency	Percent of total	Percent of group
No helmet, injuries occurred	129	17.8	47.8
No helmet, no contact	118	16.3	52.2
Unhelmeted subtotal	247	34.2	100.0
Helmet worn, no effect on injuries	65	9.0	13.7
Helmet worn, reduced injuries	103	14.2	21.7
Helmet worn, prevented injuries	162	22.4	34.2
Helmet worn, no contact	144	19.9	30.4
Helmeted subtotal	474	65.6	100.0
Unknown	2	0.3	-
Total	723		

Table 10.1.4 shows the helmet use for the 50 fatal riders within the 723 on-scene, in-depth accident cases. The helmet was worn by two-thirds of non-fatal riders but it was worn in less than half of fatal cases.

The majority of fatally injured riders (54%) were unhelmeted. Of 23 helmets worn, only seven (30%) were retained on the rider’s head to the end of the collision sequence. Six helmets were ejected because they were not fastened properly, and two because of extensive rider facial injuries (a shattered jaw can allow the chin strap to slip off.) However, seven of the 16 ejected helmets came off because of structural failures of the shell or retention system. Most fatal accidents are high-energy collisions that would severely test the best of helmets.

It should be noted that the rider fatalities were not due exclusively to head injuries; many fatally injured riders had life-threatening injuries of the chest, abdomen or pelvis. Two were run over by other vehicles (one a bus), a situation in which death is very likely, with or without a helmet.

However, the advantage of the helmet was still obvious in many ways. For example, in several of the fatal accidents, the unhelmeted riders suffered a skull fracture to an unprotected part of the head while they were involved in a low energy collision, such as a fall and tumble on the pavement.

Table 10.1.4: Type of helmet in fatal and non-fatal accident

Helmet type	Non-fatal accident		Fatal accident	
	Frequency	Percent	Frequency	Percent
No helmet	221	32.8	27	54.0
Not motorcycle helmet	14	2.1	1	2.0
Half/Police-type helmet	138	20.5	12	24.0
Open-face helmet	87	12.9	3	6.0
Full-face helmet	213	31.6	7*	14.0
Total	673	100.0	50	100.0

*Two riders were run over by another vehicle.

10.2 Factors affecting helmet use

Helmets are likely to be used less in the very situations in which accidents are more likely. A short summary is that helmet use is lower and accident risk is greater: at night, on short trips, among younger riders, among drinkers, and among riders with lower education and unskilled occupations.

Day - night use

The data shows that accident-involved riders had lower helmet use in night accidents (59%) than during daytime accidents (78%). A cross-tabulation of helmet use and time of accident is presented in Table 10.2.1.

Table 10.2.1: Ambient lighting condition and motorcycle helmet use

Ambient lighting condition	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
Daylight	53	22.0	188	78.0	241
Night	182	40.9	263	59.1	445
Dusk-Dawn	13	35.1	24	64.9	37
Total	248		475		723

Gender

Female motorcycle riders in accidents were a little more likely that males to wear a helmet, 70% versus 65%. However, female riders were such a small part of the Bangkok accident population (4%) that any effect of gender is not clear. Table 10.2.2 shows the cross-tabulation between motorcycle rider gender and helmet use.

Table 10.2.2: Rider helmet use by gender

Gender	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
Male	239	34.5	454	65.5	693
Female	9	30.0	21	70.0	30
Total	248		475		723

Age

The data from the Bangkok accidents revealed that helmet use tended to increase with age. About half of riders less than 21 years (72/142) were unhelmeted compared to only one-third of riders who were older than 20 years (176/581). Table 10.2.3 provides the cross-tabulation of motorcycle rider age and helmet use in the 723 on-scene, in-depth accident investigation cases.

Table 10.2.3: Helmet use by motorcycle rider age

Rider age (years)	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
11-20	72	50.7	70	49.3	142
21-30	119	33.5	236	66.5	355
31-40	46	27.1	124	72.9	170
41-50	10	19.6	41	80.4	51
51-60	0	0.0	3	100.0	3
Unknown	1	50.0	1	50.0	2
Total	248		475		723

Education and occupation

Generally, helmet use goes up with the level of education but the number of rider with a higher education level is small. Helmet use varied from a low of 60% among riders with a 12th grade education or less, to 83% among college graduates. Table 10.2.4 shows a cross-tabulation of motorcycle rider education and helmet use for the 723 on-scene, in-depth accident cases.

Table 10.2.4: Helmet use by motorcycle rider education

Education level	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
Grade 1 - 12	214	35.5	389	64.5	603
Partial college	10	41.7	14	58.3	24
Technical school	3	12.5	21	87.5	24
College graduate	4	17.4	19	82.6	23
Graduate school	0	0.0	1	100.0	1
Unknown	17	35.4	31	64.6	48
Total	248		475		723

Table 10.2.5 shows the results of a cross-tabulation of the motorcycle rider occupation and helmet use in the 723 on-scene, in-depth Bangkok accident cases. The data revealed that students had the lowest percent helmet use (41%) followed by military personnel (57%) and unskilled workers (61%).

Table 10.2.5: Helmet use by motorcycle rider occupation

Occupational category	No helmet		Helmet worn		Total
	Frequency	Row %	Frequency	Row %	
Unemployed	13	36.1	23	63.9	36
Manager	1	16.7	5	83.3	6
Professional	0	0.0	3	100.0	3
Office worker	5	13.2	33	86.8	38
Service worker	67	35.6	121	64.4	188
Trade worker	1	12.5	7	87.5	8
Driver, messenger	67	27.9	173	72.1	240
Machine operator	1	50.0	1	50.0	2
Unskilled worker	43	38.7	68	61.3	111
Military, active	9	42.9	12	57.1	21
Student	34	58.6	24	41.4	58
Other	0	0.0	1	100.0	1
Unknown	7	63.6	4	36.4	11
Total	248		475		723

Helmet use and trip characteristics

Helmet use tended to increase the longer the rider's intended trip. The data indicated that the highest helmet use (86%) for longer trips (over 10 kilometres) and the lowest helmet use (45%) for trips less than 1 kilometre. Table 10.2.6 shows the results of a cross-tabulation between the distance of the intended trip and helmet use.

Table 10.2.6: Helmet use by rider trip distance

Trip distance (km)	No helmet		Helmet worn	
	Frequency	Percent	Frequency	Percent
0-1	57	54.8	47	45.2
1.1-2	45	50.0	45	50.0
2.1-3	20	38.5	32	61.5
3.1-5	39	31.5	85	68.5
5.1-10	45	28.1	115	71.9
Over 10	16	13.8	100	86.2
Unknown	26	33.8	51	66.2
Total	248		475	

The highest rate of helmet use was found when work was either the origin or the destination. This is partly because professional riders such as motorcycle taxi and package delivery riders and messengers (i.e., origin and destination were both coded as “work”) had a very high rate of helmet use – 82% (123 or 151). Tables 10.2.7 and 10.2.8 display a cross-tabulation between helmet use trip origin / destination.

Table 10.2.7: Helmet use by trip origin

Trip origin	No helmet		Helmet worn	
	Frequency	Percent	Frequency	Percent
Home	49	41.9	68	58.1
Work, business	66	22.9	222	77.1
Recreation	27	42.9	36	57.1
School, university	4	40.0	6	60.0
Errand, shopping	19	51.4	18	48.6
Friends, relative	35	38.0	57	62.0
Bars, restaurant	37	40.7	54	59.3
Unknown	11	44.0	14	56.0
Total	248		475	

Table 10.2.8: Helmet use by trip destination

Destination	No helmet		Helmet worn	
	Frequency	Percent	Frequency	Percent
Home	114	33.9	222	66.1
Work, business	50	23.8	160	76.2
Recreation	11	57.9	8	42.1
School, university	1	12.5	7	87.5
Errand, shopping	23	60.5	15	39.5
Friends, relative	34	42.0	47	58.0
Bars, pub, restaurant	3	75.0	1	25.0
Other	0	0.0	1	100.0
Unknown	12	46.2	14	53.8
Total	248		475	

Alcohol

Helmet use was lower among riders who had been drinking (HBD), particularly those who appeared to be significantly impaired. Approximately 60% of drunk and impaired riders were helmeted compared to 69% of helmeted riders who had not been drinking. Table 10.2.9 shows a cross-tabulation of the helmet use and alcohol impairment.

Among the 275 riders for whom both helmet use and blood alcohol concentration (BAC) were known, helmet use was 75% for those with a BAC under 50 mg%, but 56% for those with a BAC above 100 mg%.

Table 10.2.9: Helmet use by rider alcohol involvement

Alcohol use	No helmet		Helmet worn	
	Frequency	Percent	Frequency	Percent
No alcohol involvement	135	31.4	295	68.6
HBD, not impaired	11	29.7	26	70.3
HBD, impaired	100	39.8	151	60.2
Unknown	2	40.0	3	60.0
Total	248		475	

Normal helmet use conditions

Riders were asked about the conditions under which they usually wore a helmet. Their responses are categorized in Table 10.2.10. For the rider, 57% claimed that they used the helmet "always", while 9% claimed that they never used the helmet and 14% claimed they used the helmet only on a long trip. "Other" responses included "daytime use only" or when the rider expected to see a policeman.

About 42% of the passengers reported that they never use a helmet and one-fourth claimed that they always used a helmet.

Table 10.2.10: Conditions when a helmet is usually worn

Usual helmet use conditions	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Never uses	66	9.1	100	42.2
Long trip	104	14.4	33	13.9
High way	3	0.4	3	1.3
Never in hot weather	3	0.4	0	0.0
Always	416	57.5	59	24.9
Other	61	8.4	18	7.6
Unknown	70	9.7	24	10.1
Total	723		237	

10.3 Helmet characteristics

Coverage

Helmets worn by riders were about evenly divided between the partial coverage helmets (which leave the face, ears and lower head exposed) and full facial coverage helmets (which cover the entire head and face.) Among passengers, the partial coverage helmet was clearly the most common, accounting for about 60% of those worn by passengers. "Full coverage" helmets that cover the entire head but leave the face exposed, were worn by nearly 20% of helmeted riders. Table 10.3.1 shows the type of helmet coverage worn by the motorcycle riders and passengers in accordance with the type of helmets used.

Table 10.3.1: Type of helmet coverage worn by rider and passenger

Helmet type	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Partial coverage	163	34.3	42	60.9
Full coverage	92	19.4	10	14.5
Full facial, no face shield	23	4.8	5	7.2
Full face, removable chin bar	6	1.3	0	0.0
Full face, retractable chin bar	3	0.6	0	0.0
Full facial, with face shield	188	39.6	12	17.4
Total	475		69	

Helmet manufacturer

Table 10.3.2 shows the distribution of the helmet manufacturers worn by the motorcycle rider and passenger in the 723 on-scene, in-depth accident investigation cases. The helmet manufacturer was unknown in the majority of cases because there were no clear identification labels on the helmets at the time they were evaluated by the investigators. Of those helmets that could be identified, Avex, Index, Safety-met, Pretty Lady and Million Stars were found frequently in the data set.

Table 10.3.2: Manufacturers of accident-involved helmets

Helmet manufacturer	Code	Rider helmet		Passenger helmet	
		Frequency	Percent	Frequency	Percent
Arai	A7	4	0.8	1	1.4
Index	I3	10	2.1	0	0.0
Shoei	S5	4	0.8	0	0.0
Safetymet	S9	80	16.8	8	11.6
Other	98	178	37.5	28	40.6
Unknown	99	199	41.9	32	46.4
Total		475		69	

Helmet standard qualification

Helmet standards typically set forth a series of well-defined tests under specific conditions that simulate the sort of loads helmets are expected to handle in accident conditions. Helmet standards typically include tests of the helmet's ability to absorb and dissipate impact loads. In addition, other tests within the standard examine the strength of the retention system and the helmet's ability to stay in place on the head, peripheral vision limitations, helmet hardware, etc.

Usually manufacturers test models of their helmets, either in their own laboratory or in an independent laboratory, to assure that their helmets meet the governing standards for the area where the helmet is to be sold. Ideally, a small part of every day's helmet production should be tested at random to assure that quality standards are maintained.

When meeting the standard is mandatory and the rule is enforced, low-quality helmets tend to disappear from the market. Consumers can then feel confident that they are spending money on a product that at least meets minimum standards and should provide them good protection in the event of an accident.

Unfortunately, at the time of this study, the helmet market in Thailand is flooded with too many helmets that appear to be incapable of meeting any current standard. It is not because the Thailand Industrial Standard (TIS) is inadequate. In fact, it is a good helmet standard. But it appears to go unenforced, and those who suffer preventable head injuries because of an inadequate helmet are the ones who pay the heaviest burden for the lack of enforcement.

The majority of accident-involved helmets carried no labeling to indicate they qualified for under any performance standard. However, 30% of the helmets were labeled to indicate they would meet the specifications of the TIS (Thai Industry Standard). Table 10.3.3 shows the qualifications of the motorcycle rider helmet collected as part of this study.

Table 10.3.3: Helmet standard qualification

Standard certification	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No standard	313	65.9	46	66.7
JIS-C	3	0.6	0	0.0
Thai Industrial Standard	143	30.1	20	29.0
Unknown	16	3.4	3	4.3
Total	475		69	

Helmet mass

Table 10.3.4 shows the weight distribution of the helmets worn by the motorcycle riders and passengers collected during this study. In general, it was found that those helmets with a weight between 500-650 grams were half helmet (partial coverage) type and those helmets that weighed between 800-1100 grams were open face (full coverage) helmets. Full-face helmets usually weighed between 1200-1500 grams. The data collected during this study clearly indicate that the higher weight helmets correspond to more shell and more liner for more coverage and a greater amount of protection.

Table 10.3.4: Helmet weight

Weight (grams)	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
< 600	88	18.5	21	30.4
600 – 700	67	14.1	19	27.5
700 – 800	14	2.9	1	1.4
800 – 1000	75	15.8	9	13.0
1000 – 1300	51	10.7	6	8.7
1300 – 1500	166	34.9	11	15.9
Unknown	14	2.9	2	2.9
Total	475		69	

Helmet colour

Table 10.3.5 shows the frequency and distribution of the predominating colour of the helmets worn by the accident-involved motorcycle riders and passengers. Black helmets predominated among the rider accounting for 22.3% of all helmets worn. Passengers most often wore white and red helmets.

Table 10.3.5: Colour of helmet worn by rider and passenger

Colour	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No dominant colour	51	10.7	1	1.4
White	72	15.2	12	17.4
Yellow	22	4.6	1	1.4
Black	106	22.3	7	10.1
Red	53	11.2	12	17.4
Blue	80	16.8	11	15.9
Green	29	6.1	7	10.1
Silver	20	4.2	1	1.4
Brown, tan	7	1.5	2	2.9
Purple	16	3.4	4	5.8
Gold	9	1.9	1	1.4
Chrome	1	0.2	0	0.0
Pink	8	1.7	10	14.5
Unknown	1	0.2	0	0.0
Total	475		69	

Helmet owner

Borrowed helmets are more likely to fit poorly, so helmet wearers were asked who owned the helmet they were wearing at the time of the accident. Table 10.3.6 shows that the rider owned the helmet he or she was wearing approximately 90% of the time. However, about 46% of the passenger helmets were not owned by the wearer. This was particularly evident in Bangkok where the accident-involved motorcycle was frequently a motorcycle taxi. The motorcycle taxi riders owned ten out of seventeen passenger helmets.

Table 10.3.6: Helmet owner

Helmet owner	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No	26	5.5	32	46.4
Yes	436	91.8	36	52.2
Unknown	13	2.7	1	1.4
Total	475		69	

Helmet pre-crash condition

About half of the helmets showed no significant damage prior to the collision and one-third showed minor damage, which was possibly from handing and use. In almost all cases, the damage to the shell of the helmets was innocuous and had no effect upon accident performance. However, 60 helmets – one in eight – showed damage to the retention system that rendered the retention system inoperable at the time of collision. Table 10.3.7 shows the pre-crash condition of the motorcycle rider helmets involved in the 723 on-scene, in-depth accident cases.

Table 10.3.7: Pre-crash condition of motorcycle rider helmet

Any helmet damage before accident	Frequency	
No significant prior damage	246	51.8
Minor damage from handling and use	149	31.4
Moderate, to exterior finish and comfort pad	9	1.9
Shell or liner damage, not in accident impact area	5	1.1
Other, including no retention system	60	12.6
Unknown	6	1.3
Total	475	

10.4 Retention system design and performance

The retention system has the function of keeping the helmet on the head when the crash impact occurs. In order for the retention system to function well, the helmet must fit well and the retention system must be securely fastened. If the helmet is too large or too loose, the impact may cause the helmet to rotate and be ejected from the head even though the retention system is fastened. On the other hand, if the retention system is unfastened or loosely fastened, the impact is certain to cause helmet ejection from the head.

Table 10.4.1 shows the evaluation of the helmet fit for both the motorcycle rider and the passenger. Based upon the analysis of the investigators, approximately 9% of both rider and passenger helmets were considered too large or too loose. The majority of the riders showed no helmet fit problem.

Table 10.4.1: Helmet fit evaluation

Helmet fit	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Acceptable fit	421	88.6	60	87.0
Too large, too loose	42	8.8	6	8.7
Unknown	12	2.5	3	4.3
Total	475		69	

Helmet adjustment

"Helmet adjustment" refers to how the helmet is worn on the head. A helmet that is pushed back so far that the rider's entire forehead and hairline are visible is improperly adjusted. Table 10.4.2 shows the majority of helmets worn by the motorcycle riders and passengers were properly adjusted.

Table 10.4.2: Helmet properly adjusted

Helmet adjustment	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Improper	14	2.9	0	0.0
Proper	453	95.4	68	98.6
Unknown	8	1.7	1	1.4
Total	475		69	

Retention system

"Quick-release" retention systems -- those secured by some kind of buckle -- were the majority, accounting for three-quarters of the helmets examined. The most common type of retention system worn by the rider was the (usually) plastic "barb sides" fitting (53%) or the "D-blade" type fitting (23%), which is similar to airplane safety belts. Fifteen helmets had no retention system because of prior damage. Passenger helmets showed similar findings. Table 10.4.3 shows the type of retention systems found on rider and passenger helmets evaluated during this study.

Table 10.4.3: Helmet retention system type

Retention system type	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No retention system	58	12.2	9	13.0
Double D-ring	19	4.0	3	4.3
Quick release, Barb sides	238	50.1	41	59.4
Quick release, D-blade	152	32.0	14	20.3
Other	4	0.8	1	1.4
Unknown	4	0.8	1	1.4
Total	475		69	

Helmet fastening

The helmet was securely fastened in about three-fourths of rider and passenger helmets as shown in Table 10.4.4.

Table 10.4.4: Helmet fastened

Helmet fastened	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No	123		16	
Yes	343		51	
Unknown	9		2	
Total	475		69	

Helmet ejection

The helmet ejected in about one-fourth of the cases one was worn, for both riders and passengers, most often during the initial impact. Table 10.4.5 shows the data.

Table 10.4.5: Helmet retention system performance

Helmet retention performance	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Helmet retained	351	73.9	53	76.8
Move on head but retained	13	2.7	2	2.9
Ejected during pre-crash	2	0.4	0	0.0
Ejected during crash	74	15.6	12	17.4
Ejected after collision	34	7.2	2	2.9
Unknown	1	0.2	0	0.0
Total	475		69	

Causes of helmet ejection

Rider misuse was, by far, the most frequent cause of helmet ejection. “Other” as a cause usually meant the retention system was inoperable due to prior damage or that the rider failed to fasten the retention system at all. Loose fastening was the second most frequently cited cause of helmet ejection. These failures to secure the helmet properly together accounted for 106 of 125 helmet ejections (85%). Ejection due to some structural failure of the helmet shell or retention system or impact damage combined to cause 10% of the ejections. Table 10.4.6 details these causes.

Table 10.4.6: Causes of helmet ejection

Helmet ejection causes	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Loose fastening	18	16.2	3	21.4
Helmet too large	2	1.8	0	0.0
Retention system failure	1	0.9	0	0.0
Shell failure	3	2.7	1	7.1
Helmet impact damage	7	6.3	1	7.1
Facial injury	2	1.8	0	0.0
Other *	76	68.5	9	64.3
Unknown	2	1.8	0	0.0
Total	111		14	

* Note: “Other” included no retention system and retention system not fastened.

Retention system failure

The obvious parts of the retention system are the straps and fasteners – usually some kind of quick-release buckle. Less obvious parts are the shell and the parts that attach the straps to the shell. A strong way to attach the straps to the shell is the sew the strap around a flat steel “hanger” which is then riveted securely to the helmet shell.

A “cheap and dirty” method is to rivet the strap directly to the shell – a method that simply tears the strap off if significant tension loads are applied to the retention system. Even worse methods were seen, such as attaching a strong nylon strap to a weak rubber strap that was then riveted to the shell. This system is so weak it can be torn loose by hand.

Retention system failures were associated with a tension force applied to the retention system, i.e. hanger fitting, shell rivets, or webbing laceration. Table 10.4.7 shows the distribution of retention failures for the rider and passenger helmets.

Table 10.4.7: Type of retention failure

Type of retention failure	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No failure or no retention	470	98.9	68	98.6
Hanger fitting failed	1	0.2	0	0.0
Shell rivets failed	1	0.2	0	0.0
Webbing laceration	1	0.2	0	0.0
Unknown	2	0.4	1	1.4
Total	475		69	

Another factor that appears to affect helmet retention is whether the rider was struck in the head/face region or not. Earlier (in Section 10.1) it was noted that riders whose helmet ejected suffered more – rather than fewer – head injuries than unhelmeted riders. This point is illustrated in Table 10.4.8, which compares head and face injury rates among unhelmeted riders and helmeted riders whose helmet either stayed on or ejected. The shaded columns show the average injury rates, which is simply the number of head or face injuries for each group divided by the number of riders in that group.

On average, riders whose helmets ejected suffered more injuries to the head and face than unhelmeted riders. In simple terms, they got hit more often in the head – about 65% more often than unhelmeted riders and that pummeling around the head is one of the reasons their helmets came off.

Table 10.4.8: Helmet ejection and head / face injury rates

Head or face impact	No helmet (248 riders)		Helmet retention status			
			Ejected (109 riders)		Retained (359 riders)	
	Freq	n/rider	Freq	n/rider	Freq	n/rider
Head injury	125	0.50	101	0.93	28	0.08
Face injury	211	0.85	143	1.31	113	0.31
Total	336		244		141	

10.5 Safety helmet Impact analysis

As noted earlier, 128 rider helmets and 17 passenger helmets from the Bangkok accident population were acquired. Acquisition was primarily through the offer of a replacement helmet with some form of financial compensation. The external examination and photographs were done for as many accident-involved helmets as possible. In those cases where the helmet was not obtained, it was visually examined and photographed to obtain evidence of the external impact damage. Table 10.5.1 shows the types of impact damage found on those helmets that were examined. As many as five separate impacts could be coded for each helmet, so the number of impacts exceeds the number of helmet damaged.

Abrasion was the dominant type of damage to the shell and accounted for nearly half of all impacts. "Fracture" applied to both the face shield and the shell; face shield fractures were far more common than shell fractures. In eight cases the helmet was significantly damaged usually from being run over by another vehicle. About one-fourth of rider helmets showed no evidence of damage. With respect to the passenger helmets, 46.8% were undamaged. By comparison, half the passenger helmets showed no damage. When impact damage did occur, it was most often in the form of abrasion (33%) or fracture (14%).

Table 10.5.1: Helmet impact damage type

Helmet impact damage	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No damage	153	26.5	37	46.8
Freckles	3	0.5	2	2.5
Abrasion	276	47.8	26	32.9
Fracture through	116	20.1	11	13.9
Crack	10	1.7	0	0.0
Delamination, gross	1	0.2	0	0.0
Rubber transfer	3	0.5	0	0.0
Paint transfer	5	0.9	1	1.3
Other	8	1.4	1	1.3
Unknown	3	0.5	1	1.3
Total	578		79	

Table 10.5.2 shows the distribution of helmet impacts for rider and passenger helmets. Damage was found to occur symmetrically all around the helmet: about 36% on both right and left sides; the upper front and upper rear both sustained about 23% of the impacts. Impacts to the lower front and lower rear both fell into the 10 to 15% range.

Table 10.5.2: Rider and passenger helmet impact sites

Damage location	Code	Rider		Passenger	
		Frequency	Percent	Frequency	Percent
Top center	35	58	5.6	7	6.9
Upper front, right	12 - 14	131	12.6	14	13.7
Upper front, left	22 - 24	140	13.4	14	13.7
Upper rear, right	11 - 13	136	13.1	17	16.7
Upper rear, left	21 - 23	128	12.3	14	13.7
Lower front, right	16 - 18	92	8.8	6	5.9
Lower front, left	26 - 28	81	7.8	4	3.9
Lower rear, right	15 - 17	70	6.7	12	11.8
Lower rear, left	25 - 27	53	5.1	6	5.9
Chin bar	18 - 28	109	10.5	3	2.9
Face shield	19 - 29	152	14.6	8	7.8

The locations of the impact sites on the full-face motorcycle safety helmet were divided into 10 locations and were numbered as shown in Figure 10.5.1.

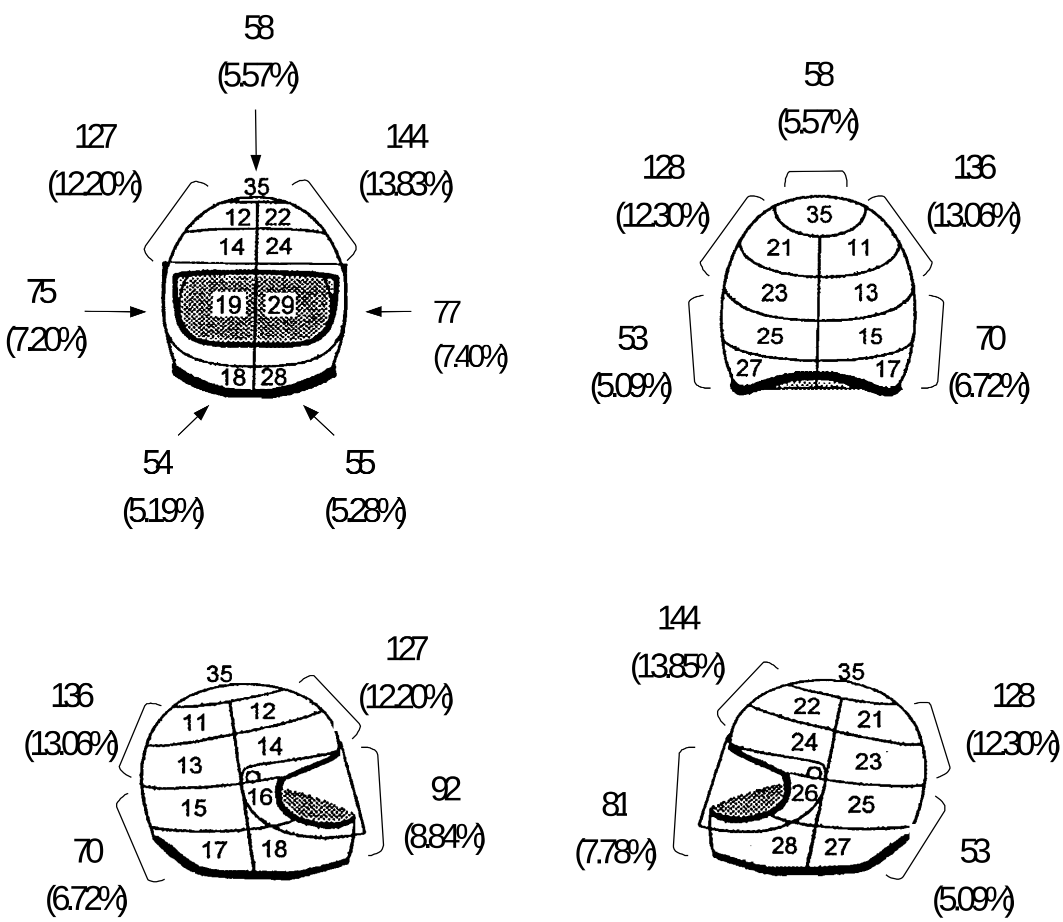

Fig. 10.5.1: showing motorcycle rider helmet impacts

Helmets can prevent injuries in some cases, but it is not possible for any helmet to prevent head and face injury in *all* cases. For example, if the rider is run over by a car, a helmet usually cannot prevent crushing injuries. In other cases, impact severity is far beyond the capacity of any helmet to protect the wearer.

Helmet protection is correlated with the extent of coverage. Half-helmets, like those worn by the police, cannot protect areas they do not cover. Impacts at the edge of the helmet may be only partially absorbed by the helmet. Therefore, full-facial coverage helmets have the potential for the greatest protection. Wearing a helmet is good and, generally, the more helmet coverage the rider wears, the better. The biggest problems seen in helmet performance in these accidents were the failure of motorcyclists to use the helmet properly -- or to wear a helmet at all.

10.6 Face shields

Face shields are distinct from eyeglasses and goggles, because a face shield is attached to the helmet, not independent of it. They are transparent plastic, and can shield the eyes from wind blast, but they are not intended to absorb impact energy in the same way as the helmet. Nonetheless, they have a limited capability to protect the eyes and face from some abrasion injuries.

Face shield color

Table 10.6.1 shows the predominating colour of the helmet face shields. Clear face shields accounted for half of all face shields collected. This was followed by grey, smoke face shields (42% of cases). Based upon our analysis of the accidents, it was felt that the face shield colour could contribute to accident causation, particularly in the low light areas and nighttime accidents.

Table 10.6.1: Motorcycle rider helmet face shield colour

Face shield colour	Frequency	
Clear	152	51.9
Green	1	0.3
Grey, smoke	124	42.3
Amber, yellow	4	1.4
Reflective	10	3.4
Unknown	2	0.7
Total	293	

Table 10.6.2 shows the distribution of face shields worn in relation to the ambient lighting conditions. There were 139 helmeted riders with tinted face shield and 77 (55.4%) of these accident-involved riders were wearing tinted face shield at nighttime.

Table 10.6.2: Face shield colour and ambient lighting conditions

Ambient lighting condition	Helmet face shield colour					
	Clear face shield		Tinted face shield		Unknown	
	Frequency	%	Frequency	%	Frequency	%
Daylight	74		51		0	
Night	69		77		2	
Dusk-Dawn	9		11		0	
Total	152		139		2	

Eyeglasses

Eyeglasses can protect the eyes from wind blast and rain while riding, but they are unlikely to offer much injury protection in an accident. One rider in every thirty-six (2.8%) wore some sort of eye protection, usually prescription eyeglasses, or in a few cases, sunglasses. Helmet mounted face shields were not considered to be eye coverage but rather a helmet appliance. It was obvious from the examination of the data that such eye coverage could not provide any protection or reduction to eye injury if it should occur. Furthermore, the lack of appropriate eye protection can cause impairment of vision from wind blast on to the bare eyes and this in turn could delay hazard detection and collision avoidance action. Table 10.6.3 shows the type of eye coverage in use at the time of the accident.

Table 10.6.3: Eye coverage in use, separate from helmet

Eye coverage type	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
None	703	97.2	234	98.7
Prescription clear glasses	14	1.9	2	0.8
Non-prescription sun glasses	4	0.6	1	0.4
Goggles	1	0.1	0	0.0
Unknown	1	0.1	0	0.0
Total	723		237	

10.7 Clothing

Upper torso coverage materials

Most riders (71%) and passengers (88%) were wearing only light cloth, such as a light shirt or T-shirt when they crashed. The remainder wore medium cloth (nylon jacket on top of the T-shirts or shirts). Only one rider wore a heavy cloth garment and two riders were wearing a leather jacket. Thailand's tropical climate does not encourage wearing heavy leather garments. The predominance of short trips in these accident data also acts to discourage use of heavy riding apparel. Table 10.7.1 shows the type of upper torso garment worn by the motorcycle riders and passenger(s).

Table 10.7.1: Rider and passenger upper torso garment

Upper torso garment	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Light cloth	515	71.2	208	87.8
Medium cloth	204	28.2	29	12.2
Heavy cloth	1	0.1	0	0.0
Leather	2	0.3	0	0.0
Unknown	1	0.1	0	0.0
Total	723		237	

Lower torso coverage materials

Most accident-involved riders and passengers wore either medium cloth garment (jeans) or light cloth garments (i.e., shorts, normal trouser, skirts, etc.) None wore leather or any sort of ballistic material such as Cordura. Table 10.7.2 illustrates the type of lower torso garment materials worn by the motorcycle riders and passengers

Table 10.7.2: Rider and passenger lower torso garment

Lower torso garment	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
Light cloth	350	48.4	142	59.9
Medium cloth	372	51.5	95	40.1
Unknown	1	0.1	0	0.0
Total	723		237	

Clothing conspicuity

A large percentage of what the other vehicle driver can see of an approaching motorcycle is the upper and lower torso garments worn by the rider. Clothing, particularly upper torso coverage, is therefore a principal means that the rider can use to affect his visibility in traffic during daylight hours. Approximately half of accident-involved riders wore clothing that was more or less neutral – it showed little or no apparent contribution to the rider's conspicuity. About (28%) of the riders were wearing dull or dark upper torso garment which decreased their conspicuity and about 20% of riders wore some bright colour with high conspicuity (Table 10.7.3).

Table 10.7.3: Protective clothing conspicuity contribution

Conspicuity of protective cloth	Frequency	
No contribution of upper or lower torso garment	366	50.6
Bright upper and lower torso garment	55	7.6
Bright upper torso garment enhanced conspicuity	92	12.7
Dark upper/lower torso garment decreased conspicuity	171	23.7
Dark upper torso garment decreased conspicuity	35	4.8
Unknown	4	0.6
Total	723	

Footwear material and type

Table 10.7.4 shows the type of footwear worn by the accident-involved riders and passengers. The overwhelming majority of riders and passengers wore light sandals or ordinary shoes. Only about 5% of the accident-involved riders were wearing heavy shoes or boots at the time of collision.

Table 10.7.4: Rider and passenger footwear

Type of footwear	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Light sandal	458	63.3	184	77.6
Medium street shoe	155	21.4	30	12.7
Athletic	75	10.4	21	8.9
Heavy shoe or boot	34	4.7	2	0.8
Unknown	1	0.1	0	0.0
Total	723		237	

Glove material

Only about one rider in 40 was wearing gloves, and none of the gloves were leather. None of the passengers used any type of protective glove at all. Table 10.7.5 shows the type of gloves worn by the motorcycle riders.

Table 10.7.5: Rider and passenger gloves

Glove material	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
None	705	97.5	237	100.0
Light cloth	6	0.8	0	0.0
Medium cloth	6	0.8	0	0.0
Heavy cloth	5	0.7	0	0.0
Unknown	1	0.1	0	0.0
Total	723		237	

10.8 Clothing effect on injuries

Because riders were almost always interviewed at the accident scene or emergency room, they were still wearing the clothing they had on at the time of the accident. Thus, it was possible to observe the damage to the clothing and ask the rider about clothing damage and any injuries in the areas where clothing showed damage. In this way, investigators were able to form a subjective evaluation of how the apparel had performed in preventing or reducing the wearer's injuries.

As with helmets, a number of factors can enter into an evaluation. For example, whether pants are long or short, heavy or light, they are not expected to prevent leg fractures, but may be able to prevent abrasions or reduce lacerations. Generally, if clothing showed damage but the rider reported no adjacent injury, the clothing was judged to have prevented injury. If the rider reported some minor injury, then the clothing was evaluated whether it reduced or had no effect in preventing injury. If clothing showed no damage and the rider had no injury, the conclusion was that there had been no injury-producing contact in the area. Evaluations of clothing effectiveness are presented in Tables 10.8.1 through 10.8.4.

Upper torso coverage

About 40% of the accident-involved riders had no evidence of injury because there was no contact in the upper torso region (Table 10.8.1). The data also showed that the upper torso coverage had no effect in 48% of cases. About half of passengers had no contact evidence and for one-third of cases, the upper torso garment had no effect upon injury prevention.

Table 10.8.1: Upper torso garment effectiveness

Upper torso garment effectiveness	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
No effect	350	48.4	89	37.6
Reduced injury	71	9.8	11	4.6
Prevented injury	9	1.2	0	0.0
No contact	293	40.5	136	57.4
Unknown	0	0.0	1	0.4
Total	723		237	

Lower torso coverage effectiveness

Table 10.8.2 shows that one-third of the accident-involved motorcycle riders received no lower torso extremity injury. Of 505 riders who sustained impact to the lower torso & leg region, 70% had injuries that were unaffected by their clothing. Clothing was thought to have reduced injuries about one-fourth of the times that impact occurred.

Table 10.8.2: Lower torso garment effectiveness

Lower torso garment effectiveness	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
No effect	353	48.8	101	42.6
Reduced injury	135	18.7	33	13.9
Prevented injury	16	2.2	2	0.8
No contact	218	30.2	100	42.2
Other	1	0.1	0	0.0
Unknown	0	0.0	1	0.4
Total	723		237	

Footwear effectiveness

In spite of wearing sandals nearly two-thirds of the riders and passengers simply had no contact in the foot region (Table 10.8.3). Nonetheless, footwear prevented or reduced injury only about once for every 12 riders who sustained contact in the foot region. This is far less than the 30% average for lower torso coverage.

In simple terms, Bangkok riders got far more “protection” from random chance than from their foot coverage. If they had contact in the foot region, their footwear would do nothing to protect them. It should be noted that sandals, like unfastened helmets, usually ejected and were found lying around the accident scene.

Table 10.8.3: Footwear effectiveness

Footwear effectiveness	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
No effect	231	32.0	60	25.3
Reduced injury	14	1.9	1	0.4
Prevented injury	11	1.5	1	0.4
No contact	467	64.6	174	73.4
Unknown	0	0.0	1	0.4
Total	723		237	

Glove effectiveness

Only 17 riders were wearing gloves at the time of the accident, and six (35%) of those were thought to have injuries prevented or reduced by the gloves as shown in Table 10.8.4. This is roughly in line with the judgments regarding the effectiveness of upper and lower torso coverage in preventing or reducing injuries.

Table 10.8.4: Rider glove material, evaluation of effectiveness

Glove effectiveness	Frequency	
Not present but injury occurred	212	29.3
Present but had no effect	4	0.6
Present and reduced injury	4	0.6
Present and prevent injury	2	0.3
No contact	501	69.3
Total	723	

11.0 Contributing Factors in Accident Causation

Throughout the 723 on-scene, in-depth accident investigation cases, each accident was thoroughly investigated in order to identify clearly all environmental, vehicle and human factors that might be related to the accident causation. It was essential to evaluate these three factors in detail in order to establish their relative contributions.

11.1 Environmental factors

Roadway design defects

Roadway design defects were classified as either design, maintenance or control defects. Design defects were those that involve engineering choices that create problems for motorists. These can include failure to provide positive guidance or control (such as a lack of signs or confusing signs), poorly designed traffic controls, poor intersection design, etc. The following are some examples of design defects that were the precipitating event or contributed to causing the 723 accidents in Bangkok.

1. Inadequate marking and guidance in and around construction zones, especially at night, caused many accidents. For example, concrete "K-rail" barriers were placed in or very close to the traffic flow with no reflectors or lighting to let motorists know of the danger.

2. Medians separating traffic lanes that flow in the same direction. It was very common for drivers to make a U-turn from the curb lane across the lanes of traffic flowing in both directions. Examples of this type of design can be found in Bangkok on Sri-Ayutthaya Road and Vitthayu Road.

3. Large pavement reflectors caused several accidents when they were impacted by the front tyre, causing loss of tyre pressure, denting of the front wheel rim of the motorcycle, and subsequently causing a fall to the roadway.

4. View obstructions – support pillars for pedestrian overpasses, telephone booths, mailboxes, walls, etc.— were frequent problems, especially when the motorcycle or other vehicle was exiting a driveway or soi.

5. Lane markings, usually paint stripes, may disappear during heavy rain, so that drivers cannot tell exactly where they should be on the roadway.

6. Curves on unlighted roads need adequate signing on the approach and through the curve, to provide proper guidance to the driver. A speed advisory sign was also found to be necessary in many cases.

7. Bridges over canals in Bangkok frequently obstructed the view of an intersection or traffic stopped on the far side of the bridge. Riders (and car drivers) sometimes found themselves coming over the top of a bridge going too fast and unable to stop before impacting the traffic on the other side of the bridge.

8. Center medians with vegetation taller than one metre above pavement level blocked the view of car drivers while seated in their vehicle.

9. Small gaps between barriers that were capable of blocking cars, but not motorcycles, from making unsafe maneuvers across traffic.

Design defects were noted in 44 cases and caused or contributed to the accident in 37 (5%) of the 723 accidents (Table 11.1.1). There were seven cases in which a roadway design defect was present but was not considered to be a contributing factor. One example of this would be a drunk rider who fell asleep and ran off a sharp curve roadway without curve-warning sign. Failure to install warning signs of the approaching curve was clearly a defect, but rider fatigue and alcohol acted as the primary contributing factors in the accident.

Poorly maintained construction zones were a major problem in two ways: inadequate signing and guidance was a major problem, particularly at night. Unmarked, unreflectorized barriers and vehicles were left too close to the traffic flow, and some riders ran into them. The second problem at construction zones was with the erected construction barriers that caused view obstruction between the rider and the other vehicle driver.

The large, “aggressive” pavement reflectors used on some roadways in Bangkok caused several motorcycles to capsize when they were struck. The large profile of these reflectors was sufficient in many cases to deflate the tyre and dent the rim.

Table 11.1.1: Roadway design defect and accident causation

Roadway design	Motorcycle path		Other vehicle path	
	Frequency	Percent	Frequency	Percent
No design defect	678	93.8	666	95.7
Not a contributing factor	7	1.0	2	0.3
Precipitating event	3	0.4	1	0.1
Primary contributing factor	1	0.1	1	0.1
Contributing factor	33	4.6	26	3.7
Other	1	0.1	0	0.0
Total	723		696	

Roadway design defects on the other vehicle path caused or contributed to 28 accidents. In 23 cases a roadway design defect contributed to causing the accident for both motorcycle and other vehicle, as shown in Table 11.1.2.

Table 11.1.2: Roadway design defect on both vehicles

Design defect contribution	Defect on other vehicle path					Total
Defect on motorcycle path	No defects	Present, no contribution	Defect was PE	Primary cause	Defect contributed	
No defects	588	0	0	0	2	590
No contribution	0	1	0	1	0	2
Defect was PE	0	1	1	0	0	2
Defect contributed	0	0	0	0	22	22
Total	588	2	1	1	24	616

Roadway maintenance defects

Maintenance defects included roadway items such as potholes, dirt from construction sites left in the roadway, worn and nearly invisible paint stripes, etc. Maintenance defects were frequent but usually did not contribute to accident causation (Table 11.1.3). In several cases, the motorcycle struck a large pothole in the roadway and this caused the motorcycle to capsize immediately. Table 11.1.4 shows only two cases where the roadway maintenance defects contributed to accident causation for both motorcycle and other vehicle.

Table 11.1.3: Roadway maintenance defect and accident causation

Maintenance defect	Motorcycle path		Other vehicle path	
	Frequency	Percent	Frequency	Percent
No maintenance defect	604	83.5	622	89.4
Not a cause factor	103	14.2	72	10.3
Precipitating event	3	0.4	0	0.0
Primary cause factor	5	0.7	0	0.0
Contributing cause factor	8	1.1	2	0.3
Total	723		696	

Table 11.1.4: Roadway maintenance defect on both vehicles

Maintenance defect contribution	Defect on other vehicle path			Total
Defect on motorcycle path	No defects	Present, no contribution	Defect contributed	
No defects	519	16	0	535
Present, no contribution	25	50	0	75
Primary cause	0	1	0	1
Defect contributed	0	3	2	5
Total	544	70	2	616

Temporary traffic obstruction

Examples of a temporary traffic obstruction included unmarked, unreflectorized barriers around a construction site. Sometimes, these barriers acted as view obstructions between the motorcycle and other vehicle when their paths were perpendicular. In one case, a large construction crane with an extended stabilizer was located in the middle of roadway without any marking. A motorcycle rider traveling at night struck the stabilizer and sustained significant leg injuries.

Temporary traffic obstructions on the motorcycle path caused or contributed to 29 accidents, and were present but did not contribute in another 14 cases (Table 11.1.5). On the other vehicle path, temporary obstructions caused or contributed to 13 accidents. Table 11.1.6 shows ten cases where a temporary traffic obstruction was present on both motorcycle and other vehicle paths in the same accident.

Table 11.1.5: Temporary traffic obstruction and accident causation

Temporary traffic obstruction	Motorcycle path		Other vehicle path	
	Frequency	Percent	Frequency	Percent
Not present	680	94.1	672	96.6
Not a cause factor	14	1.9	11	1.6
Precipitating event	3	.4	2	0.3
Primary cause factor	15	2.1	2	0.3
Contributing cause factor	11	1.5	9	1.3
Total	723		696	

Table 11.1.6: Temporary traffic obstruction on both vehicles

Temporary traffic obstruction	Defect on other vehicle path					Total
Defect on motorcycle path	No defects	Present, no contribution	Defect was PE	Primary cause	Defect contributed	
No defects	581	1	1	0	2	585
No contribution	3	8	0	0	0	11
Defect was PE	2	0	1	0	0	3
Primary cause	4	0	0	2	0	6
Defect contributed	3	1	0	0	7	11
Total	593	10	2	2	9	616

Traffic control defect or malfunction

A traffic control defect was coded only if a traffic control was present but was operating improperly. Traffic control malfunction was considered to be a primary contributing factor in only one case when a motorcycle rider entered the intersection on a red light which could not be seen because it was burned out (i.e., no traffic control signal could be seen).

Traffic control defects were found to be present but not considered to be a cause factor in four other instances (Table 11.1.7). On the other vehicle path, there were only two cases that traffic control malfunctions were present but were not considered to be a cause factor. There was no case in which traffic malfunction was present for both vehicles (Table 11.1.8).

Table 11.1.7: Traffic control malfunction and accident causation

Traffic control	Motorcycle path		Other vehicle path	
	Frequency	Percent	Frequency	Percent
No defect or malfunction	718		694	
Not a cause factor	4		2	
Primary cause factor	1		0	
Total	723		696	

Table 11.1.8: Traffic control malfunction on both vehicles

Traffic control defect contribution	Defect on other vehicle path		Total
Defect on motorcycle path	No defects	Present, no contribution	
No defects	613	0	613
Present, no contribution	0	2	2
Primary cause	1	0	1
Total	614	2	616

Summary of roadway defects

Together these various roadway defects – design, maintenance, traffic obstructions and traffic control problems – were cited in 94 cases: 13% of the 723 accidents. It is important to note that these 94 cases represent those cases where the roadway defect was a clear problem. There many other cases found by the investigators where there other unsafe design conditions, yet these conditions did not contribute directly to accident causation.

Visual obstructions

Table 11.1.9 shows there were 103 cases (14.2%) in which the accident-involved riders neglected a visual obstruction which was present and this neglect of the visual obstruction subsequently became a contributing factor to the accident. The drivers of the other vehicles were found to neglect the visual obstruction in about 11.9% of cases.

Table 11.1.9: Visual obstruction contribution

Visual obstruction contribution to accident	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No view obstruction	534	73.9	517	74.3
No contribution	85	11.8	94	13.5
Contributed to accident	103	14.2	83	11.9
Unknown	1	0.1	2	0.3
Total	723		696	

Weather related problems

In general, weather was not a major accident cause factor in this research. However, when it was present, adverse weather often contributed to accident causation. In the 18 cases in which the weather was inclement (i.e., raining) it contributed to accident causation in 12 of those cases, usually by limiting the rider's ability to see.

11.2 Vehicle factors

The evaluation of the mechanical design as a cause factor found no case in which there was a defect of the accident-involved motorcycle. The motorcycle problems that were found during the post-crash inspections were pre-existing maintenance related problems that were present prior to the accident, i.e. worn or absent brakes, loose steering, missing or burned out headlamp or rear lamp, or loose suspension. Such improper maintenance of the accident-involved motorcycles was considered to be a result of human error, not vehicle defect.

There was only one documented case in which a motorcycle component failed suddenly and caused an accident – this was a case in which the motorcycle sustained a rear tyre blow-out, causing loss of control and capsize by the motorcycle rider.

Cargo / luggage contribution to accident causation

Cargo or luggage was present in 76 cases but rarely contributed to accident causation (Table 11.2.1). In three cases, part of the cargo impacted the other vehicles. In another five cases the cargo interfered with the motorcycle controls and prevented successful collision avoidance action.

Table 11.2.1: Cargo / luggage and accident causation

Cargo and accident contribution	Frequency	
Not applicable, no cargo/luggage	647	89.5
No contribution	68	9.4
Interfered with controls during collision avoidance	5	0.7
Other	3	0.4
Total	723	

Other vehicle failure related to accident

Other vehicle failures contributed to the accident causation in 29 cases (Table 11.2.2). Most of these fell into two categories: pre-existing maintenance problems on the "other motorcycle" in a motorcycle vs. motorcycle crash, or vehicles abandoned in traffic or abandoned in the curb lane at night due to sudden mechanical failure (and left without adequate warnings, reflectors, etc.).

Table 11.2.2: Other vehicle failure and accident causation

Other vehicle failure	Frequency	
None	624	89.7
Tyre or wheel failure	4	0.6
Brake failure	3	0.4
Steering failure	1	0.1
Power transmission failure	4	0.6
Electrical failure	1	0.1
Other	16	2.3
Unknown	43	6.2
Total	696	

11.3 Rider alcohol

Alcohol may be the single most outstanding contributing factor in these accidents. Alcohol-involved accidents are almost a separate population from non-alcohol crashes. Analysis of the alcohol-involved accidents shows that alcohol-involved accidents have different time distributions, different accident configurations, population differences, differences in trip plans, helmet usage and different patterns of cause factors.

Alcohol-involved accidents occurred more often near the weekend and in the few hours around midnight. Alcohol-involved riders were more likely to be in a single vehicle accident, to run off the roadway, or to be the striking vehicle running into the rear of another vehicle. They were more likely to be inattentive or daydreaming, more likely to violate traffic control signals and to be going faster when they crashed. Alcohol-involved riders were also more likely to be the primary or even sole contributing factor in causing the accident and when they crashed, these riders were more likely to be seriously injured or killed.

Time of accident

Alcohol accidents in Bangkok occurred mostly at night, and mostly in the few hours around midnight: 205 of 289 (71%) happened between 10 p.m. and 3 a.m. Almost none of the alcohol-involved accidents occurred between 6 a.m. and 6 p.m. involved alcohol. In contrast, non-alcohol accidents showed a wide peak of occurrence during business hours (9 a.m. to 6 p.m.) and then a reduction until 8 p.m. when they increased again until 11 p.m. when they decreased again. Figure 11.3.1 shows the time distribution of alcohol and non-alcohol accidents. The data are shown in Table 11.3.1 in the Appendix.

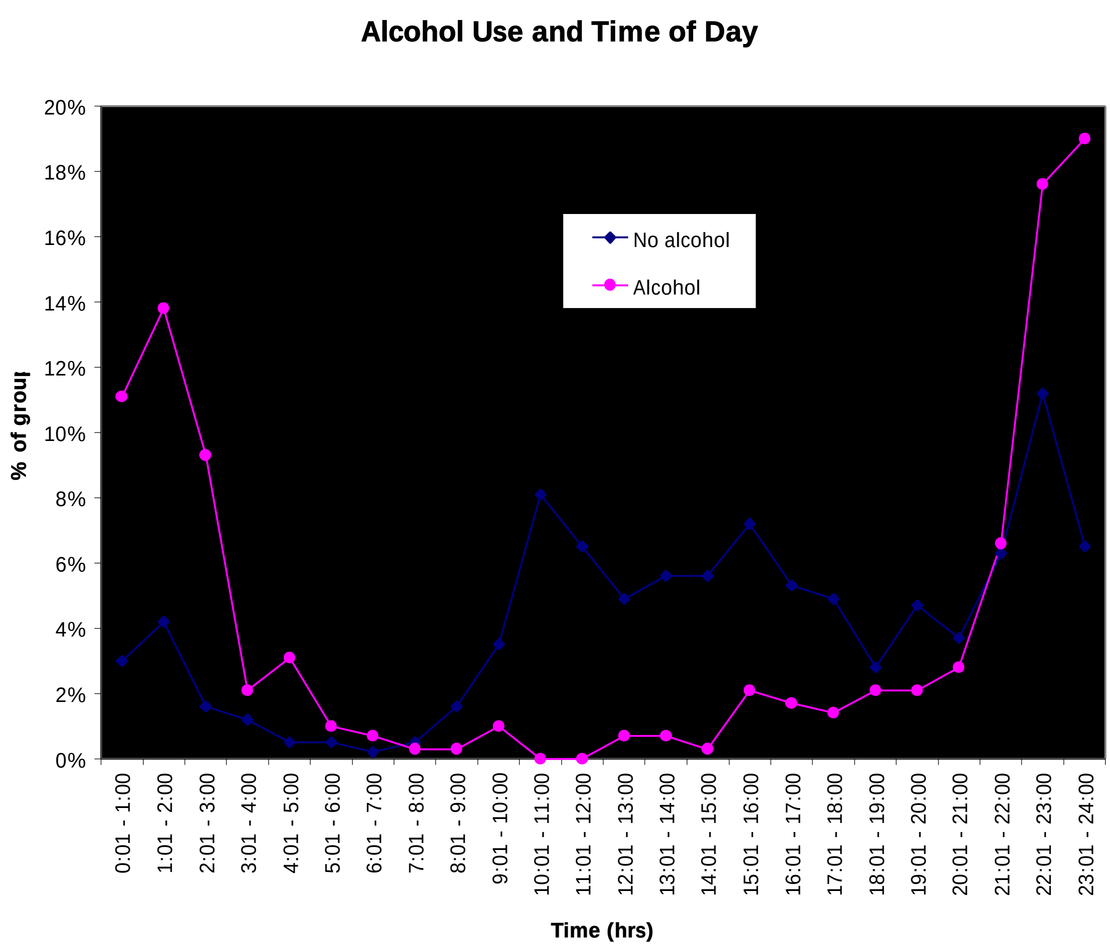

Figure 11.3.1:   Percent distribution of alcohol and non-alcohol accidents over 24 hours.

Day of the week

The frequency of alcohol-involved accidents was found to be low during the early part of the week (Monday to Wednesday) and they then began increasing on Thursdays to a peak on Sunday. Overall, alcohol was present in 40% of the Bangkok accidents, but when partitioned by day of the week, alcohol-involved accidents made up nearly half of the accidents on Sunday and Wednesday. The data are presented in Table 11.3.2 for the 719 riders whose alcohol involvement was known.

Table 11.3.2: Alcohol involvement by day of week

Day of week	No alcohol		Alcohol use		Total
	Frequency	Percent	Frequency	Percent	
Monday	55	68.8	25	31.2	80
Tuesday	59	66.3	30	33.7	89
Wednesday	34	50.7	33	49.3	67
Thursday	64	59.3	44	40.7	108
Friday	80	63.5	46	36.5	126
Saturday	75	60.0	50	40.0	125
Sunday	63	50.8	61	49.2	124
Total	430		289		719

Accident configuration

Alcohol-involved riders were twice as likely to get into single vehicle accidents. Only 9% of non-alcohol-involved accidents (38 of 430) were single-vehicle crashes, compared to 23% of alcohol-involved accidents (67 of 289). Alcohol-involved riders were 40% of the accident population, but accounted for two-thirds of the single-vehicle crashes. The data are shown in Table 11.3.3.

Table 11.3.3: Alcohol and single vehicle crashes

OV involved	No alcohol		Alcohol-involved		Total
	Frequency	%	Frequency	%	
No OV, MC solo	38		67		105
OV involved	392		222		614
Total	430		289		719

Loss of control accidents more than doubled among alcohol-involved riders and the loss of control usually involved running off the side of the road (Table 11.3.4). Only 13% of non-alcohol-involved riders (57 of 430) lost control of the motorcycle, compared to 29% (83 of 289) of alcohol-involved riders. Of 57 non-alcohol-involved riders who lost control of the motorcycle, only 8 (14%) ran off the road, but half of the alcohol-involved riders (41 of 83) ran off the roadway.

Table 11.3.4: Alcohol and motorcycle loss of control

Loss of control	No alcohol		Alcohol use	
	Frequency	Percent	Frequency	Percent
Loss of control occurred				
No loss of control	373	86.7	206	71.3
Loss of control	57	13.3	83	28.7
Total	430		289	
Loss of control mode				
Ran off road	8	14.0	41	49.4
Other loss of control mode	49	86.0	42	50.6
Total	57		83	

Alcohol and traffic control violations

Alcohol-involved riders were far more likely to violate a traffic control sign or signal when they crashed. Non-alcohol-involved riders violated a traffic control signal 26% of the time (34 of 131 cases) that a control was present, compared to 50% (49 of 98) of alcohol cases. The data are shown in Table 11.3.5.

Table 11.3.5: Alcohol and traffic control violations

Traffic control violation	No alcohol		Alcohol use		Total
	Frequency	Percent	Frequency	Percent	
No	97		49		146
Yes	34		49		83
Total	131		98		229

Alcohol and gender

Females were greatly under-represented in alcohol-involved accidents. They were 4% of accident -involved riders overall (30 of 719), but they accounted for only 4 of the 289 (1.4%) alcohol-involved riders in crashes. The data are shown are in Table 11.3.6.

Table 11.3.6: Alcohol use and rider gender

Gender	No alcohol		Alcohol use		Total
	Frequency	Percent	Frequency	Percent	
Male	404		285		689
Female	26		4		30
Total	430		289		719

Alcohol, education and occupation

Alcohol use actually varied little as a function of education or occupation in the Bangkok data. For both alcohol-involved and non-alcohol-involved riders the median number of years of formal schooling was 9 years. In addition, alcohol use showed little variation as a function of the number of years of education. College graduates who crashed a motorcycle were about as likely to have been consuming alcohol (9 of 24) as riders with a minimum education. Data are shown in Table 11.3.7.

In a similar way, alcohol use was fairly consistent across occupational categories. A few of the occupational categories are listed in Table 11.3.8, because they showed greater than normal variation from the 40% average of alcohol use. Two groups were notably under-represented in drinking accidents: motorcycle taxi riders or messengers and students. Only 30% of motorcyclists who rode (or drove a car) as part of their job had been consuming alcohol prior to the accident. The surprising exception to alcohol use was for students, who were far less likely to have been drinking before they got into a crash. While about 40% of the overall riding population had been drinking, only 14% of students (8 of 58) had been drinking.

Table 11.3.7: Alcohol use by years of formal education

Education (years)	No alcohol		Alcohol use		Total	
	Frequency	Row %	Frequency	Row %	Frequency	Row %
1 – 6	122	60.4	80	39.6	202	100.0
7 – 9	147	61.3	93	38.8	240	100.0
10 – 12	100	62.9	59	37.1	159	100.0
13 – 18	41	58.3	31	41.7	72	100.0
Unknown	21	44.7	26	55.3	47	100.0
Total	430		289		719	

Table 11.3.8: Alcohol use in selected occupational categories

Occupational category	No alcohol		Alcohol use		Total	
	Freq	Row %	Freq	Row %	Freq	Row %
Unemployed>1 month	19	52.8	17	47.2	36	100.0
Service, sales	96	51.3	91	48.7	187	100.0
Driver, messenger	169	70.7	70	29.3	239	100.0
Unskilled laborers	56	50.5	55	49.5	111	100.0
Military, active duty	9	42.9	12	57.1	21	100.0
Students	50	86.2	8	13.8	58	100.0

Alcohol and trip plans

Trip plans differed for alcohol-involved and non-alcohol-involved riders. Over half (52%) of alcohol-involved riders (150 of 289) were going home from recreation, a friend's house or a bar, compared to only 28% of non-alcohol-involved riders with a similar trip plan. About 54% of non-alcohol-involved riders (233 of 430) had started their trip at work and one-third of these riders (141) were riding as part of their work. On the other hand, 10 of 151 riders (7%) who were riding as part of the job had been consuming alcohol prior to the crash. Also, of 288 riders whose trip originated at work, 55 (19%) had been consuming alcohol. Twice as many alcohol-involved accidents originated at work as at home (55 versus 24).

These statistics reflect a picture in which most consumption of alcohol takes place outside the home, and alcohol-involved riders are most often heading home. Non-alcohol-involved accidents are mostly work-related or originate at home.

Alcohol and speed

Alcohol-involved riders in the Bangkok accidents were usually going somewhat faster when they crashed than their non-alcohol-involved counterparts. The differences between alcohol-involved and non-alcohol-involved riders were only 5 km/hr and 6 km/hr for the pre-crash and crash speeds. The differences are reported for cases where both alcohol use and speed were known. A brief summary of mean and standard deviations (SD) of pre-crash and crash speeds appears in Table 11.3.9.

Table 11.3.9: Alcohol and speed

Speed, km/hr Mean ± SD,	No alcohol	Alcohol use
Pre-crash speed	38 ± 18 km/hr	43 ± 19 km/hr
Crash speed	32 ± 16 km/hr	38 ± 18 km/hr

Alcohol and attention

Alcohol affects riders by slowing down information processing during divided-attention tasks, and operating a motorcycle is a classic divided-attention task. That is, the rider must divide his attention between vehicle speed and other controls (lights, turn signals, etc.), balance, lane position, positioning relative to other traffic and the rider’s goal of following the proper route to his chosen destination. The more one consumes alcohol, the more the ability to process information (as measured by the frequency of eye movements) slows down.

Therefore, it was expected that alcohol-involved accidents would show more attention failures than accidents without alcohol. Table 11.3.10 compares attention failures in accidents between riders who had been drinking and those who had not.

Table 11.3.10: Alcohol and rider attention

Rider attention	Alcohol use				Total
	No		Yes		
	Freq	Percent	Freq	Percent	
Inattentive, daydreaming	16		133		149
Attention to driving not a factor	359		99		458
Diverted to surrounding traffic	24		14		38
Diverted to non-traffic item	6		3		9
Diverted to passenger activities	6		3		9
Other	6		2		8
Attention unknown	13		35		48
Total	430		289		719

Alcohol-involved riders represented about 40% of the accident population, but accounted for nearly 90% of the accidents in which "daydreaming" and complete inattention appeared to precede the collision. Only one-third of alcohol-involved riders appeared to be completely attentive to the driving task, compared to about five of every six non-alcohol-involved riders.

Inattention does not always cause or contribute to a crash. Table 11.3.11 suggests that for the 263 alcohol-involved riders whose attention was evaluated, inattention was a cause factor over half the time. Among non-alcohol-involved riders, inattention was a cause factor about once in every ten accidents.

At the investigation level, it was not uncommon for alcohol drinking riders to be unable to provide any information at all about how their accident had happened. Many simply had no idea how they had gotten into an accident.

Table 11.3.11: Alcohol and attention failure contribution to accident cause

Attention failure	Alcohol use				Total
	No		Yes		
	Freq	%	Freq	%	
No attention failure	358		100		458
Failure occurred, did not contribute	15		38		53
Attention failure contributed	45		125		170
Attention contribution unknown	12		26		38
Total	430		289		719

Alcohol contribution to accident causation

The presence of alcohol may or may not be considered to be a contributing factor to accident causation depending upon the reconstruction and causation analysis. For example, if an alcohol-involved rider was stopped waiting in traffic and was struck from behind by another vehicle, then alcohol was considered not to be a contributing factor. On the other hand, if an alcohol-involved rider fell asleep while riding, or an alcohol-involved rider ran through a red light, it was then considered to be a definite contributing factor. Table 11.3.12 shows that alcohol was a contributing factor for the motorcycle rider in nearly 90% (258/289 cases) of those cases where alcohol was present. Alcohol involvement was a contributing factor for the other vehicle driver in 73% (44/60) of cases when the other vehicle driver had been drinking.

Table 11.3.12: Alcohol contribution for rider and other vehicle driver

Alcohol contribution	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No contribution	31		16	
Contributed to accident	258		44	
Total	289		60	

Alcohol and primary cause factors

As a final evaluation in each case, investigators were required to categorize and identify the main cause factors of the accident. In non-alcohol involved accidents, the rider was coded as the primary cause in 46% of the cases (199 of 430 cases). In contrast, alcohol-involved riders were considered to be the primary cause in 72% of their crashes (209 of 289).

As many as three contributing factors could be listed, the findings showed that in 172 cases, only one cause factor was listed; there was no secondary cause factor, no other contributing factor. One-third of drinking riders (92 of 289) were listed as the sole cause factor in their accident, compared to only about one in six of non-drinkers (80 of 430). The comparisons of rider error as primary or sole contributing factor are shown in Table 11.3.13.

Table 11.3.13: Alcohol and primary contributing cause factors

Accident contributing factors	No alcohol		Alcohol use	
	Frequency	Percent	Frequency	Percent
<u>Primary contributing factor</u>				
Rider error	199	46.3	209	72.3
Other than rider error	231	53.7	80	27.7
Total	430		289	
<u>Sole contributing factor</u>				
Rider error only	80	18.6	92	31.8
Other than rider error only	350	81.4	197	68.2
Total	430		289	

Alcohol and injuries

Alcohol-involved riders, as a group, were more badly injured than non-alcohol-involved riders. The higher fatality rate among alcohol-involved riders has already been noted (about one fatality in every eight crashes, compared to one in 39 for non-alcohol-involved riders).

Among non-alcohol-involved riders, three-fourths of the riders needed nothing more than emergency room treatment and they then went home after the accident. Only 58% of alcohol-involved riders were treated in the emergency department and were released. About one-fourth of alcohol-involved riders required hospital admission, compared to 16% of non-alcohol-involved riders. The only two riders who were disabled or institutionalized had been consuming alcohol before they crashed. The data are shown in Table 11.3.14 for the 719 riders whose alcohol involvement was known.

Table 11.3.14: Alcohol and rider trauma status

Trauma status	No alcohol		Alcohol use		Total
	Frequency	Percent	Frequency	Percent	
No injury	14	3	3	1	17
1st aid at scene	140	33	53	18	193
Treat & release	171	40	96	33	267
Hospital < 24 hrs	25	6	30	10	55
Hospital > 24 hrs	69	16	68	24	137
Disabled	0	0	2	1	2
Fatal at scene	5	1	23	8	28
Fatal, DOA	3	1	11	4	14
Fatal, hospitalized	3	1	3	1	6
Total	430		289		719

Alcohol summary

Alcohol was found to have a profound effect on the accident statistics presented here, because the characteristics of alcohol-involved accidents are very different from non-alcohol crashes. Alcohol-involved accidents in Bangkok occurred most often at night, in the few hours around midnight. They were more likely to involve higher speeds, inattention, running off the roadway and traffic control violations. Alcohol-involved accidents were less likely to involve a female rider or a student. Also, as shown in sections 10.2 and 8.8, alcohol-involved accidents had lower levels of helmet use (61% versus 69%) and more fatal crashes (about one per 7 accidents versus one per 39 accidents.)

11.4 Human factors

Risk-taking behavior

The on-scene, in-depth accident investigation data collected during this study clearly showed that there was a high frequency of human error in accident causation. These errors ranged from a lack of proper motorcycle maintenance to the poor choice of evasive action and/or a poor execution of that choice as well as certain unsafe acts.

Most human errors involved unsafe acts. Table 11.4.1 shows the unsafe acts committed by the accident-involved motorcycle riders. The rider's action before the precipitating event was evaluated to determine whether the rider had been engaging in risky or unsafe actions before the start of the accident sequence. Actions were classified as “major,” “moderate” or “minor” unsafe actions.

“Major” unsafe acts included traveling in the wrong direction in opposing lanes, riding at night without the headlamp illuminated, street racing, violation of traffic control signals, failure to yield the right-of-way to other vehicles, improper passing maneuvers, excessive speed, and reckless riding. All of these acts were considered likely to cause an accident and in most cases they actually did contribute to accident causation. It should be noted that the act of leaving a vehicle abandoned in a travel lane, even at the curb, was also considered to be a major unsafe act.

“Moderate” unsafe acts included following too closely or executing an improper turn maneuver, which were likely to cause traffic conflict. Failure of the motorcycle to travel along curb lane was coded as a “moderate” unsafe act, only because curb lane travel was required by law. Riding without a motorcycle license was considered to be "minor" unsafe acts since these acts did not directly contribute to the accident causation.

The cross-tabulation between the rider unsafe acts and its relationship to accident causation is shown in Table 11.4.2. The evaluation of the unsafe acts committed by the other vehicle drivers showed that 365 out of 696 drivers (52.4%) did contribute to the accident causation.

Table 11.4.1: Rider unsafe acts

Unsafe acts	Frequency	
No unsafe acts	133	
Major unsafe acts	303	
Moderate unsafe acts	245	
Minor unsafe acts	42	
Total	723	

Table 11.4.2: Unsafe act contribution to accident causation

Unsafe act contributed	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No unsafe act/not applicable	133		248	
No contribution to accident	192		78	
Contributed to accident	398		365	
Unknown	0		5	
Total	723		696	

The more serious the unsafe act, the more likely it was to have played a role in accident causation. That is, unsafe acts that were categorized as "major" contributed to accident causation over 90% of the time they occurred. By comparison, "moderate" unsafe acts contributed to the accident only about half the time they occurred. The data are shown in Table 11.4.3.

Table 11.4.3: Unsafe act severity and contribution to accident causation

Unsafe act severity	Did not contribute		Contributed		Total
	Frequency	Row %	Frequency	Row %	Frequency
Major	19	6.3	283	94.0	302
Moderate	131	53.5	114	46.5	245
Minor	40	97.6	1	2.4	41
None	133	100.0	0	0.0	133
Total	323		398		721

Lane choice

Traveling the wrong way against opposing traffic in any lane was often found to be a contributing factor to accident causation. However, failure to travel along the curb lane as required by the traffic law was not considered as a contributing factor.

Table 11.4.4 shows that, for both riders and other vehicle drivers, about one in every eight crashes involved poor lane choice that contributed to accident causation.

Table 11.4.4: Lane choice and accident causation

Lane choice	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No lane choice available	125		160	
No contribution	502		451	
Contributed to accident	96		85	
Total	723		696	

Traffic scanning errors

Traffic scanning errors were coded when the rider or other vehicle driver made unsafe actions due to a failure to see other traffic. Table 11.4.5 shows traffic scanning errors acted as a contributing factor for the rider in 210 cases (29%) and for the other vehicle driver in 28% of the cases. It should be noted that there was a view obstruction in about one-fourth of cases. An example of both view obstruction contribution and scanning error is an accident in which an OV driver attempted to make a right turn onto a major street at an intersection where a parked bus badly obstructed his view of traffic approaching from his right. Even with the view obstruction created by the bus, the OV driver did not bother to scan for cross traffic, and entered the intersection without stopping.

Table 11.4.5: Traffic scanning errors and accident causation

Traffic scan contributed	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
Not applicable	76		56	
Not contributed	434		439	
Contributed to accident	210		192	
Unknown	3		9	
Total	723		696	

Temporary traffic obstruction detection failure

Failure to detect traffic hazards on the roadway, such as a pedestrian or an animal crossing the roadway, or a failure to detect the presence of a broken sign post lying in roadway was found to be a contributing factor to accident causation for the motorcycle rider in nearly 10% of the cases collected, but rarely for the other vehicle driver, as shown in Table 11.4.6.

It should be noted that blame or fault is not necessarily attached to failure to see an obstruction. In some cases riders failed to see something they should have seen, while in other cases riders could not have seen the obstruction. Both were treated the same – the rider failed to see the obstruction and that failure was part of what caused the accident.

Table 11.4.6: Failure to detect temporary traffic obstruction

Traffic obstruction contribution	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No obstruction	649		694	
Obstruction did not contribute	5		0	
Obstruction contributed	69		2	
Total	723		696	

Faulty traffic strategy

Failures to provide a turn signal or following another vehicle too closely were considered to be examples of faulty traffic strategy. Faulty traffic strategies on the part of the motorcycle riders and other vehicle drivers were found to contribute to accident causation in about half of all cases. (Table 11.4.7).

Table 11.4.7: Faulty traffic strategy of rider and driver

Faulty strategy contribution	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
Not applicable	47		20	
Poor strategy, no contribution	295		339	
Faulty strategy contributed	381		334	
Unknown	0		3	
Total	723		696	

Speed compared to surrounding traffic

Excessively high speed relative to the surrounding traffic was considered a contributing factor in many cases. Other situations were also coded as unsafe speed relative to surrounding traffic, such as riding at a very low speed along the fast lane. Going into the opposing lanes to pass adjacent vehicles that were stopped waiting in traffic was considered to be a contribution to the accident causation and was coded as a contributing factor since the speed of the motorcycle was greater than the speed of the surrounding traffic that was traveling in the same direction. Lane-splitting was considered to be unsafe speed only if the rider was going much faster than adjacent lanes. Lane splitting when traffic was stopped was not coded as a contributing factor.

Unusual speed was found to be a contributing factor for 15% of motorcycles, but about half as often for other vehicles. This is important because a common perception of motorcyclists is that they drive too fast. These data show that speed contribution to accident causation is fairly low for both motorcycles and other vehicles. The frequency of cases in which unusual speed caused or contributed to accident causation is shown in Table 11.4.8.

Table 11.4.8: Speed compared to surrounding traffic

Speed contribution to accident	Motorcycle rider		OV driver	
	Frequency	%	Frequency	%
No unusual speed	531		571	
Unusual speed, no contribution	73		46	
Speed contributed to crash	111		50	
Unknown	8		29	
Total	723		696	

Safe position with respect to other vehicle

Traveling the wrong way, attempting to make a U-turn in the middle of roadway or following too closely were examples of an unsafe position that could contribute to accident causation. Unsafe position was a contributing factor for about one-third of all cases for both the motorcycle rider and other vehicle driver, as shown in Table 11.4.9.

Table 11.4.9: Safe position to other traffic

Contribution of unsafe position in traffic	Motorcycle rider		Other vehicle driver	
	Frequency	%	Frequency	%
No other traffic	95		1	
Unsafe position, no contribution	408		447	
Unsafe position contributed	220		248	
Total	723		696	

Alcohol and risk-taking behavior

Risk taking behavior was found to be just as common among non-alcohol-involved riders as alcohol-involved riders. Table 11.4.10 summarizes data according to alcohol-involved and non-alcohol-involved riders. In every row in Table 11.4.10, the percentages given refer to 430 non-alcohol-involved riders and 289 alcohol-involved riders.

Table 11.4.10: Unsafe acts by alcohol involvement

Action / contribution	No alcohol (n = 430)		Alcohol (n = 289)	
	Frequency	%	Frequency	%
No unsafe acts	79	18	54	19
Major unsafe act	172	40	129	45
Moderate unsafe act	154	36	89	31
Scanning error contributed	118	27	92	32
Faulty strategy contributed	218	51	161	56
Unsafe speed contributed	69	16	42	15
Unsafe position in traffic contributed	136	32	84	29

Deficient skills

In the current study, only six accident-involved riders were found to have a skill deficiency and in only three of these cases were these skill deficiencies considered to be a contributing factor (Table 11.4.11). Deficient skills were rare, but were often a contributing factor on the rare occasions they were found.

Table 11.4.11: Skills deficiency contributed to accident

Skills deficiency contributed to accident	Motorcycle rider		OV driver	
	Frequency	%	Frequency	%
No deficiency	693		589	
Deficiency did not contribute	3		3	
Deficient skills contributed	3		0	
Unknown	24		104	
Total	723		696	

Vehicle unfamiliarity

There were 55 accident-involved riders and 19 other vehicle drivers who were considered to be unfamiliar with their vehicles at the time of the accident. However, even when vehicle unfamiliarity occurred, it was a contributing factor only about 15% of the time (Table 11.4.12).

Table 11.4.12: Vehicle unfamiliarity contributed to accident

Vehicle unfamiliarity contributed to accident	Motorcycle rider		OV driver	
	Frequency	%	Frequency	%
No unfamiliarity	646		573	
Unfamiliarity did not contribute	46		16	
Unfamiliarity contributed	9		3	
Unknown	22		104	
Total	723		696	

Failure to compensate

As part of the detailed analysis of each accident, the team investigators determined if there was an error on the part of one vehicle operator and then determined if the motorcycle rider or other vehicle driver failed to take action that could have prevented the collision.

In some accidents, a rider or other vehicle driver was faced with an imminent collision and there was no action that could have prevented a collision. For example, some of the accidents reported here occurred when the motorcycle was struck by a vehicle sliding away from another collision that occurred just a second before. In such a situation there was no compensation failure.

In other cases the motorcycle rider or other vehicle driver had time to see a threatening situation develop but failed to take action. One such example is a case where a motorcycle rider made a right turn from a driveway to go east on the far side of a wide roadway, taking about 8-10 seconds to complete the turn. A rider on an eastbound motorcycle saw the first motorcycle turning but didn't slow down, speed up, go around, honk the horn or take any kind of action, and instead sideswiped the motorcycle and then fell on the curb. The first motorcycle rider made a bad turn, but the second motorcycle rider failed to compensate for the first rider's awkward turn.

Between these two extremes are accidents where skilled evasive action could have prevented a collision, but the rider or other vehicle driver instead responded with ineffective or inappropriate action. For example, honking the horn until it was too late to brake and avoid a collision was coded as a compensation failure. Also, rear-only braking by the motorcycle rider was coded as a compensation failure if based upon the accident reconstruction, skilled front and rear braking could have avoided a crash. Again, because of the complexity of motorcycle steering and brakes (separate front and rear brakes), and especially the difficulty of coordinating effective braking and steering in a panic pre-crash situation, motorcycle riders were more likely to have made a compensation failure than car drivers.

Compensation failure by the motorcycle rider was reported in 16% of all cases, but contributed to accident causation in only 60% of those. Such a failure was reported for the OV driver in about 9% of cases and contributed to causing the accident in two-thirds of those. Data are shown in Table 11.4.13.

Table 11.4.13: Compensation failure and accident causation

Compensation failure contributed to accident	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No compensation failure	606	83.8	627	90.1
Failure did not contribute	48	6.7	19	2.7
Failure contributed	69	9.5	46	6.6
Unknown	0	0.0	4	0.6
Total	723		696	

11.5 Other vehicle contribution to accident causation

Most of these accidents involved another vehicle, and most of those were non-motorcycles such as cars, trucks, buses, tuk-tuks, etc. (In this section, for brevity, any non-motorcycle other vehicle will be referred to as a “car” whether it was a passenger car, pickup truck, large truck, bus, etc.) Accident cause factors for non-motorcycle may well be different than those of motorcycles, so this section will examine other vehicle accident cause factor in more depth.

Alcohol

Alcohol use was much lower among car drivers than motorcyclists. Table 11.5.1 shows a cross-tabulation of other vehicle driver alcohol involvement as a function of the type of other vehicle (motorcycle or non-motorcycle.) If the other vehicle was another motorcycle, one-fourth of the other vehicle riders had been found to have consumed alcohol before the accident. If the other vehicle was a non-motorcycle, only 3% of other vehicle drivers were known to have been drinking alcohol prior to the crash. However, the “alcohol unknown” rate was far higher for car drivers, probably because it was much easier for a car driver to flee an accident scene than for a motorcyclist.

Table 11.5.1: Alcohol use by other vehicle type

Alcohol involvement	Other vehicle type						Total	
	Motorcycle		Not MC		Unknown			
	Freq	%	Freq	%	Freq	%	Freq	%
No alcohol use	98	70	357	77	0	0	455	74
Alcohol use	37	26	14	3	0	0	51	8
Unknown	5	4	65	14	13	100	83	13
No driver	0	0	27	6	0	0	27	4
Total	140		463		13		616	

Other vehicle driver causation and accident type

It should be noted that the types of crashes involving other vehicles differed depending on whether the other vehicle was a motorcycle or non-motorcycle and whether the other vehicle driver was the primary cause or made no contribution to accident causation. Table 11.5.2 compares the collision configuration (from Table 5.2.8) by the type of other vehicle involved. In 106 cases, there was no other vehicle. All of those involved the motorcycle falling on or running off the road or colliding with pedestrians or roadside obstacles.

The most common collision configurations are summarized in Table 11.5.3. Cars and trucks tended to be rear-ended or to violate the motorcycle right-of-way by making a right turn or U-turn in front of the accident-involved motorcycle. These three configurations accounted for about 42% of collisions in which the other vehicle was not a motorcycle. In contrast, those three configurations accounted for only 11% of motorcycle to motorcycle crashes.

Table 11.5.2: Accident configuration by other vehicle type, all crashes

Collision configuration	Other vehicle type				Total
	No OV	Motorcycle	Other than MC	Unknown	
1	0	15	12	0	27
2 & 3	0	22	36	0	58
4	0	3	5	0	8
5	0	5	30	0	35
6 & 7	0	2	52	0	54
8	0	3	2	0	5
9	0	5	7	0	12
10	0	0	13	0	13
11	0	1	29	0	30
12	0	8	22	0	30
13	0	8	95	1	104
14	0	9	13	0	22
15	0	25	24	2	51
16	0	5	48	0	53
17	0	23	41	0	64
18	24	0	1	0	25
19	44	0	2	0	46
20	0	2	23	7	32
21	0	1	3	3	7
23	24	0	1	0	25
24	14	0	1	0	15
98	0	3	4	0	7
Total	106	140	464	13	723

Table 11.5.3: Most common collision configurations when other vehicle wan not a motorcycle

Collision configuration	Motorcycle		Non-motorcycle	
	Freq	%	Freq	%
13 – MC strikes OV rear end	8	6	95	20
6&7 – OV R turn, MC coming opposite direction	2	1	52	11
16 – OV U-turn	5	4	48	10
17 - "Other" - unclassified	23	16	41	9
2&3 – Perpendicular intersection collisions	22	16	36	8

Other vehicle driver error as primary cause of collision

When other vehicle driver error was the primary cause of the accident, the most common type of accident configuration differed, depending on whether the other vehicle was a motorcycle or not. The data are shown in Table 11.5.4. The most common configurations are highlighted.

If the other vehicle was another motorcycle, only one type of accident configuration stood out – sideswipes in which both motorcycles were going the same direction. These accounted for about 20% of motorcycle-motorcycle crashes.

Table 11.5.4: Accident configuration when driver was primary cause

Collision configuration	Other vehicle type		
	Motorcycle	Other than MC	Total
1	6	5	11
2 & 3	9	9	18
4	2	3	5
5	2	17	19
6 & 7	1	36	37
8	0	1	1
9	2	1	3
10	0	11	11
11	0	8	8
12	3	12	15
13	5	16	21
14	5	4	9
15	12	10	23
16	5	34	39
17	6	5	11
18	0	1	1
20	1	9	10
21	1	1	2
98	1	1	2
Total	61	184	246

When the other vehicle was a non-motorcycle and other vehicle driver error was the primary cause, the five most common collision configurations are shown in Table 11.5.5. These five configurations account for 63% of crashes in which a car driver was the main cause of the accident.

It may seem unusual for the other vehicle to be at fault when it is rear-ended by the motorcycle. However, this occurred in situations such as taxis suddenly stopping in the curb lane to pick up a passenger. Many cases were night crashes in which the other vehicle driver left his or her vehicle parked or abandoned in the curb lane with inadequate marking, warning, or reflectors so that the other vehicle could not be seen by the motorcycle rider approaching from the rear.

Table 11.5.5: Most common collision types when driver is primary cause

Collision configuration	Frequency	
OV right turn, motorcycle approaching from opposite direction	36	20
OV U-turn	34	18
OV right turn, MC approaching from left or right side	17	9
MC hits OV rear end	16	9
OV strikes MC rear end	12	7

11.6 Accident contributing factors

In each accident, a ranking was made of the relative contributions of as many as four different factors. These were broadly classified as rider errors, other vehicle driver errors, vehicle failure, adverse weather, roadway defects, etc. A category such as "rider error" or "roadway defect" was coded only once in each case, even if multiple failures fell within in that category. For example, if a rider had a high BAC, was speeding and doing a “wheelie” in opposing lanes, "rider error" was coded only once.

An example of a simple accident would be one in which an OV driver who intends to make a turn across opposing lanes sees a motorcycle approaching from the opposite direction and violates the motorcycle right-of-way – after honking his horn to warn the rider he's going to turn. In contrast, one complicated case was a night crash in which the motorcycle and other vehicle were approaching each other from opposite directions on a rural road where a curve with trees blocked the view between the two vehicles (view obstruction). Both vehicles were on or across the centerline of the road as they rounded the curve (rider & OV driver error). The motorcycle rider swerved and skidded, causing the motorcycle to slide-out (braking error) on the roadway with wet and dry spots from recent rain (pavement contamination.)

Darkness itself was often considered to be a factor in the night accidents, but it was not coded as a cause factor. However, as noted earlier, inadequate roadway signing, particularly on curves and at construction zones at night, contributed to many crashes and was coded accordingly.

Table 11.6.1 ranks the contribution to accident causation among the motorcycle rider, other vehicle driver, passenger, vehicle factors and environmental factors for the 723 on-scene, in-depth accident investigation cases. For simplicity, the percentage of total culpability apportioned to each factor was determined by the team investigators and then ranked in order according to its overall contribution to the accident.

Table 11.6.1: Ranking of accident contributing factors

Contribution to accident causation	Ranking of importance			
	1	2	3	4
Motorcycle rider error	402	198	10	0
Other vehicle driver error	275	149	10	0
Vehicle failure	3	32	27	2
Environmental factors*	38	84	46	0
Other vehicle passenger	4	1	0	0
Motorcycle passenger	1	3	1	1

Note: Environmental factors include roadway defects, traffic control problems, roadside environment problems, animals, pedestrians or adverse weather.

Table 11.6.1 also shows that rider and other vehicle driver errors were, the most common primary and secondary factors, making up 94% of primary causes and 75% of secondary causes. However, environmental contributions were the primary cause in 5% of cases, and were cited as a contributing factor in 168 cases, nearly one-fourth of the total.

In single vehicle collisions, the motorcycle rider was the primary cause in 69 of 84 cases (80%). However, some single vehicle accidents resulted from an OV driver error without any collision contact. The motorcycle crashed while successfully avoiding the other vehicle. In addition, some single motorcycle accidents were also due to roadway defects or contamination with no rider error.

In multiple-vehicle collisions, the rider was the primary cause in half of the cases (324 of 635 cases). The other vehicle driver was the primary cause in 250 cases or about 40% of the time. The primary cause in the remainder of cases was divided between environmental problems, passengers, etc.

In general, the motorcycle rider was selected as the primary accident-contributing factor when the accident clearly showed that the rider's motion or action was responsible for the collision. For example, a typical case would be an alcohol-involved rider who simply failed to follow a roadway as it entered a curve. The action or lack of action on the part of the rider was the primary cause factor in the accident.

Environmental factors were considered to be a contributing factor whenever there was some irregularity of the roadway surface, a malfunctioning traffic control, a broken object lying on roadway, some form of roadway contamination, or a stationary view obstruction, was present. Inadequate or non-existing signs, poor lighting of construction zone and/or roadway, an abandoned or illegally parked-unlighted trucks were considered to be contributing environmental cause factors in the Bangkok accident-investigation cases accounting for 23% (168/723 cases).

Motorcycle passengers were assigned culpability in the accident when their motions distracted the motorcycle rider or caused loss of control of the motorcycle. The passenger of the other vehicle was rarely selected as a cause for culpability. There was only one case in which the motorcycle passenger was considered to be the primary cause of the accident, because the passenger jumped out and pushed the motorcycle rider after having a conflict with the rider. The motorcycle passenger was ranked as the second most culpable contributor to the accident in 3 examples and one case each in whom the passenger was ranked third and fourth.

Finally, vehicle factors were rarely chosen as the primary accident contributing factor because many of the coded vehicle failures – such as lack of front brake, or headlamp, etc. – were mainly due to preexisting maintenance problems that were the responsibility of the motorcycle rider and therefore coded as a rider error.

Summary of accident causation factors

Based on the data collected in this study, human error is the greatest cause in these motorcycle accidents, and alcohol is the most prominent of the human errors. Many riders engage in risky behavior, both with and without alcohol involvement.

The data collected in this study also show that many problems of roadway design exist in Bangkok and that these problems do contribute to motorcycle accidents. Large structures that create view obstructions and poorly maintained and marked construction sites represent hazards, which can be eliminated as Bangkok continues to grow and develop.

12.0 Exposure Data

In order to understand the relative risk of a given factor in an accident it is important to gain an understanding of the "population-at-risk." In this case, the population at risk was considered to be other motorcycle riders using the same roads under the same conditions, and therefore exposed to similar risks of accident and injury as those involved in a crash.

In order to collect information about the population at risk, investigators returned to each accident scene seven days later (sometimes more than seven days), on the same day of the week and at the same time of day to observe and count motorcycle and vehicle traffic. Information was collected for both the motorcycle and other vehicle paths of travel. Data collection included classifying and counting the traffic that passed by, with special attention to motorcycles. For non-motorcycles, the only information collected was the vehicle size and type (large and small cars, various size buses, tuk-tuks, etc.) and the number of each category that passed the exposure site. For motorcycles, additional information about the manufacturer, style (step-through, sport, etc.) headlamp use, passengers, cargo, etc., was collected. These data are referred to in this report as the on-scene exposure (OSE) data.

Visual observation does provide vehicle information; however, it does not provide any human factors information. In order to collect human factor information, investigators went to petrol stations near the accident site at the same time of day and same day of week as the accident and interviewed riders as they stopped in. The interviews are referred to here as the petrol station exposure (PSE) data. They were done in order to obtain more information, regarding the rider's age, license, height, weight, physiological status, education, occupation, alcohol use, trip plan, trip length, riding experience and protective equipment, etc.

The on-scene exposure data and PSE interviews were conducted by the same investigators who had done the on-scene investigations, so similar elements were handled essentially the same way.

12.1 Environmental factors

Traffic flow

The number of vehicles that travel along the motorcycle and other vehicle paths of travel at each accident location were counted for a one-hour duration (30 minutes before and 30 minutes after the reference accident time). For example, if the case accident involved a motorcycle going east along lane 2 and a west bound car traveling in lane 1 which turned right in front of the motorcycle, then all east bound vehicles in lane 2 were counted in the motorcycle traffic flow and all west bound vehicles that turned right were counted on the other vehicle traffic flow.

Vehicles were also classified according to motorcycle style (e.g. standard, sport, etc.), passenger car type (e.g. subcompact, compact, intermediate, saloon, pick-up trucks, minivans, full-size vans, sport utility vehicles), trucks, buses, articulated coach, special vehicles, tuk-tuks and others.

In Bangkok, nearly 225,000 vehicles passed along the motorcycle path and over 136,000 passed along the OV path. Table 12.1.1 shows the distribution of vehicles that passed the OSE sites during the one-hour data collection periods, for both the motorcycle and other vehicle paths of travel.

On motorcycle path, passenger cars (all sizes), pickups, SUVs and vans were 62% of the road users, motorcycles 29%, buses 3%, heavy trucks 1.7% and tuk-tuks 3.7%.

On other vehicle path, the vehicle distribution was similar. Passenger cars accounted for 65% of the road users, motorcycles 27%, buses 3.2%, big trucks 1.5% and tuk-tuks 3.5%.

Table 12.1.1: Vehicle types and frequencies at OSE sites

Type of vehicle	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
Motorcycles	35,445	15.8	21,743	16.0
Step-through MC	30,070	13.4	15,125	11.1
Saloon/sedan cars	1,558	0.7	990	0.7
Intermediate cars	7,243	3.2	6,523	4.8
Compact size cars	82,698	36.8	51,910	38.1
Subcompact cars	3,783	1.7	2,306	1.7
Mini light truck	35,574	15.8	21,000	15.4
Full size light truck	212	0.1	85	0.1
Sport utility vehicles	3,327	1.5	1,939	1.4
Commercial trucks	2,775	1.2	1,687	1.2
Trailer towing truck	550	0.2	355	0.3
Full size van	2,985	1.3	1,711	1.3
Minivan	2,585	1.1	1,602	1.2
Bus	6,569	2.9	3,782	2.8
Articulated coach	116	0.1	84	0.1
Trolley bus	36	0.0	31	0.0
Special vehicle	715	0.3	415	0.3
Other	255	0.1	100	0.1
Tuk-tuk	8,293	3.7	4,776	3.5
Total	224,789		136,164	

Weather

As in the accident cases, clear weather conditions predominated in the great majority of the OSE cases. Rain accounted for only 2.8% of the exposure data collections and was therefore not considered to have a significant effect upon the vehicle counts.

12.2 Vehicle data

Motorcycles passing each OSE location were immediately counted and identified, as well as videotaped for later confirmation. The motorcycles then were analyzed for type and manufacturer. Approximately 46% of the 65,515 motorcycles were the step-through frame type, nearly 30% were standard street motorcycles and 20% were sport style motorcycles (Table 12.2.1).

Table 12.2.1: Motorcycle types passing OSE sites

Motorcycle type	Frequency	
Standard street	18,727	28.6
Standard street, modified	57	0.1
Sport, race replica design	13,000	19.8
Cruiser design	978	1.5
Chopper, semi-chopper	101	0.2
Touring design	37	0.1
Scooter	2,125	3.2
Step-through	30,070	45.9
Street MC plus sidecar on right	4	0.0
Off road, enduro trials	170	0.3
Police, security	124	0.2
Other	8	0.0
Unknown	114	0.2
Total	65,515	

Motorcycle manufacturers

Honda motorcycles accounted for about 40% of the motorcycles on the road in Bangkok, followed by Yamaha (24%), Kawasaki (22%), and Suzuki motorcycles (10%), as shown in Table 12.2.2.

Table 12.2.2: Motorcycle manufacturers in OSE data

Manufacturers	Frequency	
Honda	26,192	40.0
Yamaha	15,673	23.9
Kawasaki	14,706	22.5
Suzuki	6,475	9.9
Piaggio	2,340	3.6
Other	20	0.0
Unknown	109	0.2
Total	65,515	

Headlamp usage

The motorcycle headlamp was coded as being Illuminated for 38% of the motorcycles passing the OSE location (Table 12.2.3). Of course, headlamp usage varied with the time of the day. The distribution of motorcycle headlamp observations was divided into four categories: day (combining bright and not bright), night (lighted or not lighted), dusk and dawn.

The OSE data revealed 95% headlamp use at night, but the headlamp was rarely illuminated in daytime (2.4%) and during dusk-dawn time periods. There was also a small percentage of riders who did have their headlamp illuminated; however, it was not visible to the other driver, most often due to an item placed in the parcel rack in front of the motorcycle headlamp.

Table 12.2.3: Motorcycle headlamp use at OSE data collection sites

Ambient lighting condition	Headlamp off		Headlamp on	
	Frequency	Percent	Frequency	Percent
Daylight	36,402	97.6	888	2.4
Night	1,119	4.7	22,688	95.3
Dusk	2,955	72.0	1,150	28.0
Dawn	270	86.3	43	13.7
Total	40,746		24,769	

12.3 Human factors at on-scene exposure data sites

The human factor data reported in this section comes from observations of motorcycles and riders that passed the on-scene exposure (OSE) data collection sites one week after each accident. Because it was usually not possible to stop motorcyclists for interviews, the data reported for on-scene exposure sites are limited to visual observations.

Gender

Female motorcycle riders accounted for about 3% of all riders but women were 53% of all passengers in Bangkok. The gender of riders and passengers observed during the OSE data collection sites is shown in Table 12.3.1.

Table 12.3.1: Rider and passenger gender in OSE data

Gender	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Male	63,582	97.1	9,581	47.3
Female	1,929	2.9	10,662	52.7
Unknown	4	0.0	6	0.0
Total	65,515		20,249	

Cargo or luggage carrying

About 11% (7,475) of the motorcycle riders passing OSE sites were carrying cargo or luggage. Of those carrying some item of cargo, about 60% or riders had it on a rear rack. Passengers held the items 20% of the time, while the rider carried it in a backpack 13% of the time.

The dangerous practice of the rider carrying luggage in his arms, between his legs or on the seat/tank in front of him was noted in 418 cases. The data are shown in Table 12.3.2.

Table 12.3.2: Cargo/luggage carrying on the motorcycle, OSE data

Cargo location	Frequency	
No cargo/luggage	58,040	88.6
Carried on rear rack	4,449	6.8
Carried in saddle bag	369	0.6
Carried by passenger	1,234	1.9
Carried on seat or front of rider	308	0.5
Carried between rider legs	49	0.1
Carried between rider arms	61	0.1
Carried in backpack on rider	943	1.4
Other	60	0.1
Unknown	2	0.0
Total	65,515	

Number of passengers on motorcycle

The number of passengers riding on the motorcycles at the OSE sites was counted directly and then confirmed from videotapes. In Bangkok, passengers were not present on about 70% of the motorcycles passing the OSE location while 28% of those motorcycles observed were riding with 1 passenger. Only 1.3% were riding with more than one passenger (Table 12.3.3).

Table 12.3.3: Number of passengers on the motorcycle, OSE data

Passengers on motorcycle	Frequency	
None	46,191	70.5
One	18,465	28.2
Two	796	1.2
Three	60	0.1
Four	3	0.0
Total	65,515	

Helmet use

About 86% riders passing the OSE sites were helmeted as shown in Table 12.3.4. Passenger helmet use was less than for riders in that less than half of all passengers (48%) wore a helmet. The majority of helmets worn by the rider and passenger appeared to be securely fastened. It should be noted the number of poorly fastened helmets was probably underestimated because of the limitations imposed by visual observation only. Investigators could identify a helmet as being poorly secured only in those cases where the helmet was worn so far back that the straps could not be fastened or the straps were obviously loose and blowing in the wind. It was not possible to identify accurately those cases in which the retention system was too loose or not present at all.

Table 12.3.4: Helmet use by riders and passengers in OSE data

Helmet use	Rider		Passenger	
	Frequency	Percent	Frequency	
No helmet wearing	9,254	14.2	10,566	52.2
Yes, not securely fastened	4,536	6.9	803	4.0
Yes, securely fastened	51,645	78.8	8,870	43.8
Unknown	80	0.1	10	0.0
Total	65,515		20,249	

Helmet type

Nearly half of the riders seen passing the on-scene exposure sites were wearing full-facial coverage helmets, and another one-third wore the partial coverage type of helmet often worn by police. In contrast, helmeted passengers most often wore the partial coverage type helmet, and were least likely to be wearing a full-face helmet. The distribution of rider helmet types is shown in Table 12.3.5.

Table 12.3.5: Type of helmet worn in OSE data

Helmet type	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Not MC helmet	91	0.2	29	0.3
Half/police MC helmet	18,144	32.2	4,338	50.0
Open face MC helmet	12,208	21.7	3,142	32.4
Full-face MC helmet	25,755	45.8	1,664	17.2
Unknown	63	0.1	10	0.1
Total	56,261		9,683	

Helmet use, day and night variations

Rider helmet use was highest during daylight hours (93%), but declined to about 80% at dusk and 75% at night. Passenger helmet use also declined at night compared to day. Table 12.3.6 shows a cross-tabulation of helmet use and ambient lighting condition.

Table 12.3.6: Helmet use by ambient light, OSE data

Ambient lighting condition	Helmet use	Rider		Passenger	
		Frequency	Percent	Frequency	Percent
Daylight	No	2,524	6.8	4,231	44.9
	Yes	34,766	93.2	5,186	55.1
Total		37,290		9,417	
Night	No	5,928	24.9	5,147	56.2
	Yes	17,879	75.1	4,012	43.8
Total		23,807		9,159	
Dusk	No	775	18.9	1,144	74.1
	Yes	3,330	81.1	400	25.9
Total		4,105		1,544	
Dawn	No	27	8.6	44	34.1
	Yes	286	91.4	85	65.9
Total		313		129	

12.4 Petrol station exposure data

Since it was usually not possible to interview riders on the street at the OSE sites, interviews were conducted at a petrol station as near as possible to the accident scene, on the assumption that riders using that petrol station were from the same population as those who passed OSE sites.

During January and February of 2001, the investigators returned to the study areas to collect additional human factors information by interviewing motorcycle riders at a petrol stations located as near as possible to the accident. A total of 2100 motorcycle riders were interviewed. The questions they were asked were identical or essentially similar to those asked of accident-involved riders. In addition to interview questions, information was also recorded about observable items, such as clothing, gender, helmet use, motorcycle information, etc.

12.5 Vehicle factors in petrol station interviews

Step-through motorcycles were again the most common motorcycle design seen, accounting for a little over half the exposure population. Compared to the OSE data, there were more step-through frame motorcycles but fewer standard types, with about the same proportion of sport-design types. The distribution of motorcycle types ridden by 2,100 participating riders in the petrol station exposure (PSE) study is shown in Table 12.5.1.

Table 12.5.1: Motorcycle types in PSE interviews

Motorcycle type	Frequency	
Standard street, original equipment	464	22.1
Standard street, modifications as listed	29	1.4
Sport, race replica design	456	21.7
Cruiser design	8	0.4
Scooter	40	1.9
Step through	1102	52.5
Off road, motocross, enduro, trials	1	0.0
Total	2100	

12.6 General characteristics of riders in petrol station interviews

Rider gender

Female riders accounted for about 4% of all riders, compared to 3.8% in the petrol station exposure data. In both exposure studies, male motorcycle riders represented over 95% of all riders interviewed. The gender distribution of riders interviewed is shown in Table 12.6.1.

Table 12.6.1: Rider gender in PSE interviews

Rider gender	Frequency	
Male	2,021	96.2
Female	79	3.8
Total	2,100	

Rider age

The youngest rider was found to be 14 years and the oldest rider was 63 years. The median age was 27 years. Approximately 15% of those responding riders were under the age of 21 years and 62% were 21-30 years. The age distribution of motorcycle riders interviewed in the PSE study is shown in Table 12.6.2.

Table 12.6.2: Rider age in PSE interviews

Rider age, years	Frequency	
11 – 20	324	15.4
21 – 30	1294	61.6
31 – 40	407	19.4
41 – 50	67	3.2
51 – 60	2	0.1
> 60	1	0.0
Unknown	5	0.2
Total	2100	

Rider height and weight

Rider heights varied from 148 to 183 cm, with a median height of 170 cm. Table 12.6.3 shows the height of participating riders in the PSE data.

Rider weights ranged from 39 to 92 kilograms with median weight of 60 kilograms. The distribution of rider weight in the PSE study is shown in Table 12.6.4.

Table 12.6.3: Rider height in PSE interviews

Rider height (cm)	Frequency	
146 – 150	9	0.4
151 – 155	17	0.8
156 – 160	100	4.8
161 – 165	280	13.3
166 – 170	966	46.0
171 – 175	583	27.8
176 – 180	139	6.6
> 180	6	0.3
Total	2100	

Table 12.6.4: Rider weight in PSE interviews

Rider weight (kg)	Frequency	
31 – 40	8	0.4
41 – 50	204	9.7
51 – 60	1106	52.7
61 – 70	705	33.6
71 – 80	74	3.5
> 80	3	0.1
Total	2100	

Rider education and occupation

About three-fourths of the riders interviewed had a formal education that ended prior to college. About one in five riders said they had had some college education, but only 3% claimed to be college graduates. The data are shown in Table 12.6.5.

Table 12.6.5: Rider education in PSE interviews

Rider education	Frequency	
No formal school	13	0.6
Formal education, prior to college/university	1600	76.2
Partial college/university training	392	18.7
Specialty technical school graduate	29	1.4
College/university graduate	66	3.1
Total	2100	

Elementary occupations predominated in the petrol station interviews, accounting for about one-third of the 2,100 riders who participated in the PSE study (Table 12.6.6). The next largest group was motorcycle taxi riders and messengers (22%), followed by students (16%), service workers (12%) and office workers (8%).

Table 12.6.6: Rider occupation in PSE interviews

Rider occupation	Frequency	
Unemployed	85	4.0
Legislators, senior officials, and managers	2	0.1
Technicians and associate professionals	7	0.3
Clerical, office worker	160	7.6
Service, shop and market sales workers	250	11.9
Skilled agricultural and fishery workers	2	0.1
Craft and related trades workers	6	0.3
Transport equipment operative, driver	468	22.3
Plant and machine operators and assemblers	6	0.3
Elementary occupations – unskilled laborers	722	34.4
Housewife, homemaker	14	0.7
Military, active duty	43	2.0
Military, reserve duty	1	0.0
Student, full time	332	15.8
Other	2	0.1
Total	2100	

12.7 Licensing and training of riders in petrol station interviews

Rider license qualification

About 11% of riders interviewed in the PSE data had no driver license as shown in Table 12.7.1.

Table 12.7.1: Rider motorcycle license in PSE data

Rider license held	Frequency	
No license held	229	
Motorcycle license	1871	
Total	2100	

Rider training

None of the riders interviewed in the petrol stations claimed to have any formal training in motorcycle riding. About seven out of eight were self-taught, the remainder had some training from family or friends (see Table 12.7.2).

Table 12.7.2: Rider motorcycle training in PSE data

Rider training	Frequency	
Self taught	1832	
Taught by friends or family	268	
Total	2100	

12.8 Rider experience

Table 12.8.1 shows the number of days per year that the participating riders in the PSE study had been riding. Over 90% of the riders interviewed claimed to ride daily.

Table 12.8.1: Days per year riding motorcycle in PSE data

Days per year riding	Frequency	
51 – 100	10	0.5
101 – 150	27	1.3
151 – 200	18	0.9
201 – 250	35	1.7
251 – 300	106	5.0
301 – 365	1903	90.6
Unknown	1	0.0
Total	2100	

Table 12.8.2 shows the distance traveled annually by the riders who participated in the PSE interviews. The rider estimates ranged from 100 to 43,800 kilometres. The median distance estimated by the interviewed riders was 5,000 kilometres per year.

Table 12.8.2: Distance motorcycle is ridden per year

Distance per year riding (km)	Frequency	
1 – 3000	379	18.0
3001 – 6000	769	36.6
6001 – 9000	487	23.2
9001 – 12000	188	9.0
12001 – 15000	71	3.4
15000 – 18000	0	0.0
18001 – 21000	96	4.6
> 21000	107	5.1
Unknown	3	0.1
Total	2100	

Motorcycle use patterns

Riders were asked to estimate what percentage of their vehicle operation experience was motorcycle or non-motorcycle. Then they were asked to estimate what part of motorcycle riding was basic transportation (work, shopping, etc.) and what proportion was recreational use. For example, if a rider said he drove a truck half of the time and rode a motorcycle half the time, and that half his motorcycle use was recreational, his vehicle use pattern was coded 50% "does not ride motorcycle," 25% "motorcycle - basic transportation" and 25% "motorcycle - recreation."

The estimates that riders gave were averaged, and the results appear in Table 12.8.3. The results showed that, on average, 83% of vehicle use among the riders was basic transportation use of the motorcycle – work, errands, etc. About 14% of motorcycle use was for recreational purposes. Younger riders tended to use motorcycle for both recreation and basic transportation, while older riders did less recreational use and more basic transportation.

Table 12.8.3: Vehicle use patterns in PSE data

Vehicle use	Percent use
Non-motorcycle	2.4
Recreation	14.1
Basic transport	83.5
Total	100.00

Riding experience with passengers

Riders who were carrying a passenger at the time of the interview were asked to estimate their previous experience carrying passengers. Approximately 70% of all participating riders carried no passenger. Of 628 riders who were carrying a passenger, about three-quarters described their experience as "moderate." About one in six riders (usually motorcycle taxi riders) said their experience was extensive (Table 12.8.4).

Table 12.8.4: Rider experience carrying passengers in PSE data

Experience carrying passenger	Frequency	
No passenger	1472	
Very little experience	52	
Moderate experience	476	
Extensive experience	100	
Total	2100	

Experience riding with similar cargo or luggage

Only about one motorcycle in six was carrying any cargo at the time of the PSE interview, so most of the riders were not asked about any experience carrying cargo on the motorcycle. In the OSE data, about 89% were not carrying any cargo. Of 345 riders carrying cargo, over three-quarters described their experience with similar cargo as moderate or extensive. Less than one-fourth of those carrying a load said they had little or no experience with a similar cargo. The data are shown in Table 12.8.5.

Table 12.8.5: Rider experience with similar cargo / luggage

Experience carrying cargo	Frequency	
No cargo/luggage	1755	83.6
No previous experience	1	0.0
Seldom carries similar cargo/luggage	75	3.6
Frequently carries similar cargo/luggage	160	7.6
Always carries similar cargo/luggage	109	5.2
Total	2100	

12.9 Rider's previous traffic violations and accidents

About three-fourths of the 2,100 responding riders denied any previous traffic violation during the past 5 years. Most of the riders who admitted to having a previous traffic violation said they had received only one citation. Only one rider claimed to have more than five citations. Again, because no centralized records of citations were available, rider statements could not be verified. The data are shown in Table 12.9.1.

A cross-tabulation analysis showed no strong relationship between motorcycle type and previous traffic violations. About one-third of riders riding sports or step-through motorcycles reported at least one traffic citation.

Table 12.9.1: Previous accidents and traffic violations in PSE data

Previous citation & accidents	Traffic citations		Motorcycle accidents		Non-motorcycle accidents	
	Freq	%	Freq	%	Freq	%
None	1611	76.7	1527	72.7	2059	98.0
One	371	17.7	383	18.3	35	1.7
Two	106	5.1	166	7.9	4	0.2
Three	7	0.3	20	1.0	0	0.0
Four	0	0	1	0.0	0	0.0
Five	2	0.1	1	0.0	0	0.0
Seven	1	0.0	0	0.0	0	0.0
Unknown	2	0.1	2	0.1	2	0.1
Total	2100		2100		2100	

Responding riders in the PSE study also reported a relatively low incidence of previous traffic accidents during the past 5 years. About 73% of riders interviewed in the PSE data denied any previous motorcycle accident involvement and 27% of riders reported that they had at least one previous accident (Table 12.9.1). About 98% of responding riders denied any previous traffic accident experience in a vehicle other than a motorcycle.

12.10 Rider trip

Roadway familiarity

Riders interviewed in the petrol station study were very familiar with the roadway they were traveling. Over 97% said they used it at least weekly. Only nine riders reported that they had never used the roadway before (Table12.10.1).

Table 12.10.1: Rider familiarity with the roadway in PSE data

Roadway familiarity	Frequency	
Daily use	1791	85.4
Weekly use	255	12.1
Monthly use	44	2.1
Quarterly	1	0.0
Never used this roadway before	9	0.4
Total	2100	

Trip plan

According to the riders interviewed in the PSE study, work and home were the most common points of origin and destination of the intended trip plan. The data are shown in Table 12.10.2.

Approximately 72% of responding riders reported traveling a distance of 5 kilometres or less from the point of origin to the petrol station (Table 12.10.3). The median distance of intended trip was 4 kilometres.

About 75% of participating riders had traveled only about 5 minutes or less from origin to the petrol station where they were interviewed. The median value of the riding time was 0.1 hour or 6 minutes (Table 12.10.4).

Table 12.10.2: Trip origin and destination in PSE data

Location	Trip origin		Trip destination	
	Frequency	Percent	Frequency	Percent
Home	478	22.8	1058	50.4
Work, business	660	31.4	336	16.0
Recreation	85	4.0	116	5.5
School, university	57	2.7	29	1.4
Errand, shopping	170	8.1	233	11.1
Friends, relatives	328	15.6	208	9.9
Bar, restaurant	322	15.3	120	5.7
Total	2100		2100	

Table 12.10.3: Trip distance before interview in PSE data

Length of trip (km)	Frequency	
< 0.1	5	0.2
0.1 - 1.0	267	12.7
1.1 - 2.0	401	19.1
2.1 - 3.0	290	13.8
3.1 - 5.0	557	26.5
5.1 - 10.0	503	24.0
> 10	77	3.7
Total	2100	

Table 12.10.4: Time riding before PSE interviews

Time riding (hrs)	Frequency	
0	479	22.8
0.1	1107	52.7
0.2	406	19.3
0.3	80	3.8
0.4	11	0.5
0.5	9	0.4
0.6 - 0.7	0	0.0
0.8 - 1.0	5	0.2
Unknown	3	0.1
Total	2100	

12.11 Physiological impairments and stress

The majority of riders interviewed reported no physiological impairments. Only 54 responding riders (2.5%) had vision problem as shown in Table 12.11.1, but only 20 of these riders wore eyeglasses and one used contact lenses. None of riders interviewed had any history of epilepsy.

Transient physiological impairment was uncommon. Only 5 riders interviewed reported that they were fatigued at the time of the interview.

Three riders interviewed admitted to being under significant stress at the time of the interview. One was in financial conflict and two riders had been involved in traffic conflicts (Table 12.11.2).

Table 12.11.1: Physiological impairments in PSE data

Physiological impairment	Frequency	Percent
<u>Permanent</u>		
None	2046	97.4
Vision	54	2.6
Total	2100	
<u>Transient</u>		
None	2094	99.7
Fatigue	5	0.3
Unknown	1	0.0
Total	2100	

Table 12.11.2: Stress reported in PSE interviews

Stress prior to interview	Frequency	
None	2096	
Financial distress	1	
Traffic conflict, road rage	2	
Unknown	1	
Total	2100	

12.12 Rider alcohol use

About one in six riders had been consuming alcohol before they were interviewed, and about one-fourth of those appeared to the investigators to be seriously impaired. These data are shown in Tables 12.12.1 and 12.12.2. None of participating riders admitted any kind of drug use, even though the questions regarding drug use came late in the interview in order to minimize any perceived threat of being penalized.

Table 12.12.1: Rider alcohol use in PSE interviews

Alcohol use	Frequency	
No alcohol	1736	
Had been drinking (HBD)	364	
Total	2100	

Table 12.12.2: Rider alcohol impairment, PSE interviews

Alcohol impairment	Frequency	
Not significantly impaired	277	
Significantly impaired	87	
Total	364	

12.13 Helmet use

About two-thirds of 2,100 participating riders were helmeted at the time of the petrol station interview. There were 153 riders who had a helmet present on the motorcycle but were not wearing it. Another 524 participants were unhelmeted (Table 12.13.1). Most helmets worn by participating riders were securely fastened (Table 12.13.2).

Table 12.13.1: Rider helmet use at PSE interviews

Helmet use	Frequency	
No helmet present	524	
Helmet present but not used	153	
Yes	1423	
Total	2100	

Table 12.13.2: Helmet securely fastened before PSE interviews

Helmet securely fastened	Frequency	
Poorly fastened	338	
Fastened properly	1085	
Total	1423	

Nearly 60% of the riders interviewed were wearing a partial-coverage motorcycle helmet. The distribution of helmet types seen in the petrol station interviews is shown in Table 12.13.3. It is quite different than the OSE data collected earlier.

Table 12.13.3: Rider helmet type worn in PSE interviews

Helmet type	Frequency	
Not motorcycle helmet	6	
Partial coverage, police type	825	
Open face motor vehicle	181	
Full face motor vehicle	411	
Total	1423	

Black, white and blue were the helmet colours most often worn by riders interviewed in petrol stations (see Table 12.13.4).

Table 12.13.4: Rider helmet colour in PSE data

Helmet colour	Frequency	
No dominant colour	105	7.4
White	253	17.8
Yellow	102	7.2
Black	262	18.4
Red	170	11.9
Blue	238	16.7
Green	129	9.1
Silver, grey	65	4.6
Orange	19	1.3
Brown, tan	21	1.5
Purple	36	2.5
Gold	9	0.6
Pink	14	1.0
Total	1423	

About 60% of helmeted riders had some type of face shield on their helmet. The majority of face shields (60%) were clear in colour, while another 30% were tinted a grey or smoke colour. The data are shown in Table 12.13.5.

Table 12.13.5: Rider helmet face shield colour in PSE data

Face shield colour	Frequency	
Clear	529	60.8
Green	7	0.8
Grey, smoke	275	31.6
Amber, yellow	6	0.7
Blue	4	0.5
Reflective	49	5.6
Total	870	

Most riders (97%) owned the helmet they were wearing at the time of the interview (Table 12.13.6).

Table 12.13.6: Rider helmet owner in PSE interviews

Helmet owned by wearer	Frequency	
No	47	
Yes	1376	
Total	1423	

12.14 Factors affecting helmet use

Helmet use by age

Helmet use among the youngest riders, i.e., those under 20, was about half the rate of the rest of the population. About three-quarter of the riders in each age bracket above the teenage years wore a helmet. The relationship between rider age and helmet use in the petrol station population is shown in Table 12.14.1.

Table 12.14.1: Helmet use by rider age group in PSE interviews

Rider age (years)	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
11 – 20	202	62.3	122	37.7	324
21 – 30	361	27.9	933	72.1	1294
31 – 40	94	23.1	313	76.9	407
41 – 50	18	26.9	49	73.1	67
51 – 60	0	0.0	2	100.0	2
> 60	0	0.0	1	100.0	1
Unknown	2	40.0	3	60.0	5
Total	677		1423		2100

Helmet use by gender

Helmet use was slightly higher among male motorcycle riders in that about 68% of male riders wore a helmet at the time of the petrol station interview, compared to 62% of female riders. The data are shown in Table 12.14.2.

Table 12.14.2: Helmet use by rider gender in PSE interviews

Gender	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
Male	647		1374		2021
Female	30		49		79
Total	677		1423		2100

Helmet use by education

Helmet use was found to generally increase with increasing level of education (Table 12.14.3). It was higher among college graduates and those with a technical school degree, but riders with partial college education showed no increase over those with a high school education or less.

Table 12.14.3: Rider helmet use by education in PSE interviews

Education level	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
No education	3	23.1	10	76.9	13
Grade 1 – 12	528	33.0	1072	67.0	1600
Partial college	129	32.9	263	67.1	392
Technical school	6	20.7	23	79.3	29
College graduate	11	16.7	55	83.3	66
Total	677		1423		2100

Helmet use by occupation

Very low rates of helmet use were noted for students (42%) and unemployed riders (47%). In contrast, service workers, office workers and motorcycle taxi riders had a high level of helmet use (78%-83%). Table 12.14.4 shows the helmet use among various types of occupation.

Table 12.14.4: Rider helmet use by occupation in PSE interviews

Occupation	No helmet		Helmet worn		Total
	Freq	%	Freq	%	
Unemployed	45	52.9	40	47.1	85
Managers, senior officials	0	0.0	2	100.0	2
Technicians	5	71.4	2	28.6	7
Clerical, office worker	27	16.9	133	83.1	160
Service worker	41	16.4	209	83.6	250
Skilled agricultural	1	50.0	1	50.0	2
Craft and trade worker	2	33.3	4	66.7	6
Driver, transport equipment	100	21.4	368	78.6	468
Plant, machine operators	1	16.7	5	83.3	6
Elementary, unskilled labor	249	34.5	473	65.5	722
Housewife, homemaker	3	21.4	11	78.6	14
Military, active	10	23.3	33	76.7	43
Military, reserve	0	0.0	1	100.0	1
Student, full time	193	58.1	139	41.9	332
Other	0	0.0	2	100.0	2
Total	677		1423		2100

Helmet use and rider license

Unlicensed riders were half as likely to be wearing a helmet as those who reported having a motorcycle license. The data are shown in Table 12.14.5.

Table 12.14.5: Rider helmet use by motorcycle license possession

License held	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
No license held	147		82		229
MC license	530		1341		1871
Total	677		1423		2100

Helmet use by trip plan

Table 12.14.6 shows the relationship between helmet use and the trip plan. Helmet use was found to be very high (about 90%) when work was either the origin or the destination. This finding reflected high use among riders whose job involved riding a motorcycle. On the other hand, when a bar or restaurant was the origin or destination, helmet use was below 50%. There was not a large difference when home was the origin or destination because helmet use was found to be 61% when home was the origin and 64% when home was the destination. Although the number of riders going to or from school was small, the data suggested that when school was the destination helmet use was higher than when it was origin.

Table 12.14.6: Rider helmet use by origin and destination in PSE data

Location	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
Origin					
Home	184	38.5	294	61.5	478
Work, business	62	9.4	598	90.6	660
Recreation	36	42.4	49	57.6	85
School, university	15	26.3	42	73.7	57
Errand, shopping	58	34.1	112	65.9	170
Friends, relatives	152	46.3	176	53.7	328
Bar, restaurant	170	52.8	152	47.2	322
Total	677		1423		2100
Destination					
Home	379	35.8	679	64.2	1058
Work, business	30	8.9	306	91.1	336
Recreation	40	34.5	76	65.5	116
School, university	2	6.9	27	93.1	29
Errand, shopping	88	37.8	145	62.2	233
Friends, relatives	77	37.0	131	63.0	208
Bar, restaurant	61	50.8	59	49.2	120
Total	677		1423		2100

Helmet use by trip length

Helmet use was found to increase with increasing trip length. Helmet use was the lowest (40%) for trips of less than one kilometre and increased steadily to 88% for trips longer than 10 kilometres (Table 12.14.7).

Table 12.14.7: Rider helmet use by trip length in PSE interviews

Riding distance (km)	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
< 0.1	3	60.0	2	40.0	5
0.1 – 1.0	134	50.2	133	49.8	267
1.1 – 2.0	144	35.9	257	64.1	401
2.1 – 3.0	99	34.1	191	65.9	290
3.1 – 5.0	177	31.8	380	68.2	557
5.1 – 10.0	111	22.1	392	77.9	503
> 10	9	11.7	68	88.3	77
Total	677		1423		2100

Helmet use by alcohol involvement

Alcohol-involved riders were far less likely to wear a helmet than non-alcohol-involved. Nearly three-fourths of non-alcohol-involved riders had a helmet when they entered the petrol station, compared to only 42% of alcohol-involved riders. This distribution was very similar to the accident distribution of helmeted and unhelmeted riders. The data are shown in Table 12.14.8.

Table 12.14.8: Rider helmet use by rider alcohol involvement, PSE data

Alcohol use	No helmet		Helmet worn		Total
	Frequency	Percent	Frequency	Percent	
No	466		1270		1736
Yes	211		153		364
Total	677		1423		2100

Summary of safety helmet use

Younger riders, those without motorcycle license, particularly students, alcohol-involved riders, and those riding a short distance were more likely to be unhelmeted at the time of the petrol station interview. As noted earlier, helmet use declined at night, which is probably related to the increase in alcohol use at night.

12.15 Protective clothing

Upper torso coverage

Table 12.15.1 shows the type of upper torso coverage worn by riders interviewed during the petrol station interviews. About 87% of the riders wore light cloth garments (shirt or T-shirt, trunk top), while 13% wore medium cloth garments (light jacket, jeans). Only one rider wore a heavy cloth garment (imitation leather). Three male riders were interviewed who did not wear any upper torso clothing.

Table 12.15.1: Rider upper torso garment in PSE data

Upper torso coverage	Frequency	
None	3	0.1
Light cloth garment	1830	87.1
Medium cloth garment	266	12.8
Heavy cloth garment	1	0.0
Total	2100	

Lower torso coverage

Table 12.15.2 shows the type of lower torso coverage worn by riders at the time of the PSE collection. About 55% of riders interviewed wore light cloth garments (usually short pants). One 1% wore a heavy cloth lower torso garment (imitation leather).

Table 12.15.2: Rider lower torso garment in PSE data

Lower torso coverage	Frequency	
Light cloth garment	1157	
Medium cloth garment	919	
Heavy cloth garment	24	
Total	2100	

Footwear

The majority of responding riders interviewed (57%) wore sandals. Only a few wore heavy shoes or boots as shown in Table 12.15.3.

Table 12.15.3: Rider footwear coverage in PSE interviews

Footwear type	Frequency	
Light sandal	1198	
Medium street shoe, loafer	695	
Athletic, training shoe	177	
Heavy shoe or boot	30	
Total	2100	

Gloves

Only 3% of the riders interviewed wore gloves and none were leather. Data are reported in Table 12.15.4.

Table 12.15.4: Rider glove use in PSE interviews

Glove material	Frequency	
None	2036	
Light cloth	23	
Medium cloth	38	
Heavy cloth	3	
Total	2100	

Eyeglasses

Only 54 riders of the 2100 riders interviewed were required to wear eyeglasses due to vision problems. Only 19 participating riders chose to wear prescription clear eyeglasses, one wore prescription sunglasses, and one used contact lens (Table 12.15.5). Two riders who had no vision problems wore non-prescription sunglasses at the time of petrol station interview.

Table 12.15.5: Rider eye coverage in use during PSE interview

Type of eyeglasses	Frequency	
None	2077	98.9
Prescription clear glasses	19	1.0
Non-prescription sunglasses	2	0.1
Prescription sunglasses	1	0.0
Other	1	0.0
Total	2100	

12.16 Motorcycle passengers

Number of passengers on the motorcycle

Passengers were present on about 30% of the motorcycles stopped at the PSE sites (Table 12.16.1). The percentages reported for the petrol station interviews are nearly identical to those reported for the on-scene exposure data.

Table 12.16.1: Number of passengers on motorcycle in PSE data

Number of passengers	Frequency	
None	1472	
One	602	
Two	26	
Total	2100	

Riding experience as a motorcycle passenger

The majority (69%) of the motorcycle passengers interviewed reported having a moderate amount of experience riding as a passenger. One in six said they had very little experience and 4% said they had never ridden before as a passenger (Table 12.16.2).

Table 12.16.2: Passenger riding experience as a passenger

Prior passenger experience	Frequency	
Never before rode as passenger	25	
Very little experience	101	
Moderate experience	434	
Extensive experience	68	
Total	628	

13.0 Comparison of Accident and Exposure Data

Comparisons between the accident and exposure data permits an analysis of those variables where people and motorcycles in accidents differ from others using the same roads and exposed to the same risk of being in an accident.

The chi square statistic was used to determine whether or not the accident data distributions matched the distributions obtained by sampling the population-at-risk (exposure data). The null hypothesis that was evaluated was:

H_0: Proportion in the accident group is equal to the proportion in the exposure group.

H_a: Proportion in the accident group is not equal to the exposure group.

The test statistic is

$$X^2 = \sum_{i=1}^{2} \frac{(O - E)^2}{E} \sim \chi^2_{(1)}$$

Where: O = Observed frequency (accident data)
E = Expected frequency (exposure percentage x total observation)

The level of significance α, has been set at .05 for these tests. If the p-value for the chi-square test is less than α, the null hypothesis H_0 is then rejected and it can be concluded that the proportion in the accident group is significantly different from the exposure group. A one-sided test can also be done if H_a is stated in terms of population being greater or smaller. Details of the X^2 test results are given in the Appendix.

13.1 Accident characteristics

Accident rates and ambient lighting conditions

Accident rates were lowest during daylight and nearly tripled at night. On average, 155 motorcycles passed each daylight exposure site, compared to only 54 at each site at night, even though data was collected for one hour at every single site, day or night. Table 13.1.1 shows the ratio of motorcycles passing exposure sites to the number of accident motorcycles for the different lighting conditions. The percentage of nighttime riding was significantly over-represented in the accident population when compared to the exposure population (61.55% of the accident data versus 36.34% of the exposure data, chi-square test = 198.64, df = 1, p-value < 0.0001, α = 0.05).

Table 13.1.1: Accident-to-exposure rates by ambient lighting

Ambient lighting	Accident MC	Exposure MC	Accident : exposure ratio
Daylight	241	37,290	1 : 155
Night	445	23,807	1 : 54
Dusk - dawn	37	4,418	1 : 119

13.2 Motorcycle characteristics

Motorcycle type

The step-through motorcycle type predominated in the accident, on-scene exposure data and petrol station exposure study. However, step-through motorcycles showed a rate of accident involvement that was neither over-represented nor under-represented. The data are shown in Table 13.2.1.

On the other hand, the percentage of "sport bike" (racing design) motorcycles was significantly over-represented in the accident population when compared to the OSE population (34.02% of the accident data against 19.96% of the OSE data, chi-square test = 89.51, df = 1, p-value < 0.0001, ? = 0.05). However, this does not mean that sport bikes are inherently dangerous. It more likely reflects the way they are ridden or characteristics of the population of riders attracted to sport bikes.

For example, sport bike riders were more likely to have been drinking alcohol (43% versus 39%). They also had higher pre-crash speed (mean of 43 versus 39 km/hr) and crash speed (36 versus 30 km/hr) than riders did on other vehicle.

Table 13.2.1: Motorcycle type in accident & exposure data

Motorcycle type	Accident data		On-scene exposure data		Petrol station interviews	
	Freq	%	Freq	%	Freq	%
Standard street	118	16.3	18,784	28.8	493	23.5
Sport design	246	34.0	13,000	19.9	456	21.7
Cruiser design	4	0.6	978	1.5	8	0.4
Scooter	12	1.7	2,125	3.3	40	1.9
Step through	339	46.8	30,070	46.2	1102	52.5
Off road, enduro	4	0.6	170	0.3	1	0.0
Total	723		65,127		2100	

Motorcycle manufacturer

Table 13.2.2 provides a comparison of motorcycle manufacturers in the accident and on-scene exposure data. Honda predominated followed by Yamaha, Kawasaki and Suzuki.

Table 13.2.2: Motorcycle manufacturers in accident & OSE data

Motorcycle manufacturer	Accident data		Exposure data	
	Frequency	Percent	Frequency	Percent
Cagiva	1	0.1	0	0.0
Honda	305	42.2	26,192	40.0
Kawasaki	155	21.4	14,706	22.4
Piaggio	11	1.5	2,340	3.6
Suzuki	75	10.4	6,475	9.9
Yamaha	176	24.4	15,673	23.9
Other	0	0.0	20	0.0
Unknown	0	0.0	109	0.2
Total	723		65,515	

Motorcycle headlamp use

Table 13.2.3 compares headlamp usage for the motorcycle riders in the OSE data and the accident data. The percentage of motorcycles with the headlamp off at night was found to be significantly over-represented in the accident population when compared to the OSE population (13.41% of the accident data against 4.70% of the OSE data, chi-square test = 74.50, df = 1, p-value < 0.0001, ? = 0.05).

These findings are part of the explanation for the higher incidence of motorcycle accidents at night. Any motorcycle on the roadway at night without a headlamp is at high risk of an accident because it is extremely difficult to be seen by the other vehicle drivers.

Table 13.2.3: Comparison of headlamp use in accident & OSE data

Ambient lighting	Accident data				On-scene exposure data		
	Off	On	Unknown	Total	Off	On	Total
Daylight	211	29	1	241	36,402	888	37,290
	87.5%	12.0%	0.5%		97.6%	2.4%	
Night	59	381	5	445	1119	22688	23,807
	13.3%	85.6%	1.1%		4.7%	95.3%	
Dusk	25	7	0	32	2955	1150	4,105
	77.2%	21.8%	0.0%		72.0%	28.0%	
Dawn	2	3	0	5	270	43	313
	40.0%	60.0%	0.0%		86.3%	13.7%	

Headlamp use when the OV violates the motorcycle right-of-way

Headlamp use was most important in those cases where the other vehicle made a maneuver across the path of an approaching motorcycle, with the potential of violating the motorcycle right-of-way. Table 13.2.3 combines all night accidents, whether headlamp use was important or not. In order to examine the role of headlamp use more closely, accident configurations that involved the other vehicle crossing the motorcycle path were analyzed, and headlamp use in accidents and exposure data was compared. (Specifically, the accident configurations are listed in Table 5.2.8 as codes 4 - 7 and 16).

A total of 67 night accidents were in the five selected accident configurations that clearly involve OV violation of the motorcycle right-of-way. In 20 of those accidents (30%), the motorcycle headlamp was off. Since less than 5% of motorcycles had the headlamp off at night, these data suggested a five-fold increase in the risk of getting into an accident in which the other vehicle violated the motorcycle right-of-way by riding at night without a headlamp.

13.3 Alcohol involvement

Alcohol involved riders were far more likely to get into an accident than non-alcohol involved riders. Table 13.3.1 provides a comparison of the accident and PSE data for alcohol use. The percentage of riders who had been drinking was significantly over-represented in the accident population when compared to the population-at-risk (40.19% of the accident data against 17.33% of the OSE data, chi-square test = 262.25, df = 1, p-value < 0.0001, ? = 0.05).

As shown in section 11.3, alcohol-involved accidents were different from non-alcohol accidents. Alcohol-involved accidents were more likely to occur at night, more likely to be single-vehicle accidents in which an unhelmeted male rider ran off the road, or violated a traffic control device. Serious injury and fatality rates were also higher for drinking riders.

Table 13.3.1: Comparison of rider alcohol use and impairment

Alcohol involvement	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Alcohol use				
No	430	59.5	1736	82.7
Yes	289	40.0	364	17.3
Unknown	4	0.5	0	0.0
Total	723		2100	
Alcohol impairment				
Not impaired	37	12.6	277	76.1
Significantly impaired	251	85.7	87	23.9
Unknown	5	1.7	0	0.0
Total	293		364	

13.4 Rider license qualification

Table 13.4.1 shows a comparison of the license qualification for the motorcycle rider in the accident data and PSE data. The percentage of unlicensed riders was significantly over-represented in the accident population when compared to the population-at-risk (17.70% of the accident data versus 10.90% of the OSE data, chi-square test = 33.81, df = 1, p-value < 0.0001, ? = 0.05). The over-representation of unlicensed riders in the accident population clearly identifies this group as a target group for rider safety training programs.

Table 13.4.1: Comparison of rider license in accident & PSE data

License held	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No license held	126	17.4	229	10.9
Learner's permit, only	19	2.6	0	0.0
Motorcycle license	565	78.1	1871	89.1
Automobile license	1	0.1	0	0.0
License to transport people	1	0.1	0	0.0
Unknown	11	1.5	0	0.0
Total	723		2100	

13.5 Rider general characteristics

Rider gender

Female motorcycle riders were only a small portion of the accident population (4%) and found to be an even smaller portion of the exposure population. Table 13.5.1 compares rider gender in the accident, OSE and PSE data. The percentage of female riders showed no statistically significant difference in the accident population when compared to the PSE population (4.15% of the accident data versus 3.76% of the exposure data, chi-square test = 0.30, df = 1, p-value > 0.05, ? = 0.05).

Table 13.5.1: Comparison of rider gender in accident & exposure data

Gender	Accident data		OSE data		PSE data	
	Freq	%	Freq	%	Freq	%
Male	693	96.0	63,582	97.0	2021	96.2
Female	30	4.1	1,929	3.0	79	3.8
Unknown	0	0.0	4	0.0	0	0.0
Total	723		65,515		2100	

Rider age

Table 13.5.2 shows a comparison of accident and PSE data for rider age. The percentage of riders who were older than 30 years was found to be significantly over-represented in the accident population when compared to the population-at-risk (31.07% of the accident data against 22.77% of the OSE data, chi-square test = 28.24, df = 1, p-value < 0.0001, ? = 0.05).

Table 13.5.2: Comparison of rider age in accident & PSE data

Rider age (years)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
11 – 20	142	19.6	324	15.4
21 – 30	355	49.1	1294	61.6
31 – 40	170	23.5	407	19.4
41 – 50	51	7.1	67	3.2
51 – 60	3	0.4	2	0.1
> 60	0	0.0	1	0.0
Unknown	2	0.3	5	0.2
Total	723		2100	

Rider height and weight

A comparison of accident and PSE data for motorcycle rider weight and height shows no differences (Tables 13.5.3 and 13.5.4). The distribution of recorded height and weight was essentially the same in both data sets.

Table 13.5.3: Comparison of rider height in accident & PSE data

Rider height (cm.)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0 – 145	1	0.1	0	0.0
146 – 150	2	0.3	9	0.4
151 – 155	12	1.7	17	0.8
156 – 160	67	9.3	100	4.8
161 – 165	172	23.8	280	13.3
166 – 170	269	37.2	966	46.0
171 – 175	163	22.5	583	27.8
176 – 180	29	4.0	139	6.6
> 180	3	0.4	6	0.3
Unknown	5	0.7	0	0.0
Total	723		2100	

Table 13.5.4: Comparison of rider weight in accident & PSE data

Rider weight (kg)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
31 – 40	1	0.1	8	0.4
41 – 50	93	12.9	204	9.7
51 – 60	273	37.8	1106	52.7
61 – 70	241	33.3	705	33.6
71 – 80	96	13.3	74	3.5
> 80	14	1.9	3	0.1
Unknown	5	0.7	0	0.0
Total	723		2100	

Rider education

Accident rates varied with education level, but not in a consistent way. For example, the data do not reveal a decline in accident rates as education levels go up.

Table 13.5.5 shows the educational background of the motorcycle riders in the accident and PSE data. The percentage of riders with a high school education or less (grade 1 to 12) was found to be significantly over-represented in the accident population when compared to the population-at-risk (89.33% of the accident data against 76.81% of the PSE data, chi-square test = 59.44, df = 1, p-value < 0.0001, ? = 0.05).

Table 13.5.5: Comparison of rider education in accident & PSE data

Education level	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No education	0	0.0	13	0.6
Grade 1 – 12	603	83.4	1600	76.2
Partial college	24	3.3	392	18.7
Technical school	24	3.3	29	1.4
College graduate	23	3.2	66	3.1
Graduate school	1	0.1	0	0.0
Unknown	48	6.6	0	0.0
Total	723		2100	

Rider occupation

Table 13.5.6 shows the occupations for the motorcycle riders in the accident and PSE data. The differences are listed as follows:

1. The percentage of service workers, motorcycle taxi riders or messengers was found to be significantly over-represented in the accident population when compared to the population-at-risk (60.11% of the accident data against 34.19% of the PSE data, chi-square test = 212.63, df = 1, p-value < 0.0001, ? = 0.05).

2. The percentage of laborers, students and office workers was found to be significantly over-represented in the accident population when compared to the population-at-risk (29.07% of the accident data against 57.81% of the PSE data, chi-square test = 241.06, df = 1, p-value < 0.0001, ? = 0.05).

Table 13.5.6: Comparison of rider occupation in accident & PSE data

Rider occupation	Accident data		PSE data	
	Freq	%	Freq	%
Unemployed	36	5.0	85	4.1
Legislators, managers	6	0.8	2	0.1
Professionals	3	0.4	0	0.0
Technicians	0	0.0	7	0.3
Clerical, office worker	38	5.3	160	7.6
Service, shop, market workers	188	26.0	250	11.9
Skilled agricultural, fishery	0	0.0	2	0.1
Craft and related trades	8	1.1	6	0.3
Driver, transport equipment	240	33.2	468	22.3
Plant and machine operators	2	0.3	6	0.3
Elementary, unskilled laborers	111	15.4	722	34.4
Housewife, homemaker	0	0.0	14	0.7
Military, active duty	21	2.9	43	2.1
Military, reserve duty	0	0.0	1	0.1
Student, full time	58	8.0	332	15.8
Other	1	0.1	2	0.1
Unknown	11	1.5	0	0.0
Total	723		2100	

13.6 Rider training

Training experience

A comparison of the training experience for the motorcycle riders in the accident and PSE data shows no significant differences between the accident population and the exposure population (see Table 13.6.1), probably because almost no regular training programs available. In nearly 3,000 riders who were part of this study, only one said he had formal motorcycle training, and that rider was in an accident.

Table 13.6.1: Comparison of rider training in accident & PSE data

Type of training	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Self taught	635	87.8	1832	87.2
Taught by friends or family	56	7.7	268	12.8
Special MC training	1	0.1	0	0.0
Unknown	31	4.3	0	0.0
Total	723		2100	

13.7 Rider experience

Table 13.7.1 compares the number of days per year that motorcycles are ridden. The percentage of riders who claimed to ride daily (301 - 365 days per year) was found to be significantly under-represented in the accident population when compared to the population-at-risk (84.99% of the accident data against 90.66% of the PSE data, chi-square test = 26.31, df = 1, p-value < 0.0001, ? = 0.05). Thus, riding daily appears to reduce the potential risk of accident involvement. The percentage of riders who ride less than 4 days per week (0-200 days per years) was found to be significantly over-represented in the accident population when compared to the population-at-risk (9.52% of the accident data against 2.62% of the PSE data, chi-square test = 129.44, df = 1, p-value < 0.0001, ? = 0.05). These findings suggested that perhaps riders who did ride their motorcycle infrequently (4 days or less per week) were at an increased risk of being involved in an accident.

Table 13.7.1: Comparison of riding frequency in accident & PSE data

Days per year riding	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0 – 50	5	0.7	0	0.0
51 – 100	16	2.2	10	0.5
101 – 150	26	3.6	27	1.3
151 – 200	19	2.6	18	0.9
201 – 250	6	0.8	35	1.7
251 – 300	32	4.4	106	5.1
301 – 365	589	81.5	1903	90.6
Unknown	30	4.2	1	0.1
Total	723		2100	

Table 13.7.2 compares the distance that motorcycles are ridden per year. The percentage of the motorcycle riders who rode over 9,000 kilometres per year was found to be significantly over-represented in the accident population when

compared to the population-at-risk (56% of the accident data versus 22% of the PSE data, chi-square test = 416.71, df = 1, p-value < 0.0001, ? = 0.05).

Table 13.7.2: Comparison of distance motorcycle is ridden per year

Distance riding (km)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
1 – 3000	58	8.0	379	18.0
3001 – 6000	112	15.5	769	36.6
6001 – 9000	93	12.9	487	23.2
9001 – 12000	161	22.3	188	9.0
12001 – 15000	53	7.3	71	3.4
15000 – 18000	26	3.6	0	0.0
18001 – 21000	39	5.4	96	4.6
> 21000	62	8.6	107	5.1
Unknown	119	16.5	3	0.1
Total	723		2100	

Table 13.7.3 shows a comparison of vehicle use patterns for riders in the accident data and PSE data. There were no significant differences between the accident population and the exposure population.

Table 13.7.3: Comparison of vehicle use pattern in accident & PSE data

Vehicle use pattern	Accident data	PSE data
Non-motorcycle use	0.3	2.4
Recreation	13.7	14.1
Basic transport	86.0	83.5
Total	100.0	100.0

Table 13.7.4 compares passenger-carrying experience for the motorcycle riders in the accident and PSE data who were carrying a passenger at the time that they were encountered.

Passengers were present on about 30% of motorcycles in both the accident and the PSE groups. It was 29.5% in the OSE data as well. Therefore, it appears that carrying a passenger is neither over nor under-represented in the accident data and carrying a passenger does not appear to increase the risk of being involved in an accident.

Table 13.7.4: Passenger-carrying experience in accident & PSE data

Experience carrying passenger	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No passenger	496	68.6	1472	70.1
Never carried passengers	1	0.1	0	0.0
Very little experience	44	6.1	52	2.5
Moderate experience	104	14.4	476	22.7
Extensive experience	67	9.3	100	4.8
Unknown	11	1.5	0	0.0
Total	723		2100	

Table 13.7.5 provides a comparison of riding experience with similar cargo/luggage for riders in the accident and PSE data. Riding without cargo was over-represented in the accident data, but there was no significant difference between the accident data and the exposure data.

Table 13.7.5: Cargo-carrying experience in accident & PSE data

Experience carrying cargo	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No cargo/luggage	647	89.5	1755	83.6
No previous experience	0	0.0	1	0.0
Seldom carries	13	1.8	75	3.6
Frequently carries	24	3.3	160	7.6
Always carries	39	5.4	109	5.2
Total	723		2100	

13.8 Previous traffic violations and accidents

Table 13.8.1 shows the previous traffic violation records for the motorcycle riders during the past 5 years. The percentage of the motorcycle riders who claimed to have no record of traffic citations in the previous five years was found to be significantly over-represented in the accident population when compared to the population-at-risk (93.14% of the accident data versus 76.79% of the PSE data, chi-square test = 102.75, df = 1, p-value < 0.0001, ? = 0.05). This over-representation may be due to the unwillingness of riders to provide truthful information. Since no check of driving records was possible during the time of this research, the data reported here rely completely upon rider veracity.

Table 13.8.1: Comparison of rider previous motorcycle traffic citations

Previous traffic citations	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
None	638	88.2	1611	76.7
One	20	2.8	371	17.7
Two	9	1.2	106	5.0
Three	10	1.4	7	0.3
Four	3	0.4	2	0.1
Five	3	0.4	0	0.0
> Five	2	0.3	1	0.0
Unknown	38	5.3	2	0.1
Total	723		2100	

As with previous traffic citations, data about previous accidents relies entirely on rider truthfulness. When "unknown" is excluded from the accident data, there were essentially no differences between accident and exposure populations. Table 13.8.2 provides the previous traffic accident involvement for the motorcycle riders who involved in accident with either any motorcycle or other vehicle traffic accident during the past 5 years.

Table 13.8.2: Comparison of rider previous traffic accidents

Previous traffic accident	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
MC accident				
None	478	66.1	1527	72.7
One	109	15.1	383	18.3
Two	64	8.9	166	7.9
Three	19	2.6	20	1.0
Four	9	1.2	1	0.0
Five	4	0.6	1	0.0
> Five	5	0.7	0	0.0
Unknown	35	4.8	2	0.1
Total	723		2100	
Non-MC accident				
None	674	93.2	2059	98.0
One	6	0.8	35	1.7
Two	2	0.3	4	0.2
Three	4	0.6	0	0.0
Four	1	0.1	0	0.0
Unknown	36	5.0	2	0.1
Total	723		2100	

13.9 Rider trip

Roadway familiarity

Table 13.9.1 shows a comparison of the accident and PSE data for the motorcycle rider familiarity with the roadway. The percentage of infrequent users of the roadway (i.e. monthly or annually) was significantly over-represented in the accident population when compared to the population-at-risk (8.58% of the accident data against 2.57% of the PSE data, chi-square test = 99.0, df = 1, p-value < 0.0001, ? = 0.05).

Table 13.9.1: Comparison of rider familiarity with roadway

Roadway familiarity	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Daily use	514	71.1	1791	85.3
Weekly use	115	15.9	255	12.1
Monthly use	37	5.1	44	2.1
Quarterly use	5	0.7	1	0.1
Annually use	3	0.4	0	0.0
Less than annually	2	0.3	0	0.0
Never used before	12	1.7	9	0.4
Unknown	35	4.8	0	0.0
Total	723		2100	

Trip plan

Tables 13.9.2 and 13.9.3 compare the trip plan for the motorcycle riders in the accident and PSE data.

Table 13.9.2: Comparison of trip origin in accident & PSE data

Location of trip origin	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Home	117	16.2	478	22.8
Work, business	288	39.8	660	31.4
Recreation	63	8.7	85	4.0
School, university	10	1.4	57	2.7
Errand, shopping	37	5.1	170	8.1
Friends, relatives	92	12.7	328	15.6
Bar, pub restaurant	91	12.6	322	15.3
Unknown	25	3.5	0	0.0
Total	723		2100	

Table 13.9.3: Comparison of trip destination in accident & PSE data

Location of trip destination	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Home	336	46.5	1058	50.4
Work, business	210	29.0	336	16.0
Recreation	19	2.6	116	5.5
School, university	8	1.1	29	1.4
Errand, shopping	38	5.3	233	11.1
Friends, relatives	81	11.2	208	9.9
Bar, pub restaurant	4	0.6	120	5.7
Others	1	0.1	0	0.0
Unknown	26	3.6	0	0.0
Total	723		2100	

Work and recreation-oriented travel were found to be over-represented for the point of origin while work and friends-family oriented travel were found to be over-represented for the trip destination in the accident data. Work was common as both origin and destination because about one-third of the non-drinking riders in accidents crashed while on work-related travel. For drinking riders who crashed, home was the most common destination (195 of 289), usually from a bar, friend's house, work or recreation. Comparisons between the accident data and the exposure population did not reveal any significant differences between groups.

Table 13.9.4 provides a comparison of the distance of the rider's intended trip in the accident and PSE data. Table 13.9.5 compares the time riding since departure from trip origin to the time of accident or PSE interview. There was no significant difference between the accident data and the petrol station exposure data; therefore, time since departure does not appear to be a risk factor for accident involvement.

Table 13.9.4: Intended trip distance in accident & PSE data

Length of intended trip (km)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
< 0.1	11	1.5	5	0.2
0.1 – 1.0	93	12.9	267	12.7
1.1 – 2.0	90	12.4	401	19.1
2.1 – 3.0	52	7.2	290	13.8
3.1 – 5.0	124	17.2	557	26.5
5.1 – 10.0	160	22.1	503	24.0
> 10.0	116	16.0	77	3.7
Unknown	77	10.7	0	0.0
Total	723		2100	

Table 13.9.5: Comparison of time riding before accident / interview

Time riding (hrs)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0	65	9.0	479	22.8
0.1	257	35.5	1107	52.7
0.2	151	20.9	406	19.3
0.3	104	14.4	80	3.8
0.4	1	0.1	11	0.5
0.5	45	6.2	9	0.4
0.6 - 0.7	4	0.6	0	0.0
0.8 - 1.0	4	0.6	5	0.2
> 1.0	1	0.1	0	0.0
Unknown	91	12.6	3	0.1
Total	723		2100	

13.10 Physiological impairments

Riders with vision problems were not found to be over-represented in accidents, even though four of them were not wearing required eye correction when they crashed. The riders with a permanent impairment other than vision were over-represented in the accident data but the number of cases was considered too small for statistical analysis. Table 13.10.1 provides a comparison of permanent and transient physiological impairment for the accident-involved motorcycle riders and those observed in the PSE data.

Table 13.10.1: Comparison of rider physiological impairments

Physiological impairment	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Permanent impairment				
None	660	91.3	2046	97.4
Vision	18	2.5	54	2.6
Respiratory, cardiovascular	5	0.7	0	0.0
Amputee	2	0.3	0	0.0
Neurological, epilepsy	2	0.3	0	0.0
Endocrine, digestive	1	0.1	0	0.0
Other	3	0.4	0	0.0
Unknown	32	4.4	0	0.0
Total	723		2100	
Transient impairment				
None	632	87.4	2094	99.7
Fatigue	31	4.3	5	0.2
Hunger	3	0.4	0	0.0
Thirst	1	0.1	0	0.0
Unknown	56	7.8	1	0.1
Total	723		2100	

Only fatigue, among the temporary impairments, was found to be over-represented in the accidents (4.3% versus 0.2% of the PSE data), but once again, the number of cases was too small for a meaningful statistical analysis. However, the presence of fatigue-related accidents does suggest that riders should be warned of the increased risk of accident involvement due to fatigue. Epilepsy was not a common problem, but two accidents occurred when the riders had a seizure while operating the motorcycle.

Stress and conflicts

Stress was very infrequent among accident-involved riders. Only 3 riders in the petrol station interviews (one in 700) reported any stress, compared to one in 28 accident-involved riders. Table 13.10.2 shows a comparison of stress for the accident-involved motorcycle riders and those observed in the PSE data.

Table 13.10.2: Comparison of rider stress and conflicts

Stress experienced	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
None observed or noted	642	88.8	2096	99.9
Conflict with friends, family	6	0.8	0	0.0
Work related problems	4	0.6	0	0.0
Financial distress	9	1.2	1	0.0
Legal, police problems	1	0.1	0	0.0
Traffic conflict, road rage	2	0.3	2	0.1
Other	3	0.4	0	0.0
Unknown	56	7.8	1	0.0
Total	723		2100	

13.11 Helmet use

The most important piece of protective equipment for the motorcycle rider is the safety helmet. Table 13.11.1 provides a comparison of the on-scene accident, OSE and PSE data regarding the usage of safety helmets. The percentage of unhelmeted riders was found to be significantly over-represented in the accident population when compared to the OSE population-at-risk (34.30% of the accident data against 14.13% of the OSE data, chi-square test = 242.65, df = 1, p-value < 0.0001, ? = 0.05). However, the percentage of unhelmeted riders showed no statistically significant difference when the accident and PSE data were compared (34.30% of the accident data versus 32.24% of the PSE data, chi-square test = 1.41, df = 1, p-value > 0.05, ? = 0.05).

Although the results showed a large difference in the accident and OSE data, there was only a slight difference in the accident and PSE data. The OSE data is considered to be more accurate than the PSE data for several reasons: 1)

OSE data was collected usually one week after the accident occurred, compared to one year for the PSE data, so there is far less opportunity for time-related variations in the OSE data, 2) The OSE represents a much larger rider population relative to the PSE data (i.e. 65515 riders versus 2100 riders), and should be considered more representative of the riding population, and 3) the OSE data required no volunteering as the PSE data collection did.

Table 13.11.1: Helmet use in accident & exposure data

Helmet use by rider	Accident data		OSE data		PSE data	
	Freq	%	Freq	%	Freq	%
No	248		9254		677	
Yes	475		56261		1423	
Total	723		65515		2100	

Table 13.11.2 compares the helmet types worn by the motorcycle riders in the accident and on-scene exposure data. The percentage of full-face helmet worn by the riders showed no statistically significant difference when the accident and OSE data were compared (46.32% of the accident data versus 45.83% of the OSE data, chi-square test = 0.05, df = 1, p-value > 0.05, ? = 0.05). Although the percentage of non-motorcycle helmet was found to be over-represented in the accident data (3.2% of the accident data versus 0.2% of the OSE data), the number of cases was too small for a meaningful statistical analysis.

Table 13.11.2: Helmet type in accident & exposure data

Helmet type	Accident data		OSE data	
	Frequency	Percent	Frequency	Percent
Not motorcycle helmet	15	3.2	91	0.2
Half/police helmet	150	31.6	18144	32.2
Open-face helmet	90	18.9	12208	21.7
Full-face helmet	220	46.3	25755	45.8
Unknown	0	0.0	63	0.1
Total	475		56261	

13.12 Summary of accident – exposure comparisons

The most prominent differences between accident and exposure data involve alcohol, helmet use and rider licensing. Alcohol-involved riders, unhelmeted riders and unlicensed riders, all were found to be significantly over-represented in these accident data and they make up and large portion of the accident population. Countermeasures should therefore target these identified groups. Other factors were found to have a statistically significant effect, but their proportion of the accident population is often small, and countermeasures are less clear.

Failure to use the headlamp at night was a serious problem that needs immediate action. The headlamp was found to be off in 30% of the night-time accidents where the other vehicle violated the motorcycle right of way compared to only 5% of motorcycles with the headlamp off in OSE data. The risk of an accident appears to go up significantly if the headlamp is burned out or if it is left off.

A number of other factors reported here were found to have no apparent effect on accident involvement. These factors included education trip length, riding experience, rider height and weight.

14.0 Comparison of Accidents in Bangkok and Upcountry

Considerable differences were found between the Bangkok and upcountry accident populations. Accidents in Bangkok involved more alcohol involvement than upcountry.

Female motorcycle riders were almost entirely absent in Bangkok, in both accident and exposure data. However, in the upcountry sampling regions they were approximately one-fourth of the exposure and accident populations. Helmet use was far higher in Bangkok than upcountry (65% vs. 25%).

The upcountry sampling regions were remarkable for the predominance of step-through frame motorcycles (87%). In Bangkok, step-through frame motorcycles were still the most common (47%) but there were far more sport bikes (34%) and standard motorcycles (13%) when compared to the upcountry accident data and exposure data.

On the other hand, there were also many similarities between the two accident populations. Alcohol-involved accidents were very similar in Bangkok and upcountry, as were non-alcohol accidents. Most motorcycle riders in both areas were males in the 18 to 33 age bracket, with a high school education or less, and were employed in relatively unskilled occupations. These findings are detailed in the sections that follow.

14.1 Accident characteristics

Day of week

Bangkok accidents tended to occur on weekends: 52% occurred on Friday, Saturday and Sunday, compared to only 38% of upcountry accidents on those same three days. Upcountry accidents tended to occur on Wednesday, Thursday and Friday, when 49% of accidents occurred compared to 42% in Bangkok in those three days. In both Bangkok and upcountry, Sunday accidents involved high levels of alcohol use: 50% in Bangkok, 60% upcountry.

Time of day

Bangkok and upcountry accidents showed similar accident time-of-day patterns. During daylight hours, very few accidents involved alcohol. Both areas showed a peak of alcohol accidents late at night, although the exact time of the peak differed. In Bangkok alcohol accidents peaked in the few hours on either side of midnight: 10 p.m. until 3 a.m. In the upcountry sampling regions, alcohol accidents peaked in the few hours around 10:30 p.m. Accident time-of-day comparing 3-hour time blocks is shown in Table 14.1.1

Table 14.1.1: Accident time of day, Bangkok & upcountry

Time (24 hour)	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
0:01 – 3:00	139	19.2	27	7.5
3:01 – 6:00	27	3.7	11	3.1
6:01 – 9:00	16	2.2	35	9.7
9:01 – 12:00	84	11.6	45	12.5
12:01 – 15:00	79	10.9	43	12.0
15:01 – 18:00	85	11.8	74	20.6
18:01 – 21:00	78	10.8	60	16.7
21:01 – 24:00	215	29.7	64	17.8
Total	723		359	

Ambient lighting

Roughly half of the upcountry accidents occurred during daylight hours, compared to only one-third of Bangkok accidents. On the other hand, over 60% of Bangkok accidents occurred at night, compared to only 43% of upcountry crashes, as shown in Table 14.1.2. If the dusk-dawn crashes are removed, the day - night distribution shows a statistically significant difference ($p < 0.0001$, significance level ? = 0.05).

Table 14.1.2: Accident scene, roadway illumination

Ambient light	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
Daylight, bright	241		181	
Night	445		153	
Dusk – dawn	37		25	
Total	723		359	

Other vehicle involvement

Single vehicle accidents were found to be more common in upcountry (i.e., nearly 20%) but only occurred in about 14.8% of accidents in Bangkok. The difference was statistically significant ($p<0.0001$, significance level ? = 0.05). The data are shown in Table 14.1.3.

Table 14.1.3: Other vehicle involvement, Bangkok and upcountry

Other vehicle involved	Bangkok		Upcountry		Total	
	Frequency		Frequency		Frequency	
Yes	616		292		908	
No	107		67		174	
Total	723		359		1082	

Hit-and-run accidents

Hit-and-run accidents were more than twice as common upcountry (15%) as in Bangkok (7%), and the difference was found to be statistically significant ($p < 0.001$, significance level ? = 0.05). The data are shown in Table 14.1.4. Note that hit-and-run accidents include those cases in which the driver fled, leaving the OV behind as well the more conventional cases in which driver fled in the OV.

Table 14.1.4: Other vehicle hit-and-run crashes, Bangkok and upcountry

Other vehicle hit-and-run	Bangkok		Upcountry	
	Frequency		Frequency	
No	649		261	
Yes	47		47	
Total	696		308	

Accident configuration

Table 14.1.5 shows the distribution of accident types for the Bangkok and upcountry data sets. Generally, there were no significant differences between the two sampling regions for most individual accident configurations. One of the few accident configurations in which there was a large difference was collision, in which the motorcycle rear-ended an OV, which were more common in Bangkok.

Table 14.1.5: Accident configuration, Bangkok and upcountry

Accident configuration	Code	Bangkok		Upcountry	
		Freq.	%	Freq.	%
Head on collision	1	27	3.7	14	3.9
OV into MC, paths perpendicular	2	31	4.3	13	3.6
MC into OV, paths perpendicular	3	27	3.7	23	6.4
OV turning L ahead of MC, paths perpendicular	4	8	1.1	5	1.4
OV R turn ahead of MC, paths perpendicular	5	35	4.8	19	5.3
MC & OV opposite directions, OV turns, crossing MC path	6 - 7	54	7.5	17	4.7
MC L turn in front of OV, OV either direction perpendicular to MC	8	5	0.7	3	0.8
MC R turn, OV going either direction perpendicular to MC path	9	12	1.7	11	3.1
MC passing OV, OV turns left	10	13	1.8	8	2.2
MC overtaking OV, OV turns right	11	30	4.1	10	2.8
OV impacts rear of MC	12	30	4.1	19	5.3
MC impacts rear of OV	13	104	14.4	33	9.2
Sideswipe, opposite directions	14	22	3.0	22	6.1
Sideswipe, same direction	15	51	7.1	26	7.2
OV U-turn or Y-turn ahead of MC	16	53	7.3	22	6.1
Other MC – OV impacts	17	64	8.9	32	8.9
MC fall on roadway, no OV	18	25	3.5	23	6.4
MC running off roadway, no OV	19	46	6.4	24	6.7
MC fall on roadway avoiding OV	20	32	4.4	10	2.8
MC running off road avoiding OV	21	7	1.0	1	0.3
MC impacts pedestrian or animal	23	25	3.5	19	5.3
MC impacts environmental object	24	15	2.1	2	0.6
Other	98	7	1.0	3	0.8
Total		723		359	

Primary contributing factor

In both Bangkok and upcountry, human error was identified as the most important contributing factor in accident causation, with about 93% in both regions (including passengers and non-contacted vehicles). However, motorcycle rider errors were a greater proportion of the human errors in Bangkok: 60% versus 53%. The data are shown in Table 14.1.6.

Table 14.1.6: Primary contributing factor in Bangkok and upcountry

Primary contributing factor	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
Motorcycle rider	409	56.6	177	49.3
Other vehicle driver	251	34.6	151	42.1
Vehicle	2	0.3	1	0.3
Roadway defect	8	1.1	2	0.6
Traffic control	7	1.0	3	0.8
Roadside environment	20	2.8	19	5.3
Non-contacted vehicle	19	2.6	3	0.8
Motorcycle passenger	2	0.3	2	0.6
Other vehicle passenger	2	0.3	0	0.0
Other	3	0.4	1	0.3
Total	723		359	

Fatalities

The fatality rate was more than twice as high in Bangkok as in the upcountry sampling regions. In Bangkok, 57 riders or passengers died in 723 cases (7.9%), compared to 13 in 359 (3.6%) of upcountry crashes. The data are shown in Table 14.1.7

Table 14.1.7: Fatal accidents, Bangkok and upcountry

Fatality	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
No	666		346	
Yes	57		13	
Total	723		359	

Traffic density

It was not surprising that more Bangkok accidents occurred when traffic was heavy on the motorcycle path, 13% in Bangkok compared to less than 2% upcountry. However, in both areas, the majority of accidents occurred in light or moderate conditions: 84% in Bangkok and 95% upcountry. This trend was similar for the other vehicle path, as shown in Table 14.1.8.

Table 14.1.8: Traffic density at the time of accident

Traffic density	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
Motorcycle path				
No other traffic	18	2.5	11	3.1
Light traffic	289	40.0	184	51.3
Moderate traffic	319	44.1	158	44.0
Heavy traffic, traffic moving	76	10.5	5	1.4
Heavy traffic, congested	18	2.5	1	0.3
Other	3	0.4	0	0.0
Total	723		359	
Other vehicle path				
No other traffic	15	2.2	14	4.5
Light traffic	265	38.1	139	45.1
Moderate traffic	311	44.7	151	49.0
Heavy traffic, traffic moving	77	11.1	4	1.3
Heavy traffic, congested	23	3.3	0	0.0
Other	5	0.7	0	0.0
Total	696		308	

14.2 Motorcycle characteristics

Motorcycle type

As noted earlier, motorcycle type differed greatly between the Bangkok series and the upcountry data where the large majority of motorcycles (almost 90%) were the step-through frame variety (Table 14.2.1). In the Bangkok sampling region the motorcycle types were far more varied.

Table 14.2.1: Motorcycle types in Bangkok and upcountry

Motorcycle type	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
Standard street	95	13.1	14	3.9
Standard street, modifications	23	3.2	0	0.0
Sport, race replica design	246	34.0	26	7.2
Cruiser design	4	0.6	2	0.6
Scooter	12	1.7	5	1.4
Step through	339	46.9	312	86.9
Off road, enduro	4	0.6	0	0.0
Total	723		359	

Motorcycle manufacturer

Accident-involvement rates were similar in Bangkok and upcountry for Honda and Yamaha, with about 40 to 45% of all accidents involving a Honda motorcycle, and 20 to 25% of all accidents involving a Yamaha motorcycle. However, Suzuki and Kawasaki motorcycles showed a large difference between the Bangkok and upcountry sampling regions. Kawasaki motorcycles accounted for 21% of Bangkok crashes but only 5% of the upcountry crashes. Conversely, Suzuki made up only 10% of Bangkok crashes, but 27% of the upcountry cases. The differences mostly reflect differences in exposure rates between the two areas.

14.3 Rider characteristics

Gender

Males dominated both upcountry and Bangkok, accidents (Table 14.3.1). However, even though female motorcycle riders made up over 20% of upcountry accidents, they were virtually absent as motorcycle operators in Bangkok. The difference between the two sampling regions was found to be statistically significant ($p < 0.001$, significance level ? = 0.05).

Table 14.3.1: Rider gender in Bangkok and upcountry

Gender	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
Male	693		282	
Female	30		77	
Total	723		359	

Rider age

Generally, rider age in the upcountry sampling regions showed a much broader distribution than in Bangkok, where rider age appeared to be sharply focused in the 18 to 35 year old bracket. The mean ages of the two data sets were nearly identical at about 28 years, but the standard deviation was 12.5 years in the upcountry data and 7.9 years in the Bangkok data.

In Bangkok, 60% of riders were 19 to 33 years old; only 7.5% were under 18 and another 7.5% were over 40. In the upcountry data, less than half were 19 to 33, while 15% were under 18 and another 15% over 40. About 60 to 65% of riders in both areas were under 30 years of age. Age ranges, in 10-year groups, are shown in Table 14.3.2.

Table 14.3.2: Motorcycle rider age in Bangkok and upcountry

Age (years)	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
11 – 20	142	19.6	112	31.2
21 – 30	355	49.1	127	35.4
31 – 40	170	23.5	64	17.8
41 – 50	51	7.1	36	10.0
51 – 60	3	0.4	12	3.3
> 60	0	0.0	8	2.2
Unknown	2	0.3	0	0.0
Total	723		359	

Rider occupation

Rider occupation differed between upcountry and Bangkok. The data are compared in Table 14.3.3.

Table 14.3.3: Rider occupations, Bangkok and upcountry

Occupational category	Bangkok		Upcountry	
	Frequency	%	Frequency	%
Unemployed, over 1 month	36	5.0	27	7.5
Senior officials and managers	6	0.8	1	0.3
Professionals	3	0.4	3	0.8
Minor professionals	0	0.0	3	0.8
Clerical, office worker	38	5.3	12	3.3
Service, shop, market sales	188	26.0	20	5.6
Skilled agricultural / fishery	0	0.0	2	0.6
Skilled craft and trades	8	1.1	0	0.0
Transport driver	240	33.2	15	4.2
Machine and assemblers	2	0.3	2	0.6
Unskilled laborers	111	15.4	163	45.4
House wife, homemaker	0	0.0	4	1.1
Military, active duty	21	2.9	5	1.4
Student, full time	58	8.0	96	26.7
Retired, civilian	0	0.0	4	1.1
Other	1	0.1	1	0.3
Unknown	11	1.5	1	0.3
Total	723		359	

In the upcountry data, two occupations dominated; unskilled laborers (mostly farm workers), who were nearly half of the accident group, and full-time students, who were another one-fourth of the accident population. In contrast, the range of occupations in Bangkok was broader and was dominated by riders whose jobs required motorcycle riding (i.e., mostly taxi, delivery and messengers on motorcycles), who made up one third of the accidents. Service workers made up about one-fourth of the accidents in Bangkok, and unskilled laborers about one in six. Students were a much smaller proportion of the Bangkok data (8% in Bangkok versus 26% upcountry.)

Motorcycle license

Motorcycle riders in Bangkok were for more likely to have a motorcycle license (78%) than those riders in the upcountry data (48%). The data are shown in Table 14.3.4.

Table 14.3.4: Motorcycle license held, Bangkok and upcountry

Motorcycle license held	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
No license	126		179	
MC license	565		173	
Other license	32		7	
Total	723		359	

Alcohol

Drinking alcohol before riding was common in both the Bangkok and the upcountry accident data, but it was a higher proportion of the Bangkok data set: 40% of all accidents versus 30% of the upcountry accidents. A comparison is shown in Table 14.3.5.

Table 14.3.5: Rider alcohol use in Bangkok and upcountry

Alcohol use	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
None	430		253	
Alcohol use only	289		105	
Unknown	4		1	
Total	723		359	

Helmet use

Helmet use by riders, and particularly by passengers, was much higher in the Bangkok data than in the upcountry data (Table 14.3.6). Overall, among 960 riders and passengers in Bangkok, 544 of them (56%) were wearing a helmet at the time of the accident, and helmet use was about twice as high among riders as passengers. In the upcountry accident data, only 86 of 521 motorcyclists (16%) had a helmet on and helmet use was far higher among riders than passengers.

Table 14.3.6: Rider & passenger helmet use, Bangkok & upcountry

Helmet use	Bangkok		Upcountry	
	Frequency	Percent	Frequency	Percent
MC rider				
No	248	34.3	280	78.0
Yes	475	65.7	79	22.0
Total	723		359	
MC passenger				
No	168	70.9	155	95.7
Yes	69	29.1	7	4.3
Total	237		162	

15.0 Findings

The data obtained from all 723-on scenes, in-depth accident investigation cases reveal several important findings related to accident causation, injury information and accident characteristics of motorcycle accidents. Summaries of these findings are as follows:

1. Human errors, by both the motorcycle and other vehicle drivers were the most frequent cause of the 723 Bangkok motorcycle accidents.

2. Alcohol was a key factor in the Bangkok accidents. Alcohol-involved riders were more likely to be the primary or sole cause of the accidents they got into and were more likely to crash by losing control of the motorcycle, usually by running off the road. They were less likely to be wearing a helmet and more likely to be hospitalized or killed.

3. Roadway design and maintenance problems were a contributing factor in at least 13% of these accidents.

4. Motorcycle problems were a negligible contributing factor, and the problems encountered in these accidents were predominantly due to poor maintenance, and not to poor design or manufacturing.

5. The most frequent motorcycle-related problem was riding at night without the headlamp illuminated, which was considered to actually be a rider failure. The lack of headlamp use greatly increased the risk of being involved in a right-of-way collision with another vehicle.

6. Adverse weather (i.e.–rain) was not a major cause factor because most riders stopped riding while it was raining. However, when rain was present in an accident, it contributed to causing the accident in about two-thirds of rain cases (12 of 18 accidents).

7. Only one accident-involved rider and none of the exposure interviewees reported having any formal motorcycle training. This indicates that many riders lacked knowledge of defensive riding strategies to avoid potential collision situations.

8. The accident-involved riders also showed poor collision avoidance skills when faced with an imminent collision. About two-thirds of the riders took evasive action. Of those who took action, only 12% chose the best action and executed it skillfully.

9. The average (median) time from the precipitating event to impact was 1.9 seconds. In many cases, there was too little time for effective evasive action. While rider training should include collision avoidance skills, the

emphasis should be on defensive driving skills to minimize potential accident situations.

10. When riders used the helmet properly so that it remained on the head, helmets showed a great reduction in head injuries.

11. Many helmets in Thailand are used improperly or not used at all.

12. Many helmets seen in this study would fail if tested for compliance with the Thailand Industrial Standard. At present, no mechanism exists to require compliance with the standard. As a result, far too many helmets offered to consumers are substandard and inadequate, and consumers have no way of knowing if the helmet they purchase can actually protect them in an accident.

13. Helmet users too often defeat the protection offered by their helmet by wearing it poorly -- usually with the straps fastened loosely or not fastened at all. As a result, one-fourth of the helmets worn were ejected from the rider's head.

14. Unhelmeted riders were more likely to get into a crash than those wearing a helmet. About 15% of the riders passing exposure sites were not wearing a helmet, while 35% of the accident-involved riders had no head protection.

15. Three-fourths of the motorcycle accidents in Bangkok involved collisions with other vehicles, usually a passenger car. About one-fourth of 616 crashes reported (24%) here involved two motorcycles.

16. Accident rates nearly tripled at night compared to day. During daylight hours, there was one crash for every 155 motorcycles on the road. At night, the rate was 55 motorcycles per crash.

17. The most frequent accident configuration in the Bangkok series was the motorcycle impacting the rear of the OV. The next most common was a single vehicle crash in which the motorcycle fell or ran off the road, or struck some environmental object. Other vehicle turns across the path of an oncoming motorcycle were also very frequent.

18. Parked or abandoned trucks at the side of the road at night failed to provide proper warning to drivers approaching from the rear in every single night-rear-end collision in this study. This accident situation accounted for one-fourth of the rear-end collisions (25 of 104 cases); the other three-fourths were mainly the typical result of following too closely in traffic.

19. Most accidents occurred when traffic conditions were light or moderate.

20. Half of the accidents reported here occurred at intersections. Most intersection accidents involved a crossing-path collision with an OV.

21. Non-intersection accidents were more varied, with more pedestrians and single motorcycle crashes, but the majority still involved another vehicle..

22. Running over raised pavement reflectors caused several accidents in Bangkok. These large reflectors sometimes caused immediate loss of front tyre pressure and dented front rims, and consistently caused motorcycles to lose control and fall.

23. No accidents occurred as a result of stuck throttles, a side stand being left in the down position, or dynamically unstable oscillations such as weave, wobble or pitch-weave. Under-inflated tyres, a loose steering stem or swing arm pivot or unwieldy cargo can contribute to dynamic instability problems and while these factors were coded as being present for some accidents, they were never considered to contribute to accident causation.

24. No fires and no fuel burn injuries were seen in the Bangkok accidents. Although half of motorcycles leaked a few milliliters of fuel from the carburetor or filler cap while lying on their side at point of rest, and a few spilled larger quantities, this presented no particular problem. The few burn injuries that occurred resulted from direct contact with a hot exhaust pipe or muffler.

25. Almost half of the motorcycles in the Bangkok accidents were the step-through frame type. Sport-bikes (race replica design) models were over-represented in Bangkok accidents, but this appears to reflect the characteristics of sport bike riders, who were more likely to be young males, to have been drinking and driving faster before the accident than riders of other motorcycles.

26. About half of the accident-involved motorcycles had no rear view mirror on either side. This was felt to be a factor when riders failed to detect another vehicle coming from behind.

27. Roadway design defects were considered to be the cause of the accident in about 5% of crashes. Beside the large pavement reflectors, other design problems included inadequate signing and guidance at curves, and view obstructions.

28. Accidents around construction zones were a significant problem in Bangkok, especially at night. This was due to view obstructions, poor signing and guidance, unmarked barriers and construction equipment left

too close to the traffic flow, and poor pavement conditions. These problems occurred in the upcountry accidents as well, but were much less frequent.

29. Roadway maintenance defects (i.e. potholes, debris, etc.) were present in 119 cases but were the accident cause factor in only 16 cases (2%) of the accidents.

30. Traffic control malfunction was a contributing factor in 5 cases (1%) for the motorcycle and 2 cases for the other vehicle.

31. The rear position lamp and stop lamp were missing or inoperable in 31 cases. In three of those situations, the motorcycle was rear-ended by another vehicle at night.

32. In the Bangkok accident data set, the median pre-crash speed of the motorcycle was 39 kilometres per hour and the median crash speed was 31 kilometres per hour.

33. Crash speeds, on average, were higher in fatal accidents than in non-fatal crashes. The mean pre-crash and crash speeds for the fatal motorcycle accidents were 50 and 48 kilometres per hour.

34. About 20% of the Bangkok accidents involved motorcycle loss of control, usually running off the road or a braking slide-out during collision avoidance. Alcohol-involved riders were especially prone to loss of control (29% of alcohol-involved riders versus 13% of non-alcohol-involved riders).

35. For the Bangkok data, the median rider age was 27 years. Motorcycle riders under the age of 21 accounted for 20% of all accidents, while 72% fell into the 21 to 40 age bracket.

36. Female motorcycle riders were slightly over-represented in the Bangkok accident data set, accounting for 4% of accidents and 3% of exposure data cases.

37. Over 80% of accident-involved riders had no education beyond 12th grade, and only 5% were college graduates.

38. Unlicensed riders were over-represented in the Bangkok accident data. They were 11% of those interviewed in petrol stations, but made up 17% of the accident population.

39. Among physiological impairments, only fatigue appears to be over-represented in accidents. Two riders had an epileptic seizure while riding.

40. Motorcycles with passengers (or even multiple passengers) were not over-represented in accidents. Passengers did contribute to accident causation in six cases by distracting the rider or interfering with motorcycle balance.

41. None of the accident-involved drivers reported any formal training. This suggests that many drivers lacked knowledge of defensive driving strategies to avoid potential collision situation.

42. About half of other vehicle drivers committed an unsafe act that contributed to the accident causation.

43. When another vehicle was involved and the type of other vehicle was known, it was a motorcycle nearly one-fourth of the time.

44. If the other vehicle was a motorcycle, the collision was likely to be a same-direction-sideswipe, head-on crash or perpendicular intersection collision. These three configurations accounted for 44% of motorcycle to motorcycle crashes but only 16% of collisions where the other vehicle was not a motorcycle. When the other vehicle driver error was the primary cause factor, again the most common accident configuration was a same-direction-sideswipe collision.

45. When the other vehicle was not a motorcycle and other vehicle driver error was identified as the primary cause of the accident, three configurations predominated. All three configurations involved the other vehicle making a turn across the motorcycle path (i.e., a U-turn or a right turn - either in front of a motorcycle approaching from the opposite direction or from the perpendicular direction).

46. Pedestrians were involved in 26 collisions in the Bangkok data set and half of these accidents occurred during daylight hours. When the motorcycle struck a pedestrian at night, the motorcycle headlamp was off in two of thirteen cases. Only four of the pedestrians were in a crosswalk at the time of the accident.

47. Injuries to the upper and lower extremities were common. Together the two regions accounted for two-thirds of all rider injuries.

48. Most fatal injuries involved trauma to the chest, head and neck.

16.0 Proposed Countermeasures

16.1 Training

Rider error was the most prominent cause factor in these accidents. Whether the accidents were single-vehicle crashes involving only the motorcycle or multiple vehicle accidents, rider error was more likely to be the primary contributing factor. There is simply no way to address this problem without communicating some information directly to the riders themselves. Because so many motorcyclists begin riding at a young age, particularly in the upcountry (often by the age of 15) and because so many do not continue schooling beyond high school, rider education in the school, and rider training outside the schools, is needed.

Many accident-involved riders who were interviewed were unaware that they had violated the law or engaged in some unsafe action that led to their accident. The need for basic safety information was clear throughout this research. Information regarding defensive driving practices for motorcycles, alcohol risks, proper helmet use and proper collision avoidance maneuvers all must be conveyed to motorcycle riders, and rider training courses would be a primary means of doing this.

In Thailand, only the Honda Safety Training Program was available during the time of this research. The training course provided by the Honda Safety Training is well developed and has proven effective by providing the basic ingredients needed for safe operation of motorcycles in traffic and knowledge on safe traffic strategy as well as collision avoidance skills. However, few riders have the advantage of such specialized motorcycle training because not enough safety training centers are available.

One way of doing this may be to allow police officers and others who have completed the Honda safety training course to obtain additional instructor training, so that they may offer courses in motorcycle safety as an alternative to payment of a fine for traffic violations. Ideally, riders who have been cited for traffic violations would be able to avoid a fine by completing a rider training course at a certified motorcycle traffic safety school. In this way, reliable safety information and traffic skills could be communicated to the motorcycling population.

16.2 Licensing

Unlicensed riders were over-represented in Bangkok accidents. As mentioned in the previous section, interviews with many accident-involved riders revealed their lack of awareness of basic traffic laws. Requiring all motorcyclists to obtain a license that includes testing for knowledge of motorcycle safety, or perhaps showing proof of completion of a motorcycle safety course, may help to reduce accidents by assuring that riders have obtained basic information about traffic laws and, hopefully, about safe motorcycling practices.

At present, riders must do little more than register for a license and pay a fee in order to operate a motorcycle in Bangkok. The current system therefore misses a major opportunity to require riders to obtain knowledge and skills that could some day save their lives.

Motorcycle riders are a diverse group and few opportunities exist to reach them with vital information about traffic safety and self-protection. Licensing is one of the few avenues for the government to reach this group.

16.3 Law enforcement and record keeping

1. Alcohol-involved motorcycle riding should be a major target for law enforcement action. No other single factor caused so many accidents or affected accident characteristics in Thailand as much as alcohol. Based on the information collected in this study, it should not be hard for law enforcement officials to find the riders who have been drinking alcohol. They are mostly young males, found between 10 p.m. and 3 a.m., often riding without a helmet.

2. Traffic violations, including running red lights, driving in opposing lanes of traffic, failure to yield right-of-way and unsafe passing or vehicle turning maneuvers caused many accidents. Such unsafe actions require consistent, visible law enforcement efforts.

3. Increased police efforts should be directed at reducing the number of riders who are riding at night without a headlamp. The data collected in this study show that 13% of Bangkok riders failed to use a headlamp at night and their risk of colliding with a car that violated their right-of-way increases dramatically. Improvements in law enforcement are needed to ensure that motorcycle riders use a headlamp at night so that other drivers can see them.

4. Regulations that require restricted curb lane travel for the motorcycle should be abandoned, especially in commercial areas of cities. Requiring motorcycles to travel in the curb lane exposes them to more cross traffic of other vehicles entering and exiting driveways and sois (small streets and lanes). Curb lane travel also exposes motorcycles to more risk of vehicles pulling out of parking spaces, and the proximity to parked cars means more view obstruction related problems. In areas where multiple lanes were available, failure to ride in the curb lane was not found to contribute to accident causation. The curb lane riding requirement also resulted in many fatalities, when riders obeying the law rear-ended poorly marked vehicles that were left illegally along the roadside.

5. An inordinate number of riders were killed when they rear-ended large commercial trucks that were parked or abandoned at the roadside at night

with no warning lights, markers or reflectors. Usually these trucks were covered with dust and dark tarpaulins that made them extremely difficult to see at night. Stronger legislation should require all large trucks to carry highly conspicuous reflectorized materials permanently affixed to the rear of large commercial trucks.

6. Jaywalking was the most common reason pedestrians were involved in collision with a motorcycle. Law enforcement action is needed to reduce this problem.

7. Riding with dangerous cargo such as propane tanks or unwieldy cargo such as car bumpers, ladders, piles of clothes, etc. is unusually risky. Consideration should be given to banning motorcycle transport of large bulky items, particularly propane tanks.

8. Improvements in record keeping of Bangkok accidents should be initiated as soon as possible. Police agencies should be encouraged to record and track all accidents so that more meaningful accident frequency and accident typology information will become available to government and other road safety officials.

16.4 Environment factors

1. Many crashes involved one vehicle turning right across the path of another vehicle approaching from the opposite direction. Right turn-only lanes with traffic lights would nearly eliminate this collision problem.

2. Many roadways allow drivers to make dangerous turns across traffic. Better-designed physical barriers are necessary to prevent such dangerous maneuvers.

3. Stationary view obstructions such as telephone booths, advertising signs, trees, etc. should be relocated away from intersections to minimize effect of view obstruction.

4. Additional traffic controls are necessary at some intersections. Many accidents occurred because a traffic control signal, stop sign or yield sign was not present to regulate the flow of traffic going from a soi onto a larger roadway.

5. Many night accidents occurred, especially upcountry, on curves that were poorly marked. Curve warning signs, speed advisory signs and better positive guidance through curves can eliminate many of these night crashes.

6. Many construction sites were badly designed and badly marked at night, with uneven pavement, view obstructions, unmarked vehicles and obstacles such as immovable barriers placed in or too close to the traffic flow. Higher standards of construction zone safety should be developed to assure safe traffic flow around construction sites. Many motorcycle accidents will be prevented when proper standards are applied and enforced.

7. The large raised pavement reflectors with a sharp edge currently in use in Bangkok, and upcountry cause motorcycles to lose control and fall. They should be replaced by smaller, less aggressive reflectors that serve the same purpose.

8. "Speed bumps" should not be placed in or near curves, where the motorcycle must lean because they can cause loss of control and a fall. In addition, roadway defects such as potholes, large cracks, etc. should be quickly repaired, especially in curves.

9. The center medians of divided roadways need to be low and have low shrubs to avoid view obstruction problems. Shrubs should not extend more than one metre above pavement level, which is the height of the car driver's eyes.

10. At intersections where traffic control signals blink at night, they should adjusted to blink red in one direction and yellow in the other so that one driver will stop and yield to the other.

11. Traffic control signs must be easily visible and placed in locations where drivers expect to see them, or they will not be obeyed. Violations of this simple rule caused several upcountry accidents.

16.5 Vehicle factors

Three issues stand out in regards to motorcycle improvement and they are described below.

Motorcycle maintenance

Pre-existing maintenance problems with the accident-involved motorcycles, i.e. worn or absent brakes, loose steering, missing or burned out headlamp or stop lamp and turn signal, or loose suspension also contributed to the accident causation. Periodic vehicle inspections by national licensing authorities would ensure that motorcycles remained in good operating condition.

Conspicuity

Many accidents, particularly nighttime accidents, occurred because the other vehicle driver did not see the motorcycle. Headlamp use is the principal means of increasing the conspicuity of the motorcycle in traffic. At present, headlamp use is nearly non-existent in the daytime and inconsistent at night. Redesigning the headlamp control system so that the headlamp and tail lamp operate whenever the engine is running would assure a higher level of headlamp use and greater conspicuity at all times.

The parcel rack should be re-designed to prevent parcels from obstructing the headlamp. This prevents other drivers from seeing the motorcycle headlamp and contributes to accidents at night.

Braking

Inadequate collision avoidance action was a frequent part of these Bangkok accidents. Few riders used proper collision avoidance action, and fewer riders executed it properly. Improper braking (i.e. lack of front and rear braking action) was the most significant problem. Current motorcycles have separate controls for front and rear brakes, which allows finer control in some situations, but may not be the best system in imminent collision situations. Interconnected front and rear brakes for simultaneous operation by a single control (i.e., combined braking) is an alternative and that may provide an advantage in collision avoidance conditions. More complex antilock braking systems (ABS) are found on a few motorcycles in Europe, Japan and the U.S.

16.6 Protective equipment

A proper motorcycle safety helmet can prevent or reduce head injury to a significant extent. Many helmets (though not all) seen in this study would fail if tested for compliance with the Thailand Industrial Standard. At present, no mechanism exists to require compliance with the standard. As a result, far too many helmets offered to consumers are substandard, and consumers have no way of knowing if the helmet they purchase can actually protect them in an accident.

Helmet users too often defeat the protection offered by their helmet by wearing it poorly, usually with the straps fastened loosely or not fastened at all. A good quality, full-face helmet is worthless as head protection when it is pushed back on the rider's head far enough to expose his entire face. It will fly off immediately in an accident and leave the rider completely unprotected.

It is essential that all motorcycle helmets sold to the public comply with the minimum performance requirements of the Thailand Industrial Standard or some other contemporary motorcycle helmet standard. This requirement extends to assuring that helmets on store shelves are "spot-checked" by laboratory testing occasionally. In addition, helmet legislation must assure that riders wear a motorcycle helmet (i.e., not construction hard-hats, football helmets, etc.) and that the helmet is properly fastened.

Action by the police to enforce the helmet law is unquestionably effective. Many riders who were interviewed reported that they wore a helmet only when they expected to be someplace where the police would see them. For this reason, helmet use was far higher in Bangkok than in the upcountry regions.

It is recommend that all helmets sold in Thailand comply with the minimum performance requirements of a contemporary standard, and that all motorcycle riders and passengers be required to wear a qualified helmet properly for protection. A program of regular checking and testing of helmets on store shelves around the country is also recommended in order to assure that helmets available to the public comply with the helmet standard. These efforts will reduce the public cost of catastrophic head injuries and help increase public confidence in the motorcycle helmets.

The majority of the riders in this study did not wear any eye protection, even though it is vital to shield the eyes from wind blast as well as protect the eyes during an accident. Because riders with eye protection were greatly under-represented in the accident data, it appears that eye protection may very well reduce accident involvement.

Education program regarding the benefits of personal protective equipment is essential. Accurate factual information about the benefits of helmets should be made available to every motorcycle rider and especially to riders who have been cited for a traffic violation. Public service announcements on television and billboards, which are common in Bangkok, should include the information regarding proper helmet use, the importance of motorcycle headlamp and tail lamp visibility, alcohol involvement in accidents, etc.

17.0 References

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Appendix A

Table 7.9.4: Points of collision contact, other vehicle

Points of collision contact	Code	Frequency	Percent
Automobile, Van, Bus, Truck			
Front bumper	F01X	97	13.9
Front push bar	F02X	2	0.3
Front grille	F03X	4	0.6
Front corner	F04X	21	3.0
Front windshield surface	F10X	2	0.3
Front undercarriage	U01X	6	0.9
Front unknown	F99X	4	0.6
Rear bumper	R01X	73	10.5
Rear step bumper	R02X	3	0.4
Rear lamp	R06X	7	1.0
Rear door panel, center	R10X	1	0.1
Rear corner	R13X	6	0.9
Lower rear corner, attached truck cab	R14X	1	0.1
Lower rear corner, van	R16X	9	1.3
Rear, back light glass	R21X	1	0.1
Rear underride bar	R30X	2	0.3
Other rear	R98X	5	0.7
Rear, unknown	R99X	1	0.1
Rear, undercarriage	U02X	3	0.4
Spare tyre	U04X	1	0.1
Side of front bumper	S01X	30	4.3
Side corner	S02X	12	1.7
Front mudguard fender	S03X	24	3.4
Front mudguard, wheel house	S04X	9	1.3
Front tyre	S05X	20	2.9
Side of bonnet	S06X	3	0.4
Rocker panel	S07X	9	1.3
Lower A-pillar	S08X	6	0.9
Front door, front	S10X	25	3.6
Front door, rear	S11X	14	2.0
Front door, belt line	S12X	1	0.1
Front door, handle	S14X	1	0.1
Lower B-pillar	S17X	2	0.3
Rear door, front	S19X	9	1.3
Rear door, rear	S20X	14	2.0
Rear door, belt line	S21X	1	0.1
Center panel (van, bus)	S25X	2	0.3
Lower C-pillar	S26X	2	0.3
Upper C-pillar	S27X	1	0.1
Rear mudguard, wheel house	S28X	3	0.4
Rear tyre	S29X	10	1.4

Points of collision contact	Code	Frequency	Percent
Rear mudguard (fender)	S30X	11	1.6
Side of boot lid, edge	S31X	5	0.7
Lower rear corner	S32X	3	0.4
Side of rear bumper	S34X	4	0.6
Rear wheel	S45X	1	0.1
Side other	S98X	1	0.1
Side unknown	S99X	5	0.7
Front boot lid	T10X	1	0.1
Unknown	9999	9	1.3
<u>Motorcycle as an other vehicle</u>			
Left front	MCLF	22	3.2
Right front	MCRF	27	3.9
Center front	MCCF	41	5.9
Left center	MCLC	9	1.3
Right center	MCRC	11	1.6
Left rear	MCLR	7	1.0
Right rear	MCRR	14	2.0
Center rear	MCCR	2	0.3
Top front	MCTF	2	0.3
Undercarriage center	MCUC	2	0.3
Undercarriage, front	MCUF	3	0.4
Undercarriage, rear	MCUR	1	0.1
<u>Tuk-Tuk</u>			
Right front	TTFR	2	0.3
Left front	TTFL	2	0.3
Right rear	TTRR	3	0.4
Left rear	TTRL	3	0.4
Step	TT07	1	0.1
Upper A-pillar	TT09	1	0.1
Rear mudguard, wheel house	TT28	1	0.1
Seal beam	TT37	1	0.1
Other	TT98	3	0.4
Unknown	TT99	1	0.1
<u>Tricycle</u>			
No collision contact	OVNC	50	7.2
Total		696	100.0

Table 9.12.2: Motorcycle Contact Surface Related to Injuries

Category Label	Frequency	Percent
Front crash bar	1	0.1
Wind screen	15	1.8
Fairing	64	7.8
Head lamp	24	2.9
Front turn signal	23	2.8
Speedometer	11	1.3
Tachometer	6	0.7
Handlebars	118	14.3
Throttle	3	0.4
Clutch lever	32	3.9
Brake lever	21	2.5
Right rear mirror post	10	1.2
Left rear mirror post	22	2.7
Front suspension	27	3.3
Front wheel / tyre	23	2.8
Front fender	43	5.2
Front brake	3	0.4
Seat	7	0.8
Frame	29	3.5
Grab rail	6	0.7
Fuel tank	68	8.2
Motor crank case	8	1.0
Transmission case	14	1.7
Rear brake pedal	28	3.4
Shift lever	36	4.4
Footpegs	102	12.4
Side stand	3	0.4
Center stand	2	0.2
Muffler	19	2.3
Parcel rack	5	0.6
Rear position lamp	4	0.5
Stop lamp	3	0.4
Rear turn signal	6	0.7
Rear suspension	5	0.6
Rear wheel / tyre	6	0.7
Rear fender	1	0.1
Side cover	27	3.3
Total	825	100.0

Table 9.12.3: Other vehicle contact surface

Category label	Code	Frequency	Percent
Vehicle Front and Front Corner			
- Bumper, front	F01X	87	6.85
- Push bar, front	F02X	3	0.24
- Grill, front	F03X	13	1.02
- Front corner, headlamp nacelle	F04X	85	6.69
- Side of front bumper	S01X	26	2.05
- Side corner, headlamp nacelle	S02X	26	2.05
- Front unknown	F99X	8	0.63
- undercarriage, front	U01X	8	0.63
Vehicle Side Front			
- Front mudguard (fender)	S03X	66	5.20
- Front mudguard (wheel house)	S04X	19	1.50
- Front tyres	S05X	68	5.35
- Side of bonnet (hood) edge	S06X	12	0.94
- Rocker panel, sill beam, steps	S07X	9	0.71
- Lower A-pillar	S08X	18	1.42
- Upper A-pillar	S09X	10	0.79
- Front door, front	S10X	28	2.20
- Front door, rear	S11X	13	1.02
- Front door, belt line	S12X	11	0.87
- Front door side glass	S13X	15	1.18
- Front door handle and external	S14X	9	0.71
- Front roof rail	S15X	16	1.26
- Front edge or side of bonnet	F05X	23	1.81
- Front side of upper A-pillar	F07X	1	0.08
- External rear mirror	S43X	9	0.71
- Front wheels	S44X	8	0.63
Vehicle Side Rear			
- Rear roof rail	S16X	10	0.79
- Lower B-pillar	S17X	4	0.31
- Upper B-pillar	S18X	9	0.71
- Rear door, front	S19X	24	1.89
- Rear door, rear	S20X	5	0.39
- Rear door belt line	S21X	2	0.16
- Rear door side glass	S22X	17	1.34
- Back light (window) side frame	S24X	1	0.08
- Center panel (van, bus)	S25X	9	0.71
- Lower C-pillar	S26X	2	0.16
- Upper C-pillar	S27X	25	1.97
- Rear mudguard, wheel house	S28X	12	0.94
- Rear tyres/wheel	S29X	35	2.76
- Rear mudguard (fender), panel	S30X	28	2.20

Category label	Code	Frequency	Percent
- Side of boot (truck) lid	S31X	8	0.63
- Side others	S98X	48	3.78
- Side unknown	S99X	25	1.97
<u>Vehicle Rear and Rear Corner</u>			
- Lower rear corner (truck, van, bus)	S32X	30	2.36
- Upper rear corner (truck, van, bus)	S33X	5	0.39
- Side of rear bumper	S34X	9	0.71
- Bumper, rear	R01X	64	5.04
- Step bumper, rear	R02X	4	0.31
- Rear lamp	R06X	36	2.83
- Tailgate	R08X	30	2.36
- Rear door panel, top	R09X	3	0.24
- Rear door panel, center	R10X	5	0.39
- Rear door panel, bottom	R11X	4	0.31
- Rear corner, truck bed	R13X	38	2.99
- Lower rear corner, attached truck cap	R14X	6	0.47
- Upper rear corner, attached truck cap	R15X	2	0.16
- Lower rear corner, van	R16X	36	2.83
- B-pillar, rear (truck only)	R18X	5	0.39
- Back light, header	R20X	1	0.08
- Back light, glass	R21X	15	1.18
- Back light lower molding	R22X	2	0.16
- Lower C-pillar	R23X	1	0.08
- Rear door frame header	R25X	1	0.08
- Spare tyre, housing	R28X	11	0.87
- Underride bar	R30X	3	0.24
- Rear of undercarriage	U02X	20	1.57
- Unknown undercarriage	U99X	1	0.08
<u>Vehicle Top Surface</u>			
- Top of bonnet, front	F06X / T01X	23	1.81
- Top of bonnet, center	T02X	5	0.39
- Top of bonnet, rear	T03X	2	0.16
- front cowl	F08X	13	1.02
- Roof top, rear	T08X	7	0.55
- Bootlid center	T11X	4	0.31
- Bootlid rear	T12X	3	0.24
- Windshield lower molding	F09X	5	0.39
- Windshield surface	F10X	13	1.02
- Windshield header	F11X	8	0.63
Total		1270	100.00

Table 9.12.4: Environment contact surface

Environment contact surface	Code	Frequency	Percent
Asphalt pavement	EA01	1021	47.09
Concrete pavement	EC01	666	30.72
Concrete post	EC02	82	3.78
Concrete embankment	EC03	4	0.18
Concrete barrier	EC04	18	0.83
Concrete curb	EC06	104	4.80
Concrete flat surface	EC13	15	0.69
Concrete blunt surface	EC14	3	0.14
Glass unpaved shoulder	EG07	3	0.14
Glass sharp edge	EG11	4	0.18
Hard-packed soil, embankment	EL03	2	0.09
Hard-packed soil, unpaved shoulder	EL07	5	0.23
Hard-packed soil, flat surface	EL13	10	0.46
Metal, yielding barrier	EM04	28	1.29
Metal, yielding blunt edge	EM10	3	0.14
Metal, yielding sharp edge	EM11	16	0.74
Metal, yielding blunt surface	EM14	36	1.66
Pedestrian	EP98	3	0.14
Metal rigid pavement	ER01	1	0.05
Metal rigid post	ER02	37	1.71
Metal rigid, sharp edge	ER11	2	0.09
Metal rigid, pointed object	ER12	1	0.05
Gravel pavement	GS01	28	1.29
Gravel, soil embankment	GS03	2	0.09
Gravel, soil unpaved shoulder	GS07	3	0.14
Loose soil, brush	GS09	5	0.23
Wood, post	EW02	50	2.31
Wood, building structure	EW05	2	0.09
Wood, shrubbery	EW09	13	0.60
Wood, blunt surface	EW14	1	0.05
Total		2168	100.00

Table 11.3.2: Alcohol involvement and time of accident

Time of accident	No alcohol	Alcohol use	Total
0:01 - 1:00	13	32	45
1:01 - 2:00	18	40	58
2:01 - 3:00	7	27	34
3:01 - 4:00	5	6	11
4:01 - 5:00	2	9	11
5:01 - 6:00	2	3	5
6:01 - 7:00	1	2	3
7:01 - 8:00	2	1	3
8:01 - 9:00	7	1	8
9:01 - 10:00	15	3	18
10:01 - 11:00	35	0	35
11:01 - 12:00	28	0	28
12:01 - 13:00	21	2	23
13:01 - 14:00	24	2	26
14:01 - 15:00	24	1	25
15:01 - 16:00	31	6	37
16:01 - 17:00	23	5	28
17:01 - 18:00	21	4	25
18:01 - 19:00	12	6	18
19:01 - 20:00	20	6	26
20:01 - 21:00	16	8	24
21:01 - 22:00	27	19	46
22:01 - 23:00	48	51	99
23:01 - 24:00	28	55	83
Total	430	289	719

Appendix B (Statistical analysis)

Table 13.1.1: Accident-to-exposure rates by ambient lighting

Ambient Lighting at night	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Night	445	262.73	23807	61.55	36.34
Others	278	460.27	41708	38.45	63.66
Total	723	460.27	65515	100.00	100.00
	x^2 =	198.64	P - Value < 0.0001		Reject H_0

Table 13.2.1: Comparison of MC type in accident & exposure data

Motorcycle Type	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Sport	246	144.32	13000	34.02	19.96
Not Sport	477	578.68	52127	65.98	80.04
Total	723	723.00	65127	100.00	100.00
	x^2 =	89.51	P - Value < 0.0001		Reject H_0

Table 13.2.3: Comparison of headlamp in accident & OSE data at nighttime

Ambient Lighting	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Off	59	20.68	1119	13.41	4.70
On	381	419.32	22688	86.59	95.30
Total	440	440.00	23807	100.00	100.00
	x^2 =	74.50	P - Value < 0.0001		Reject H_0

Table 13.3.1: Comparison of rider alcohol use and impairment

Alcohol Involvement	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Alcohol use	289	124.63	364	40.19	17.33
No alcohol use	430	594.37	1736	59.81	82.67
Total	719	719.00	2100	100.00	100.00
	x^2 =	262.25	P - Value < 0.0001		Reject H_0

Table 13.4.1: Comparison of rider license in accident & PSE data

License Held	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No license held	126	77.64	229	17.70	10.90
Others	586	634.36	1871	82.30	89.10
Total	712	712.00	2100	100.00	100.00
	x^2 =	33.81	P - Value < 0.0001		Reject H_0

Table 13.5.1: Comparison of rider gender in accident & exposure data

Gender	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Female	30	27.20	79	4.15	3.76
Male	693	695.80	2021	95.85	96.24
Total	723	723.00	2100	100.00	100.00
	x^2 =	0.30	P - Value > 0.05		Accept H_0

Table 13.5.2: Comparison of rider age in accident & PSE data

Category Label	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Lower 30	497	556.84	1618	68.93	77.23
Upper 30	224	164.16	477	31.07	22.77
Total	721	721.00	2095	100.00	100.00
	x^2 =	28.24	P - Value < 0.0001		Reject H_0

Table 13.5.5: Comparison of rider education in accident & PSE data

Education Level	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Lower Grade 12	603	518.46	1613	89.33	76.81
Others	72	156.54	487	10.67	23.19
Total	675	675.00	2100	100.00	100.00
	x^2 =	59.44	P - Value < 0.0001		Reject H_0

Table 13.5.6: Comparison of rider occupation in accident & PSE data

Rider Occupation	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Service workers&Driver	428	243.44	718	60.11	34.19
Others	284	468.56	1382	39.89	65.81
Total	712	712.00	2100	100.00	100.00
	x^2 =	212.63	P - Value < 0.0001		Reject H_0

Table 13.5.6: Comparison of rider occupation in accident & PSE data

Occupation	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Labour, student, office worker	207	411.60	1214	29.07	57.81
Others	505	300.40	886	70.93	42.19
Total	712	712.00	2100	100.00	100.00
	x^2 =	241.06	P - Value < 0.0001		Reject H_0

Table 13.7.1: Comparison of riding frequency in accident & PSE data

Days per year riding	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Daily (301 - 365 days)	589	628.29	1903	84.99	90.66
Others	104	64.71	196	15.01	9.34
Total	693	693.00	2099	100.00	100.00
	x^2 =	26.31	P - Value < 0.0001		Reject H_0

Table 13.7.1: Comparison of riding frequency in accident & PSE data

Days per years riding	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
0 - 200	66	18.16	55	9.52	2.62
> 200	627	674.84	2044	90.48	97.38
Total	693	693.00	2099	100.00	100.00
	x^2 =	129.44	P - Value < 0.0001		Reject H_0

Table 13.7.2: Comparison of distance motorcycle is ridden per year

Distance riding (km)	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
1 - 9000	263	470.93	1635	43.54	77.97
> 9000	341	133.07	462	56.46	22.03
Total	604	604.00	2097	100.00	100.00
	x^2 =	416.71	P - Value < 0.0001		Reject H_0

Table 13.8.1: Comparison of rider previous motorcycle traffic citations

Previous traffic citations	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No	638	525.99	1611	93.14	76.79
Yes	47	159.01	487	6.86	23.21
Total	685	685.00	2098	100.00	100.00
	x^2 =	102.75	P - Value < 0.0001		Reject H_0

Table 13.9.1: Comparison of rider familiarity with roadway

Roadway Familiarity	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Daily&Weely Use	629	670.31	2046	91.42	97.43
Others	59	17.69	54	8.58	2.57
Total	688	688.00	2100	100.00	100.00
	x^2 =	99.00	P - Value < 0.0001		Reject H_0

Table 13.11.1: Helmet use in accident & OSE

Helmet use	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No	248	102.12	9254	34.30	14.13
Yes	475	620.88	56261	65.70	85.87
Total	723	723.00	65515	100.00	100.00
	x^2 =	242.65	P - Value < 0.0001		Reject H_0

Table 13.11.1: Helmet use in accident & PSE

Helmet use	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No	248	233.08	677	34.30	32.24
Yes	475	489.92	1423	65.70	67.76
Total	723	723.00	2100	100.00	100.00
	x^2 =	1.41	P - Value > 0.05		Accept H_0

Table 13.11.2: Helmet type in accident & exposure data

Helmet Type	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Full Face Helmet	220	217.69	25755	46.32	45.83
Others	255	257.31	30443	53.68	54.17
Total	475	475.00	56198	100.00	100.00
	x^2 =	0.05	P - Value > 0.05		Accept H_0

Appendix C (Motorcycle components)

Front crash bars

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	719	99.4	99.4	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	1	.1	.1	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	3	.4	.4	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	2	.3	.3	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear crash bar

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	721	99.7	99.7	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	721	99.7	99.7	99.7
	1	2	.3	.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	721	99.7	99.7	99.7
	1	2	.3	.3	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	721	99.7	99.7	99.7
	1	2	.3	.3	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Engine guard

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	719	99.4	99.4	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	3	.4	.4	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	3	.4	.4	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	719	99.4	99.4	99.4
	1	1	.1	.1	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Windscreen

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	234	32.4	32.4	32.4
	2	488	67.5	67.5	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	234	32.4	32.4	32.4
	1	478	66.1	66.1	98.5
	2	10	1.4	1.4	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	234	32.4	32.4	32.4
	1	482	66.7	66.7	99.0
	2	6	.8	.8	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	234	32.4	32.4	32.4
	1	243	33.6	33.6	66.0
	2	245	33.9	33.9	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Fairing

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	118	16.3	16.3	16.3
	2	605	83.7	83.7	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	118	16.3	16.3	16.3
	1	594	82.2	82.2	98.5
	2	11	1.5	1.5	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	118	16.3	16.3	16.3
	1	601	83.1	83.1	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	118	16.3	16.3	16.3
	1	184	25.4	25.4	41.8
	2	421	58.2	58.2	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Headlamps

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	20	2.8	2.8	2.8
	2	703	97.2	97.2	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	694	96.0	96.0	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	2	697	96.4	96.4	99.2
	9	6	.8	.8	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	695	96.1	96.1	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	439	60.7	60.7	63.5
	2	264	36.5	36.5	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Headlamp nacelle

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	628	86.9	86.9	86.9
	2	95	13.1	13.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	628	86.9	86.9	86.9
	1	92	12.7	12.7	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	628	86.9	86.9	86.9
	1	94	13.0	13.0	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	628	86.9	86.9	86.9
	1	59	8.2	8.2	95.0
	2	36	5.0	5.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Auxiliary headlamp

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	716	99.0	99.0	99.0
	2	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	716	99.0	99.0	99.0
	1	2	.3	.3	99.3
	2	5	.7	.7	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	716	99.0	99.0	99.0
	2	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	716	99.0	99.0	99.0
	1	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	716	99.0	99.0	99.0
	1	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front reflectors

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	720	99.6	99.6	99.6
	2	2	.3	.3	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	720	99.6	99.6	99.6
	1	1	.1	.1	99.7
	7	1	.1	.1	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	720	99.6	99.6	99.6
	2	2	.3	.3	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	720	99.6	99.6	99.6
	1	2	.3	.3	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	720	99.6	99.6	99.6
	1	1	.1	.1	99.7
	2	1	.1	.1	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front turn signals

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	88	12.2	12.2	12.2
	2	635	87.8	87.8	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	88	12.2	12.2	12.2
	1	632	87.4	87.4	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	88	12.2	12.2	12.2
	1	9	1.2	1.2	13.4
	2	621	85.9	85.9	99.3
	9	5	.7	.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	88	12.2	12.2	12.2
	1	635	87.8	87.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	88	12.2	12.2	12.2
	1	327	45.2	45.2	57.4
	2	307	42.5	42.5	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Speedometer

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	42	5.8	5.8	5.8
	2	681	94.2	94.2	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	42	5.8	5.8	5.8
	1	678	93.8	93.8	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	42	5.8	5.8	5.8
	1	52	7.2	7.2	13.0
	2	624	86.3	86.3	99.3
	9	5	.7	.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	42	5.8	5.8	5.8
	1	678	93.8	93.8	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	42	5.8	5.8	5.8
	1	542	75.0	75.0	80.8
	2	139	19.2	19.2	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Tachometer

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	372	51.5	51.5	51.5
	2	351	48.5	48.5	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	372	51.5	51.5	51.5
	1	349	48.3	48.3	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	372	51.5	51.5	51.5
	1	32	4.4	4.4	55.9
	2	315	43.6	43.6	99.4
	9	4	.6	.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	372	51.5	51.5	51.5
	1	349	48.3	48.3	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	372	51.5	51.5	51.5
	1	257	35.5	35.5	87.0
	2	94	13.0	13.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Handlebars

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	710	98.2	98.2	98.2
	2	13	1.8	1.8	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	710	98.2	98.2	98.2
	2	13	1.8	1.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	345	47.7	47.7	47.7
	2	378	52.3	52.3	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Throttle

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	716	99.0	99.0	99.0
	2	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	8	1.1	1.1	1.1
	2	714	98.8	98.8	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	722	99.9	99.9	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	661	91.4	91.4	91.4
	2	61	8.4	8.4	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Clutch lever

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	134	18.5	18.5	18.5
	2	589	81.5	81.5	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	134	18.5	18.5	18.5
	1	580	80.2	80.2	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	134	18.5	18.5	18.5
	1	6	.8	.8	19.4
	2	582	80.5	80.5	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	134	18.5	18.5	18.5
	1	587	81.2	81.2	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	134	18.5	18.5	18.5
	1	380	52.6	52.6	71.1
	2	209	28.9	28.9	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Brake lever

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	2	.3	.3	.3
	2	721	99.7	99.7	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	711	98.3	98.3	98.6
	2	10	1.4	1.4	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	15	2.1	2.1	2.4
	2	706	97.6	97.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	720	99.6	99.6	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	477	66.0	66.0	66.3
	2	244	33.7	33.7	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Right side rear view mirrors, posts

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	283	39.1	39.1	39.1
	2	440	60.9	60.9	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	283	39.1	39.1	39.1
	1	315	43.6	43.6	82.7
	2	125	17.3	17.3	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	283	39.1	39.1	39.1
	1	9	1.2	1.2	40.4
	2	430	59.5	59.5	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	283	39.1	39.1	39.1
	1	426	58.9	58.9	98.1
	2	14	1.9	1.9	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	283	39.1	39.1	39.1
	1	260	36.0	36.0	75.1
	2	180	24.9	24.9	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Left side rear view mirrors, posts

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	317	43.8	43.8	43.8
	2	406	56.2	56.2	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	43.8	43.8	43.8
	1	292	40.4	40.4	84.2
	2	114	15.8	15.8	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	43.8	43.8	43.8
	1	8	1.1	1.1	45.0
	2	396	54.8	54.8	99.7
	9	2	.3	.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	43.8	43.8	43.8
	1	395	54.6	54.6	98.5
	2	11	1.5	1.5	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	43.8	43.8	43.8
	1	228	31.5	31.5	75.4
	2	177	24.5	24.5	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front suspension

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	719	99.4	99.4	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	8	1.1	1.1	1.1
	2	715	98.9	98.9	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	717	99.2	99.2	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	470	65.0	65.0	65.0
	2	253	35.0	35.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front tyre/wheel

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	353	48.8	48.8	48.8
	2	363	50.2	50.2	99.0
	9	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	1.2	1.2	1.2
	2	714	98.8	98.8	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	705	97.5	97.5	97.5
	2	14	1.9	1.9	99.4
	9	4	.6	.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	517	71.5	71.5	71.5
	2	206	28.5	28.5	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Front fender

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	5	.7	.7	.7
	2	718	99.3	99.3	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	.7	.7	.7
	1	704	97.4	97.4	98.1
	2	14	1.9	1.9	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	.7	.7	.7
	1	7	1.0	1.0	1.7
	2	711	98.3	98.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	.7	.7	.7
	1	711	98.3	98.3	99.0
	2	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	.7	.7	.7
	1	329	45.5	45.5	46.2
	2	389	53.8	53.8	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front brakes

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	9	1.2	1.2	1.2
	2	714	98.8	98.8	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	9	1.2	1.2	1.2
	1	693	95.9	95.9	97.1
	2	21	2.9	2.9	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	9	1.2	1.2	1.2
	1	8	1.1	1.1	2.4
	2	706	97.6	97.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	9	1.2	1.2	1.2
	1	707	97.8	97.8	99.0
	2	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	9	1.2	1.2	1.2
	1	667	92.3	92.3	93.5
	2	47	6.5	6.5	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Seat

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	645	89.2	89.2	89.2
	2	78	10.8	10.8	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	6	.8	.8	.8
	2	717	99.2	99.2	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	709	98.1	98.1	98.1
	2	14	1.9	1.9	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	653	90.3	90.3	90.3
	2	70	9.7	9.7	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Sissy bar/passenger back rest

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	720	99.6	99.6	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	720	99.6	99.6	99.6
	1	2	.3	.3	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	720	99.6	99.6	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	720	99.6	99.6	99.6
	1	3	.4	.4	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	720	99.6	99.6	99.6
	1	3	.4	.4	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Side reflectors

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	668	92.4	92.4	92.4
	2	55	7.6	7.6	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	668	92.4	92.4	92.4
	1	54	7.5	7.5	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	668	92.4	92.4	92.4
	2	55	7.6	7.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	668	92.4	92.4	92.4
	1	55	7.6	7.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	668	92.4	92.4	92.4
	1	46	6.4	6.4	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Frame

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	723	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	722	99.9	99.9	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	688	95.2	95.2	95.2
	2	35	4.8	4.8	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Grab rails/hand holds

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	177	24.5	24.5	24.5
	2	546	75.5	75.5	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	177	24.5	24.5	24.5
	1	534	73.9	73.9	98.3
	2	12	1.7	1.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	177	24.5	24.5	24.5
	1	541	74.8	74.8	99.3
	2	5	.7	.7	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	177	24.5	24.5	24.5
	1	434	60.0	60.0	84.5
	2	112	15.5	15.5	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Fuel tank

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	721	99.7	99.7	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	720	99.6	99.6	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	531	73.4	73.4	73.4
	2	192	26.6	26.6	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Motor crankcase, cylinders

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	721	99.7	99.7	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	722	99.9	99.9	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	698	96.5	96.5	96.5
	2	25	3.5	3.5	100.0
	Total	723	100.0	100.0	

Trasmission case

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	723	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	702	97.1	97.1	97.1
	2	21	2.9	2.9	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Oil tank

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	23	3.2	3.2	3.2
	2	700	96.8	96.8	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	23	3.2	3.2	3.2
	1	699	96.7	96.7	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	23	3.2	3.2	3.2
	1	700	96.8	96.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	23	3.2	3.2	3.2
	1	664	91.8	91.8	95.0
	2	36	5.0	5.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Battery, battery box

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	16	2.2	2.2	2.2
	2	707	97.8	97.8	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	2.2	2.2	2.2
	1	706	97.6	97.6	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	2.2	2.2	2.2
	1	707	97.8	97.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	2.2	2.2	2.2
	1	692	95.7	95.7	97.9
	2	15	2.1	2.1	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Rear brake pedal

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	.1	.1	.1
	2	722	99.9	99.9	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.1	.1	.1
	1	711	98.3	98.3	98.5
	2	11	1.5	1.5	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.1	.1	.1
	1	10	1.4	1.4	1.5
	2	711	98.3	98.3	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.1	.1	.1
	1	716	99.0	99.0	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.1	.1	.1
	1	530	73.3	73.3	73.4
	2	192	26.6	26.6	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Shift lever

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	1.5	1.5	1.5
	2	712	98.5	98.5	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	1.5	1.5	1.5
	1	700	96.8	96.8	98.3
	2	12	1.7	1.7	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	1.5	1.5	1.5
	1	8	1.1	1.1	2.6
	2	704	97.4	97.4	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	1.5	1.5	1.5
	1	708	97.9	97.9	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	1.5	1.5	1.5
	1	503	69.6	69.6	71.1
	2	209	28.9	28.9	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Foot pegs, footrests

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	15	2.1	2.1	2.1
	2	708	97.9	97.9	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	15	2.1	2.1	2.1
	1	680	94.1	94.1	96.1
	2	28	3.9	3.9	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	15	2.1	2.1	2.1
	1	4	.6	.6	2.6
	2	704	97.4	97.4	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	15	2.1	2.1	2.1
	1	702	97.1	97.1	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	15	2.1	2.1	2.1
	1	255	35.3	35.3	37.3
	2	453	62.7	62.7	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Side stand

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	28	3.9	3.9	3.9
	2	695	96.1	96.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	28	3.9	3.9	3.9
	1	689	95.3	95.3	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	28	3.9	3.9	3.9
	1	4	.6	.6	4.4
	2	691	95.6	95.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	28	3.9	3.9	3.9
	1	692	95.7	95.7	99.6
	2	3	.4	.4	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	28	3.9	3.9	3.9
	1	667	92.3	92.3	96.1
	2	28	3.9	3.9	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Side stand interlock

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	715	98.9	98.9	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	715	98.9	98.9	98.9
	1	2	.3	.3	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	715	98.9	98.9	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	715	98.9	98.9	98.9
	1	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	715	98.9	98.9	98.9
	1	7	1.0	1.0	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Centre stand

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	215	29.7	29.7	29.7
	2	508	70.3	70.3	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	215	29.7	29.7	29.7
	1	507	70.1	70.1	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	215	29.7	29.7	29.7
	2	508	70.3	70.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	215	29.7	29.7	29.7
	1	506	70.0	70.0	99.7
	2	2	.3	.3	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	215	29.7	29.7	29.7
	1	479	66.3	66.3	96.0
	2	29	4.0	4.0	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Muffler/exhaust system

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	675	93.4	93.4	93.4
	2	48	6.6	6.6	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	2	.3	.3	.3
	2	721	99.7	99.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	680	94.1	94.1	94.1
	2	43	5.9	5.9	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	510	70.5	70.5	70.5
	2	213	29.5	29.5	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Tank bag

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	722	99.9	99.9	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	722	99.9	99.9	99.9
	1	1	.1	.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	722	99.9	99.9	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	722	99.9	99.9	99.9
	1	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Luggage/cargo rack

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	693	95.9	95.9	95.9
	2	30	4.1	4.1	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	693	95.9	95.9	95.9
	2	30	4.1	4.1	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	693	95.9	95.9	95.9
	1	22	3.0	3.0	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	693	95.9	95.9	95.9
	1	24	3.3	3.3	99.2
	2	6	.8	.8	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Parcel rack

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	676	93.5	93.5	93.5
	2	47	6.5	6.5	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	676	93.5	93.5	93.5
	1	42	5.8	5.8	99.3
	2	5	.7	.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	676	93.5	93.5	93.5
	1	47	6.5	6.5	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	676	93.5	93.5	93.5
	1	15	2.1	2.1	95.6
	2	32	4.4	4.4	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Rear position lamps

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	20	2.8	2.8	2.8
	2	703	97.2	97.2	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	681	94.2	94.2	97.0
	2	22	3.0	3.0	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	11	1.5	1.5	4.3
	2	686	94.9	94.9	99.2
	9	6	.8	.8	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	694	96.0	96.0	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	20	2.8	2.8	2.8
	1	652	90.2	90.2	92.9
	2	51	7.1	7.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Stop lamp

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	17	2.4	2.4	2.4
	2	706	97.6	97.6	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	687	95.0	95.0	97.4
	2	19	2.6	2.6	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	12	1.7	1.7	4.0
	2	687	95.0	95.0	99.0
	9	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	698	96.5	96.5	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	673	93.1	93.1	95.4
	2	33	4.6	4.6	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear reflectors

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	213	29.5	29.5	29.5
	2	488	67.5	67.5	97.0
	3	1	.1	.1	97.1
	4	21	2.9	2.9	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	213	29.5	29.5	29.5
	1	502	69.4	69.4	98.9
	2	6	.8	.8	99.7
	8	2	.3	.3	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	213	29.5	29.5	29.5
	2	510	70.5	70.5	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	213	29.5	29.5	29.5
	1	509	70.4	70.4	99.9
	2	1	.1	.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	213	29.5	29.5	29.5
	1	489	67.6	67.6	97.1
	2	21	2.9	2.9	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear turn signals

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	82	11.3	11.3	11.3
	2	641	88.7	88.7	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	82	11.3	11.3	11.3
	1	636	88.0	88.0	99.3
	2	5	.7	.7	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	82	11.3	11.3	11.3
	1	11	1.5	1.5	12.9
	2	623	86.2	86.2	99.0
	9	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	82	11.3	11.3	11.3
	1	641	88.7	88.7	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	82	11.3	11.3	11.3
	1	542	75.0	75.0	86.3
	2	98	13.6	13.6	99.9
	9	1	.1	.1	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear suspension

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	723	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	701	97.0	97.0	97.0
	2	22	3.0	3.0	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	3	.4	.4	.4
	2	720	99.6	99.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	715	98.9	98.9	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	703	97.2	97.2	97.2
	2	20	2.8	2.8	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear tyre/wheel

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	321	44.4	44.4	44.4
	2	395	54.6	54.6	99.0
	9	7	1.0	1.0	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	.3	.3	.3
	2	721	99.7	99.7	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	701	97.0	97.0	97.0
	2	19	2.6	2.6	99.6
	9	3	.4	.4	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	687	95.0	95.0	95.0
	2	36	5.0	5.0	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Rear fender

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	17	2.4	2.4	2.4
	2	706	97.6	97.6	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	697	96.4	96.4	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	2	706	97.6	97.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	690	95.4	95.4	97.8
	2	16	2.2	2.2	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	17	2.4	2.4	2.4
	1	657	90.9	90.9	93.2
	2	49	6.8	6.8	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear brakes

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	2	.3	.3	.3
	2	721	99.7	99.7	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	713	98.6	98.6	98.9
	2	8	1.1	1.1	100.0
	Total	723	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	10	1.4	1.4	1.7
	2	711	98.3	98.3	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	717	99.2	99.2	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	2	.3	.3	.3
	1	712	98.5	98.5	98.8
	2	9	1.2	1.2	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Tools, tool box

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	362	50.1	50.1	50.1
	2	361	49.9	49.9	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	362	50.1	50.1	50.1
	1	361	49.9	49.9	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	362	50.1	50.1	50.1
	1	361	49.9	49.9	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	362	50.1	50.1	50.1
	1	356	49.2	49.2	99.3
	2	5	.7	.7	100.0
	Total	723	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Side covers

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	29	4.0	4.0	4.0
	2	694	96.0	96.0	100.0
	Total	723	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	29	4.0	4.0	4.0
	1	690	95.4	95.4	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	29	4.0	4.0	4.0
	1	690	95.4	95.4	99.4
	2	4	.6	.6	100.0
	Total	723	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	29	4.0	4.0	4.0
	1	374	51.7	51.7	55.7
	2	320	44.3	44.3	100.0
	Total	723	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown