MOTORCYCLE ACCIDENT CAUSATION AND IDENTIFICATION OF COUNTERMEASURES IN THAILAND
VOLUME II: UPCOUNTRY STUDY

BY

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1.0 Executive Summary

A total of 359 on-scene, in-depth accident-involved motorcycles were investigated in five provincial sampling regions between March 8 and September 15, 2000. Approximately 85% of 359 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 contributing factor in the majority of both single and multiple vehicle accidents. Two problems stand out among the rider errors. The first and most readily recognized, is alcohol. Alcohol-involved accidents preceded 30% of all accidents reported here. The second problem is less easily defined, but it amounts to poor motorcycle riding. About 40% of the accidents involved improper traffic strategy such as unsafe speed, unsafe position, or following another vehicle too closely.

These errors were not restricted to motorcycle riders. Other vehicle drivers often 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 maintenance-related problems. These included absent or inoperable components (e.g., headlamp, front brake, rear brake, rear position lamp, stop lamp, rear view mirrors, etc.) and one rear tyre blowout. About 86% of the motorcycles were step-through frame design.

Problems of roadway design and maintenance contributed to many of these accidents in the upcountry data set - at least one in sixth. Such problems were rarely the sole cause of a motorcycle crash, but were frequent, particularly in night accidents. The great majority of design and maintenance problems seen in this study affected all road users, not just motorcycles. Improvements in roadway design and maintenance, traffic controls and construction zone safety could greatly reduce the number of traffic accidents in Thailand.

About one-fourth of the motorcycle accidents were single vehicle collisions. Half of the accidents occurred during daylight and 43% of the accidents occurred at night, usually on unlighted roadways. The most frequent accident configuration was a motorcycle falling on the road or running off the road. 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 made up almost 80% of the accident population, and most riders fell into the 18 to 35 age category. The average education level was nine years. About one-third of the riders were unskilled laborers and another one-fourth were full-time students.

About 30% of the accident-involved riders appeared to have been consuming alcohol prior to the collision. Alcohol-involved accidents differed in many ways from non-alcohol-involved accidents. Compared to non-alcohol accidents, alcohol-involved accidents were twice as likely to be single vehicle crashes, three times as likely to involve loss of control, twice as likely to involve running off the road, and three times as likely to involve violation of traffic control signals or signs. Alcohol-involved accidents also occurred at higher speeds (about 10 km/hr on average). Alcohol-involved riders were half as likely to wear a helmet as non-alcohol-involved riders, and more likely to be hospitalized or to die as a result of the crash. Alcohol-involved riders 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, the time distributions were different between the two accident conditions: most alcohol accidents occurred between 8 p.m. and 1 a.m., while most non-alcohol accidents happened between 6 a.m. and 7 p.m.

Approximately half of the accident-involved riders were unlicensed and none had any formal training in motorcycle riding techniques and collision avoidance strategies. Most were self-taught or learned from friends and family. 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 twice 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 vehicle 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 parcels carried cannot block the headlamp from being seen by other motorists.

About half of the accident-involved riders who took evasive action made a proper choice, although far fewer were able to carry it out effectively. The most frequent problem was improper braking (i.e. use of only the rear brake to avoid a collision). This suggests that there is a 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.

Only 22% of the accident-involved riders were wearing a helmet at the time of the accident. Helmet use was much lower among passengers: only about 4%. Helmet use declined sharply at night. Few riders said they always wear a helmet, and many admitted that they wear a helmet only when they think they might encounter police. Head injuries were less frequent among those who wore a helmet.

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 to the accident victims were to the chest, head and neck.

The results of this study suggest that rider training is badly needed in the upcountry regions. Not one single rider in 359 accidents or 1060 exposure interviews reported any formal motorcycle training. At present, the only formal training is offered by the Honda Safety Training Center, and most of those participating in the training program are police officers. There appears to be no mechanism for introducing this valuable knowledge into the larger population of motorcycle riders in the upcountry regions. Such a program could provide instruction on traffic laws, safe riding strategies, helmet selection and use, and collision avoidance skills. Safety 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. The motorcycle traffic school may represent another opportunity to provide road users with critical safety information.

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

Roadway design and maintenance need many improvements. The first suggestion would be to provide better warning signs and guidance through curves, particularly at night. The second suggestion is to provide better warning signs and guidance, and fewer view obstructions, at construction sites. While many such sites do not present a problem during daylight hours, they become a big problem at night due to a lack of proper warning lights and reflectors.

The requirement for motorcycles to ride in the curb lane should be discontinued, at least in non-rural areas, as this 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 of the helmets inspected in this study had no qualification and could definitely be improved in terms of impact attenuation capability and helmet retention capability. About one-third of the helmets were ejected before providing any crash protection because the helmet was strapped loosely or not strapped at all.

A helmet testing laboratory should be established to monitor the quality of helmets sold to the public. Enforcement authority is needed to remove substandard helmets from the marketplace and to assure that all helmets sold to Thai consumers are capable of providing significant protection during a collision. Furthermore, 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 absence 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.

Education program regarding protective equipment is essential. 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 this has become a major public health problem. This is due to the fact that the riders and/or passengers have an increased exposure risk to traffic accidents, simply as a function of the vehicle they are using. Many motorcycle riders and/or passengers were killed or disabled largely due to the fact that they have no crash protection available as in the case of conventional automobiles [2-5]. Riding a motorcycle thus becomes a very vulnerable form of motor vehicle transportation.

The most comprehensive motorcycle accident research was released in 1981 by the University of Southern California, "*Motorcycle Accident Cause Factors and Identification of Countermeasures",* which was 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.

Although there have been a few published studies of motorcycle accidents in Thailand, many questions regarding motorcycle accident causation remain unknown because the previous studies were solely based upon police traffic accident reports or hospital evaluation [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 on 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 involved 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 cost for this on-scene, in-depth investigation is high. According to the Hurt Report, which was conducted from 1975 to 1980, the overall cost of 900 on-scene, in-depth motorcycle accident investigation cases was US$501,814 at the time, a cost that would be higher now due to simply inflation.

2.2 Objectives of the research

Five specific objectives were identified at the start of this study. 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 that cause these injuries.

4. To compare the accident population and exposure population from the same region in order to identify risk factors that 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 accidents do 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 investigations were conducted for 359 motorcycle accidents in five provinces representative of the various geographical regions of Thailand (Figures 1 and 2). 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.

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 any vehicles had been moved in at least 63% to 95% of the accidents, depending upon the sampling region.

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, the rider's home, or at the police station. All physical evidence such as tyre skid patches, headlamp condition, fuel tank and cap, etc. were photographed and recorded.

In-depth investigation also involved interviewing motorcycle riders and 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 rural, suburban and urban city center 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 that eluded the authorities.

2.4 Helmet analysis

In 1992 the Thai Parliament adopted the mandatory helmet use law for motorcycle riders and passengers. Enforcement of the law began on January 1, 1993. However the number of helmeted riders was low in the accident data, particularly in the upcountry sampling areas. Throughout the collection period of the accident investigation, it was found that approximately 65% 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%. 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

The medical records regarding injuries sustained by the motorcycle rider and/or passenger were collected and, in most cases, injuries were observed directly at the accident scene or in the emergency room. All discrete injuries were coded using the Abbreviated Injury Scale (AIS) of the American Association for the Advancement of Automotive Medicine (1990 revision). In the 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 were exposed to the same risk of an accident, but who were not involved in a crash. The exposure data were collected at the scene of previously investigated accidents, on the same day of the week, same time of day and under similar weather conditions as the related accidents.

The gathering of exposure data began half an hour before the referenced accident time and concluded half 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 on the motorcycle and the other vehicle paths of travel (if applicable), vehicle types, safety helmet use, headlamp use, the number of passengers and any cargo. Video taping of the traffic flow of these accident scenes was the primary exposure data collection technique. In addition, traffic flows were tabulated using manually operated tally counters for later comparison and to assure the maximum accuracy of the data.

In addition to the on-scene exposure (OSE) studies, interviews were conducted at petrol stations located near the accident scenes with those motorcycle riders and passengers who stopped. Although the number of interviews varied at each exposure site, the overall average was three exposure interviews for each accident case. The questions asked in the petrol station exposure (PSE) data interviews were essentially identical to those asked in the accident study with respect to rider training, riding experience, personal information, trip information, and the same methods of cross-verifying answers were used. The interviews were prefaced by an explanation of the research purpose and offered anonymity and privacy to the rider. The exposure interview results then were analyzed as a separate data set and then used for later 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 General considerations of upcountry site selection

Cooperative agreements

Two main concerns arose regarding the selection of sites for the upcountry sampling regions. The first one was the attempt to sample areas representative of the geographic and ethnic diversity of Thailand. The second concern was the reality that without a delicate network of cooperative agreements and logistical support needed at an upcountry sampling site, any research effort had no chance of success. The research team had to have the support of all necessary agencies involved in responding to motorcycle accidents, including police, regional emergency medical service, both private and public hospitals and local NGO groups, in order to work in a selected province. Forging a network of cooperative agreements with all parties was found to be a challenging undertaking. The lack of cooperation by any single one of these groups can cripple the team's chance of success.

Sampling regions

As mentioned earlier, there are six general regions in Thailand. Eastern and Central Thailand are not strongly differentiated by language, ethnicity or geography. The area is mainly a flat fertile plain devoted almost entirely to farming, planting and industry. People are mostly Thai with a mix of Chinese and they also speak same dialect as people in Bangkok.

The western region is a mix of mountainous and flat land. The people are mostly Thai with small minorities of Burmese and Karen. Main occupations include farming, planting and mining. People in western Thailand generally speak the same dialect as people in Bangkok.

The northern region is largely a forested mountain area where the people speak a slower dialect than the central area. The population is represented by groups of minorities who are from Burma, local hill-tribes, and Thai-yai..

The northeastern region is a highland plateau. It is the most densely populated portion outside of Bangkok, and the largest land area. The people speak a Lao dialect, which differs significantly from other regions.

The southern region extends almost 1,400 kilometres down the Thai Peninsula, and is a more tropical climate with a mix of farming, fishing and tourism. People in the upper southern portion are mostly Thai, while in the far southern peninsula they are a mix of Muslim and Thai. They speak a fast and different dialect.

The primary statistical variables considered in each province were population density, per capita income and the ratio of the number of motorcycles to the provincial population. Specific provinces were identified as possible investigation sites if the above characteristics were generally similar for the larger region.

This site selection procedure excluded many provinces that differed too greatly from the average for a geographic region. After sorting for such statistical variables, the feasibility of establishing the critical network of cooperative agreements was evaluated.

Some provinces were eliminated because no emergency medical service system had been established. Still others were excluded because of poor transportation connections that made it impossible for the pathologist to travel from Bangkok in order to perform the detailed head-and-neck autopsy procedure in fatal cases. The provinces immediately surrounding Bangkok were not included because many accidents had been investigated in Bangkok and because this region represents the same geographic area as Bangkok in the view of most Thais.

Selected sampling provinces

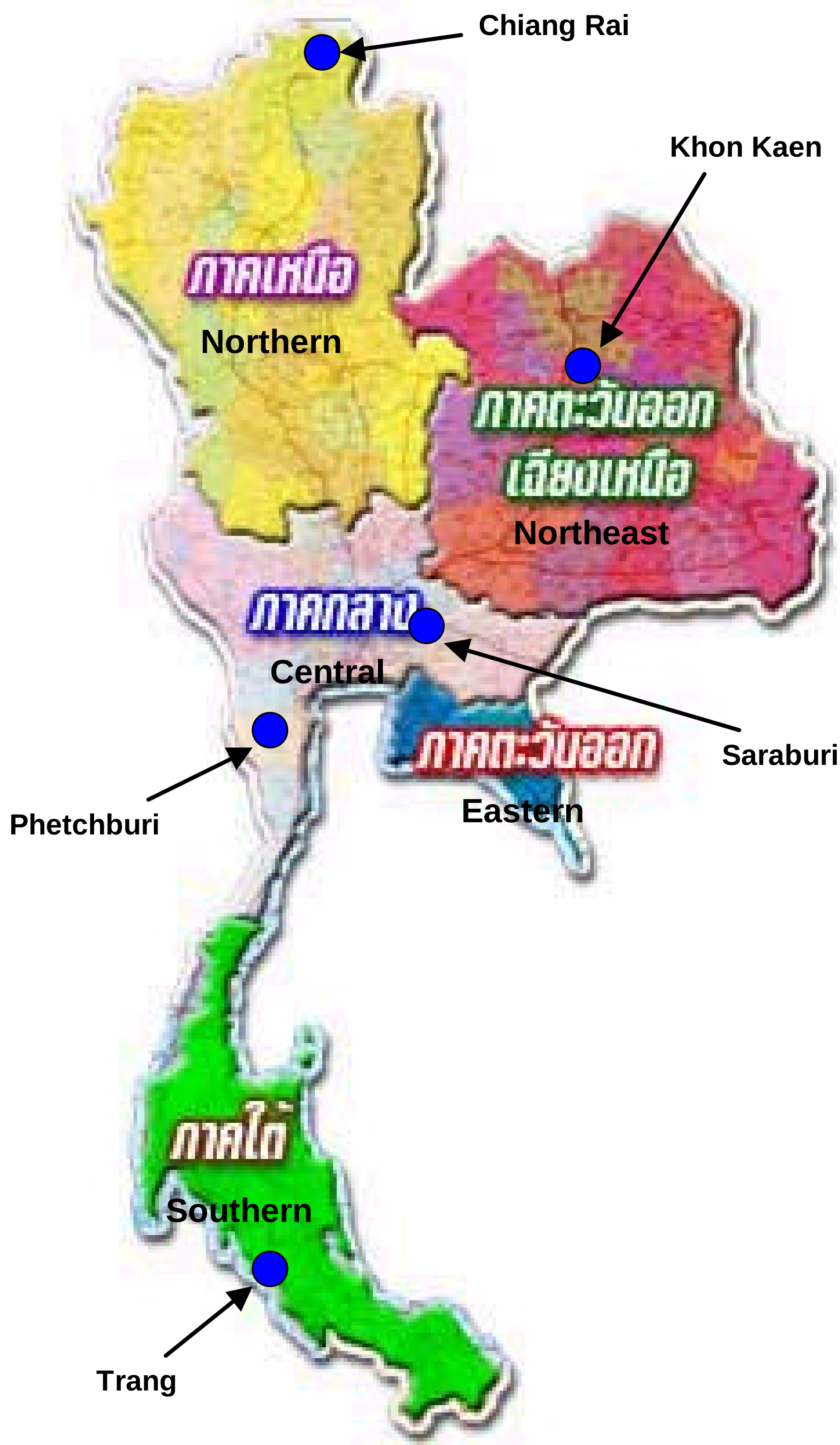
Within the central and eastern regions only Saraburi met all the statistical and feasibility criteria. Saraburi is representative of central Thailand farming regions. Support from local authorities was extremely strong. Phetchburi was the only province in the western region that qualified using the statistical and feasibility requirements. Local agencies were overwhelmingly supportive.

In the northern region Chiang Rai and Phitsanulok both met the necessary statistical sampling requirements. However, Chiang Rai was chosen over Phitsanulok because this region better represents the far northern area. Chiang Rai is located 805 kilometres from Bangkok, while Phitsanulok is only 400 kilometres away. In the northeast, a number of provinces could have qualified for inclusion in this study but Khon Kaen was selected for the ease of developing cooperative agreements there. Trang was the only province in the southern Thailand that satisfied both statistical and feasibility criteria. Support from local authorities was extremely strong.

Province profiles

1. Saraburi is a mixed hill/forest and farming region.
   - Distance is 108 kilometres northeast from Bangkok.
   - Total area is about 3,577 square kilometres with 13 districts
   - Population is about 600,000.
   - Number of persons to each motorcycle is 4.5 (mean value of the central and eastern region is 4.9 and 4.5 respectively in 1997).

2. Phetchburi is a mixed mountain/beach tourist town.
   - Distance is 160 kilometres southwest from Bangkok.
   - Total area is about 6,266 square kilometres with 8 districts.
   - Population is about 560,000.
   - Number of persons to each motorcycle is 4.1 (mean value of the western region is 4.3)


Chiang Rai
Khon Kaen
ภาคเหนือ
Northern
ภาคตะวันออก
เฉียงเหนือ
Northeast
ภาคกลาง
Central
Saraburi
Phetchburi
ภาคตะวันออก
Eastern
ภาคใต้
Southern
Trang

3. Khon Kaen is highland plateau.
   - Distance is 445 kilometres northeast from Bangkok.
   - Total area is about 10,890 square kilometres with 20 districts.
   - Population is about 1,700,000.
   - Number of persons to each motorcycle is 6.8 (mean value of the northeast region is 8.2)
   -
4. Chiang Rai is a far northern mountain region.
   - Distance is 805 kilometres north from Bangkok.
   - Total area is about 11,680 square kilometres with 16 districts
   - Population is about 1,200,000.
   - Number of persons to each motorcycle is 5.0 (mean value of the northern region is 4.5).
   -
5. Trang is a far southern hill and beach.
   - Distance is 828 kilometres south from Bangkok.
   - Total area is about 4,918 square kilometres with 9 districts.
   - Population is about 580,000. About 15% of the total population is Muslim.
   - Number of persons to each motorcycle is 3.3 (mean value of the southern region is 3.8).

2.9 Sample size

Reliable information regarding motorcycle accidents in Thailand is largely non-existent because of the variations in reporting and the fact that many motorcycle accidents or single vehicle accidents are under-reported by law enforcement agencies.

For example, in 1997 Tanaboriboon reported that over 80% of traffic accidents (all vehicle types) in Khon Kaen were fatalities [7]. However, in the Bangkok accident investigation, the fatality rate among motorcycle accidents was approximately 8%. It is almost certainly lower for other vehicles in the traffic mix such as cars and trucks. The most likely explanation for the apparently spectacular fatality rate in Tanaboriboon's data is the under-reporting of non-fatal accidents.

It is, therefore, impossible to know exactly how many accidents should be sampled from each province. We thus chose to collect one accident case per 12,000 - 17,000 population.

It was felt that the factors used to describe the study area were adequate for the purpose of analyzing the general characteristics of motorcycle accidents in Thailand. Therefore, the findings and recommended countermeasures reported here should be applicable to the majority of motorcycle accidents in this country.

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 investigations 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 disc 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 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 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, wheelies, 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.

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.

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

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 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.

The detailed accident data that was reported in each case included all necessary elements as follows:

1. Accident typology and classification

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

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

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

5. 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.,

6. 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).

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

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

9. 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 the on-scene, in-depth accident investigation, certain additional modifications of the data form were also necessary to provide enough details to adequately describe the complexity of motorcycle accidents in Thailand. For example, the motorcycle accident may involve three or four or even more vehicles, multiple motorcycle passengers, etc.

3.3 Project schedule

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

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

- October 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, case quality control review, data editing, data analysis and review, exposure data collection, editing, analysis and review.

- January through February, 2000:
  Data review and quality control (ongoing), upcountry site selection and establishment of cooperative agreements with local authorities.

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

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

- March through September, 2001:
  Accident and exposure data compilation, final analysis and review, final report preparation.

3.4 Project personnel

The project personnel were as follows:

Principal Investigator:	Prof. Vira Kasantikul, M.D.
Research Associate:	Ittipon Diewwanit, Sc.D.
Research Assistants:	Atit Ingkavanich Banpoch Tengwongwatana Mek Chaiyasonth Pranot Nilkumhaeng Rakfa Surisuk Ratchada Pichitponlachai Visa Phromhong Chatchawal Panpradit Terachai Polchamni Sakulchai Kumkao Lukchai Kunsuwan Pongsathon Pinit Weerapon Sudchada Pranodpol Tantavichien
Secretarial Staff:	Montarat Laorat Nadesurang Kongsittichoke Supaporn Kanitaboonyavinit
Research consultants:	James V. Ouellet Terry A. Smith, Ph.D. David R. Thom Sandra L. Brown Irving Rehman Jon McKibbon Prof. Hugh H. Hurt, Jr. (Head Protection Research Laboratory)

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 including 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 at the time the accident occurs.

2. Cooperation of the investigating police officer on scene in order to gain access to 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 helmet 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

Co-operative agreements were obtained so that the research team members could be stationed at the ambulance dispatch centers of public hospitals in each province. Dispatchers at the hospitals monitored police radio communication frequencies 24 hours a day, dispatching the ambulance service as needed and notifying the team members in the event of a motorcycle accident. Upon receipt of a notification the research team members responded immediately in an emergency van with lights and sirens activated. 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 as part of this research project.

A second source of accident notification was from motorcycle riders who had sustained minor injury in a crash and came directly to the hospital to seek medical attention. In those cases, notification occurred when the motorcycle rider arrived 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 emergency vehicle with lights and sirens to get to the accident scene also greatly increased the number of case acquisitions.

4.3 Access to the accident scene

The cooperative agreements with the Chief of Royal Thai Police and the chiefs of various regional police headquarters in the upcountry sampling areas provided official approval for Chulalongkorn investigators to examine accident-involved vehicles and accident scenes in all instances. The cooperative agreements also permitted access to vehicle storage yards and impound facilities where the accident-involved vehicles were taken. Officers also allowed Chulalongkorn personnel to interview the motorcycle rider and the driver of the other vehicle (OV), either at the accident scenes or at the police station.

4.4 On-scene investigation

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

The investigation team was divided into units that completed on-scene measurements, driver, rider, passenger, and witness interviews. The environmental evidence was photographed and later diagrammed. The accident-involved vehicle was photographed to define the collision damage and impact areas. The motorcycle was examined, documented, 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, 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 at either 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 the other vehicle drivers 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. Infrequently, it was examined elsewhere, e.g. a tow yards, the rider's home or at the hospital where the rider sought medical attention.

4.7 Human factors

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

However, when physical evidence conflicted with eyewitness statements, the latter was given less significance in favor of the physical evidence. In fatal cases or those involving severe head injury and loss of consciousness, interviews were conducted with family members, friends, riding partners or coworkers who could provide information about the injured victim. Photographs of 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, the 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 the hospital emergency room, access to the medical information of the injured rider was allowed by the cooperative agreements between the principal investigator and the treating hospitals. The nature and location of the injuries were mainly obtained from the treating physicians and nurses. X-rays were photographed whenever possible.

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

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 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 was up to 56% in the upcountry series.

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 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

Each accident required about 2300 data entries, which included environmental, vehicle, and human factors, injury data and an evaluation of accident cause factors. Therefore, a high level of quality control was essential to assure the validity and reliability of data. Quality control procedures thus took place on virtually every level of the research effort including data collection, accident reconstruction, editing of the data and statistical analysis of the data. In this research project, 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 taken during the initial investigation needed improvement to better illustrate the characteristics of the impact, prompting on-scene investigators to modify or improve their photography work.

Quality control procedures were also applied in 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 of the accident for speeds, injury contact surfaces, collision dynamics, etc. The reconstruction and review of the each case was performed by the investigators who had worked that particular accident, then it was double-checked by the principal investigator for the overall consistency. The cases were then forwarded to the Head Protection Research Laboratory for final review by HPRL staff members. The results of the HPRL quality control review were then returned to the Chulalongkorn investigators for continual upgrading of the quality of the investigators and modification of the data forms if necessary.

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 print 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 entered electronically. The first step of quality control of the data entry was to make simple random checks against the case data form. A simple frequency count of the responses to each question helped to locate incorrect entries. Many cross-tabulations of various data elements were also 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 extraordinary in some way.

4.12 Data processing and analysis

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

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 rider, passenger, other vehicle driver, witnesses, police, etc., were still present. This was not always possible, but it was achieved for about 63% to 95% of the time.

Table 5.1.1 shows the performance of the research team regarding the collection of the motorcycle accident data. About 85% of the accidents were investigated at the accident location, immediately after the occurrence of the accident and with involved persons and vehicles still at the accident scene. The remaining 15% were conducted by follow-up activities within 1 to 2 hours after the accident took place.

In many cases, a rider who had sustained minor injury often came directly to the hospital by his or her vehicle to seek medical attention. Therefore, notification was made upon the rider's arrival at the hospital. This was the most common cause of follow-up investigation rather than on-scene investigation. It occurred more often in Petchburi, Trang and Saraburi than in Khon Kaen and Chiang Rai. . The number of on-scene accident investigations is also depended on the dispatcher unit at the hospital where the team investigation stationed.

Table 5.1.1: Type of investigation

Type of investigation	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
On-scene	49	34	92	32	98	305
	89%	67%	93%	63%	95%	85%
Follow-up	6	17	7	19	5	54
	11%	33%	7%	37%	5%	15%

5.2 General accident characteristics

Although this study reports on 359 motorcycle accident cases, there were, in fact, 303 crashes. Fifty-six crashes in this study involved two motorcycles colliding with each other. They were reported here as 112 motorcycle accident cases, because each motorcycle and rider experienced different crash circumstances. In another 13 motorcycle to motorcycle crashes, one motorcycle fled the scene. Motorcycle to motorcycle crashes were thus 69 of the 303 crashes (23%) but 125 of 359 (35%) of total cases reported here.

Time of accident

Table 5.2.1 illustrates the distribution of accidents by the time of day. At night, the most frequent time of accident occurrence was between 8 and 10 p.m.

During daytime, the accidents occurred most often between 4 and 5 p.m. The fatal accidents in the upcountry data set were evenly divided between nighttime and daytime (Table 5.2.2). Only one fatal case occurred at sundown.

It should be noted that in the Phetchburi and Trang sampling areas the daytime accidents occurred more often during morning or evening rush hours (8-9 a.m., 3 p.m.-6 p.m.) and night accidents accounted for about one-third of all accidents. In contrast, in Saraburi, Chiang Rai and Khon Kaen the nighttime accidents accounted for about 40 to 50% of cases.

Table 5.2.1: Accident time of day

Time	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
0:01 – 3:00	3	4	8	3	9	27
	5.5%	7.8%	8.1%	5.9%	8.7%	7.5%
3.01 – 6.00	1	2	4	0	4	11
	1.8%	3.9%	4.0%	0.0%	3.9%	3.1%
6:01 – 9:00	7	2	13	8	5	35
	12.7%	3.9%	13.1%	15.7%	4.9%	9.7%
9:01 – 12:00	7	10	11	5	12	45
	12.7%	19.6%	11.1%	9.8%	11.7%	12.5%
12:01 – 15:00	6	10	11	3	13	43
	10.9%	19.6%	11.1%	5.9%	12.6%	12.0%
15:01 – 18:00	17	10	15	13	19	74
	30.9%	19.6%	15.2%	25.5%	18.4%	20.6%
18:01 – 21:00	7	8	17	5	23	60
	12.7%	15.7%	17.2%	9.8%	22.3%	16.7%
21:01 – 24:00	7	5	20	14	18	64
	12.7%	9.8%	20.2%	27.5%	17.5%	17.8%
Total	55	51	99	51	103	359

Table 5.2.2: Ambient lighting condition and fatal accidents.

Ambient lighting	Province					
	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
Daylight	1	1	1	3	0	6
Night	0	0	3	1	2	6
Dusk-Dawn	0	1	0	0	0	1
Total	1	2	4	4	2	13

Table 5.2.3 shows the accident distribution by days of the week. Accidents were notably less frequent on Sundays.

Table 5.2.3: Accident day of the week

Accident day of week	Frequency	
Monday	50	13.9
Tuesday	52	14.5
Wednesday	59	16.4
Thursday	63	17.5
Friday	53	14.8
Saturday	48	13.4
Sunday	34	9.5
Total	359	

Objects involved in collision with the motorcycle

Table 5.2.4 lists the objects involved in collision with the motorcycle. Three-fourths of the 359 accident cases involved a collision with another vehicle and 24% of all collisions were single vehicle collisions where the motorcycle did not make contact with another vehicle.

Table 5.2.4: Objects struck by the motorcycle

Object struck	Frequency	
Other motor vehicle in traffic(OV)	265	73.8
Other motor vehicle, parked	10	2.8
Roadway	40	11.1
Off road environment, fixed object	16	4.5
Bicycle	3	0.8
Pedestrian	10	2.8
Animal	9	2.5
Other	6	1.7
Total	359	

In 15 of the 81 single vehicle collisions, another vehicle was involved in accident causation but no collision contact occurred. A typical accident of this type involved a motorcycle that followed another vehicle too closely. When the leading vehicle braked suddenly, the rider then swerved and over-braked, causing a slide-out and fall to the roadway. In many cases another vehicle turned or changed lanes in front of the oncoming motorcycle, again causing the rider to over-brake and lose control. Ten collisions involved an OV parked or abandoned at the roadside but still remaining in the traffic flow. These were almost invariably night crashes in which the other vehicle was a large truck that was nearly invisible due to its lack of lighting, marking or warnings.

Most accidents involved the motorcycle and one other vehicle, but some involved a motorcycle only, while others had multiple vehicles. Table 5.2.5 shows the number of other vehicles involved in all accidents. Nearly one-fifth involved no other vehicle, while three-fourths involved one other vehicle. Only about one in twenty involved a motorcycle and two other vehicles.

Table 5.2.5: Number of other vehicles involved

Number of other vehicle	Frequency	
No other vehicle	67	19
One	276	77
Two	16	5
Total	359	

Fatal Accidents

Thirteen accidents involved fatal injuries (3.6%) in the up-country data set, which included 12 riders, and 4 passengers (Table 5.2.6). Three cases were double fatalities, which involved both rider and passenger. The highest rate of fatal accidents was noted in the Saraburi sampling region, where they accounted for 8% of the accidents.

Table 5.2.6: Fatal accidents by province

Fatal	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
No	54 (98%)	49 (96%)	95 (96.0%)	47 (92%)	101 (98%)	346 (96%)
Yes	1 (3%)	2 (4%)	4 (4%)	4 (8%)	2 (2%)	13 (4%)
Total	55	51	99	51	103	359

Collision Configuration

Accident 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 hit 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 5.2.7 shows the distribution of various collision configurations in this data series.

Table 5.2.7: Accident configuration

Accident configuration	Code	Frequency	
- Head on collision	1	14	3.9
- OV into MC impact at IS, paths perpendicular	2	13	3.6
- MC into OV impact at IS, paths perpendicular	3	23	6.4
- OV turning L ahead of MC, paths perpendicular	4	5	1.4
- OV turning R ahead of MC, paths perpendicular	5	19	5.3
- MC and OV in opposite directions, OV turns ahead of MC crossing MC path; OV impacting MC or MC impacting OV*	6 - 7	17	4.7
- MC turning left in front of OV, OV proceeding in either direction perpendicular to MC path	8	3	
- MC turning right in front of OV, OV proceeding in either direction perpendicular to MC path	9	11	
- MC overtaking OV while OV turning left	10	8	2.2
- MC overtaking OV while OV turning right	11	10	2.8
- OV impacting rear of MC	12	19	5.3
- MC impacting rear of OV	13	33	9.2
- Sideswipe, both travelling in opposite directions	14	22	6.1
- Sideswipe, both travelling in same directions	15	26	7.2
- OV making U-turn or Y-turn ahead of MC	16	22	6.1
- Other MC/OV impacts	17	32	8.9
- MC falling on roadway, no OV involvement	18	23	6.4
- MC running off roadway, no OV involvement	19	24	6.7
- MC fall on roadway in collision avoidance with OV	20	10	2.8
- MC running off roadway in collision avoidance	21	1	0.3
- MC impacting pedestrian or animal	23	19	5.3
- MC impacting environmental object	24	2	0.6
- Other	98	3	0.8
Total		359	

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

The configurations listed above that involved other vehicle violation of the motorcycle right-of-way (4, 5 6, 7 and 16) accounted for 11% of the accidents. Motorcycle-solo crashes (codes 18, 19 and 24) were 14% of the total accidents collected. The motorcycle rear-ended the other vehicle in 33 cases. Two-thirds of those were cases in which the motorcycle was following too closely to the other vehicle, but 11 cases involved the motorcycle striking the rear of a large truck parked or abandoned at the roadside at night, and nearly invisible due to a lack of markers, reflectors, etc.

Thirteen accidents involved a fatal injury to at least one person on the motorcycle. Three accidents were head-on collisions and in three cases, another vehicle rear-ended the motorcycle. Another three cases were night accidents in which the motorcycle rear-ended a large truck left parked at the roadside, as noted above.

5.3 Accident scene

Table 5.3.1 shows that most motorcycle accidents (55%) occurred in a commercial area. The combination of commercial and residential housing areas (16%) accounted for nearly three-fourths of collision areas. This was probably due to the fact that people often combined their living and business accommodations. As a result of this, accidents in the urban area predominated in each province. Truly undeveloped rural areas were found in only about 3% of all upcountry cases.

Table 5.3.1: Accident scene, type of area

Land use type	Same side as MC		Opposite side	
	Frequency	Percent	Frequency	Percent
Commercial, shopping	197	55	183	51
Housing apartments	4	1	0	0
Housing residential	56	16	58	16
Urban school	10	3	11	3
Urban park	2	0.6	3	1
Agriculture, farming	75	21	88	25
Undeveloped, wilderness	10	3	11	3
Rural school	3	1	3	1
Other	2	0.6	2	0.6
Total	359		359	

Roadway illumination

Half of the accidents occurred during daytime. About 64% of night accidents (98/153) occurred on unlighted roadways. Accidents rarely occurred during dusk-dawn. The distribution of lighting conditions for each province is shown in Table 5.3.2.

Table 5.3.2: Accident scene, roadway illumination

Ambient light	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
Daylight, bright	30 55%	27 53%	45 46%	19 37%	43 43%	164 46%
Daylight, not bright	0 0%	3 6%	2 2%	7 14%	5 5%	17 5%
Dusk, sundown	7 13%	3 6%	3 3%	2 2%	3 3%	18 18%
Night, lighted	7 13%	7 14%	12 12%	5 10%	24 23%	55 15%
Night, no light	11 20%	10 20%	33 33%	17 33%	27 26%	98 27%
Dawn, sunrise	0 0%	1 2%	4 4%	1 2%	1 1%	7 2%
Total	55	51	99	51	103	359

Weather

Adverse weather was not a major factor in the majority of the motorcycle accidents. The accident investigation showed favorable weather (clear, cloudy or overcast) in 95% of all accidents, while riding in the rain was found in the other 5% (Table 5.3.3). It may appear that rain was a factor in Chiang Rai, where 15% (15/103) of the accidents occurred during rain. However, investigations in Chiang Rai took place from mid-August to mid-September, 2000, during the height of the rainy season.

Table 5.3.3: Weather conditions at time of accident

Weather	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
Clear	50 91%	34 67%	60 61%	31 61%	42 41%	217 60%
Cloudy	5 9%	14 28%	34 34%	14 28%	43 42%	110 31%
Overcast	0 0%	2 4%	4 4%	4 8%	3 3%	13 4%
Drizzle Light rain	0 0%	1 2%	1 1%	2 4%	12 12%	16 5%
Moderate or heavy rain	0 0%	0 0%	0 0%	0 0%	3 3%	3 1%
Total	55	51	99	51	103	359

5.4 Roadway surface for motorcycle

Roadways surfaces were mainly asphalt (68%) or concrete (31%). Unpaved surfaces accounted for only 2% of crashes. The distribution of roadway surface types is shown in Table 5.4.1.

Table 5.4.1: Roadway surface

Surface material	Frequency	
Concrete	110	31
Asphalt	243	68
Gravel	3	1
Dirt	1	0.3
Other	2	0.6
Total	359	

Type of intersection

Slightly over half of the crashes occurred at non-intersection areas. Of the 173 intersection collisions, 36% of cases involved a T-intersection, 32% occurred at alleys or driveways, and 24% at a cross intersection (Table 5.4.2).

Table 5.4.2: Type of intersection

Intersection type	Frequency	
Non-intersection	186	52
T-intersection	62	17
Cross intersection	41	11
Angle intersection	8	2
Alley, driveway	56	16
Offset intersection	3	1
Other	3	1
Total	359	

Type of roadway

Table 5.4.3 shows the type of roadway that the motorcycle was traveling at the accident location. Major roadways and sub-arterials were the main traffic ways traveled by the motorcycle (76%). The minor arterial or local roadway accounted for 18% of upcountry accidents and alley or driveway accounted for 5% of all cases. Traveling along a lane that was under construction was found in 2 cases. Only one case occurred on a fly-over bridge.

Table 5.4.3: Motorcycle roadway type

Roadway type	Code	Frequency	
Major arterial, non-tollway	6	146	40.7
Non-arterial, sub-arterial	7	125	34.8
Construction detour	9	2	0.6
Alley	11	13	3.6
Driveway	12	6	1.7
Minor arterial or local street	14	66	18.4
Other	98	1	0.3
Total		359	

Number of through lanes and lane traveled

Lanes were counted starting at the center of the roadway and counting outward toward the side of the roadway. Only through lanes were counted. Driveways had zero through lanes, as did a vehicle stopped at a T-intersection where its roadway did not continue on the other side of the intersection. Almost all roadways thus had at least a #1 lane. Lane counting reflected the number of *marked* lanes, not the number of lanes used by traffic. In some cases, the roadway had room for two lanes and traffic moved in two lanes, but there was no divider to clearly mark each lane. Such a situation was coded as a one-lane roadway. Table 5.4.4 shows the number of through lanes, which is clearly dependent upon the type of traffic way. The majority of motorcycles traveled along lane 1 (the fast lane) followed by lane 2 and 3, respectively.

Table 5.4.4: Number of through lanes, motorcycle direction

Number of through lanes	Frequency	
None	14	3.9
One lane	160	44.6
Two lanes	108	30.1
Three lanes	56	15.6
Four lanes	19	5.3
Five lanes	2	0.6
Total	359	

Table 5.4.5 shows the lane in which the motorcycle was traveling just before the accident sequence began. The motorcycle traveled the wrong way in 7% of the accident cases. Curb lane traveling in multiple lane roadways (excluding roadways with only one lane each direction) accounted for 60 cases (16.7%). The "curb lane" was the through lane closest to the left roadway edge. Outside urban areas, this “curb lane” was usually 1 to 2 metres wide and separated from other traffic lanes by a solid painted stripe. It is a travel lane

reserved for smaller vehicles such as motorcycles, tuk-tuks and bicycles. Eleven of 33 cases (33%) in which the motorcycle impacted the rear of another vehicle took place along the curb lane.

Table 5.4.5: Lane traveled by motorcycle

Lane traveled	Frequency	
No through lane	14	3.9
Lane 1	216	60.2
Lane 2	62	17.3
Lane 3	30	8.4
Lane 4	4	1.1
Right turn only	1	0.3
Left turn only	4	1.1
Opposing lanes, wrong way	25	7.0
U-turn only	3	0.8
Total	359	
Curb lane	60	

Roadway surface condition and defects

Table 5.4.6 shows the number of cases where serious roadway conditions and roadway defects were noted. No defect of the pavement surface was reported in 93% of upcountry accidents. Surface cracking was noted in seven cases but did not appear to be a contributing factor in any of the collected cases. Potholes were present in 5 cases. “Raised reflector” was coded as a surface defect in four cases, because they were large enough to cause the motorcycle to fall (and, in some cases to cause a rapid loss of front tyre pressure and denting of the wheel rim) even when no other problem was found. Occasionally, these defects such as potholes could cause motorcycle loss of control.

Table 5.4.6: Surface conditions and defects on motorcycle roadway

Surface irregularity	Frequency	
None	332	92.5
Surface cracking	7	1.9
Spalling, erosion	3	0.8
Holes	5	1.4
Ruts	1	0.3
Bump	1	0.3
Pavement edge	2	0.6
Bitumen	3	0.8
Tram/train rails	1	0.3
Other	4	1.1
Total	359	

Roadway surface contamination

The motorcycle roadway was usually dry and clean at the time of the accident (Table 5.4.7). Piles of dirt on the roadway without proper warning caused two motorcycle accidents in Phetchburi. Sand, soil, dirt and gravel could also interfere with braking performance. The presence of roadway contamination must be considered unsafe for all vehicles concerned.

Table 5.4.7: Surface contamination on motorcycle roadway

Type of contamination	Frequency	
None	298	83.0
Water	22	6.1
Sand, soil, dirt	23	6.4
Gravel	1	0.3
Parked vehicles	11	3.1
Other	4	1.1
Total	359	

Roadway alignment, horizontal and vertical

Tables 5.4.8 and 5.4.9 show that the majority of the upcountry motorcycle accidents occurred on a roadway that was straight (86%) and level (97%). In at least one case, the crest of a hill created a view obstruction that contributed to causing the accident. Many accidents occurred on curves, particularly at night when signs to warn the rider of the approaching curve were not posted or were inadequate.

Table 5.4.8: Vertical alignment of motorcycle roadway

Slope	Motorcycle	
	Frequency	Percent
Level	348	96.9
Slope of hill	6	1.7
Crest of hill, loft	1	0.3
Slope of hill, downgrade	3	0.8
Bottom of hill	1	0.3
Total	359	

Table 5.4.9: Horizontal alignment of motorcycle roadway

Roadway curvature	Motorcycle	
	Frequency	Percent
Straight	309	86.1
Curve right	28	7.8
Curve left	17	4.7
Corner right	1	0.3
Jog right	1	0.3
Jog left	2	0.6
Other	1	0.3
Total	359	

5.5 Other vehicle roadway

The other vehicle roadway was similar to the motorcycle roadway in the majority of the accident cases. Table 5.5.1 shows the frequency and distribution of the type of roadway that the other vehicle was traveling. In three of four crashes, the OV was traveling on either a major arterial or a sub-arterial roadway.

Table 5.5.1: Other vehicle roadway type

Other vehicle roadway type	Frequency	
Major arterial, non-tollway	119	38.6
Non-arterial, sub-arterial	109	35.4
Construction detour	2	0.6
Parking lot, parking area	1	0.3
Alley	10	3.2
Driveway	12	3.9
Minor arterial or local street	54	17.5
Other	1	0.3
Total	308	

The other vehicle roadway was usually dry and without defect or contamination. No case was identified in which a roadway defect or roadway contamination caused the other vehicle to collide with the motorcycle or made it impossible for the other vehicle driver to avoid the colliding with the motorcycle (Tables 5.5.2 and 5.5.3).

Table 5.5.2: Other vehicle roadway surface conditions and defects

Roadway surface irregularities	Frequency	
None	294	95.5
Surface cracking	4	1.3
Spalling, breaking up, erosion	2	0.6
Holes	3	1.0
Bump	1	0.3
Bitumen repair	2	0.6
Tram/train rails	1	0.3
Other	1	0.3
Total	308	

Table 5.5.3: Other vehicle roadway surface contamination or obstacles

Contamination or obstacle	Code	Frequency	
None	1	267	86.7
Water	2	17	5.5
Sand, soil, dirt	4	13	4.2
Parked vehicles	9	9	2.9
Other	98	2	0.6
Total		308	

Other vehicle lane traveled

Lane 1 was again the most frequent lane used by the other vehicles. The other vehicle traveled in the wrong direction in 5% of the accidents. Curb lane travel at the time of the accident accounted for 36 cases (12%), as shown in Table 5.5.4.

Table 5.5.4: Lane traveled by other vehicle

Other vehicle lane traveled	Frequency	
No through lane	28	9.1
Lane 1	188	61.0
Lane 2	49	15.9
Lane 3	18	5.8
Lane 4	4	1.3
Left turn only	2	0.6
Wrong direction	15	4.9
U-turn only	2	0.6
Other	2	0.6
Total	308	
Curb lane	36	

Tables 5.5.5 and 5.5.6 show the alignment of the other vehicle roadway. The other vehicle roadway was level (97%) and straight (90%) in most accident cases. Again, accidents on curves were more common than this on the crests of hills because roadway curvature (often combined with tall roadside vegetation) was more likely than hills to create a view obstruction between motorcycle rider and other vehicle driver in the seconds just before a crash.

Table 5.5.5: Other vehicle vertical roadway alignment

Roadway slope	Code	Other vehicle	
		Frequency	Percent
Level	1	298	96.8
Slope of hill	2	8	2.6
Crest of hill, loft	3	0	0.0
Slope of hill, downgrade	4	2	0.6
Bottom of hill	5	0	0.0
Total		308	

Table 5.5.6: Other vehicle horizontal roadway alignment

Roadway curvature	Code	Other vehicle	
		Frequency	Percent
Straight	1	276	89.6
Curve right	2	16	5.2
Curve left	3	15	4.9
Corner right	4	0	0.0
Jog right	6	1	0.3
Jog left	7	0	0.0
Other	8	0	0.0
Total		308	

5.6 Traffic controls

Table 5.6.1 shows that no traffic control was present on the motorcycle or other vehicle paths in about 83% of cases. The motorcycle rider violated the traffic control in 19 of 60 cases (31%), a rate that was exceeded by other vehicle drivers, who violated the traffic control 41% of the accident. Running through a red light or failure to stop at the stop sign were the most common violations of traffic controls. (Table 5.6.2)

Table 5.6.1: Traffic controls on vehicle paths of travel

Traffic control type	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
None	299	83.3	252	81.8
Stop sign	6	1.7	8	2.6
Traffic control signal	35	9.7	34	11.0
Traffic advisory signage	19	5.3	14	4.5
Total	359		308	

Table 5.6.2: Traffic control violation by motorcycle or other vehicle

Control violation	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No	41		33	
Yes	19		23	
Total	60		56	

Thirty-four accidents occurred at intersections controlled by a traffic light. In five cases (15%) the motorcycle ran the red light, while the other vehicle ran the red light in 10 cases (29%). Together, 15 of 34 accidents (44%) at intersections controlled by a traffic signal involved one party running a red light, and the other vehicle driver was the violator two-thirds of the time.

5.7 Traffic density

The traffic density along the motorcycle and other vehicle paths was similar (Table 5.7.1). Light traffic density on the motorcycle path was encountered in about half of the accident cases followed by moderate traffic condition (44%). As to the other vehicle path, moderate traffic density was the most frequent situation followed closely by light traffic condition.

Table 5.7.1: Traffic density at the time of accident

Traffic density	Motorcycle roadway		Other vehicle road	
	Frequency	Percent	Frequency	Percent
No other traffic	11	3	14	5
Light traffic	184	51	139	45
Moderate traffic	158	44	151	49
Heavy traffic, but moving	5	1.4	4	1
Heavy traffic, congested	1	0.3	0	0
Total	359		308	

5.8 Stationary and mobile view obstructions

Stationary view obstructions were reported in 14% of upcountry cases. Table 5.8.1 lists the stationary view obstructions for the motorcycle rider and other vehicle driver just prior to the collision. On straight roadways, high walls, buildings, trees, and telephone booth were often found at intersections. These view obstructions frequently contributed to causing the accident, particularly when one of the vehicles made a turning maneuver in front of the other.

Table 5.8.1: Stationary view obstructions

Type of view obstruction	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No other vehicle driver	0	0.0	19	6.2
None	308	85.8	233	75.6
Building	16	4.5	18	5.8
Sign	0	0.0	1	0.3
Vegetation, trees, walls	11	3.1	14	4.5
Hill	1	0.3	1	0.3
Blind curve	5	1.4	3	1.0
Stationary or parked vehicles	13	3.6	13	4.2
Barricades	1	0.3	1	0.3
Other	4	1.1	5	1.6
Total	359		308	

Mobile view obstructions

Moving vehicles or vehicles stopped in traffic often affect the ability of the rider or other vehicle driver to see a traffic hazard ahead. This is particularly true when passing a line of slower moving traffic. Table 5.8.2 shows the data for mobile view obstructions. It is important to note that the presence of mobile view obstructions also affected the motorcyclist's view of a jaywalking pedestrian.

Table 5.8.2: Mobile view obstructions

Mobile view obstruction	Motorcycle		Other vehicle	
	Frequency	Percent	Frequency	Percent
No other vehicle driver	0	0.0	19	6.2
None	327	91.1	258	83.8
Passenger cars	14	3.9	14	4.5
Light trucks and vans	10	2.8	12	3.9
Trucks and buses	7	1.9	5	1.6
Other	1	0.3	0	0.0
Total	359		308	

For both motorcycle (32/359 cases) and the other vehicle (31/292 cases), mobile view obstructions occurred in about 10% of cases. For both, the vast majority of view obstructions occurred when traffic was light or moderate (29/ 32 cases for motorcycle, 29/31cases for other vehicle).

5.9 Pedestrian and animal involvement

The motorcycle struck a pedestrian in 10 cases (3%) and crashed trying to avoid a pedestrian in one other case. No pedestrian was involved in any of the cases collected in the Phetchburi sampling area.

Most pedestrian accidents involved a single pedestrian; one case involved two pedestrians. Most pedestrians were jaywalking at the time of impact (Table 5.9.1). Two pedestrians were struck while running across the roadway from the roadside.

Pedestrians were struck under less-than-optimal lighting conditions: night (5 cases) or in rain at dusk (2 cases). Four (36%) were struck during daylight and good weather. The motorcycle headlamp was off in two of the five night crashes and one case of a heavy overcast at sundown. Pedestrian accidents typically injure at least two people -- the rider and the pedestrian. The benefit to pedestrians of an automatic-on headlamp (one that operates whenever the engine is running) should be taken into account.

Table 5.9.1: Pedestrian location at impact

Pedestrian location	Frequency	
Jaywalking	8	73
Darting from roadside	1	9
Darting from roadside near school	1	9
Other	1	9
Total	11	

Animal involvement

Twelve accidents (3%) involved collision with an animal, usually a dog. In two cases, the motorcycles struck a cow (Phetchburi and Trang) resulted in one fatal crash for the motorcyclist (Trang) as shown in Table 5.9.2. In three cases, an animal was not hit by the motorcycle; however, the motorcycle lost control and crashed while trying to avoid these animals. The bird-involved crash in Saraburi occurred because the rider was steering with one hand while carrying a basket in the other. He crashed but successfully avoided hitting a chicken.

In summary, animals were struck in less than 6% of cases in all provinces, except Saraburi, where they were 11% of all cases.

Table 5.9.2. Animal involvement

Animal	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
None	54	48	98	45	102	347
	98%	94%	99%	88%	99%	97%
Small dog	0	2	1	4	1	8
	0%	4%	1%	8%	1%	2%
Big dog	0	0	0	1	0	1
	0%	0%	0%	2%	0%	0.2%
Bird	0	0	0	1	0	1
	0%	0%	0%	2%	0%	0.2%
Cow	1	1	0	0	0	2
	2%	2%	0%	0%	0%	0.6%
Total	55	51	99	51	103	359

6.0 Vehicle Mechanical Factors

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

6.1 Motorcycle characteristics

Table 6.1.1 shows the manufacturers of the motorcycles involved in the upcountry accidents. Honda motorcycles accounted for nearly half of all upcountry accidents (46%) followed by Suzuki (27%), Yamaha (21%), Kawasaki (5%) and Piaggio motorcycles (0.6%). It should be noted that only in Saraburi Suzuki was found to be more common than Honda (20 motorcycles versus 12). Generally, there was wide variation in the distribution of motorcycle manufacturer from one province to another.

Table 6.1.1: Motorcycle manufacturers, by province

Manufacturer	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
Honda	19	29	34	12	70	164
	35%	57%	34%	24%	68%	46%
Kawasaki	2	2	9	6	0	19
	4%	4%	9%	12%	0%	5%
Piaggio	1	0	1	0	0	2
	2%	0%	1%	0%	0%	1%
Suzuki	14	16	26	20	21	97
	26%	31%	26%	39%	20%	27%
Yamaha	19	4	29	13	12	77
	35%	8%	29%	26%	12%	21%
Total	55	51	99	51	103	359

Motorcycle type

The overwhelming majority of accident-involved motorcycles were the step-through frame type such as the Honda Dream or Kawasaki Leo (Table 6.1.2). Sport-design motorcycles are those that resemble racing motorcycles, such as the Honda NSR or Kawasaki KRR. Standard street motorcycles differ from those with a step-through frame because the rider must throw his leg over the seat to get on the motorcycle, and the riding position has the fuel tank located between the rider's knees. Scooters, such as the Piaggio or Vespa, were rare. Only two cruiser-type motorcycles were seen in this study.

Table 6.1.2: Motorcycle type

Motorcycle type	Frequency	
Standard street, no significant modification	14	3.9
Sport, race replica design	26	7.2
Cruiser design	2	0.6
Scooter	5	1.4
Step through	312	86.9
Total	359	

Motorcycle colour

Darker colour motorcycles predominated in these accidents as shown in Table 6.1.3. The majority of accident-involved motorcycles were red, followed by black, blue and multi-coloured.

Table 6.1.3: Motorcycle predominating colour

Predominating colour	Code	Frequency	
No dominating colour, multi-coloured	0	61	17.0
White	1	8	2.2
Yellow	2	2	0.6
Black	3	68	18.9
Red	4	97	27.0
Blue	5	63	17.5
Green	6	25	7.0
Silver, grey	7	7	1.9
Orange	8	1	0.3
Brown, tan	9	22	6.1
Purple	10	3	0.8
Other	98	2	0.6
Total		359	

Motorcycle engines

Engine displacement in Thailand is limited by high tariffs on motorcycles over 150cc. Only two motorcycles in the upcountry data exceeded the 150cc limit, as shown in Table 6.1.4. Because seven of eight motorcycles were step-through frame designs, which usually have engines in the 90 – 125 cc range, the great majority of engines fall into that range. Only 25 motorcycles (7%) were seen that had an engine displacement between 126 cc. and 150 cc.

Except for a single four-stroke, four-cylinder engine, all but one of the motorcycles was single-cylinder, two-stroke type.

Table 6.1.4: Motorcycle engine displacement

Motorcycle engine displacement (cc)	Frequency	
< 100	110	30.6
101 – 125	221	61.6
126 – 150	25	7.0
> 150	2	0.6
Unknown	1	0.3
Total	359	

Motorcycle modifications

Few motorcycles showed any significant modification. The ten most common modifications made to the motorcycles in the 359 on-scene, in-depth accident investigation cases are listed in Table 6.1.5.

Table 6.1.5: Motorcycle modifications

Modification	Frequency	
Muffler	11	39.5
Front suspension	7	25.1
Front brake	3	10.8
Rear brake	3	10.8
Handlebar	1	3.6
Center stand	1	3.6
Rear view mirror	1	3.6
Cargo rack	1	3.6
Oil tank	1	3.6

6.2 Motorcycle tyres and wheels

Table 6.2.1 provides the tyre manufacturers, while Table 6.2.2 shows the rim manufacturers among the accident-involved motorcycles in our data series. 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 manufacturer	Code	Front		Rear	
		Frequency	Percent	Frequency	Percent
Dunlop	6	8	2.2	3	0.8
IRC	9	95	26.5	69	19.2
Metzeler	13	0	0.0	1	0.3
Michelin	14	8	2.2	15	4.2
Hutchison	18	6	1.7	6	1.7
Other	98	242	67.4	265	73.8
Total		359		359	

Table 6.2.2: Motorcycle rim manufacturers

Wheel rim manufacturer	Code	Front		Rear	
		Frequency	Percent	Frequency	Percent
Original equipment	0	25	7.0	26	7.2
Daido(DID)	1	25	7.0	28	7.8
Douglas	2	1	0.3	0	0.0
Enkai	3	16	4.5	17	4.7
Other	8	116	32.3	110	30.6
Union Cycle	U1	166	46.2	170	47.4
Unknown	9	10	2.8	8	2.2
Total		359		359	

Table 6.2.3: Motorcycle tyre size

Tyre size	Front		Rear	
	Freq	Percent	Freq	Percent
Original equipment (OE)	179	49.9	156	43.5
Not OE, but special size	82	22.8	96	26.7
Proper rim size, oversize section	9	2.5	8	2.2
Proper rim size, undersize section	77	21.4	83	23.1
Improper rim size, too large	5	1.4	1	0.3
Improper rim size, too small	5	1.4	13	3.6
Unknown	2	0.6	2	0.6
Total	359		359	

Motorcycle tyre tread type and condition

Table 6.2.4 shows the tread type of both front and rear tyres for all 359 upcountry cases. Nearly all rear tyres were all-weather type with either angle or diamond-type tread patterns. Worn-out tyres (i.e., depth $\leq$ 1 mm) were found in about 41% of the front tyres and 34% of the rear tyres inspected (Table 6.2.5).

Table 6.2.4: Tread types of front and rear tyres

Tyre tread pattern	Front		Rear	
	Frequency	%	Frequency	%
Straight rib tread pattern	131	36.5	0	0.0
Block pattern, trials type	1	0.3	2	0.6
All weather, diagonal or diamond pattern	145		280	
All weather, angle groove	82	22.8	77	21.4
Total	359		359	

Table 6.2.5: Tread depth of front and rear tyres

Tread depth (mm)	Front		Rear	
	Frequency	%	Frequency	%
0	53	14.8	67	18.7
1	95	26.5	57	15.9
2	109	30.4	104	29.0
3	73	20.3	69	19.2
4	12	3.3	31	8.6
5	11	3.1	18	5.0
6	4	1.1	8	2.2
7	0	0.0	3	0.8
8	2	0.6	1	0.3
9	0	0.0	1	0.3
Total	359		359	

Motorcycle tyre pressure

Table 6.2.6 shows the tyre inflation pressure of front and rear tyres for all accident-involved motorcycles. All measurements were taken immediately following the accident and therefore the measured tyre pressure was considered to be indicative of the tyre pressure at the time of the accident. The tyre sometimes deflated during the accident events, usually as the result of impact damage (45 front tyres and 5 rear tyres). In these cases, the tyre pressure was coded as unknown.

About one-third the front tyres and 40% of rear tyres were close to the recommended inflation pressure (usually about 200kPa.) About 14% of front and rear tyres were far out of the recommended inflation pressure, as shown in Table 6.2.7.

Although tyres with excessive high or low pressure could reduce braking or cornering ability, and tyres worn smooth could reduce traction in the rain, dynamic tyre failure was rarely involved as an accident contributing factor. There was only one instance in which a tyre problem – a rear tyre blow-out after five hours of highway riding – was the primary accident cause factor.

Table 6.2.6: Inflation pressure of front and rear tyres

Inflation Pressure, (KPa)	Front		Rear	
	Frequency	Percent	Frequency	Percent
< 80	9	2.5	2	0.6
81 – 120	14	3.9	5	1.4
121 – 160	67	18.7	25	7.0
161 – 200	104	29.0	91	25.3
201 – 240	65	18.1	106	29.5
241 – 280	24	6.7	68	18.9
281 – 320	16	4.5	30	8.4
> 320	15	4.2	27	7.5
Unknown	45	12.5	5	1.4
Total	359		359	

Table 6.2.7: Tyre inflation relative to recommended pressure

Tyre inflation proper	Front		Rear	
	Frequency	%	Frequency	%
Unknown, deflated during accident	45	12.5	5	1.4
Inflation within ± 15%	119	33.1	144	40.1
Tyre inflation ±16 - 39%	143	39.8	161	44.8
Tyre grossly underinflated, <40%	25	7.0	11	3.1
Tyre grossly overinflated, over 40%	27		38	
Total	359		359	

Braking evidence on motorcycle tyres

About 96% of cases showed no evidence of front braking and 86% of motorcycles showed no sign of rear braking. (Table 6.2.8).

Table 6.2.8: Braking evidence on front and rear tyres

Braking evidence on tyre	Front		Rear	
	Frequency	%	Frequency	%
None	347	96.7	310	86.4
Locked wheel braking, one skid patch	7	1.9	29	8.1
Heavy braking without wheel lock up	0	0.0	9	2.5
Other	0	0.0	1	0.3
Unknown	5	1.4	10	2.8
Total	359		359	

6.3 Motorcycle frame and suspension

Table 6.3.1 shows the various frame types for the accident involved motorcycles. Frame types tended to vary with motorcycle type. The tubular step-through frame was found on the step-through motorcycles while the perimeter frame, extrusion element type was usually found in sport-design motorcycles. Conventional tube cradle type with either single or double down tube(s) was found in the standard street motorcycle. Almost all frames were steel.

Table 6.3.1: Motorcycle frame type

Frame type	Code	Frequency	
Step-through, formed sheet metal	0	5	1.4
Step-through tubular frame	1	312	86.9
Conventional tube cradle-type with single down tube	2	5	1.4
Conventional tube cradle-type with double down tubes	3	8	2.2
Perimeter frame, extrusion element	7	29	8.1
Total		359	

Front and rear suspension

About 95% of the front suspensions were telescoping tube type with a conventional lower fork leg -- a small diameter upper fork tube that compresses into the larger fork slider (Table 6.3.2). Modification of the front suspension was found in only 7 cases (2%) and usually amounted to nothing more complicated than raising the forks higher in the triple clamps to give the motorcycle a “raked” appearance.

Table 6.3.3 shows the type of rear suspension. Nearly two-thirds were conventional fork swing arm with double exterior tubular shocks. A conventional fork swing arm with mono-shock was another one-third. A few were a combined engine-rear suspension typical of scooters. No modifications were seen. Inoperable rear suspension was noted in one case. There were no cases in which the type of or condition of the rear suspension contributed to accident causation.

Table 6.3.2: Front suspension type

Front suspension type	Code	Front	
		Frequency	Percent
Telescoping tube, conventional lower fork legs	11	342	95.3
Telescoping tube, inverted fork legs	12	1	0.3
Trailing link, single or double sided	17	16	4.5
Total		359	

Table 6.3.3: Rear suspension type

Rear suspension type	Code	Rear	
		Frequency	Percent
Fork swing arm, double exterior tubular shocks	11	231	64.3
Conventional fork swing arm, mono-shock	12	123	34.3
Other	98	5	1.4
Total		359	

6.4 Motorcycle steering adjustment

Loose steering stem adjustment, which can contribute to control difficulty, was found in 14 cases (4%). Despite the risk of control problems, there were no cases in which steering stem maladjustment appeared to cause or contribute to the crash. Adjustment was unknown in 12 cases due to impact damage.

A tubular steering damper on one side of the motorcycle (always an aftermarket modification) was found on only five motorcycles (1.4%) and had no relation to accident involvement.

Motorcycle rear swing arm

A loose rear swing arm was found in 11 cases (3%) of the accident-involved motorcycles. The main source for such rear swing arm problem was a loose pivot bolt in 9 cases and worn bearings in 2 cases.

6.5 Motorcycle brakes

The different brake configurations of the front and rear brakes observed during this study are shown in Table 6.5.1. Disc brakes were almost always hydraulic, while drum brakes were mechanically operated. Front brakes were much more likely than rear to be hydraulically actuated disc brakes (Table6.5.2).

The front brake was working badly or not at all on 28 motorcycles (8%). In 22 of these cases, parts of the brake system were missing. Six motorcycles had extreme wear of the brake friction surfaces that severely limited their usefulness. Only one accident-involved motorcycle had no rear brake, and in two cases the rear brake was inoperable. It is ironic that the front brake was far more likely to be inoperable, because the majority of the motorcycle's stopping power comes from the front brake.

Table 6.5.1: Brake mechanism configuration

Brake type	Front brake		Rear brake	
	Frequency	Percent	Frequency	Percent
None	22	6.1	1	0.3
Drum, single leading shoe	190	52.9	279	77.7
Single disc, single piston	21	5.8	6	1.7
Single disc, multi piston	126	35.1	73	20.3
Total	359		359	

Table 6.5.2: Brake mechanism actuation

Brake actuation type	Front brake		Rear brake	
	Frequency	Percent	Frequency	Percent
Not applicable	22	6.1	1	0.3
Hydraulic	147	40.9	79	22.0
Mechanical	190	52.9	279	77.7
Total	359		359	

6.6 Motorcycle headlamp

Seven out of eight motorcycles (313 of 359 cases) were equipped with a single headlamp. A double headlamp was found in 43 cases (12%). The headlamp had been removed in 3 cases.

Headlamp use

Headlamp usage was almost non-existent in daylight and dusk crashes. In one of every eight night crashes, the rider was riding in darkness without a headlamp illuminated so in effect the other vehicle drivers could not see the motorcycle.

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 as a result violated the rider's right-of-way. In many cases, the OV driver stated that 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. It quickly becomes obvious that the headlamp is the primary source available to provide the high contrast needed to attract attention.

Headlamp usage in the upcountry sampling regions varied with ambient light conditions, which are grouped here into three categories: 1) daytime (bright and not bright), 2) night (with or without street lamps) and, 3) dusk/dawn categories. Table 6.6.1 shows that the headlamp was not operating in about 94% of daytime accidents, 88% of dusk-dawn accidents and 12% of night accidents.

Table 6.6.1: Headlamp use and ambient light

Ambient lighting	Headlamp use				Total
	Off		On		
	Freq	Row %	Freq	Row %	
Daylight	171	94	10	6	181
Night	18	12	134	88	153
Dusk	18	100	0	0	18
Dawn	4	57	3	43	7
Total	211		147		359

6.7 Motorcycle fuel systems

The type of fuel tank depended largely upon the motorcycle type. Step-through frame motorcycles almost always had the tank under the seat. The conventional "saddle-type" fuel tanks located between the rider's knees were found on sport or standard street bikes. All tanks were made of steel in this data set.

Tank retention

All but one of the fuel tanks were completely retained in position throughout the entire accident sequence. The sole exceptions involved one partial separation of the tank from its mounting, and two cases in which the tank completely separated from the motorcycle.

Tank deformation

Only 8% of fuel tanks had any denting, which was usually mild when it occurred. Severe deformation was found in only 1 case (Table 6.7.1). The source of the gas tank deformation was mainly from contact with the handlebars or the rider's body as shown in Table 6.7.2.

Tank failure that allowed fuel to spill occurred in only two cases. In both, a laceration in the tank material was a result from edge or sharp object impact.

Table 6.7.1: Degree of fuel tank deformation

Fuel tank deformation	Code	Frequency	
No tank deformation	0	331	92.2
Mild denting	1	25	7.0
Moderate denting	2	2	.6
Severe damage	3	1	.3
Total		359	

Table 6.7.2: Sources of tank deformation

Fuel tank deformation cause	Frequency	
No tank damage	331	92.2
Contact from motorcyclist's body	7	1.9
Collision contact from other MC parts	12	3.3
Collision contact with other vehicle	4	1.1
Collision contact with roadway surface	1	.3
Collision contact with environment	1	.3
Other	3	.8
Total	359	

Motorcycle fuel cap type

Fuel cap type actually corresponds closely to motorcycle type. Seven-eighths of motorcycles were step through frame types, which tend to have the fuel tank under the seat along with a bayonet-type cap that is covered by the motorcycle seat. However, some covered bayonet type caps were found on saddle-type fuel tanks under a small flip-up cover. Fuel caps that were smooth with the tank top were usually found on sport bikes, while the Monza type fuel caps were usually found on older conventional street motorcycles. Table 6.7.3 shows the distribution of fuel tank cap types.

Table 6.7.3: Types of fuel tank cap

Fuel tank cap type	Frequency	
No tank cap, cap missing	1	0.3
Internal screw type, no ratchet, no cover	1	0.3
Internal screw type, ratchet, no cover	1	0.3
Internal screw type, ratchet, covered, or recessed	1	0.3
Exposed bayonet type, no cover, no guard	2	0.6
Covered, guarded, or recessed bayonet type	322	89.7
Smooth with tank top surface, no cover	26	7.2
Monza, flip-up	5	1.4
Total	359	

The fuel cap remained securely in place in 98% of these accidents, displacing in only six cases (Table 6.7.4). The cap was ejected completely in four cases and partially in two more cases. The majority of those tank caps that opened from collision were covered-guarded or recessed type.

Table 6.7.4 Fuel tank cap retention

Fuel tank cap performance	Frequency	
No tank cap, cap missing	1	0.3
Retained securely, no venting or fuel loss from cap	353	98.3
Not retained, ejected completely from tank body	3	0.8
Opened but remained attached to tank	1	0.3
Displaced sufficiently to allow fuel loss	1	0.3
Total	359	

Motorcycle fuel spills and leaks

The majority of fuel spills occurred after collision. Most were 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 6.7.5. The carburetor vents were the primary source of the fuel leaks, accounting for 60% of the 240 cases in which a leak occurred.

No crash and post-crash fires occurred in any of the 359 accident cases, although moderate fuel spills and large quantities of fuel leaks were found in about 3.4% of all accident cases (Table 6.7.6). Minor leaks of the fuel system occurred in nearly two-thirds of 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 6.7.5: Source of fuel spills or leaks

Fuel source	Frequency	
No fuel spills or leaks	115	32.0
Primary fuel tank	2	.6
Fuel lines and fitting	3	.8
Carburetor	216	60.2
Fuel cap	6	1.7
Other	13	3.6
Unknown	4	1.1
Total	359	

Table 6.7.6: Size of fuel spills

Fuel spill size	Code	Frequency	
None	0	115	32.0
Minor leaks, little or no fire hazard	1	227	63.2
Moderate leak or spill, some fire hazard	2	10	2.8
Large quantity lost with severe fire hazard	3	2	0.6
Other	8	1	0.3
Unknown	9	4	1.1
Total		359	

6.8 Motorcycle exhaust system

The vast majority (97%) of the exhaust systems inspected were original equipment or an original equipment replacement (Table 6.8.1). Most mufflers were in good condition, as shown in Table 6.8.2.

Table 6.8.1: Exhaust system, type

Exhaust system type	Frequency	
Original equipment (OE)	344	95.8
Original equipment replacement or equivalent	7	1.9
Aftermarket accessory	5	1.4
Aftermarket accessory, modified	3	.8
Total	359	

Table 6.8.2: Exhaust system condition

Exhaust condition	Frequency	
Good condition	353	98.3
Worn or damaged	2	.6
Worn or damaged; excessive noise	2	.6
High performance equipment; excessive noise	2	.6
Total	359	

6.9 Other components

Handlebars

The handlebar was mainly the original equipment supplied with the motorcycle (Table 6.9.1). Modification of the handlebar was not found in any case. The handle bar was often made of steel tube (58%) or cast steel with steel tube (42%). There was only 1 motorcycle that the handlebar construction was cast aluminum alloy.

Table 6.9.1: Handlebar inspection

Handlebar type	Frequency	
Original equipment	353	
Clip on	2	
Clubman or racer	4	
Total	359	

Motorcycle throttle

Only three cases involved a badly working throttle, due to cable or return spring problems. In two cases, throttle malfunction made no contribution to the crash. In the third case, the rider mentioned throttle problems but said he crashed because he had been forced off the road by another vehicle, whose existence could not be verified.

Motorcycle foot pegs

Tables 6.9.2 and 6.9.3 show the presence or absence of rider and passenger foot-pegs of the accident-involved motorcycles. Only the scooter models were not equipped with foot-pegs for either the rider or passenger. About 75% of the rider foot-pegs were rigid metal pegs with rubber covers and 20% were rigid metal folding pegs with rubber covers. The passenger foot pegs were mainly metal folding pegs with rubber covers (94.7%), without rubber covers (1.9%), and there were 12 motorcycles without passenger footrest.

Table 6.9.2: Types of rider foot pegs/footrest

Foot peg type	Frequency	
None	6	1.7
Rigid metal pegs, no covers	14	3.9
Rigid metal peg, rubber covers	268	74.7
Metal folding pegs, rubber covers	71	19.8
Total	359	

Table 6.9.3: Types of passenger foot pegs/footrest

Passenger foot peg type	Frequency	
None	12	
Rigid metal folding pegs, no covers	7	
Metal folding pegs, rubber covers	340	
Total	359	

Motorcycle side stand

When side stands were present, they were always original equipment on the left side. All had a metal end or pad at the tip. None of the upcountry accidents involved a situation in which the rider left the side stand in the down position. The data are shown in Table 6.9.4.

Table 6.9.4: Side stand inspection

Side stand type	Frequency	
None	11	
Original equipment, left side, metal end or pad	348	
Total	359	

Motorcycle center stand

The center stand was not equipped in 33 cases (8.9%). When present, they were often the original equipment (Table 6.9.5). Removal of the original center stand was found to have occurred in 2 cases. Only one case of modification to the center stand was found among the accident-involved motorcycles.

Table 6.9.5: Center stand inspection

Center stand	Code	Frequency	
None	0	33	
Original equipment, installed	1	324	
Original equipment, removed	2	2	
Total		359	

6.10 Motorcycle mechanical problems

The major mechanical problems of the accident-involved motorcycles were generally found to be the result of poor motorcycle maintenance as listed in Table 6.10.1. The pre-existing maintenance problems were found in about 9% of motorcycles. Most did not cause or contribute to the accident.

Only the absence of an operating headlamp at night stood out as a serious vehicle related accident cause factor. Most often the lack of a headlamp was the result of rider failure to turn on the headlamp, but in three cases the headlamp components were completely missing. Brakes were sometimes missing or inoperative, but this was never an accident cause factor.

In other instances, rear view mirrors were absent. In most cases this was not a factor, but in at least one accident in Khon Kaen, it may have been a contributing factor when an alcohol-involved rider with two passengers made a lane change across a construction zone in front of a faster-moving OV approaching from behind.

Table 6.10.1: Motorcycle mechanical problems

Problem	Frequency	
Headlamp		
not equipped	3	0.8
Front turn signal		
not equipped	26	7.2
inoperable	3	0.8
Throttle		
poor operation	3	0.8
Clutch lever		
poor operation	1	0.3
Brake lever		
not equipped	9	2.5
Inoperable	7	1.9
Right rear view mirror		
not equipped	177	35.4
Inoperable	1	0.3
Left rear view mirror		
not equipped	131	36.5
Inoperable	1	0.3
Front suspension		
Inoperable	2	0.6
Front brake		
not equipped	22	6.1
Inoperable	6	1.7
Rear brake pedal		
Inoperable	1	0.3
Shift lever		
Inoperable	1	0.3
Rear position lamp		
not equipped	7	1.9
Inoperable	4	1.1
Stop lamp		
not equipped	7	1.9
Inoperable	3	0.9
Rear reflector		
not equipped	193	53.8
Rear turn signal		
not equipped	39	10.9
Inoperable	4	1.1
Rear brake		
not equipped	1	0.3
inoperable	2	0.6

6.11 Other vehicle characteristics

Other vehicle type

Of the 308 motorcycles involved in multiple vehicle accidents, half the other vehicles were some types of passenger vehicle (all sizes of cars plus pickups, sport utility vehicles, and vans) and 39% were another motorcycle (Table 6.11.1). Other accident involved vehicles include a "steel buffalo" which is a small tractor used on Thai farms. It is a two-wheeled, single-axle vehicle steered by two long "tillers." Usually the operator walks along behind the steel buffalo, but it can be hitched to a trailer and then ridden. One steel buffalo towing a small, unlighted trailer at night was involved in a fatal crash on a dirt farm road in Khon Kaen when a drunk rider on a motorcycle without a headlamp rear-ended the trailer.

Table 6.11.1: Other vehicle classification

Other vehicle type	Frequency	
Compact automobile	48	15.6
Sub-compact automobile	6	1.9
Bus	5	1.6
Step-through motorcycle	103	33.4
Motorcycle	16	5.2
Special or other bus	1	0.3
Mini light truck, cargo rating < 454 kg	90	29.2
Full size light truck, cargo rating of $\geq$ 454 kg/1000 lbs	5	1.6
Sport utility vehicle	1	0.3
Commercial truck	6	1.9
Trailer towing vehicle/truck	2	0.6
Tuk Tuk	2	0.6
Full size van with less than 9 seats	3	1.0
"Steel buffalo"	2	0.6
Other	9	2.9
Unknown	9	2.9
Total	308	

Other vehicle manufacturer, cars trucks and buses

Tables 6.11.2 shows the manufacturers of other vehicles including automobiles, truck, buses, etc. The motorcycle manufacturers are listed in Table 6.11.3. Again, Honda motorcycles predominated followed by Suzuki, Yamaha and Kawasaki motorcycles. Only in the Saraburi sampling region were Suzuki motorcycles found to be accident-involved more often than Honda motorcycles.

Table 6.11.2: Other vehicle manufacturers, cars, trucks, buses

Manufacturer	Code	Frequency	
BMW	B2	2	1.1
Daewoo	D2	1	0.5
Daihatsu	D4	1	0.5
Datsun	D5	1	0.5
Ford	F3	4	2.2
Honda	H1	11	6.0
Hino	H2	1	0.5
Hyundai	H4	1	0.5
Isuzu	I3	25	13.7
Mazda	M3	6	3.3
Mercedes Benz	M4	1	0.5
Mitsubishi	M6	14	7.7
Nissan	N1	20	10.9
Opel	O2	2	1.1
Peugeot	P3	1	0.5
Rover, Land Rover	R3	1	0.5
Scania-Varis	S2	1	0.5
Toyota	T1	51	27.9
Volvo	V3	2	1.1
Other	98	5	2.7
Unknown	99	32	17.5
Total	Total	183	

Table 6.11.3: Other vehicle manufacturer as another motorcycle

Manufacturer	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	All Provinces
Honda	8	8	10	5	23	54
	36.4%	20.5%	35.7%	25.0%	54.8%	43.2%
Kawasaki	2	0	2	3	0	7
	9.1%	0.0%	7.1%	15.0%	0.0%	5.6%
Suzuki	3	4	7	7	10	31
	13.6%	10.3%	25.0%	35.0%	23.8%	24.8%
Yamaha	6	0	6	3	5	20
	27.3%	0.0%	21.4%	15.0%	11.9%	16.0%
Unknown	3	1	3	2	4	13
	13.6%	7.7%	10.7%	10.0%	9.5%	10.4%
Total	22	13	28	20	42	125

Other vehicle mass

Table 6.11.4 shows the distribution of the other vehicle curb mass ranging from 10 kilograms (bicycle) to 21,000 kilograms (heavy truck).

Table 6.11.4: Distribution of other vehicle curb mass

Curb mass (Kg)	Frequency	
0 – 50	3	1.0
51 – 250	111	36.0
251 – 400	4	1.3
401 – 1200	35	11.4
1201 – 1500	78	25.3
1501 – 2000	19	6.2
2001 – 10000	4	1.3
10001 – 15000	9	2.9
> 15000	2	.6
Unknown	43	14.0
Total	308	

Mechanical problems in other vehicle

Table 6.11.5 shows the distribution of mechanical problems of the other vehicle involved in collision. Pre-existing maintenance related problems were found in seven motorcycles in motorcycle to motorcycle collisions.

Table 6.11.5: Other vehicle mechanical problems

Other vehicle mechanical problem	Frequency	
No mechanical problem	256	
Other	13	
Unknown	39	
Total	308	

7.0 Motorcycle and Other Vehicle Collision Kinematics

This section summarizes data from the reconstruction of 359 upcountry accident investigation cases. A complete description of the crash kinematics summarizes what happened 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 of the vehicles to each other at impact was recorded. Finally, the post-crash motions of rider, passenger, motorcycle and other vehicle were noted.

7.1 Motorcycle pre-crash motions

Precipitating event

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 precipitating event was the same whether motorcycle movements or other vehicle movements were under consideration. In other words, each accident had only one precipitating event that applied to all vehicles rather than separate PE's for each vehicle.

Motorcycle motion before precipitating event

Motion before the PE describes the normal traffic flow conditions just before the accident occurs. Motion after the PE sometimes describes the change in action that was the PE and other times describes reactions that occurred after the PE. For example, in the first situation above, the other vehicle motion before PE would be, "stopped in traffic, speed is zero;" the motion after PE would be "turning right, accelerating," so the change in motion describes the PE. 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 is usually "going straight, constant speed." In the third example, the motorcycle following too closely, the change in motion before & after PE reflects a reaction to the situation.

Table 7.1.1 shows the distribution of pre-crash motions before the PE for the accident-involved motorcycles in our study. The vast majority (70%) of accident-involved motorcycles were moving in a straight line at constant speed just prior to the PE. No other pre-crash motion exceeded 5%. The next most common maneuvers were "stopped in traffic", "traveling in opposing lanes," "straight, throttle off", "straight, braking" and "right turn constant speed," all of which were in the 3 – 5% range.

Table 7.1.1: Motorcycle motion before precipitating event

Motorcycle motion before PE	Code	Frequency	
Stopped in traffic, speed is zero	0	12	3.3
Moving in a straight line, constant speed	1	252	70.2
Moving in a straight line, throttle off	2	16	4.5
Moving in a straight line, braking	3	12	3.3
Moving in a straight line, accelerating	4	7	1.9
Turning right, constant speed	5	14	3.9
Turning right, throttle off	6	1	0.3
Turning right, accelerating	8	1	0.3
Turning left, constant speed	9	9	2.5
Turning left, braking	11	1	0.3
Stopped at roadside, or parked	13	4	1.1
Changing lanes to right	22	1	0.3
Entering from left shoulder or parked	26	3	0.8
Passing maneuver, passing on right	29	5	1.4
Passing maneuver, passing on left.	30	1	0.3
Wrong way, against opposing traffic	32	15	4.2
Lane-splitting, longitudinal motion only	33	5	1.4
Total		359	

Motorcycle motion after precipitating event

The motorcycle motions after the precipitating event are shown in Table 7.1.2. "Moving straight" accounted for two-thirds of the MC motions, while 18% were making a turn. About 5% of cases were traveling the wrong way, against opposing traffic.

Table 7.1.2: Motorcycle, pre-crash motion after precipitating event

Motorcycle motion after PE	Code	Frequency	
Stopped in traffic, speed is zero	0	4	1.1
Moving in a straight line, constant speed	1	129	35.9
Moving in a straight line, throttle off	2	4	1.1
Moving in a straight line, braking	3	79	22.0
Moving in a straight line, accelerating	4	9	2.5
Turning right, constant speed	5	27	7.5
Turning right, throttle off	6	2	0.6
Turning right, braking	7	9	2.5
Turning right, accelerating	8	10	2.8
Turning left, constant speed	9	7	1.9
Turning left, braking	11	6	1.7
Turning left, accelerating	12	3	0.8
Making U-turn right	17	5	1.4
Making U-turn left	18	1	0.3
Changing lanes to left	21	5	1.4
Changing lanes to right	22	13	3.6
Merging to right	24	2	0.6
Passing maneuver, passing on right	29	10	2.8
Passing maneuver, passing on left.	30	5	1.4
Crossing opposing lanes of traffic	31	3	0.8
Wrong way, against opposing traffic	32	20	5.6
Lane-splitting, longitudinal motion only	33	2	0.6
Other	98	4	1.1
Total		359	

Pre-crash control operations

Approximately 83% of the motorcycle riders were not performing any particular pre-crash control operation just before the PE; they were simply riding straight ahead at a steady speed. Roughly 10% of motorcycle riders were steering or turning and 4% were accelerating prior to the collision. There were no cases in which the pre-crash control operations caused any control problems or appeared to interfere with the operation of the motorcycle. Table 7.1.3 shows the pre-crash control actions just before the precipitating event for the 359 up-country accident investigation cases.

Approximately 27% of riders said that they had their fingers on the front brake lever while riding in traffic. In general, if the fingers are extended to the brake lever, the reaction time should be 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 show that the majority of the accident-involved riders tend to use rear braking as a collision avoidance maneuver more often than the front wheel braking.

Table 7.1.3: Motorcycle control operation before precipitating event

Pre-crash control action	Frequency	
None	299	83.3
Accelerating, upshifting	14	3.9
Decelerating, downshifting	2	0.6
Decelerating, braking	4	1.1
Steering, turning	37	10.3
Other	1	0.3
Unknown	2	0.6
Total	359	

7.2 Motorcycle pre-crash and crash speeds

Each of the 359 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 marks and post-crash trajectory analysis. Occasionally, there was insufficient physical evidence for the speed analysis and the pre-crash speed was based upon on the rider's interview and an estimate of the crash speed required to cause the motorcycle and other vehicle damage.

Pre-crash speeds ranged from 0 to 124 km/hr, with a median speed of 35 kilometres per hour for all 359 cases. One-fourth of the cases had a pre-crash speed below 25 km/hr, and another one-fourth had a pre-crash speed above 50 km/hr.

Crash speeds averaged about 5 km/hr less than pre-crash speeds and had the same range of 0 to 124 km/hr. The median crash speed was 30 km/hr. One fourth of the crash speeds were below 20 km/hr, and another 25% were above 45 km/hr. Table 7.2.2 shows the distribution of crash speeds. The percent distribution of motorcycle pre-crash and crash speeds is shown in Figure 7.2.1. The data illustrated in Figure 7.2.1 can be seen in the Appendix as Table 7.2.1.

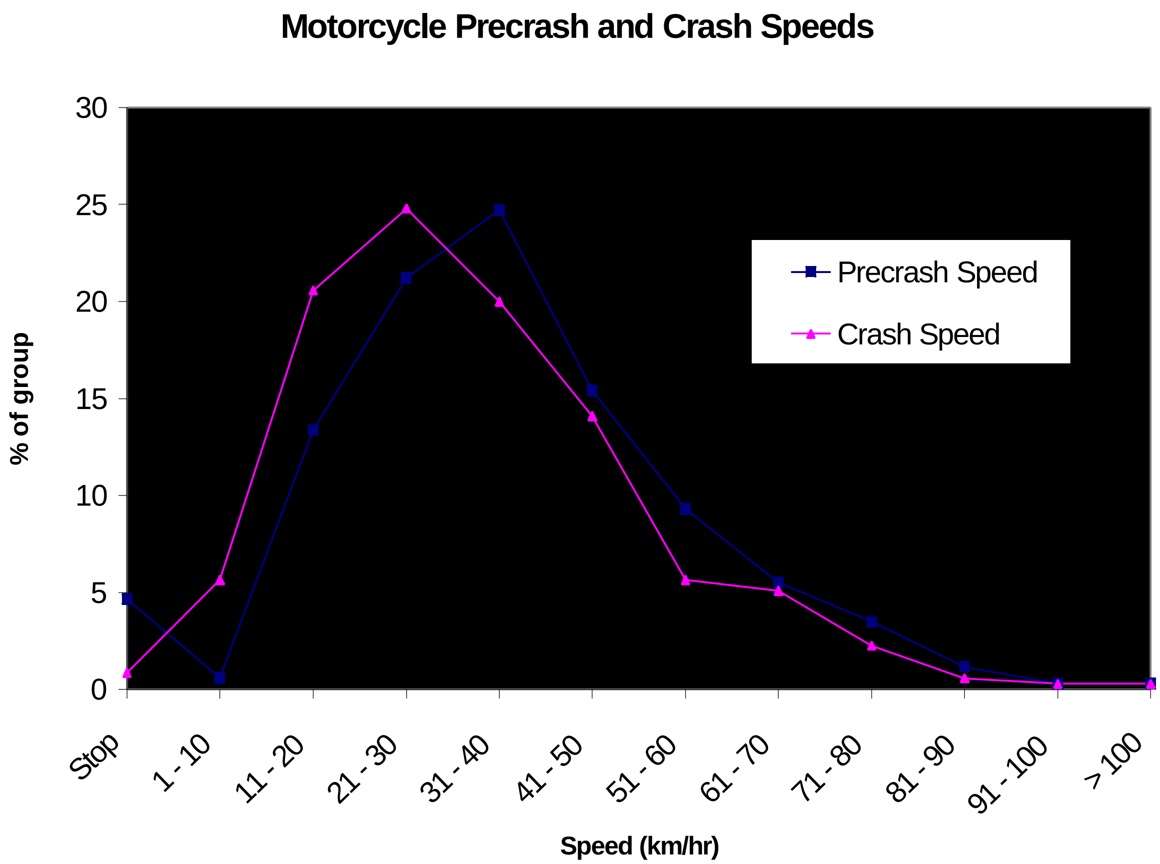


Figure 7.2.1: Percent distribution the pre-crash and crash speeds of the accident-involved motorcycles.

Speeds in fatal accidents

Speeds in fatal accidents averaged approximately 20 km/hr faster than in nonfatal crashes. The median for known pre-crash speeds in fatal cases was 53 km/hr, compared to 35 km/hr in non-fatal cases. Similarly, the median crash speeds were 50.5 km/hr in fatal cases and 30 km/hr in non-fatal crashes. The data are shown in Tables 7.2.2 (pre-crash speeds) and 7.2.3 (crash speeds).

Table 7.2.2: Pre-crash speed of fatal and non-fatal crashes

Motorcycle pre-crash speed (km/hr)	Fatal injuries involved		Total
	No	Yes	
Stop	16	0	16
1 – 10	2	0	2
11 – 20	46	0	46
21 – 30	72	1	73
31 – 40	84	1	85
41 – 50	51	2	53
51 – 60	30	2	32
61 – 70	17	2	19
71 – 80	10	2	12
81 – 90	4	0	4
91 – 100	1	0	1
> 100	1	0	1
Unknown	12	3	15
Total	346	13	359

Table 7.2.3: Crash speed of fatal and non-fatal accidents

Motorcycle crash speed (km/hr)	Fatal injuries involved		Total
	No	Yes	
Stop	3	0	3
1 – 10	19	1	20
11 – 20	73	0	73
21 – 30	86	2	88
31 – 40	70	1	71
41 – 50	48	2	50
51 – 60	19	1	20
61 – 70	16	2	18
71 – 80	6	2	8
81 – 90	2	0	2
91 – 100	1	0	1
> 100	1	0	1
Unknown	2	2	4
Total	346	13	359

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 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.

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 the other vehicle to the motorcycle) provides information regarding that part of the motorcycle was exposed to the view of the other vehicle driver.

Figure 7.3.1 shows the distribution for the pre-crash lines-of-sight from the motorcycle to the other vehicle for the 292 cases that involved another vehicle. No data regarding line-of-sight was coded for single vehicle collisions or for any cases where the motorcycle impacted a pedestrian, an animal or a fixed object.

The highest concentration of line-of-sight orientations was at 1 o'clock, followed by 11 and 12 o'clock, with two-thirds of the hazards in that one quadrant in front of the motorcycle rider. When the line-of-sight from the motorcycle to other vehicle is in the 11-12-1 o'clock range, the other vehicle driver would see mainly the front end of the motorcycle. Therefore, improvements in conspicuity should focus on the front of the motorcycle and the rider.

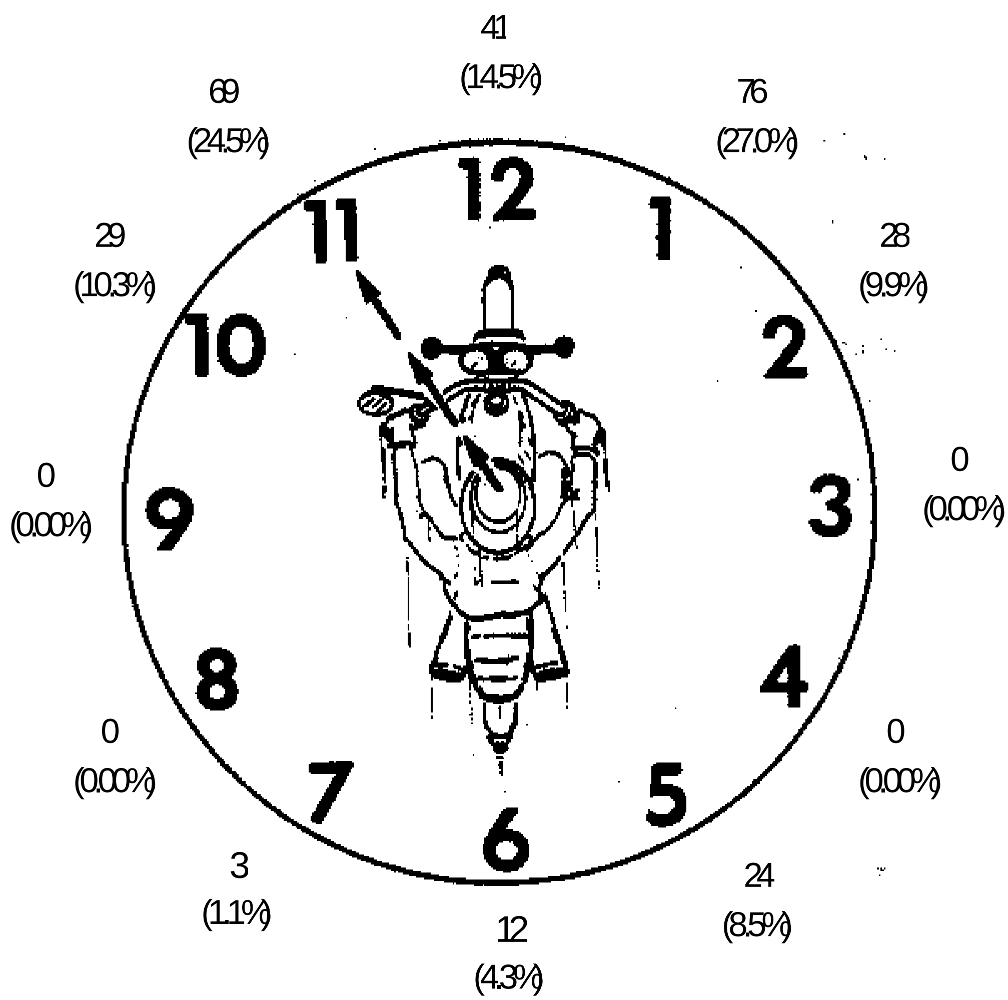


Figure 7.3.1: Pre-crash line-of-sight from motorcycle to the other vehicle

The 11% of accidents that occurred with a pre-crash line-of-sight in the 5-6-7 o’clock quadrant also suggest the need for more conspicuous rear lamps and rear reflectors.

Pre-crash lines of sight were distributed about the same over the different ambient lighting conditions of day, night and dusk-dawn, as shown in Table 7.3.1. The most notable exception occurs at the 11 o'clock line-of-sight, where the percentage of daylight accidents was higher than for night or dusk-dawn.

Nearly half (133/282) of the multiple vehicle accidents occurred during the night and dusk-dawn. The motorcycle was approaching the other vehicle with a pre-crash line of sight between 10 and 2 in 117 (88%) of those cases. If the 18 non-daylight cases in which the motorcycle rear-ended the other vehicle are eliminated, then 75% of night crashes (99/133) involved the other vehicle having a view of the front of the motorcycle in the moments just before the collision.

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

MC-to-OV line of sight	Ambient lighting condition						Total
	Daylight		Night		Dusk-Dawn		
	Freq	%	Freq	%	Freq	%	
1 o’clock	41	25.8	31	27.2	4	21.1	76
2 o’clock	14	8.8	9	7.9	5	26.3	28
5 o’clock	17	10.7	6	5.3	1	5.3	24
6 o’clock	6	3.8	6	5.3	0	0.0	12
7 o’clock	0	0.0	3	2.6	0	0.0	3
10 o’clock	15	9.4	12	10.5	2	10.5	29
11 o’clock	47	29.6	19	16.7	3	15.8	69
12 o’clock	19	11.9	28	24.6	4	21.1	41
Total	159		114		19		282

Table 7.3.2 shows the combined pre-crash lines-of-sights between the motorcycle and the other vehicle. The rider and other vehicle driver saw each other in the front half of the visual field (10-to-2 o'clock line-of-sight) in more than half (158 of 292) of the multiple-vehicle accidents. Another important line-of-sight combination occurred in 27 accidents in which the other vehicle made a U-turn or lane change into the path of a motorcycle approaching from the rear. In this situation the lines-of-sight were 11 o'clock from motorcycle rider to other vehicle, and 5 o'clock from other vehicle driver to the motorcycle. Together these line-of-sight combinations accounted for nearly two-thirds (185 of 292) of the multiple-vehicle accidents. The other vehicle driver error was the primary contributing factor in 104 (56%) of those.

While these data do not prove that other vehicle drivers failed to see the motorcycle in many accidents where they should have, it certainly suggests that motorcycle frontal conspicuity may be a contributing factor in about one-third of motorcycle to other vehicle crashes.

Table 7.3.2: Combined line-of-sight between motorcycle and OV

		Other vehicle line-of-sight to motorcycle										
MC line-of-sight to OV		1	2	4	5	6	7	8	10	11	12	Total
	1	44	2	0	1	0	15	0	6	7	1	76
	2	0	0	0	0	0	0	2	14	12	0	28
	5	0	0	0	0	0	0	0	0	23	1	24
	6	0	0	0	0	0	0	0	0	0	12	12
	7	3	0	0	0	0	0	0	0	0	0	3
	10	5	24	0	0	0	0	0	0	0	0	29
	11	4	13	1	40*	0	1	0	1	9	0	69
	12	1	1	0	2	33	0	0	0	1	13	51
	Total	57	40	1	43	33	16	2	21	52	27	292

?? Includes 21 OV U-turns and 6 OV unsafe lane changes

7.4 Motorcycle collision avoidance

Each one of the 359 on-scene, in-depth accident cases was completely reconstructed and evaluated in order to determine the collision avoidance actions of the motorcycle rider. There were several cases in which it was not possible to determine these collision avoidance actions, either due to a motorcycle rider fatality or a motorcycle hit and run accident. These cases were coded as unknown. Table 7.4.1 shows the evasive actions taken by the accident-involved motorcyclists.

Table 7.4.1: Evasive action taken by the rider

Evasive action taken	Code	Motorcycle rider	
		Frequency	Percent
None, continuation	01	191	46.5
Honk horn	02	2	0.5
Flashing headlamp high beams	03	1	0.2
Rear braking	04	78	19.0
Front braking	05	27	6.6
Swerve	07	89	21.7
Jump or bail out	12	1	0.2
Braking, unknown which wheel(s)	13	17	4.1
Other	98	2	0.5
Unknown	99	3	0.7
Total		411	

In accident-involved motorcycles, it was expected that this type of analysis would show collision avoidance problems that could be related to detection, decision or reaction failures. About half of riders did not take any evasive action. The most frequent collision avoidance action performed by the riders was swerving. The second most frequent was rear braking.

Table 7.4.1 also shows that nearly half (46%) of the accident-involved motorcycle riders did not take any evasive action. There can be a variety of reasons that a rider takes no evasive action. One is that the accident happens so fast that the rider has no time to take action. Alternatively, the rider may fail to detect a problem, or detect a problem too late.

Some examples of typical accidents where there was no evasive action include:

1. A motorcycle rider stopped in traffic is rear-ended by the other vehicle.

2. Another collision occurs immediately in front of the rider, forcing a vehicle directly into the path of the motorcycle.

3. The motorcycle rider fails to notice oil spilled on a rain-slick roadway and immediately loses control and the motorcycle capsizes.

4. An OV runs a red light at an intersection, striking the motorcycle. Buildings obstructed 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. An alcohol-involved rider runs off a right-hand curve without any evasive action.

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

Based on the analysis of each accident case, detection failures were the most frequent reason for no evasive action. In some cases the rider failed to detect a plainly visible hazard (example 7 above), while in other cases it was impossible to detect the hazard (examples 3 and 4 above). Decision failures (example 5) and reaction failures (example 6) occurred less frequently.

There were 31 cases (13%) similar to examples 1 & 2 in which the riders took no collision avoidance action because no action was possible. 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 OV was coded as a detection failure.

Reaction failures were usually coded for situations like 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 or had taken drugs, while “strategic” failures were those that occurred in the absence of alcohol or drugs.

Table 7.4.2: Reason for rider failure to take evasive action

No evasive action due to	Code	Motorcycle rider	
		Frequency	Percent
Strategic detection failure	2	82	34.6
Impairment detection failure	3	49	20.7
Strategic decision failure	4	31	13.1
Impairment decision failure	5	20	8.4
Strategic reaction failure	6	6	2.5
Impairment reaction failure	7	14	5.9
No failure	8	31	13.1
Unknown	9	4	1.7
Total		237	

Evasive action evaluation

If the rider took evasive action, his choice of evasive action may be correct or incorrect, and the 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 pulled 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 to be the “best” response, as front-and-rear braking most often would be. Rear-only braking was almost always coded an incorrect choice of evasive action.

In a similar manner, “proper execution” was coded “yes” only if the rider showed 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 execute it skillfully and 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 162 cases in which both the choice and the execution of the evasive action were evaluated. In the other 194 upcountry cases, either no evasive action was taken or, in three cases, the investigators were unable to decide.

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

Evasive action evaluation	Proper execution				Total	
	No		Yes			
Proper choice	Freq		Freq		Freq	
No	51		41		92	
Yes	47		23		70	
Total	98		64		162	

Table 7.4.3 also shows that only 43% of riders who took evasive action (19% of al 359 cases) made the proper choice. Only 40% of those who took evasive action (23% of 359 cases) executed their chosen evasive action properly. Only 14% of those who took evasive action (6% of 359 cases) chose the proper evasive action AND executed it properly.

Table 7.4.4 shows the reason that collision avoidance maneuvers failed to avoid a collision. In one-fourth of all cases evasive action failure was due to a decision failure. Forty percent of the time that riders took evasive action, the failure to avoid a collision was due to inadequate time available, and in 20% of cases the rider lost control while performing the collision avoidance maneuver. In about 10% of all cases there was a reaction failure.

In this study many accident-involved motorcycle riders used only the rear brake. The failure to use the front brake is a critical element in collision avoidance because proper use of the front and rear brake greatly increases the braking power of the motorcycle. In some cases the use of both brakes would have avoided the collision or at least greatly reduced the impact speed and thus reduced the potential for serious injury.

Table 7.4.4: Evaluation of evasive action, motorcycle rider

Collision avoidance failed due to	Frequency	
Decision failure	44	26.7
Reaction failure	17	10.3
Inadequate time available	66	40.0
Loss of control	34	20.6
Other	4	2.4
Total	165	

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 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.

7.5 Motorcycle loss of control

Motorcycles are single-track vehicles that balance on two wheels and therefore, can lose control in ways completely unlike conventional two-track vehicles such as cars and trucks.

There was a documented motorcycle loss of control in 74 cases. Running off the road was the most common, accounting for over one-third of loss-of-control cases. It was usually not related to excessive speed entering a turn; far more often the rider had been drinking alcohol (21 of 28 cases) and simply failed to steer properly or failed to steer at all. Riders also ran off straight roads, especially when they had consumed alcohol; at other times riders crossed into the opposing lanes and collided with an oncoming vehicle. The typical outcome of running off the road was a collision with some part of the environment.

"Slide out" and "high side" loss of control occur when the either or both wheels lose traction and slide across the pavement. They were usually due to errors of braking, most often skidding the rear wheel while trying to swerve. Over braking at the front causes the front wheel to lock up, usually with an immediate fall. Capsize was defined as simply falling over at very low speed on the pavement. Table 7.5.1 shows the frequency of the loss of control.

Table 7.5.1: Motorcycle loss of control mode

Motorcycle loss of control mode	Code	Motorcycle rider	
		Frequency	Percent
No loss of control	00	285	79
Capsize/ fall over	01	15	4
Braking slide-out, low side	02	21	6
Braking slide-out, high side	03	2	1
Cornering slide out, low side	04	1	0
Cornering slide-out high side	05	1	0
Ran wide on turn	06	28	8
Loss wheelie	07	1	0
Continuation	14	2	1
Other	98	2	1
Unknown	99	1	0
Total		359	

7.6 Rider position on motorcycle just before impact

All but two accident-involved riders were in the normal riding position. In one case, a rider and passenger jumped off a stopped motorcycle just before a large truck making a right turn ran over and crushed the motorcycle. Occasionally, riders commented that they lifted a leg to avoid the impact with the other vehicle. However, this was not considered an abnormal riding position prior to impact. Data regarding rider position are shown in Table 7.6.1.

Table 7.6.1: Riding position on motorcycle

Riding position at time of crash	Frequency	
Normal seating position	357	
Dismounting, jumping to side	1	
Dragging feet, foot down	1	
Total	359	

7.7 Time from precipitating event to impact

In general, the time available to the motorcycle rider for collision avoidance begins with the initiation of the precipitating event (PE) and terminates with the impact. The median time from PE to impact was 1.9 seconds. Twenty-five percent of these crashes occurred within one second or less of the PE, while 75% occurred with less than 3 seconds from PE to impact. Table 7.7.1 shows the frequency distribution of the time from precipitating event to impact for all 359 on-scene, in-depth accident investigation cases.

Table 7.7.1: Time from precipitating event to impact

Time (sec)	Frequency	
0 - 0.5	38	10.6
0.6 – 1.0	29	8.1
1.1 – 1.5	73	20.3
1.6 – 2.0	40	11.1
2.1 – 2.5	51	14.2
2.6 – 3.0	33	9.2
3.1 – 3.5	19	5.3
3.6 – 4.0	14	3.9
4.1 – 4.5	8	2.2
4.6 – 5.0	4	1.1
> 5.0	6	1.7
Unknown	44	12.3
Total	359	

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.

7.8 Collision contact on the motorcycle

Figure 7.8.1 shows the distribution of first collision contacts for the 359 on-scene, in-depth accident investigation cases. In about one-fourth of cases, the collision contact was located at the center front of the motorcycle, including the front tyre and wheel, fender, and forks. Another 21% and 17% of collision contacts were at the left and right front of the accident-involved motorcycle. When these three regions are combined, about two-thirds of the motorcycle collision contacts were frontal impacts.

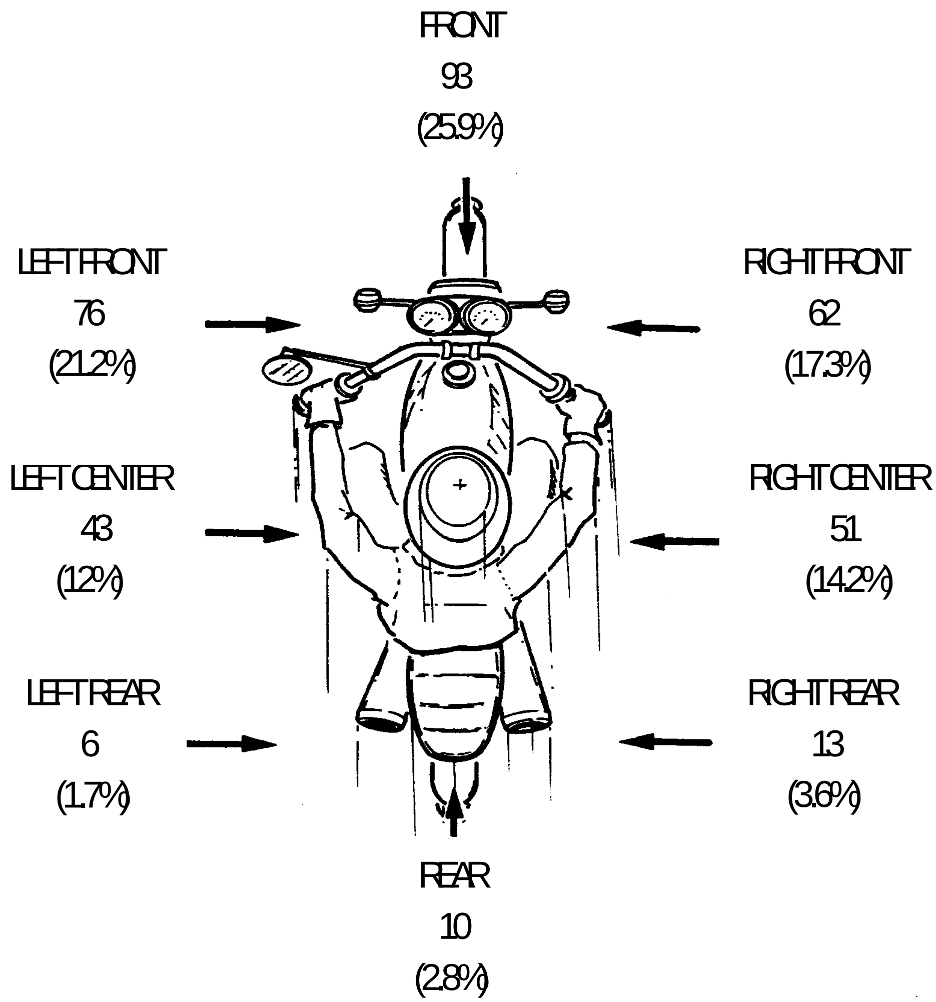


Fig. 7.8.1: First collision contact on the accident-involved motorcycle

7.9 Post-crash motions of the motorcycle, rider and passenger

The majority of the motorcycles skidded and slid from point-of impact (POI) to point of rest (POR), accounting for 56% of all accidents investigated. Table 7.9.1 shows the motion of the accident-involved motorcycle after the collision for 359 upcountry on-scene, in-depth accident cases.

Table 7.9.1: Motorcycle post-crash motion

Motorcycle post-crash motion	Code	Frequency	
Stopped at point of impact (POI)	0	25	7.0
Stopped within 2 m of POI	1	27	7.5
Rolled on wheels from POI to POR	2	12	3.3
Rolled on wheels from POI, then impacted other object at POR	3	4	1.1
Vehicle rollover from POI to POR	4	1	0.3
Skidded, slid from POI to POR	5	201	56.0
Skidded, slid from POI, then impacted other object at POR	6	22	6.1
Run over at POI	10	1	0.3
Run over, dragged from POI to POR	11	6	1.7
Caught by or landed on OV; carried to POR, different from other vehicle POR	12	1	0.3
Engaged, entangled, or entrapped with OV (other than run over); POR same as OV POR	13	7	1.9
Vehicles did not separate; PORs are essentially same for motorcycle and OV	15	12	3.3
Spun or yawed, sliding from POI to POR	16	25	7.0
Other	98	15	4.2
Total		359	

Most riders (43%) did not separate from the motorcycle until they were at or near their POR. About 10% of the riders stopped at or near the point of impact (POI), while one-fourth skidded and slid from POI to POR. Three riders were run over and dragged from POI to the POR and all three were killed. The distribution of the rider post-crash motions is shown in Table 7.9.2. Passenger post-crash motions were essentially very similar to those of the rider as shown in Table 7.9.3

Table 7.9.2: Rider post-crash motion

Rider post-crash motion	Code	Frequency	
Stopped at point of impact (POI)	1	11	3.1
Stopped within 2 m of POI	2	21	5.8
Tumbled and rolled from POI to POR	3	28	7.8
Tumble from POI, impact other object at POR	4	1	0.3
Skidded, slid from POI to POR	6	94	26.2
Slid from POI, impacted other object at POR	7	5	1.4
Vaulted above ride height, then rolled to POR	8	7	1.9
Vaulted above ride height, then slid to POR	9	17	4.7
Vaulted above ride height from POI, then impacted other object at POR	10	1	0.3
Run over, dragged from POI to POR	12	3	0.8
Caught by or landed on OV, carried to POR, different from OV POR	13	11	3.1
Did not separate from motorcycle	15	157	43.7
Other	98	3	0.8
Total		359	

Table 7.9.3: Passenger post-crash motion

Passenger post-crash motion	Code	Frequency	
Stopped at point of impact (POI)	1	6	3.7
Stopped within 2 m of POI	2	18	11.1
Tumbled and rolled from POI to POR	3	9	5.6
Skidded, slid from POI to POR	6	51	31.4
Slid from POI, impacted other object at POR	7	4	2.5
Vaulted above ride height, then rolled to POR	8	3	1.9
Vaulted above ride height POI, then slid to POR	9	7	4.3
Caught by or landed on OV, carried to POR, different from OV POR	13	5	3.1
Did not separate from motorcycle	15	58	35.8
Other	98	1	0.6
Total		162	

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

About one-fourth of the riders and passengers were found to be within 2 metres from POI. The median distance was 5.4 metres for the riders and 4.2 metres for the passenger. Table 7.9.4 shows the distance between POI and POR of the accident-involved riders and passengers.

Table 7.9.4: Rider and passenger distance from POI to POR

POI to POR distance (m)	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Stopped at POI	18	5.0	8	4.9
0.6 – 2.0	53	14.8	33	20.4
2.1 – 4.0	69	19.2	39	24.1
4.1 – 6.0	50	13.9	20	12.3
6.1 – 8.0	34	9.5	9	5.6
8.1 – 10.0	25	7.0	10	6.2
10.1 – 15.0	38	10.6	17	10.5
15.1 – 20.0	29	8.1	12	7.4
> 20.0	35	9.7	8	4.9
Unknown	8	2.2	6	3.7
Total	359	100.0	162	

7.10 Other vehicle pre-crash motions

About two-thirds of the accident-involved other vehicles were moving in a straight line before the precipitating event, while 15% were stopped in traffic or parked at roadside (Table 7.10.1).

Table 7.10.1: Other vehicle pre-crash motion before precipitating event

Other vehicle pre-crash motion before PE	Code	Frequency	
Stopped in traffic, speed is zero	1	13	4.2
Moving in a straight line, constant speed	2	154	50.0
Moving in a straight line, throttle off	3	35	11.4
Moving in a straight line, braking	4	22	7.1
Moving in a straight line, accelerating	5	7	2.3
Turning right, constant speed	6	6	1.9
Turning right, throttle off	7	2	0.6
Turning left, constant speed	10	7	2.3
Turning left, braking	12	1	0.3
Turning left, accelerating	13	3	1.0
Stopped at roadside, or parked	14	28	9.1
Changing lances to right	23	1	0.3
Merging to left	24	1	0.3
Entering traffic from left shoulder or parked	27	1	0.3
Passing maneuver, passing on right	30	7	2.3
Crossing opposing lanes of traffic	32	1	0.3
Travelling wrong way, against opposing traffic	33	10	3.2
Stripe-riding, longitudinal motion only	34	2	0.6
Other	98	6	1.9
Unknown	99	1	0.3
Total		308	

Other vehicle motion after precipitating event

The most common OV motion after the precipitating event was proceeding in a straight line with or with out braking (42%). One-fourth of other vehicles were making a turning motion, while 8% made a U-turn to the right. Table 7.10.2 shows the other vehicle pre-crash motion after the precipitating event.

Table 7.10.2: Other vehicle pre-crash motion after precipitating event

Other vehicle pre-crash motion after PE	Code	Frequency	
Stopped in traffic, speed is zero	1	6	1.9
Moving in a straight line, constant speed	2	71	23.1
Moving in a straight line, throttle off	3	2	0.6
Moving in a straight line, braking	4	50	16.2
Moving in a straight line, accelerating	5	6	1.9
Turning right, constant speed	6	20	6.5
Turning right, throttle off	7	4	1.3
Turning right, braking	8	12	3.9
Turning right, accelerating	9	15	4.9
Turning left, constant speed	10	15	4.9
Turning left, throttle off	11	1	0.3
Turning left, braking	12	6	1.9
Turning left, accelerating	13	2	0.6
Stopped at roadside, or parked	14	15	4.9
Backing up, steering left	15	1	0.3
Making U-turn right	18	23	7.5
Changing lanes to left	22	9	2.9
Changing lances to right	23	9	2.9
Entering traffic from left shoulder, median, or parked	27	1	0.3
Passing maneuver, passing on right	30	6	1.9
Passing maneuver, passing on left	31	1	0.3
Crossing opposing lanes of traffic	32	2	0.6
Traveling wrong way	33	18	5.8
Stripe-riding between lanes, longitudinal motion only	34	2	0.6
Other	98	10	3.2
Unknown	99	1	0.3
Total		308	

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

The highest concentration of pre-crash lines of sight from the other vehicle to the motorcycle was frontal. In approximately two-thirds of the cases, the other vehicle driver would see the motorcycle ahead or to the side, between 10 to 2 o'clock using the clock face system. Once again, the data confirmed that frontal conspicuity is an important issue in motorcycle accidents. The distribution of the pre-crash line-of-sight from the other vehicle to the accident-involved motorcycle is shown in Table 7.11.1. Similar to the accident-involved motorcycle pre-crash line-of-sight, two-thirds fall in the 10 to 2 o'clock range.

Table 7.11.1: Pre-crash line-of-sight from other vehicle to motorcycle

Other vehicle-to-motorcycle line of sight	Frequency	
1	66	21.4
2	40	13.0
4	1	0.3
5	47	15.3
6	34	11.0
7	16	5.2
8	2	0.6
10	21	6.8
11	54	17.5
12	27	8.8
Total	308	

7.12 Other vehicle pre-crash and crash speeds

The median pre-crash speed was found to be 24 km/hr and the median impact speed was 21 km/hr. The pre-crash speed was not known in 37 cases (12%) due to insufficient physical evidence or a hit-and-run situation. The relationship between the pre-crash and crash speeds is illustrated in Figure 7.12.1.

About 5% of accident-involved vehicles showed no collision contact and 31 cases (10%) occurred when the other vehicle was either stopped waiting in traffic or parked at the roadside. Data regarding other vehicle pre-crash and crash speeds are shown in Table 7.12.1 in the Appendix.

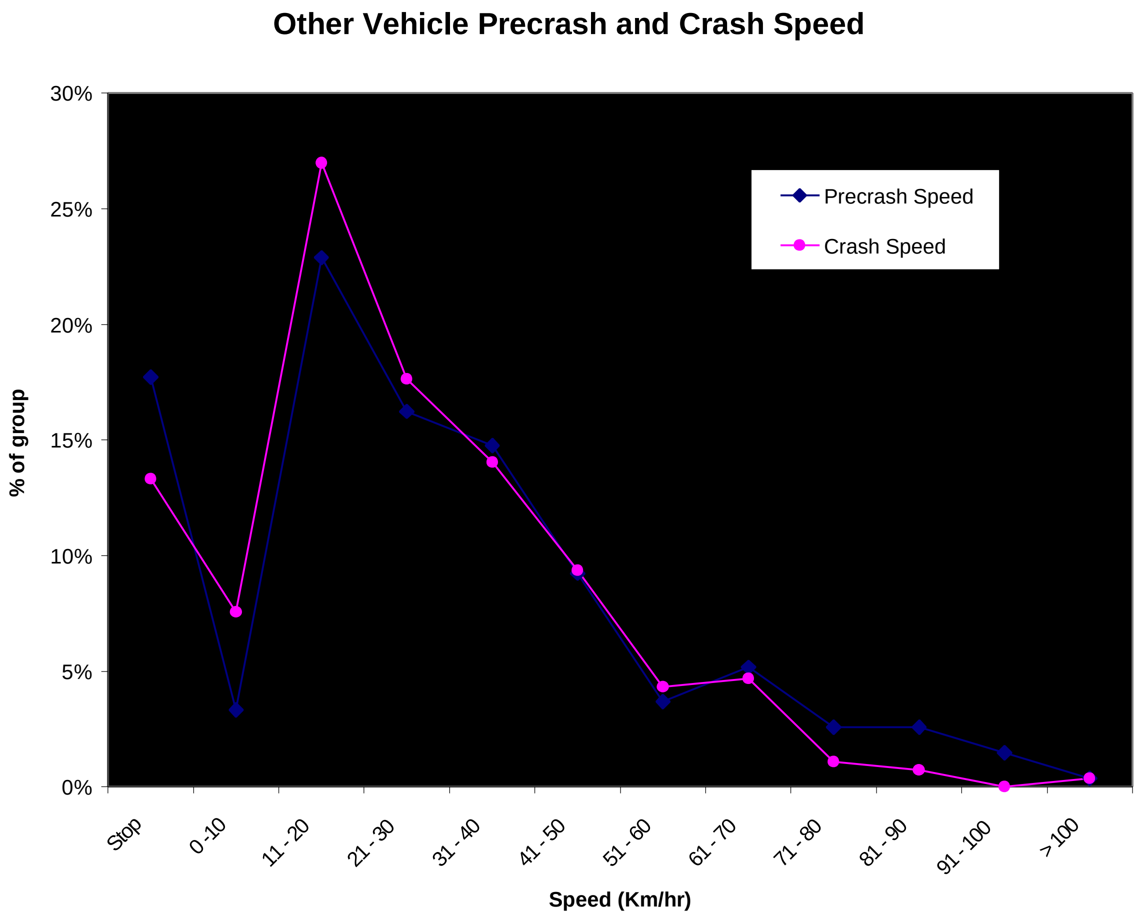


Fig. 7.12.1: The distribution of other vehicle pre-crash and crash speeds

7.13 Other vehicle collision avoidance action

Nearly two-thirds of the accident-involved drivers did nothing to avoid the collision. Of course, no collision avoidance action occurred in 19 cases when the other vehicle was a parked or abandoned vehicle. Table 7.13.1 shows the collision avoidance action taken by the driver of the other vehicle. About one-fourth of the drivers used braking with or without steering as the collision avoidance action.

When evasive actions were taken the other vehicle drivers often chose the proper actions and properly executed the proper actions.

Table 7.13.1: Other vehicle collision avoidance actions

Collision avoidance action	Other vehicle drivers	
	Frequency	Percent
No driver, OV left parked in traffic	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	

The reason the other vehicle driver failed to take evasive action was determined in each case, and the results are shown in Table 7.13.2. Half of the other vehicle drivers who failed to take any collision avoidance action did so because of "strategic" (i.e., non-impaired) failures to detect the collision threat.

Table 7.13.2: Other vehicle, cause of continuation

Reason for no evasive action	Code	Frequency	
Strategic detection failure	2	109	51
Impairment detection failure	3	13	6
Strategic decision failure	4	33	16
Impairment decision failure	5	6	3
Strategic reaction failure	6	1	0
Other	8	36	17
Unknown	9	14	7
Total		212	

Other vehicle collision avoidance evaluation

As with motorcycles, the other vehicle driver who takes avoidance action can make an error either in the action he or she chooses, or in the way in which the chosen action is carried out. These possibilities were reviewed as part of the reconstruction of each case, and the results are shown for all 308 other vehicles in Table 7.13.3.

When an OV driver took evasive action, about half chose the proper action (44 of 91) and half did not (47 of 91). This percentage is roughly comparable to the 43% of motorcycle riders made the correct choice. However, unlike motorcyclists, other vehicle drivers were much more like to execute the evasive action properly (65% versus 40%).

About half the time that collision avoidance actions failed, the reason was too little time to successfully complete the avoidance maneuver.

Table 7.13.3: Other vehicle collision avoidance evaluation

Collision avoidance evaluation	Frequency	
Evasive action proper for situation		
Not applicable	215	70
No	47	15
Yes	44	14
Unknown	2	1
Total	308	
Evasive action properly executed		
Not applicable	215	70
No	25	8
Yes	65	21
Unknown	3	1
Total	308	
Failed avoidance due to		
Not applicable	215	70
Decision failure	24	8
Reaction failure	16	5
Inadequate time available	45	15
Loss of control	1	0
Other	4	1
Unknown	2	1
Total	308	

7.14 Comparison of motorcycle and other vehicle collision avoidance

When evasive action was taken, the other vehicle drivers were more likely to execute it properly (68% compared to 39%.) The reasons for this are probably related to the relative complexity of the motorcycle controls relative to an automobile. In a car, the driver can do two very simple maneuvers: turn the wheel, or slam on the single brake pedal in order to cause prodigious braking force at all wheels. Neither swerving nor braking a car requires great skill, and even if the tyres skid, the car will not fall over on its side as a motorcycle is likely to do.

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 is another level of control complexity. Combined braking and swerving, which is often needed, requires skilled modulation of front and rear brakes, refined counter-steering and leaning.

7.15 Collision contact location on other vehicle

As with motorcycles, most collision contacts on the OV were to the front or front-side of the other vehicle (Table 7.15.1). Some of the most common contacts are summarized below, and a complete listing appears in the Appendix.

Table 7.15.1: Points of collision contact on the other vehicle

Collision contact	Code	Frequency	
Automobile, Van, Bus, Truck			
Front bumper	F01X	44	14.3
Side of front bumper	S01X	30	9.7
Side corner	S02X	12	3.9
Front tyres	S05X	15	4.9
Front door, front	S10X	8	2.6
Motorcycle as an OV			
Right front	MCRF	29	9.4
Center front	MCCF	27	8.8
Left front	MCLF	21	6.8
Tuk-Tuk			
Right front	TTRF	1	0.3
Left front	TTLF	1	0.3

7.16 Other vehicle post-crash motion

Nearly 1 in 7 accidents (47 of 308) were hit-and-run and another 12 drivers of non-contact other vehicles fled the scene. These 59 vehicles leaving the scene represented nearly 20% of the involved other vehicles. Table 7.16.1 shows the other vehicle post-crash motion. About one-third of other vehicles simply skidded to a stop after the crash.

Table 7.16.1: Other vehicle post-crash motion

Other vehicle post-crash motion	Code	Frequency	
Stopped at point of impact(POI)	1	37	12.0
Stopped within 2 m of POI	2	13	4.2
Rolled on wheels from POI to POR	3	58	18.8
Rolled on wheels, impacted other object at POR	4	3	1.0
Skidded, slid from POI to POR	6	103	33.4
Skidded from POI, impacted other object at POR	7	4	1.3
Vehicles did not separate; POR's same	16	17	5.5
Spun or yawed, sliding from POI to POR	17	7	2.3
Hit and run, driver fled in OV	18	41	13.3
Driver fled scene but left OV at scene	19	6	1.9
Other	98	19	6.2
Total		308	

Other vehicle distance traveled after impact

Table 7.16.2 shows the distribution of distances between the other vehicle POI and POR. About one-fourth of the time, the distance from POI to POR was 2 metres or less. The median distance from POI to POR was 4.8 metres.

Table 7.16.2: Other vehicle POI - POR distance

Distance from POI to OV POR (m)	Frequency	
Stop At POI	41	13.3
0.6 - 2.0	36	11.7
2.1 - 4.0	30	9.7
4.1 - 6.0	27	8.8
6.1 - 8.0	15	4.9
8.1 - 10.0	17	5.5
10.1 - 15.0	23	7.5
15.1 - 20.0	17	5.5
> 20.0	21	6.8
OV no contact	15	4.9
Unknown	66	21.4
Total	308	

8.0 Human Factors – General

This chapter describes the general characteristics of the motorcycle rider, passenger and the driver of other vehicle involved in the accident. Findings regarding variables such as age, gender, driver's 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 specific data, which relate to the collision, are also included, such as alcohol involvement, stress, attention to riding and driving, rider position, passenger location on motorcycle and recommended countermeasures.

8.1 General characteristics of riders, passengers & other vehicle drivers

Age

. The youngest rider was 12 years old and the oldest rider was 71 years. The median age was 25 years. About one-third of all riders were 21 to 30 years and one-third were under the age of 21 year. About 15% were over 40 years.

Passengers tended to be younger than riders. The youngest passenger was 1 year old, and the oldest was 71 years. The median passenger age was 19 years. Fifteen passengers were below the age of 10 years, and about 44% were 11 to 20 years.

Other vehicle drivers tended to be older than motorcycle riders and passengers, with a median age of 31 years. About 43% of the drivers were 21 to 40 years and for 20% age was unknown, usually because they fled the scene after the crash. The age distribution of the motorcycle riders, passengers and other vehicle drivers is shown in Figure 8.1.1. Data underlying Figure 8.1.1 is presented in Table 8.1.1 in the Appendix.

Table 8.1.2 shows the distribution of motorcycle rider age in fatal and nonfatal crashes. The median age of the fatally injured riders was 31 years. The youngest rider in a fatal accident was 18 years old and the oldest was 69. About two-thirds of fatal cases were 21 to 40 years old.

Table 8.1.2: Rider age in fatal & non-fatal crashes

Rider's age (years)	Fatal injuries involved		Total
	No	Yes	
11 – 20	111	1	112
21 – 30	123	4	127
31 – 40	60	4	64
41 – 50	34	2	36
51 – 60	12	0	12
> 60	7	1	8
Total	347	12	359

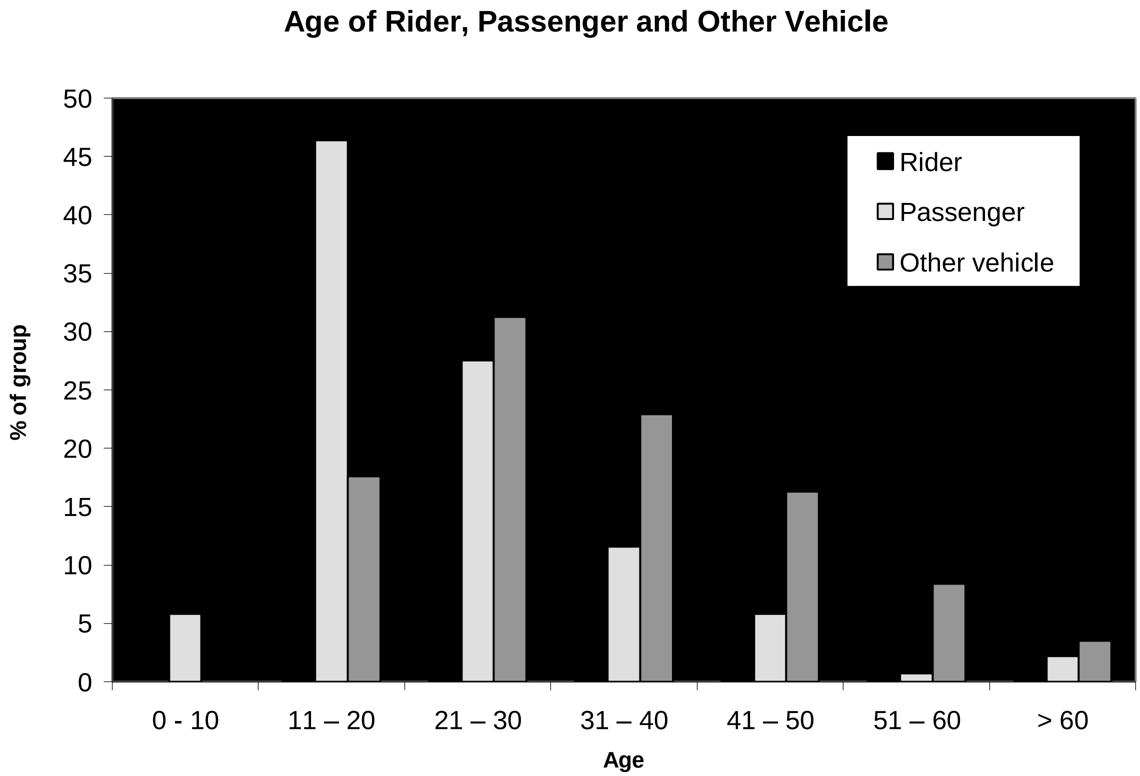


Figure 8.1.1: Percent distributions of rider, passenger and OV driver age

Gender – Riders, passengers and other vehicle drivers

Table 8.1.3 shows the gender distribution of motorcycle riders, passengers and OV drivers for 359 on-scene, in-depth accident-investigation cases in five sampling regions. Males were at the controls nearly 80% of the time as both motorcycle operators and other vehicle drivers. Motorcycle passenger gender was more evenly split; passengers were slightly more likely to be female.

In 59 cases, the rider was one gender and the passenger the opposite gender. In 51 of those (86%), the rider was male.

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

Gender	MC rider		MC passenger		OV driver	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	282		74		190	
Female	77		88		50	
Total	359		162		240	

Male motorcycle riders had higher crash speeds and they were more likely to take evasive action to avoid a crash (50% compared to 38%). The median crash speed for males was 40 km/hr, for females 30 km/hr. Male riders were also far more likely to have been drinking alcohol (35% vs. 6%).

Height and weight

Riders ranged from 140 to 182 cm tall, with a mean height and standard deviation (SD) of all motorcycle riders was 165 $\pm$ 7 cm. For males, it was 167 $\pm$ 6 cm and for females 159 $\pm$ 5 cm. Table 8.1.4 shows the height distribution for the accident-involved motorcycle riders for all 359 on-scene, in-depth accident investigation cases collected in the sampling regions.

Table 8.1.4: Riders, passengers & other vehicle drivers, height distribution

Height (cm)	MC rider		MC passenger		OV driver	
	Freq	%	Freq	%	Freq	%
No driver in OV	-	-	-	-	19	6.2
0 – 140	1	0.3	15	9.3	2	0.6
141 – 145	2	0.6	5	3.1	0	0.0
146 – 150	9	2.5	15	9.3	0	0.0
151 – 155	21	5.8	20	12.3	5	1.6
156 – 160	70	19.5	33	20.4	20	6.5
161 – 165	99	27.6	32	19.8	45	14.6
166 – 170	99	27.6	29	17.9	60	19.5
171 – 175	46	12.8	13	8.0	54	17.5
176 – 180	11	3.1	0	0.0	38	12.3
> 180	1	0.3	0	0	7	2.3
Unknown	0	0	0	0	58	18.8
Total	359		162		308	

Passengers ranged from 60 to 175 cm tall. The median height was 160 cm. Passenger weight varied from 6 kg (a one-year-old boy) to 80 kg with a median of 50 kg. Passengers were, on average, smaller than riders, reflecting their younger age (more children) and greater tendency to be female.

Other vehicle driver height ranged from 130 -180 cm with a median of 165 cm. Weights varied from 28 to 140 kg with a median of 60 kg. The lightest other vehicle driver was an 11-year-old boy on a bicycle.

Rider weight varied from 40 to 85 kilograms. The mean weight and standard deviation for all accident involved motorcycle riders was 58 $\pm$ 9 kilograms. The mean weight for the male riders was also 60.5 $\pm$ 8 kilograms and the mean weight for female riders was 50 $\pm$ 7.5 kilograms. Table 8.1.5 shows the weight distribution for all 359 on-scene, in-depth accident involved riders. As with weight, passengers tended to be smaller than riders. Other vehicle drivers had a weight distribution very similar to that of riders.

Table 8.1.5: Riders, passengers & other vehicle drivers, weight distribution

Weight (kg)	MC rider		MC passenger		OV driver	
	Frequency	%	Frequency	%	Frequency	%
No OV driver	-	-	-	-	19	6
11 - 20	0	0	4	3	0	0
21 - 30	0	0	9	6	1	0
31 - 40	10	3	13	8	5	2
41 - 50	76	21	59	36	45	15
51 - 60	162	45	53	33	94	31
61 - 70	89	25	19	12	64	21
71 - 80	21	6	5	3	19	6
> 80	1	0	0	0	3	1
Unknown	0	0	0	0	58	19
Total	359		162		308	

Education

The educational background of all 359 accident-involved riders is shown in Table 8.1.6. Just over three-fourths had formal education of 12 years or less. Those riders with a partial college education were 11% of the accident data set. One in 20 riders were college graduates. Passengers tended to have slightly less education than riders. In contrast, other vehicle drivers had higher education levels. Twenty percent (20%) of those whose education level was known (50 of 250) were college graduates.

Table 8.1.6: Riders, passengers & other vehicle drivers, education level

Educational status	MC rider		MC passenger		OV driver	
	Freq	%	Freq	%	Freq	%
No driver in OV	0	0.0	0	0.0	19	6.2
No formal schooling	5	1.4	7	4.3	3	1.0
High school degree or less	282	78.6	127	78.4	149	48.4
Partial college/university	40	11.1	15	9.3	22	7.1
Technical school graduate	13	3.6	8	4.9	7	2.3
College/university graduate	18	5.0	3	1.9	46	14.9
Advanced degree	0	0.0	0	0.0	4	1.3
Unknown	1	0.3	2	1.2	58	18.8
Total	359		162		308	

Occupations

Nearly half of the motorcycle riders in the upcountry accidents were unskilled laborers, many of them farm workers. Another one-fourth of motorcycle riders were students. The third and fourth most frequent categories were unemployed and sales and shop workers. Among passengers, one-third were unskilled laborers and over 40% were students.

Consistent with their higher level of education, OV drivers showed a wider range of occupations. Only 20% were unskilled laborers, and one-eighth were students. About one-fourth of other vehicle drivers were clerical, sales or shop workers. The data regarding occupations are shown in Table 8.1.7.

Table 8.1.7: Riders, passengers & other vehicle drivers, occupation

Occupation category	Code	MC rider		Passenger		OV driver	
		Freq	%	Freq	%	Freq	%
Unemployed > 1month	1	27	7.5	15	9.3	5	1.7
Senior officials, managers	2	1	0.3	0	0.0	5	1.7
Professionals	3	3	0.8	0	0.0	6	2.1
Minor professionals	4	3	0.8	0	0.0	6	2.1
Clerical, office worker	5	12	3.3	2	1.2	32	11.1
Service, shop & sales	6	20	5.6	4	2.5	41	14.2
Skilled agricultural workers	7	2	0.6	1	0.6	3	1.0
Skilled craft & trade	8	0	0.0	0	0.0	2	0.7
Transport drivers	9	15	4.2	2	1.2	26	9.0
Assembly workers	10	2	0.6	2	1.2	2	0.7
Unskilled labor	11	163	45.4	54	33.3	57	19.7
Housewife, homemaker	12	4	1.1	9	5.6	4	1.4
Active military	13	5	1.4	1	0.6	3	1.0
Student, full time	15	96	26.7	69	42.6	37	12.8
Retired, civilian	16	4	1.1	0	0.0	2	0.7
Retired, gov't, military	17	0	0.0	0	0.0	1	0.3
Other	98	1	0.3	1	0.6	1	0.3
Unknown	99	1	0.3	2	1.2	56	19.4
Total		359		162		289	

8.2 Motorcycle rider licensing and training

Rider license qualification

Only half of the riders in the upcountry accidents had a motorcycle license. A few riders had some sort of license, but one that was not specific to motorcycles. Table 8.2.1 shows a type of licenses held by the accident-involved motorcycle riders.

Table 8.2.1: Motorcycle license qualification

License type	Frequency	
No license held	179	49.9
Learner's permit, only	1	0.3
Motorcycle license	173	48.2
Automobile license	6	1.7
Total	359	

8.3 Rider training

Table 8.3.1 shows that the majority of accident-involved riders were self-taught (76%) followed by those who learned to ride the motorcycle from family and friends (22%). There were two riders who said they received no training before.

The findings clearly represent a major problem regarding the lack of appropriate training for motorcycle riders. All too often, training by family or friends amounts to instruction in how to operate the throttle, clutch, gear shifter and brakes, but very little or no training on defensive riding strategies, proper braking, collision avoidance skills, etc. The data collected in this study clearly show that most riders lack proper training in defensive riding strategies and accident prevention. The lack of formal training also suggests that many riders have no appreciation of proper protective equipment and they do not understand the importance of proper collision avoidance action.

Table 8.3.1: Training experience, motorcycle rider

Rider training	Frequency	
No training	2	0.6
Self taught	274	76.3
Taught by friends or family	79	22.0
Unknown	4	1.1
Total	359	

8.4 Rider motorcycling experience

Overall riding experience

Approximately 90% of the riders claimed to ride daily, implying high usage of the motorcycle. Many riders indicated that they depend upon the motorcycle as their only means of personal motorized transportation. Table 8.4.1 shows the distribution of the number of days per year that the accident-involved rider used his or her motorcycle.

Table 8.4.1: Days per year riding motorcycle

Days riding per year	Frequency	
0 – 50	4	1.1
51 – 100	3	0.8
101 – 150	7	1.9
151 – 200	6	1.7
201 – 250	0	0
251 – 300	14	3.9
301 – 365	323	90.0
Unknown	2	0.6
Total	359	

All riders were asked how many months or years they had operated motorcycles, and how many months they have been operating the accident-involved motorcycle. Table 8.4.2 shows the distribution of the months of any street motorcycle riding experience claimed by the accident-involved riders. The median experience of all motorcycle riders was about 98 months (8 years.)

Table 8.4.2 also shows the distribution of the months of experience on the accident-involved motorcycle by the riders. The median duration of experience was approximately 24 months. About 6% of all accident-involved riders had experience of less than 1 month and about one-fourth of riders had experience of less than 6 months.

Table 8.4.2: Rider's motorcycle experience

Rider's experience (months)	All motorcycles		Accident motorcycle	
	Frequency	Percent	Frequency	Percent
< 1	2	0.6	23	6.4
1 – 6	4	1.1	63	17.5
7 – 12	7	1.9	54	15.0
13 – 24	16	4.5	48	13.4
25 – 36	20	5.6	45	12.5
37 – 48	27	7.5	27	7.5
49 – 60	39	10.9	32	8.9
61 – 72	25	7.0	20	5.6
73 – 84	21	5.8	20	5.6
> 84	195	54.3	25	7.0
Unknown	3	0.8	2	0.6
Total	359		359	

Rider ownership of the accident motorcycle

Table 8.4.3 shows that over two-thirds of the accident-involved motorcycles were operated by the registered owner, and approximately one-third of cases were being operated with consent of the owner. In most cases where the rider had less than one month experience on the accident motorcycle, the owner was usually a parent, friends, or employer of the rider.

Table 8.4.3: Owner of the accident motorcycle

Motorcycle owner	Frequency	
Motorcycle rider	250	70
Motorcycle passenger	7	2
Operated with consent of owner	101	28
Unknown	1	0
Total	359	

Distance riding motorcycles per year

Table 8.4.4 shows the distance traveled annually by the accident-involved riders. Distance was based on the rider's estimate of distance traveled or on a calculation of motorcycle odometer reading and age of the motorcycle. The median distance traveled was 6,000 kilometres per year.

Table 8.4.4: Distance rider rides a motorcycle per year

Distance ridden per year (km)	Frequency	
0	2	0.6
1 – 3000	77	21.4
3001 – 6000	109	30.4
6001 – 9000	54	15.0
9001 – 12000	65	18.1
12001 – 15000	15	4.2
15001 – 18000	3	0.8
18001 – 21000	22	6.1
> 21000	7	1.9
Unknown	5	1.4
Total	359	

Rider's motorcycle use patterns

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 8.4.5 shows the average estimated motorcycle percent use by the accident-involved rider. Basic transportation accounted for three-fourths of use, recreation 22% and operating a vehicle other than a motorcycle only 1.3%. Younger riders tended to use the motorcycle for both recreation and basic transportation, older riders for basic transportation only. For the great majority of riders, 100% of their transportation was on motorcycles.

Table 8.4.5: Purposes of motorcycle use, motorcycle rider

Vehicle operation	Average percent of total time
Use of non-motorcycle	1.3
Using motorcycle for recreation	22.5
Using motorcycle for basic transportation	76.2
Total	100.0

8.5 Experience carrying passengers and cargo

Table 8.5.1 shows the rider's experience with carrying passengers on the motorcycle. This experience was reported only if the motorcycle was carrying a passenger when the accident occurred, which was about 31% of accident cases. Of those cases where a passenger was involved, 5% of riders claimed they had very little experience carrying a passenger, 28% had moderate experience, and 6% had extensive experience. When this data was cross-tabulated with rider occupation, it was found that those riders with extensive experience were mainly motorcycle taxi riders and students.

Table 8.5.1: Rider experience carrying passengers

Passenger carrying experience	Frequency	
Not applicable, no passenger	215	60
Never before carried passengers	2	1
Very little experience	18	5
Moderate experience	102	28
Extensive experience	22	6
Total	359	

Riding experience with similar cargo

Riders who were carrying some kind of cargo were asked how often they carried a similar load. Their answers are shown in Table 8.5.2. About 81% of riders did not carry cargo and 9% seldom carried similar cargo. Usually, the cargo/luggage made no contribution to accident causation. However, in four cases, the cargo/luggage directly impacted another vehicle or interfered with control and therefore contributed to the accident causation (Table 8.5.3.)

Table 8.5.2: Rider experience with similar cargo/luggage

Experience with similar cargo	Frequency	
Not applicable, no cargo/luggage	292	81.3
No previous experience	1	0.3
Seldom carries similar cargo/luggage	32	8.9
Frequently carries similar cargo/luggage	25	7.0
Always carries similar cargo/luggage	9	2.5
Total	359	

Table 8.5.3: Luggage/cargo contribution to accident causation

Cargo contribution to cause	Frequency	
Not applicable	292	81.3
No contribution	62	17.3
Loose, caused rider loss of control	1	.3
Interfered with controls	1	.3
Other	2	.6
Unknown	1	.3
Total	359	

8.6 Rider's prior violation and accident experience

Traffic violations

About 10% of riders (35) involved in the accidents claimed to have at least one traffic violation in the previous five years. Unfortunately, it was not possible to verify rider claims against driving records. Table 8.6.1 shows the number of cases in which the motorcycle rider had previous traffic violations during the past 5 years.

Table 8.6.1: Rider traffic violations in last 5 years

Prior traffic citations	Frequency	
None	319	88.9
One	24	6.7
Two	5	1.4
Three	4	1.1
Four	1	0.3
Five	1	0.3
Unknown	5	1.4
Total	359	

Rider previous accident experience

Riders were asked about any accidents they had been in (as a vehicle operator, not as a passenger) during the previous five years, either on a motorcycle or some other type of vehicle. Of those, 91 riders reported at least one previous motorcycle traffic accident. Only nine riders reported a previous non-motorcycle traffic accident. The twelve fatal cases were evenly divided between "none", "one" or "unknown" previous accidents. The data are shown in Table 8.6.2.

Table 8.6.2: Rider's previous traffic accident for last 5 years

Previous crashes	Motorcycle crashes		Non-motorcycle crashes	
	Frequency	Percent	Frequency	Percent
None	263	73	345	96
One	57	16	8	2
Two	19	5	0	0
Three	7	2	1	0
Four	1	0	0	0
Five	5	1	0	0
Six	1	0	0	0
Eight	1	0	0	0
Unknown	5	1	5	1
Total	359		359	

8.7 Rider trip

Rider familiarity with roadway

Most riders were very familiar with the roadway and area in which they had their motorcycle accident. Table 8.7.1 shows the distribution of answers made by the riders. About 85% of riders claimed daily or weekly use of the roadway on which the accident happened. Only 13 riders (4%) had never traveled the accident roadway before.

Table 8.7.1: Rider familiarity with roadway

Roadway familiarity	Frequency	
Never used this roadway before	13	3.6
Daily use	295	82.2
Weekly use	34	9.5
Monthly use	10	2.8
Quarterly use	1	0.3
Annually use	1	0.3
Less than annually	1	0.3
Unknown	4	1.1
Total	359	

Rider trip plan

The origins and destinations of the trip are shown in Table 8.7.2. Home and work predominated as the point of origin or the destination in each of these categories, followed by visits to a friend and relative.

Table 8.7.2: Rider trip origin and destination

Origin / destination	Origin		Destination	
	Frequency	Percent	Frequency	Percent
Home	116	32.3	175	48.7
Work, business	75	20.9	68	18.9
Recreation	20	5.6	9	2.5
School, university	10	2.8	16	4.5
Errand, shopping	42	11.7	33	9.2
Friends, relatives	66	18.4	46	12.8
Bar, pub, café	27	7.5	9	2.5
Unknown	3	0.8	3	0.8
Total	359		359	

The distribution of the length of the intended trip for the motorcycle rider was shown in Table 8.7.3. The median distance was 5 kilometres. The great majority of motorcycle trips in the accident data were short trips, in some cases less than half a kilometre. One third of all cases were less than two kilometres from origin to destination, and two-thirds of the accident cases were less than five kilometres.

Table 8.7.3: Distance of rider's intended trip

Trip length (km)	Frequency	
< 0.5	5	1
0.5 - 1.0	47	13
1.1 - 2.0	67	19
2.1 - 3.0	44	12
3.1 - 5.0	70	20
5.1 - 10.0	56	16
> 10.0	62	17
Unknown	8	2
Total	359	

Table 8.7.4 provides the time from the trip origin to the accident location. The median value of the riding time was 0.1 hour, or about 6 minutes, and 99% were less than one hour.

Table 8.7.4: Time since departure to the time of accident

Time riding before crash (hrs)	Frequency	
0.0	51	14
0.1	163	45.4
0.2	68	18.9
0.3	44	12.3
0.5	13	3.6
0.8 - 1.0	4	1.1
> 1.0	3	0.8
Unknown	13	3.6
Total	359	

Most crashes occurred on short trips (half were under 5 km, 80% under 10 km), and familiar roads. Both factors can operate to discourage the rider from using protective equipment.

8.8 Rider impairments

"Impairments" are defined relative to physical conditions rather than alcohol or drugs, which are discussed in the next section. Table 8.8.1 shows the frequency of permanent physiological impairment of the accident-involved motorcycle riders. The majority of riders had no permanent physiological impairment. About 5% of the riders suffered from vision impairment that required glasses. One rider upcountry crashed as a result of an epileptic seizure while riding on the accident-involved motorcycle.

Table 8.8.1: Rider permanent physiological impairment

Permanent impairment	Frequency	
None	332	92.5
Vision	19	5.3
Respiratory, cardiovascular	2	0.6
Neurological, epilepsy, stroke	1	0.3
Unknown	5	1.4
Total	359	

Temporary impairments are defined as conditions such as sleepiness or hunger that can be a problem but will go away. The frequency of the temporary physiological impairment for the accident-involved motorcycle riders is shown in Table 8.8.2. Fatigue predominated as a temporary physiological condition and was found in 14 cases It appeared to be a contributing factor in accident causation because the riders tended to fall asleep while riding.

Table 8.8.2: Rider temporary physiological impairment

Temporary impairment	Frequency	
None	330	91.9
Fatigue	14	3.9
Thirst	1	0.3
Headache	1	0.3
Unknown	13	3.6
Total	359	

Rider stress on day of accident

The stress that was admitted by the accident-involved motorcycle riders is shown in Table 8.8.3. Most rider stress due to was conflicts with friends and relative and work related problem.

Table 8.8.3: Rider stress on the day of accident

Type of stress	Frequency	
None observed or noted	337	93.9
Conflict with friends, relatives	4	1.1
Work related problems	2	0.6
Other	2	0.6
Unknown	14	3.9
Total	359	

8.9 Rider alcohol

Nearly 30% of riders in the upcountry accidents had been drinking alcohol before the accident. Approximately 88% of 105 riders who had been consuming alcohol appeared to be significantly impaired (Table 8.9.1). It should be noted that riders who were either police or military personnel often refused to cooperate with alcohol testing although observation by investigators suggested they were impaired.

Table 8.9.1: Rider alcohol impairment

Alcohol impairment	Code	Frequency	
Not applicable, no drinking	0	253	
Not significantly impaired	1	11	
Significantly impaired	2	94	
Unknown	9	1	
Total		359	

Alcohol-involved riders were far more likely to be killed than non-alcohol-involved riders. Table 8.9.2 compares alcohol use in fatal and non-fatal crashes. Two thirds of fatally injured riders had been drinking alcohol. Seven of the eight fatally injured riders who had been drinking had blood alcohol concentrations above the legal limit of 50 mg% (i.e., 50 mg/ 100cc of blood).

Table 8.9.2: Alcohol in fatal and non-fatal accidents

Alcohol impairment	Fatal injury involvement				Total
	No		Yes		
No	249		4		253
Yes	97		8		105
Unknown	1		0		1
Total	347		12		359

Table 8.9.3 shows the distribution of rider blood alcohol concentration (BAC) at the time of the accident investigation. There were 59 riders (17%) whose BAC was above the legal limits. It is important to note that not all riders who appeared to be impaired were tested, so the number of legally impaired riders is most likely higher than 17%.

BAC values reported here are those found when blood was drawn; they were not corrected to estimate the BAC at the time of the accident. This is because in most cases there was little time lapse between the crash and the time blood was drawn. In fatal cases, the breakdown of alcohol ended at death, which was usually within a couple hours of the crash in most fatal cases. In the non-fatal cases, BAC was usually obtained by extraction of a blood sample during transportation to the emergency room or at the emergency room.

Table 8.9.3: Rider blood alcohol concentration (BAC)

Blood alcohol concentration (mg%)	Frequency	
Not detected	253	70.5
1 – 50	6	1.7
51 – 100	15	4.2
101 – 200	29	8.1
201 – 300	12	3.3
> 300	3	0.8
Unknown	41	11.4
Total	359	

The method for testing BAC is shown in Table 8.9.4. Riders tested for BAC via breath testing analysis were usually those with minor injuries. Of those tested, 71% were blood tests, and 29% had a breath test.

The high frequency of alcohol involvement represents a major contributing factor, particularly in the fatal motorcycle accidents as well as the night accidents. Alcohol also strongly affects the kinds of accident rider get into as well as the kinds of errors they make. The role of alcohol in motorcycle accident causation is elaborated in section 11.3 of this report.

Table 8.9.4: Rider blood alcohol concentration testing method

Blood alcohol concentration test method	Frequency	
Not applicable, no test	261	72.7
Breath testing	28	7.8
Blood testing	70	19.5
Total	359	

8.10 Rider attention to driving task

Table 8.10.1 shows the motorcycle rider attention to the riding task during the pre-crash phase of the accident. Inattention or daydreaming was found in about 17% of the accident-involved riders, particularly in the drunk riders or those riders who were fatigued due to a long work period. In this current study, three riders fell asleep while riding.

Attention was directed to adjacent traffic and non-traffic items in 5% of the 359 on-scene, in-depth accident cases. The findings also revealed that about 20% of cases involved either distraction or inattention. The results strongly indicate that the lack of attention represents a prominent contributing factor to the accident (Table 8.10.2).

Table 8.10.1: Rider attention to driving tasks

Rider attention	Frequency	
Inattentive mode, daydreaming	61	17.0
Attention not a factor	261	72.7
Attention diverted to surrounding traffic	6	1.7
Attention diverted to non-traffic item	12	3.3
Attention diverted to passenger activities	5	1.4
Other	3	0.8
Unknown	11	3.1
Total	359	

Table 8.10.2: Contribution of rider attention failure to accident cause

Contribution of attention to accident cause	Frequency	
Not applicable, no attention failure	261	72.7
Attention failure occurred, no contribution	14	3.9
Attention failure contributed to the accident	73	20.3
Unknown	11	3.1
Total	359	

8.11 Rider recommendations for accident countermeasures

The majority of the accident-involved motorcycle riders recommended no countermeasure. Those who did often recommended something that was directed towards their opinion of the improper driving of the other involved driver or rider. The same was true of car drivers, who usually recommended improved motorcycle rider training. Recommendations seemed to focus on blaming the other driver, regardless of who contributed what to accident causation. Table 8.11.1 shows the accident-involved rider's recommended countermeasures. About 9% (32/359) of the riders suggested an improvement of driver training courses, 3% required improvement of motorcycle rider training courses and 1.4% suggested more rigorous traffic law and drunk driving laws enforcement.

Table 8.11.1: Countermeasures recommended by motorcycle rider

Recommendation	Frequency	
No recommendation	282	78.6
Improved motorcycle licensing procedures	1	0.3
Improved motorcycle procedures for other drivers	3	0.8
Improved motorcycle rider training courses	11	3.1
Improved driver training courses	32	8.9
More rigorous traffic law enforcement	2	0.6
More rigorous drunk driving law enforcement	3	0.8
Mandatory helmet use law enforcement	1	0.3
Other	9	2.5
Unknown	15	4.2
Total	359	

8.12 Motorcycle passengers

Number of passengers on motorcycle

Table 8.12.1 shows the distribution of the number of motorcycle passengers for the 359 accident investigation cases. No passenger was present in about 60% of crashes, while multiple passengers were found in 6% of cases.

Table 8.12.1: Number of passengers on the accident motorcycle

Passengers on motorcycle	Frequency	
No passenger	220	61.3
One	118	32.9
Two	19	5.3
Three	2	0.6
Total	359	

Passenger riding/driving license

No license is required in order to be a passenger on a motorcycle. Nonetheless, passengers were asked about their license and their responses are reported in Table 8.12.2, which shows that only 10% held a motorcycle license, compared to about 50% of the accident-involved riders.

Table 8.12.2: Driver's license held by motorcycle passengers

Passenger driving license held	Frequency	
No license held	143	88.3
Learner's permit, only	1	0.6
Motorcycle license	16	9.9
Unknown	2	1.2
Total	162	

Passenger riding experience

Passengers were asked about their previous experience riding as passenger on any motorcycles, on the accident-involved motorcycle, or in non-motorcycles. Passenger motorcycling experience is summarized in Table 8.12.3. Only about 5% had less than a month of riding experience, while 85% claimed to have ridden as a passenger for more than one year. However, about two-thirds of the passengers had ridden the accident motorcycle less than one year.

Experience as a passenger in non-motorcycles is shown in Table 8.12.4.

Table 8.12.3: Passenger experience riding motorcycles

Passenger's experience (months)	Any motorcycles		Accident motorcycle	
	Frequency	Percent	Frequency	Percent
< 1	8	4.9	24	14.8
1 – 6	4	2.5	58	35.8
7 – 12	11	6.8	30	18.5
13 – 24	27	16.7	13	8.0
25 – 36	8	4.9	14	8.6
37 – 48	16	9.9	5	3.1
49 – 60	17	10.5	7	4.3
61 – 72	11	6.8	2	1.2
73 – 84	7	4.3	1	0.6
> 84	50	30.9	4	2.5
Unknown	3	1.9	4	2.5
Total	162		162	

Table 8.12.4: Passenger riding experience in all vehicles

Passenger experience (years)	Frequency	
0 – 1	20	12.3
2 – 3	36	22.2
4 – 5	35	21.6
5 – 7	19	11.7
8 – 10	21	13.0
11 – 15	18	11.1
16 – 20	9	5.6
21 – 30	1	0.6
Unknown	3	1.9
Total	162	

Passenger days per year on a motorcycle

About two-thirds of the passengers claimed that they rode a motorcycle daily, which indicated a high usage of the motorcycle as a primary source of transportation. Table 8.12.5 shows the number of days per year that the passenger rides the motorcycle.

Table 8.12.5: Passenger days per year on motorcycle

Passenger days per year on motorcycle	Frequency	
0 – 50	9	5.6
51 – 100	9	5.6
101 – 150	9	5.6
151 – 200	11	6.8
201 – 250	1	0.6
251 – 300	12	7.4
301 – 365	108	66.7
Unknown	3	1.9
Total	162	

About 60% of these accident-involved passengers reported having moderate experience riding as a motorcycle passenger. Table 8.12.6 shows the riding experience as a passenger on the motorcycle.

Table 8.12.6: Experience as a passenger on motorcycle

Experience as MC passenger	Frequency	
Never before rode as passenger	5	3.1
Very little experience	24	14.8
Moderate experience	100	61.7
Extensive experience	30	18.5
Unknown	3	1.9
Total	162	

Passenger's motorcycle training

About two-thirds of the passengers were either self taught or learned from friends and about one-third of received no training as the motorcycle rider as shown in Table 8.12.7.

Table 8.12.7: Passenger motorcycle training experience

Motorcycle training	Frequency	
No training	60	37.0
Self taught	61	37.7
Taught by friends or family	38	23.5
Unknown	3	1.9
Total	162	

Passenger's vehicle use patterns

About two-thirds of the passengers claimed that they used motorcycle as the basic transportation and 23% as recreation as shown in Table 8.12.8.

Table 8.12.8: Passenger's vehicle use patterns

Vehicle use type	Average percent use
Non-motorcycle use	8.9
Motorcycle for recreation	23.4
Motorcycle for basic transportation	67.7
Total	100.0

Passenger alcohol involvement

About one-sixth of the 162 passengers in this study had been drinking alcohol as shown in Table 8.12.9. However, the exact level of intoxication in terms of BAC was difficult to determine because the passengers usually refused blood or breath tests. BAC was known for five of those 25 passengers who had been drinking alcohol, and all five were above the legal limit of 50 mg%. Passenger BAC levels ranged from 61 mg% to 264 mg%.

If only one person on the motorcycle has been drinking alcohol, it was usually the rider. The data are shown in Table 8.12.10.

Table 8.12.9: Passenger alcohol impairment

Passenger alcohol	Frequency	
No alcohol	136	84.0
Had been drinking, not obviously impaired	5	3.1
Significantly impaired	20	12.3
Unknown	1	0.6
Total	162	

Table 8.12.10: Comparison of rider and passenger alcohol involvement

Alcohol involvement	Passenger	
Rider	Yes	No
Yes	23	11
No	0	105
Total	23	139

Passenger physical impairments

The majority of the passengers did not have any permanent or transient physiological impairment. Only 3 passengers had a vision problem and 2 complained of being fatigued.

Passenger location on motorcycle at time of collision

The majority of the accident-involved passengers (81.5%) were in the normal riding position, seated behind the motorcycle rider, at the time of the collision. There were 15 cases in which the second passenger was seated in front of the rider and 13 cases where the second passenger was seated behind the first passenger. Two passengers jumped of before the collision occurred (Table 8.12.11).

Table 8.12.11: Passenger riding position on motorcycle

Passenger riding position	Frequency	
Immediately behind motorcycle rider	132	81.5
Immediately in front of motorcycle rider	15	9.3
Behind first passenger	13	8.0
Jump or bail out before collision	2	1.2
Total	162	

Passenger attention to the riding task

Four passengers claimed to be asleep while riding on the motorcycle. About 10% (17 of 162) were inattentive at the time of the collision, usually due to alcohol. However, there were no cases in which passenger inattention or sleeping contributed to the crash. Table 8.12.12 shows the passenger's attention at the time of the collision.

Table 8.12.12: Passenger attention to riding tasks

Passenger attention before crash	Frequency	
Inattentive mode, daydreaming	17	10.5
Attention not a factor	133	82.1
Attention diverted to surrounding traffic	2	1.2
Attention to motorcycle normal operation	2	1.2
Other	4	2.5
Unknown	4	2.5
Total	162	

Passenger recommendations for accident countermeasures

The majority of the accident-involved passengers did not provide any recommendations for countermeasures to the investigators. Ten passengers suggested improvements of driver training, and two recommended improved motorcycle rider training courses.

8.13 Other vehicle driver

Other vehicle river license qualification

About one-third of the accident-involved drivers held only an automobile license; about 20% held a motorcycle license, and another 21% had no license at all. However, the 21% rate of unlicensed other vehicle was much lower than the 49% unlicensed rate among motorcycle riders. Table 8.13.1 shows the type of driver's licenses held by the driver of the accident-involved other vehicle.

Table 8.13.1: Driver's license qualification, other vehicle driver

License type	Frequency	
No driver in vehicle	19	6.2
No license held	65	21.1
Learner's permit, only	1	0.3
Motorcycle license	53	17.2
Automobile license	106	34.4
Commercial license	1	0.3
License to transport people	3	1.0
Heavy truck license	1	0.3
Other license	1	0.3
Unknown	58	18.8
Total	308	

Other vehicle driver training

About three-fourths of the accident-involved drivers in our series were self-taught or taught by friends or family. None had any formal training (Table 8.13.2). This finding suggests that important driving information about laws, defensive driving strategies and collision avoidance is not passed on to new drivers in any organized or consistent way.

As shown in Table 8.13.3, about two-thirds of other vehicle drivers did not take any collision avoidance and when the evasive action was taken, they tended to be an improper choice (45 cases of improper choice versus 39 cases of proper choice).

Table 8.13.2: Other vehicle driver training

Other vehicle driver training	Code	Frequency	
No driver in vehicle	0	19	6.2
No training	1	0	0.0
Self taught	2	160	51.9
Taught by friends or family	3	65	21.1
Other	8	5	1.6
Unknown	9	59	19.2
Total		308	

Table 8.13.3: Other vehicle driver training and collision avoidance

Other vehicle driver training	No collision avoidance		Evasive action proper for situation				Total	
			No		Yes			
	Freq	Row %	Freq	Row %	Freq	Row %	Freq	Row %
No training	101	63	35	22	24	15	160	100
Self taught	44	68	8	12	13	20	65	100
Taught by friends	1	20	2	40	2	40	5	100
Other	50	85	2	3	5	9	59	100
Total	196		47		44		289	

8.14 Other vehicle driver driving experience

Only two accident-involved drivers claimed to have less than 1 year of driving experience and the median experience for all other vehicle drivers was 10 years. Table 8.14.1 shows the distribution of years of vehicle driving experience on all vehicles of the other vehicle drivers.

Table 8.14.1: Other vehicle driver driving experience on all vehicles

Operator's experience (years)	Frequency	
No Driver	19	6.2
0 – 1	2	0.6
2 – 3	20	6.5
4 – 5	34	11.0
5 – 7	21	6.8
8 – 10	50	16.2
11 – 15	31	10.1
16 – 20	41	13.3
21 – 30	20	6.5
> 30	11	3.6
Unknown	59	19.2
Total	308	

About 30% of OV drivers had no previous motorcycle riding experience, but another 30% had been riding more than 7 years. The majority of the other vehicle drivers with any motorcycle riding experience often held a motorcycle license. Table 8.14.2 shows the distribution of any street motorcycle experience for the accident-involved driver. The median time of riding was 48 months.

Table 8.14.2: Other vehicle driver previous motorcycle riding experience

Experience on any street motorcycle (month)	Frequency	
No Driver	19	6.2
< 1	89	28.9
1 – 6	0	0.0
7 – 12	0	0.0
13 – 24	7	2.3
25 – 36	8	2.6
37 – 48	15	4.9
49 – 60	8	2.6
61 – 72	8	2.6
73 – 84	6	1.9
> 84	89	28.9
Unknown	59	19.2
Total	308	

Table 8.14.3 shows the other vehicle driver experience with the accident-involved vehicle. In 11 cases the other vehicle driver had less than one month experience with that vehicle. The median time of driving experience for the other vehicle driver was 36 months.

Table 8.14.3: Other vehicle driver experience In the accident vehicle

Experience in accident vehicle (month)	Frequency	Percent
No Driver	19	6.2
< 1	11	3.6
1 – 6	26	8.4
7 – 12	28	9.1
13 – 24	43	14.0
25 – 36	31	10.1
37 – 48	20	6.5
49 – 60	28	9.1
61 – 72	12	3.9
73 – 84	14	4.5
> 84	17	5.5
Unknown	59	19.2
Total	308	

Other vehicle driver vehicle use patterns

About two-thirds of the accident-involved other vehicle drivers said they did not ride motorcycles at all. Most other vehicle drivers who rode a motorcycle were riding another motorcycle involved in a motorcycle to motorcycle collision. Riders of the other motorcycles involved in collision also tended to ride the motorcycle as basic transportation followed by recreation. The data are summarized in Table 8.14.4.

Table 8.14.4: Vehicle use patterns of other vehicle drivers

Vehicle use	Average percent
Uses vehicles other than motorcycle	46.7
Uses motorcycle for recreation	12.1
Uses motorcycle for basic transportation	41.2
Total	100.0

8.15 Other vehicle driver previous traffic violations and accidents

A total of 28 drivers (12.6%) reported having at least one previous traffic violations within the past five years. As with motorcycle riders, official driving records were not available for verification. The data reported here rely on the truthfulness of the driver. Table 8.15.1 shows the traffic violation records of the accident-involved driver during the past 5 years.

Table 8.15.1: Other vehicle driver traffic violation in last 5 years

Previous traffic citations	Frequency	
None	203	70.2
One	22	7.6
Two	2	0.7
Three	3	1.0
Four	1	0.3
Unknown	58	20.1
Total	289	

Other vehicle driver's previous accidents

Table 8.15.2 shows the previous traffic accident reported by the driver of the other vehicle during the past 5 years. There were 17 drivers who had at least one reportable traffic accident with passenger automobiles, trucks or buses. There were 27 drivers who had at least one reportable traffic accident with the motorcycle.

Table 8.15.2: Other vehicle driver traffic accidents in last 5 years

Number of traffic accidents, last 5 years	Previous automobile accidents		Previous motorcycle accidents	
	Frequency	Percent	Frequency	Percent
None	214	74.0	204	70.6
One	14	4.8	16	5.5
Two	3	1.0	6	2.1
Three	0	0	3	1.0
Five	0	0	1	0.3
Six	0	0	1	0.3
Unknown	58	20.1	58	20.1
Total	289		289	

8.16 Other vehicle driver accident trip

The distribution of the origin and destinations for the other vehicle driver is shown in Table 8.16.1. Home and work predominated and accounted for half of the origin and destination of the other vehicle driver trip plan.

Table 8.16.1: Other vehicle driver trip origin and destination

Location	Trip origin		Trip destination	
	Frequency	Percent	Frequency	Percent
Home	67	23.2	99	34.3
Work, business	78	27.0	61	21.1
Recreation	9	3.1	2	0.7
School, university	3	1.0	9	3.1
Errand, shopping	34	11.8	23	8.0
Friends, relatives	26	9.0	32	11.1
Bar, pub, café’	14	4.8	5	1.7
Other	1	0.3	1	0.3
Unknown	57	19.7	57	19.7
Total	289		289	

Other vehicle driver trip length and time driving before accident

On average, other vehicle drivers estimated they were going 5 kilometres from origin to their intended destination. Table 8.16.2 shows the frequency distribution of the distance of the intended trip. The data indicated that 45% of cases had the distance less than 5 kilometres. The distribution of time driving from trip origin to the accident location is shown in Table 8.16.3 and the median time of driving was 0.1 hour or 6 minutes. The data suggested that 42% of other vehicles crashed near the trip origin, less than six minutes after the departure.

Table 8.16.2: Other vehicle driver length of intended trip

Distance of trip (km)	Frequency	
< 0.1	2	0.7
0.1 - 1.0	30	10.4
1.1 - 2.0	33	11.4
2.1 - 3.0	20	6.9
3.1 - 5.0	45	15.6
5.1 - 10.0	37	12.8
> 10.0	63	21.8
Unknown	59	20.4
Total	289	

Table 8.16.3: Time driving before accident

Length of time (hrs)	Frequency	
0.0	36	12.5
0.1	87	30.1
0.2	46	15.9
0.3	30	10.4
0.4	1	0.3
0.5	10	3.5
0.6 - 0.7	1	0.3
0.8 - 1.0	11	3.8
> 1.0	7	2.4
Unknown	60	20.8
Total	289	

Other vehicle driver familiarity with accident roadway

Table 8.16.4 shows the frequency that the accident-involved other vehicle driver traveled upon that roadway. Generally, most other vehicle drivers were familiar with the roadway that they were traveling upon. About 73% of the drivers claimed to travel that roadway on a daily or weekly basis. There were only 3 cases in which the accident-involved drivers had never used that roadway before and 4 cases reported using the roadway infrequently (less than monthly use).

Table 8.16.4: Other vehicle driver roadway familiarity

Prior road use	Frequency	
Daily use, i.e., once per day	183	63.3
Weekly use, i.e. once per week	30	10.4
Monthly use, i.e., once per month	10	3.5
Quarterly, i.e., once per quarter	1	0.3
Annually, i.e., once per year	3	1.0
Never used this roadway before	3	1.0
Unknown	59	20.4
Total	289	

8.17 Other vehicle driver alcohol involvement

Table 8.17.1 shows the frequency of alcohol involvement for the accident-involved driver. Only 27 other vehicle drivers had been drinking alcohol and 24 (89%) of those alcohol-involved drivers were found to be impaired. The distribution of the blood alcohol concentration level for these drunk drivers who were tested is shown in Table 8.17.2.

Table 8.17.1: Other vehicle driver alcohol use

Other vehicle driver alcohol use	Frequency	
No alcohol use	204	
Alcohol use only	27	
Unknown	58	
Total	289	

Table 8.17.2: Other vehicle driver blood alcohol concentration

Blood alcohol concentration (mg%)	Frequency	
Not detected	204	70.6
1 – 50	1	0.3
51 – 100	2	0.7
101 – 200	3	1.0
201 – 300	2	0.7
> 300	2	0.7
Unknown	75	26.0
Total	289	

The number of other vehicle driver who had been drinking alcohol appears to be far less than the number of impaired motorcycle riders. However, about one-fourth of the drivers were unknown because the drivers left scene after a hit-and-run collision or after precipitating a non-contact collision. In other cases, the other vehicle was parked and unoccupied.

8.18 Other vehicle driver physiological impairments

Most drivers of the other vehicles who were involved in the collision with the motorcycle were physiologically normal. There were twenty-six (9%) other vehicle drivers who reported some vision problem (Table 8.18.1). Only 2% of other vehicle drivers reported that they were fatigued.

Table 8.18.1: Other vehicle driver physical impairments

Other vehicle driver impairment	Code	Frequency	
Permanent			
None	1	205	70.9
Vision	2	26	9.0
Unknown	99	58	20.1
Total		289	
Transient			
None	1	227	78.5
Fatigue	2	2	0.7
Unknown	99	60	20.8
Total		289	

Other vehicle driver stress

Table 8.18.2 shows very little evidence of any reported stress in the accident-involved drivers. Only 2 drivers reported conflicts with a friend or relative, and one reported a death in the family on the day of the accident.

Table 8.18.2: Other vehicle driver stress on the day of accident

Other vehicle driver stress	Frequency	
None observed or noted	226	78.2
Conflict with friends, relatives, spouse.	2	0.7
Death of family, friend	1	0.3
Unknown	60	20.8
Total	289	

8.19 Other vehicle driver attention to driving task

Table 8.19.1 shows the attention of the other vehicle drivers, who were involved in the collision with the motorcycle. Inattention was identified in about 4% of reported cases. Poor attention contributed to the accident in 21 of 24 drivers who had attention failure (Table 8.19.2).

Table 8.19.1: Other vehicle driver attention to driving tasks

Other vehicle driver attention	Frequency	
Inattentive mode, daydreaming	13	4.5
Attention to driving tasks not a factor	206	71.3
Attention diverted to surrounding traffic	6	2.1
Attention diverted to non-traffic item	4	1.4
Attention diverted to passenger activities	1	0.3
Unknown	59	20.4
Total	289	

Table 8.19.2: Contribution of other vehicle driver inattention

Contribution of OV driver inattention	Frequency	
Not applicable, no attention failure	209	72.3
Attention failure did not contribute	3	1.0
Attention failure contributed to the accident	21	7.3
Unknown	56	19.4
Total	289	

8.20 Other vehicle driver recommendations for accident countermeasures

About 11% of the other vehicle drivers involved in a collision with a motorcycle recommended improving motorcycle rider training courses (Table 8.20.1). As with motorcyclists, other vehicle driver recommendations tended to focus on improving the rider's riding regardless of whether the other vehicle driver had contributed to accident causation or not.

Table 8.20.1: Other vehicle driver recommended countermeasures

Driver countermeasure recommendations	Frequency	
None	169	58.5
Improved motorcycle licensing procedures	11	3.8
Improved licensing car drivers	1	0.3
Improved motorcycle rider training courses	33	11.4
Improved driver training courses, including motorcycle awareness	7	2.4
More rigorous traffic law enforcement	2	0.7
More rigorous drunk driving law enforcement	3	1.0
Other	4	1.4
Unknown	59	20.4
Total	289	

9.0 Human Factors - Injuries

The injuries reported here were collected for the motorcycle riders and passengers from the 359 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. Riders and passengers were often photographed at the accident scene or at the hospital during 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 coded using the Abbreviated Injury Scale (AIS, 1990 revision) to identify injury location, type and severity.

9.1 Rider and passenger trauma status

Nearly three fourths of these accidents involved relatively minor injuries to the rider. One-fifth (109 of 521 riders and passengers) did not even go to the hospital, while 53% were treated briefly in the emergency room and released. However, one in five were hospitalized longer than 24 hours and two riders became disabled as a result of the accident. Twelve of 359 riders (3.3% or one in 30) were killed. Table 9.1.1 shows the trauma status of the accident-involved riders and passengers.

Passengers generally were less severely injured than riders. A larger percentage of passengers required only treatment at the scene or in the emergency room, and fewer were hospitalized or killed.

Table 9.1.1: Trauma status of motorcycle rider and passenger

Trauma status	Rider		Passenger	
	Frequency		Frequency	
No Injury	1		6	
First aid at scene	66		36	
Treat at hospital, clinic	182		92	
Hospitalized for less than 1 day	13		2	
Hospitalized longer than 1 day	83		21	
Disabled, institutionalized	2		0	
Fatal, dead on scene	6		1	
Fatal, dead on hospital arrival	4		2	
Fatal after hospitalization	2		1	
Unknown	0		1	
Total	359		162	

Of 521 riders and passengers, nearly 80% required no hospitalization. However, about 8% required significant hospitalization, beyond a week. Table 9.1.2 shows the length of hospital stay for the injured motorcycle riders and passengers.

Table 9.1.2: Length of hospital stay for riders and passengers

Hospital stay (days)	Rider		Passenger	
	Frequency		Frequency	
0	271		138	
1	12		5	
2 – 3	21		4	
4 – 7	19		9	
> 7	35		6	
Unknown	1		0	
Total	359		162	

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 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.

Tables 9.2.1 and 9.2.2 show the distributions of injury regions and severity. These tables include all the injuries sustained by riders and passengers, rather than counting each person once.

A total of 1533 injuries were reported among 359 riders, for an average of 4.27 injuries per rider. Two thirds of the reported injuries were "minor," such as contusions, abrasions and lacerations, etc. "Moderate" injury (300 injuries) averaged nearly one per accident. Passengers averaged fewer injuries, about 2.8 injuries per accident.

About one-fourth of the injuries involved the upper extremities and one-third the lower extremities. Although the injuries to the extremities were frequent, they were not life threatening in most cases.

Among riders, 150 injuries were "serious" or worse -- about 10% of those reported. "Serious" injuries are considered to be life threatening.

The most frequent causes of fatal injuries in the upcountry accident data were injuries to the head, face, neck, and chest. Three riders sustained massive fractures of the pelvic bones (from a run over) and subsequently died because of massive hemorrhages from blood vessel laceration.

Table 9.2.1: Rider injury region and severity

Region	Rider injury severity						
	Minor	Moderate	Serious	Severe	Critical	Fatal	Total
Head	28	25	3	10	29	1	96
Face	209	96	5	0	0	0	310
Neck	11	1	0	0	6	0	18
Thorax	31	1	3	2	13	4	54
Abdomen	21	2	5	3	5	2	38
Spine	0	0	0	0	11	1	12
Upper extremities	389	56	10	0	0	0	455
Lower extremities	389	118	36	0	0	0	543
Pelvis	0	1	3	0	3	0	7
Total	1078	300	65	15	67	8	1533

Table 9.2.2: Passenger injury region and severity

Region	Severity of passenger injury						
	Minor	Moderate	Serious	Severe	Critical	Fatal	Total
Head	14	8	0	3	5	0	30
Face	34	17	0	0	0	0	51
Neck	2	0	0	0	0	0	2
Thorax	3	0	0	1	0	0	4
Abdomen	7	0	0	0	0	0	7
Spine	0	0	0	0	3	0	3
Upper Extremities	123	13	3	0	0	0	139
Lower Extremities	158	26	10	0	0	0	194
Pelvis	1	0	0	0	0	0	1
Total	342	64	13	4	8	0	431

9.3 Rider head injuries

Based on the injury data collected in this study, minor abrasions and lacerations and bruises make up the great majority of injuries that motorcycle riders and passengers suffer. Hence, the discussion will focus on the less frequent and more serious injuries. Skull fractures accounted for 11.5% of all 96 head injuries. There were 25 occurrences of discrete injuries of the brain; additional brain injuries which were not coded can be inferred from the "loss of consciousness" cases (Table 9.3.1). A significant interaction between facial injuries and the life-threatening injuries to the central nervous system was observed. 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 injury lesion type

Head injury lesion	Frequency	
Abrasion and contusion, scalp	27	28.1
Laceration, scalp	25	26.0
Penetration	1	1.0
Fracture, base of skull	7	7.3
Fracture, vault	3	3.1
Fracture skull with brain loss	1	1.0
Subdural hematoma	8	8.3
Epidural hematoma	1	1.0
Subarachnoid hemorrhage	6	6.3
Brain contusion	2	2.1
Brain laceration	4	4.2
Brain hemorrhage	3	3.1
Unconscious	5	5.2
Amnesia	2	2.1
Cranial nerve VII (Facial)	1	1.0
Total	96	

9.4 Rider face injuries

Table 9.4.1 shows the type of lesions affecting the head and face of the injured riders. Fracture of the facial bones, i.e. mandible, maxilla, nose, orbit, teeth and zygoma accounted for 4.8% of the facial injuries. It is important to note that the facial fractures are rarely life-threatening skull fractures, 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: Rider face injury type

Face injury type	Frequency	
Abrasion and contusion	177	57.1
Laceration, skin	94	30.3
Eye injury	3	1.0
Nose injury	7	2.3
Ear injury	1	0.3
Mouth injury	13	4.2
Teeth fracture	8	2.6
Mandible fracture	3	1.0
Maxilla fracture	1	0.3
Nose fracture	1	0.3
Orbit fracture	1	0.3
Zygoma fracture	1	0.3
Total	310	

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.

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 tended to stress the autopsy findings of the head, chest, abdomen and limbs. This was seen in the two fatal cases in which the principal investigator did not do the autopsy. In these cases the neck examination was not included in the normal routine autopsy and no information was provided as to whether soft tissue neck injuries had occurred or not.

Table 9.5.1: Rider soft tissue neck injuries

Neck injury type	Frequency	
Neck contusion	1	
Minor laceration	1	
Carotid sheath hematoma	6	
Thyroid contusion	1	
Neck muscle hemorrhage	9	
Total	18	

The in-depth head-neck autopsy procedure revealed other life-threatening injuries in the cervical regions such as fractures of the cervical spine, subluxation of the atlanto-axial ligament or atlanto-occipital ligament, which clearly represent a life threatening injury. These are discussed in the section on spinal injuries.

The deep injuries to the neck had great potential for critical and fatal outcome. It is also important to note that the injuries to the deeper structures such as soft tissue hemorrhage, fracture cervical spine, etc. were found only during the detailed autopsy examination.

9.6 Thorax injuries

Table 9.6.1 shows the type of lesions that occurred to the rider's thoracic region. Excluding the abrasions, chest injuries were infrequent, but when they occurred they did have had a very high potential for critical or fatal injury. Typical life-threatening injuries to the chest were rib fractures associated with a laceration to the lungs, esophagus, aorta or major blood vessels and the heart. Rupture of the heart was found in three fatal cases as a result of direct impact loading to the thorax.

Table 9.6.1: Rider thorax injuries

Thorax injury type	Frequency	
Abrasion and contusion	30	
Laceration, skin	1	
Major artery laceration	3	
Trachea laceration	1	
Heart laceration	3	
Lung contusion	2	
Lung laceration	5	
Rib fracture	8	
Sternum fracture	1	
Total	54	

9.7 Abdominal injuries

Abdomen injuries were not a common injury found in this data set, but when internal organ injuries such as laceration or rupture of the kidney, spleen, and liver did occur they were often found in fatal cases. Table 9.7.1 illustrates the distribution of the different types of lesions to the abdomen.

Table 9.7.1: Rider abdominal injuries

Abdominal injury type	Frequency	
Abrasion and contusion	21	
Laceration, skin	2	
Laceration, blood vessel	2	
Liver laceration	5	
Spleen laceration	3	
Kidney laceration	3	
Retroperitoneum hemorrhage	2	
Total	38	

9.8 Upper extremity injuries

Table 9.8.1 illustrates the type of injuries affecting the upper extremities. Skin injuries such as abrasions, contusions, and lacerations were the most frequent, accounting for 86% of all upper extremity injuries. Fractures and dislocation accounted for 11% of all injuries to the upper extremities. Upper extremities injuries are generally not considered to be a threat to life, but can be disabling, particularly to those whose occupations involve manual labor.

Table 9.8.1: Upper extremity injuries

Upper extremity injury type	Frequency	
Abrasion and contusion	372	81.8
Laceration, skin	19	4.2
Tendon laceration	2	0.4
Joint contusion, sprain	14	3.1
Joint dislocation	3	0.7
Closed fracture, humerus	4	0.9
Open fracture, humerus	4	0.9
Closed fracture, radius	8	1.8
Open fracture, radius	4	0.9
Closed fracture, ulna	8	1.8
Open fracture, ulna	2	0.4
Fractured clavicle	6	1.3
Fracture scapula	3	0.7
Fracture finger	3	0.7
Fracture metacarpus (wrist)	2	0.4
Finger (crush)	1	0.2
Total	455	

9.9 Pelvic region injuries

Seven riders sustained pelvic region injuries. This number was even lower among the passengers involved in the accidents. Table 9.9.1 shows the type of lesions occurring to the pelvic region. Only one case showed injury to the male genitalia and 6 cases involved a 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 series, riders rarely complained of pain due to groin injury even when the motorcycle fuel tank showed unmistakable evidence of significant pelvic impact. Three riders died from massive hemorrhages due to comminuted fracture of the pelvic bone, which lacerated major blood vessels of the pelvic region.

Table 9.9.1: Rider pelvic region injuries

Pelvic injury type	Frequency	
Testes laceration, massive	1	
Pelvis closed fracture	3	
Pelvis open/comminuted Fracture	2	
Displaced fracture with artery laceration	1	
Total	7	

9.10 Spinal injuries

Spine injuries were rare, accounting less than 1% of all injuries to accident-involved riders. In the upcountry data, all the spinal cord injuries occurred in fatal accidents. As shown in Table 9.10.1, the cervical spine was the most frequently injured location, with two-thirds of the spinal injuries. Although spine injuries were infrequent in this study, they represented serious, life-threatening injuries that often had a great potential for a fatal outcome. Two riders with simple thoracic spine fracture died. Two riders had fracture of the lumbar spine, and one of those died.

Table 9.10.1: Rider spine injury

Spinal injury type	Frequency	
Cervical spine fracture with cord injury	1	
Cervical spine fracture	3	
Cervical spine dislocation (subluxation)	3	
Cervical cord contusion without fracture and dislocation	1	
Thoracic spine fracture	2	
Lumbosacral spine fracture	2	
Total	12	

9.11 Lower extremity injuries

Table 9.11.1 shows the type of lower extremity injuries sustained by the motorcycle riders. The highest frequency of long bone fractures was for the femur, tibia and fibula. Injuries to the lower extremity were very common, and sometimes serious or severe but in only one case were they ever considered to be a threat to life. However, the serious and severe nature of the injuries to the knee, ankle and long bones could cause physical impairment and long term disability.

Table 9.11.1: Rider lower extremity injuries

Lower extremity injury type	Frequency	
Abrasion and contusion	379	
Burn	5	
Laceration	80	
Avulsion	6	
Penetrating wound	2	
Femoral artery injury	1	
Ankle contusion and sprain	3	
Ankle dislocation	2	
Hip contusion	1	
Hip dislocation	2	
Metatarsal, Phalangeal, or Interphalangeal Joint Dislocation	1	0.2
Fracture femur	21	
Patella Fracture	1	
Fracture fibula	9	
Open fracture fibula	6	
Fracture tibia	12	
Open fracture tibia	8	
Fracture foot bone	4	
Total	543	

Lower extremity injuries are important because they can prevent the victim from earning a living if his or her occupation involves manual labor or extended walking or standing. Motorcycle riders are especially vulnerable because most of them lack any education beyond high school (over 80% in this study) and are employed in basic occupations.

9.12 Injury contact surfaces

The contact surfaces were identified as part of the analysis of each of the discrete injuries for the 359 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 surfaces responsible for the right leg injury are described and 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, 1,533 motorcycle rider somatic injuries and 1,882 contact surfaces were identified. The frequency of the various contact surfaces causing the motorcycle rider somatic injuries is shown 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 the pavement actually caused the injury. However, in five 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 : Summary of rider injury contact surfaces

Object contacted	Frequency	
Motorcycles	339	
Other vehicles	432	
Environment	1106	
Helmet	5	
Total	1882	

Contact surfaces on the motorcycle

A list of the seven most frequent motorcycle contact surfaces related to the rider somatic injuries is presented in Table 9.12.2. A complete list of the injuries is provided in the Appendix, also as Table 9.12.2

Injury contact surfaces were often immediately adjacent to injured area. For example, some riders sustained a laceration to the medial surface of the foot from the rear brake pedal or gear shift lever. On the other hand, there were cases in which the contact surface or the point of force application was remote to the actual injury location. For example, impact loading of the knee may cause fracture located along the shaft of the femur. These were considered to be inertial or indirect injuries.

Handlebars were the most frequent motorcycle injury contact surface, accounting for 20% of all the documented rider somatic injuries. The kinematics analysis of these somatic injuries indicated that the handlebar could cause injury as the rider vaults forward in a frontal impact. Motorcycle foot pegs, brake pedal and shifters often acted as a contact surface against the rider's foot. The fuel tank was often identified as a contact surface for the rider's pelvis, although remarkably few riders complained of groin injury.

The motorcycle fairing acted as a somatic injury contact surface in 45 cases. In most cases the broken fairing simply acted as a replacement surface. There were 13 cases where the motorcycle rider or passenger was identified as the injury surface. In all of these cases the documented injuries involved only laceration or contusion.

Table 9.12.2: Motorcycle injury contact surfaces

Motorcycle contact surface	Code	Frequency	
Handlebars	MC02	67	19.8
Fairing	MC09	45	13.3
Frame tube, Frame element	MC23	18	5.3
Engine - transmission cases	MC25	16	4.7
Shifter	MC29	33	9.7
Rear brake pedal	MC31	17	5.0
Rider foot pegs, foot rests	MC37	32	9.4

Injury contact surfaces in the environment

Pavement, either asphalt or concrete was the primary environmental injury contact surface, representing over 80% of the total injury contact surfaces from the environment. Part of Table 9.12.3 shown here provides the most frequent environment contact surfaces. A complete listing of Table 9.12.3 is in the Appendix.

Table 9.12.3: Environment contact surface

Environment contact surface	Code	Frequency	
Asphalt pavement	EA01	658	
Concrete pavement	EC01	246	
Concrete pole or post	EC02	17	
Concrete curb	EC06	12	
Gravel, soil pavement	ES01	17	
Gravel, soil unpaved shoulder	ES07	40	
Wood shrubbery	EW09	57	

Injury contact surfaces on the other vehicle

The front surface and front-side of the cars forward of the front wheel accounted for 11% of all somatic injury contact surface (209/1882). The rear and rear corners of the other vehicle accounted for only 5% (86/1882) of all somatic injury contact surfaces. A complete version of Table 9.12.4 appears in the Appendix. An abbreviated version showing only the most frequent other vehicle contact surfaces appears below.

Table 9.12.4: Other vehicle injury contact surfaces

Other vehicle contact surface	Code	Frequency	
Vehicle Front and Front Corner			
Front bumper	F01X	42	10.4
Front corner, headlamp nacelle	F04X	22	5.5
Vehicle Side Front			
Front mudguard (fender)	S03X	10	2.5
Front tyres	S05X	25	6.2
Front door, front	S10X	10	2.5
Front door side glass (window)	S13X	12	3.0
Front edge of hood	F05X	13	3.2
External rear view mirror	S43X	13	3.2
Vehicle Side Rear			
Side, other object not assigned a code	S98X	12	3.0
Vehicle Rear and Rear Corner			
Rear lamp, sub-boot (sub trunk) panel	R06X	13	3.2
Tailgate	R08X	35	8.7
Upper rear corner, van	R17X	12	3.0
Vehicle Top Surface			
Top of bonnet, rear	T03X	12	3.0
Windshield surface	F10X	25	6.2
Unknown OV part	9999	11	2.7

Helmet parts as injury contact surfaces

In a few cases, part of the rider's own helmet caused injury. Most of the time however, injury contact involving a motorcycle helmet occurred when the unhelmeted rider hit the helmet worn by another person, usually on another motorcycle or perhaps on his own motorcycle. The injury coding here makes no distinction as to whose helmet caused the injury. Helmet injury contact surfaces are listed in Table 9.12.5.

The helmet shell was the most frequent contact surface followed by face shield and chin piece. Thirteen riders received facial injury or head contusion from contact with the helmet worn by another person the passenger of motorcycle as well as the rider on the other motorcycle involved in collision.

Table 9.12.5: Injury contact surfaces on safety helmets

Helmet	Code	Frequency	
Shell	SH01	3	60
Energy-absorbing liner	SH06	1	20
Face shield	SH11	1	20

10.0 Protective Clothing and Equipment

Motorcycle riders and passengers are generally at high risk and vulnerable to injuries due to their exposed position on the motorcycle and the lack of a protective envelope similar to a the conventional car or truck. The evaluation of the effect of protective clothing and equipment was therefore, considered essential to better understand rider injuries and to find ways of reducing injuries.

Helmets

Since it was introduced in 1993, the mandatory helmet law in Thailand has been widely ignored. Helmet use in the upcountry region was found to be very low with less than one-fourth of accident-involved riders wearing a helmet and only 4% of passengers wearing a helmet. In addition, riders were often found to fail to wear their helmet properly. Wearing an unfastened helmet is equivalent to wearing no helmet, because an unfastened helmet will eject off of the head immediately in a collision.

10.1 Helmet performance

In this study, a large quantity of data was collected to describe the use and performance of the helmets involved in the motorcycle accidents. The analysis of the helmet damage then associated the helmet performance with the detailed information on injuries. The results of this analysis then provided an adequate measurement of helmet effectiveness in preventing or reducing head injuries.

It should be noted that the study areas for 359 on-scene, in-depth accident investigation cases were subject to the mandatory helmet use law. However, only one-fourth of riders and about 4% of passengers wore helmets. Combining the 359 riders and 162 passengers, a helmet was worn by only one in six persons riding a motorcycle (86 of 521). Most of the helmets worn in these accidents were acquired for further examination. In addition, photos of the rider and passenger helmets were taken.

Rider helmet use rates varied from province to province, from a high of 33% in Chiang Rai to a low of 10% in Phetchburi, as shown in Table 10.1.1. Table 10.1.1 shows the distribution of helmeted and unhelmeted riders and passengers in the various provinces.

Helmet use in accidents was lower at night (9%) than in the daytime (32%) and dusk-dawn (28%) accidents. A cross-tabulation of helmet use and lighting conditions at the time of accident is presented in Table 10.1.2.

Table 10.1.1: Helmet use by motorcycle riders and passengers

Helmet use	Phetchburi	Trang	Khon Kaen	Saraburi	Chiang Rai	Total
MC rider						
No	49	41	79	34	77	280
	89.1%	80%	80%	66.7%	74.8%	78.0%
Yes	6	10	20	17	26	79
	10.9%	20%	20%	33.3%	25.2%	22.0%
Total	55	51	99	51	103	359
MC passenger						
No	26	33	37	21	38	155
	96.3%	97%	97%	87.5%	97.4%	95.7%
Yes	1	1	1	3	1	7
	3.7%	2.9%	2.6%	12.5%	2.6%	4.3%
Total	27	34	38	24	39	162

Table 10.1.2: Rider helmet use in different lighting conditions, by province

Ambient lighting condition, by province	Motorcycle rider helmet use				Total
	No		Yes		
	Frequency		Frequency		
Phetchburi					
Daylight	26	86.7	4	13.3	30
Night	16	88.9	2	11.1	18
Dusk-Dawn	7	100.0	0	0.0	7
Trang					
Daylight	22	73.3	8	26.7	30
Night	16	94.1	1	5.9	17
Dusk-Dawn	3	75.0	1	25.0	4
Khon Kaen					
Daylight	33	70.2	14	29.8	47
Night	41	91.1	4	8.9	45
Dusk-Dawn	5	71.4	2	28.6	7
Saraburi					
Daylight	15	57.7	11	42.3	26
Night	18	81.8	4	18.2	22
Dusk-Dawn	1	33.3	2	66.7	3
Chiang Rai					
Daylight	27	56.3	21	43.8	48
Night	48	94.1	3	5.9	51
Dusk-Dawn	2	50.0	2	50.0	4
All Provinces					
Daylight	123	68.0	58	32.0	181
Night	139	90.8	14	9.2	153
Dusk-Dawn	18	72.0	7	28.0	25

Helmet effectiveness

Helmets prevented or reduced head injuries, particularly if the helmet stayed on the rider's head through the entire collision sequence. About five out of six unhelmeted riders (84%) had no head injury at all, compared to 90% of helmeted riders (Table 10.1.3).

Among 46 unhelmeted riders who sustained some sort of injury to the head, over 60% had only a minor injury, and one had a severe scalp laceration. The rest were brain injuries: nearly 40% of unhelmeted riders with a head injury suffered a brain injury. Helmeted riders were 22% of the accident population, but accounted for only two of 19 of brain injuries.

As a result, helmeted riders had lower brain injury rates than riders who did not wear a helmet. Two of 79 helmeted riders suffered brain injury (2.5%) compared to 17 of 279 unhelmeted riders (6.1%). Riders without a helmet thus were approximately 2½ times more likely to suffer a brain injury as helmeted riders. Table 10.1.4 illustrates the investigator's assessment of the effectiveness of the helmet based upon the accident reconstruction and injury analysis. It should be noted that "no contact" included both helmeted and unhelmeted riders who had no injury because there was no contact to the head region.

Table 10.1.3: Rider helmet use and head injury severity

Helmet retention	Severity of most severe head injury							Total
	None	Minor	Moderate	Serious	Severe	Critical	Fatal	
No helmet	234	28	1	8	6	2	1	280
Worn, ejected	16	6	0	0	1	0	0	23
Retained on head	55	0	0	1	0	0	0	56
Total	305	34	1	9	7	2	1	359
All helmets	71	6	0	1	1	0	0	79

Table 10.1.4: Helmet effectiveness evaluation

Helmet effect	Frequency	
No helmet present, injuries occurred	145	40.4
Worn but no effect on injuries	10	2.8
Worn and reduced injuries	16	4.5
Worn and prevented injuries	26	7.2
No contact, helmet worn or not worn	162	45.1
Total	359	

The helmet use rate was about the same in both fatal and non-fatal accidents (20 - 25%). However, this does not mean that helmets are unable to prevent deaths. Some riders die as a result of injuries sustained outside the head region, particularly chest and abdominal injuries, which no helmet can prevent. Two of the three fatally injured riders who wore a helmet were run over, a situation with a very high fatality rate whether a helmet is worn or not. Of course, death due to non-head injuries occurred among unhelmeted riders, and helmet use could not have prevented those fatalities. All three helmets in the fatal accidents were open-face helmets.

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 10.1.5 shows the helmet use for the 12 fatally injured riders in the 359 on-scene, in-depth accident cases.

Table 10.1.5: Type of helmet in fatal and non-fatal accidents

Helmet type	Non-fatal accidents		Fatal accidents	
	Frequency	Percent	Frequency	Percent
No helmet	271	78	9	75
Not MC helmet	2	1	0	0
Half/Police-type helmet	42	12	0	0
Open-face helmet	30	9	3*	25
Full-face helmet	2	1	0	0
Total	347		12	

*Two riders were run over by the OV.

The results revealed about 3% (8/280) of unhelmeted riders had AIS > 1, compared to 1.2% (1/79) of helmeted riders. About 2.5% (7/280) of unhelmeted riders sustained life-threatening injuries (severe to fatal), while there were no life threatening head injuries to helmeted riders. The data suggested that the unhelmeted riders had a greater risk of neck injury than the helmeted riders did as shown in Table 10.1.6.

Table 10.1.6: Neck injury severity and type of helmet.

Helmet type	Severity of neck injury							Total
	None	Minor	Moderate	Severe	Serious	Critical	Fatal	
No helmet	272	0	1	5	1	1	0	280
Not MC helmet	0	0	0	0	0	0	0	0
Half helmet	41	0	0	0	0	0	0	41
Open-face	33	2	1	0	0	0	0	36
Full-facial	2	0	0	0	0	0	0	2
Total	348	2	2	5	1	1	0	359

10.2 Factors affecting helmet use

Day - night use

As mentioned earlier (see Table 10.1.2) the helmet use during daylight averaged 32%, but fell to less than 10% at night.

Gender

Females were more likely to use a helmet than males (31% versus 19%). Table 10.2.1 shows the cross-tabulation between motorcycle rider gender and helmet use.

Table 10.2.1: Helmet use by motorcycle rider, gender

Gender	Helmet use				Total
	No		Yes		
Male	227	80.5%	55	19.5%	282
Female	53	68.8%	24	31.2%	77
Total	280		79		359

Helmet use and rider age

Rider helmet use was found to increase with age, from 9% among teenaged riders, to 22% of riders in their 20's, and averaged 35% among those over 30 years of age. The data are shown in Table 10.2.2.

Table 10.2.2: Helmet use by motorcycle rider age

Rider age (years)	Helmet use				Total
	No	%	Yes	%	
11-20	103	92	9	8	112
21-30	99	78	28	22	127
31-40	42	66	22	34	64
41-50	23	64	13	36	36
51-60	7	58	5	42	12
Over 60	6	75	2	25	8
Total	280		79		359

Helmet use, education and occupation

Generally, helmet use tended to go up with the level of education. However, the effect of education level was confounded with age. For example, the overwhelming majority of those with a partial college education (95 riders) were under 30, an age group in which helmet use is low. Table 10.2.3 shows a cross-tabulation of motorcycle rider education and helmet use for the 359 on-scene, in-depth accident cases.

Table 10.2.3: Rider helmet use by education

Education level	No helmet		Helmet worn		Total
	Freq	%	Freq	%	
No formal schooling	3	60	2	40	5
High school or less	223	79	59	21	282
Partial college	33	82	7	18	40
Specialty or technical school	11	85	2	15	13
College graduate	9	50	9	50	18
Unknown	1	0	0	0	1
Total	280		79		359

Helmet use in the upcountry accidents varied by occupation as shown in Table 10.2.4. Students had the lowest rate of helmet use (10%), followed by unemployed riders (11%) and unskilled workers (25%).

Table10.2.4: Helmet use by motorcycle rider occupation

Occupation category	No helmet		Helmet worn		Total
	Freq	Row %	Freq	Row %	
Unemployed	24	88.9	3	11.1	27
Manager	1	100.0	0	0.0	1
Professional	1	33.3	2	66.7	3
Technician	0	0.0	3	100.0	3
Office worker	9	75.0	3	25.0	12
Service worker	14	70.0	6	30.0	20
Skilled agriculture	2	100.0	0	0.0	2
Driver, messenger	9	60.0	6	40.0	15
Machine operator	2	100.0	0	0.0	2
Unskilled labor	123	75.5	40	24.5	163
Housewife	4	100.0	0	0.0	4
Military, active	1	20.0	4	80.0	5
Student	86	89.6	10	10.4	96
Retired, civilian	3	75.0	1	25.0	4
Other	0	0.0	1	100.0	1
Unknown	1	100.0	0	0.0	1
Total	280		79		359

Helmet use and alcohol

Riders who had been drinking alcohol were half as likely to wear helmet as non-alcohol-involved riders (12% to 26%). Table 10.2.5 shows a cross-tabulation of the helmet use and alcohol impairment.

Table 10.2.5: Helmet use by rider alcohol involvement

Alcohol use	Rider helmet use			
	No		Yes	
	Frequency	Row %	Frequency	Row %
No alcohol involvement	187	73.9	66	26.1
Alcohol use, not impaired	10	90.9	1	9.1
Alcohol impaired	82	87.2	12	12.8
Unknown	1	100.0	0	0.0
Total	280		79	

Helmet use and trip characteristics

The highest amount of helmet use was found on long trips and the lowest amount of helmet use was found on short trips, those less than 2 kilometres. 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)	Helmet use				Total
	No		Yes		
	Frequency	Row %	Frequency	Row %	
<0.1	5	100.0	0	0.0	5
0.1-1.0	37	78.7	10	21.3	47
1.1-2.0	58	86.6	9	13.4	67
2.1-3.0	35	79.5	9	20.5	44
3.1-5.0	54	77.1	16	22.9	70
5.1-10	45	80.4	11	19.6	56
Over 10	41	66.1	21	33.9	62
Unknown	5	62.5	3	37.5	8
Total	280	78.0	79	22.0	359

The highest rate of helmet use occurred when “work“ was either the origin or the destination. Tables 10.2.7 and 10.2.8 display cross-tabulations between the trip origin and destination and the presence of helmet use.

Table 10.2.7: Helmet use by trip origin.

Trip origin	Helmet use			
	No		Yes	
	Frequency	Row %	Frequency	Row %
Home	92	79.3	24	20.7
Work, business	48	64.0	27	36.0
Recreation	19	95.0	1	5.0
School, university	8	80.0	2	20.0
Errand, shopping	30	71.4	12	28.6
Friends, relative	54	81.8	12	18.2
Bars, pub, restaurant	26	96.3	1	3.7
Unknown	3	100.0	0	0.0
Total	280		79	

Table 10.2.8: Helmet use by trip destination.

Destination	Helmet use			
	No		Yes	
	Frequency	Row %	Frequency	Row %
Home	139	79.4	36	20.6
Work, business	43	63.2	25	36.8
Recreation	8	88.9	1	11.1
School, university	12	75.0	4	25.0
Errand, shopping	26	78.8	7	21.2
Friends, relative	40	87.0	6	13.0
Bars, pub, restaurant	9	100.0	0	0.0
Unknown	3	100.0	0	0.0
Total	280		79	

Motorcycle riders and passengers were asked about the conditions when they usually wore a helmet. Over half the riders (55%) claimed that they never used a helmet. Only 17% claimed that they always used a helmet. Responses categorized as "other" included "daytime only" and "only when they expected to see a policeman."

Almost 80% of passengers reported that they never use a helmet, and only 3% claimed that they always used a helmet. Table 10.2.9. lists the conditions under which a helmet was usually worn by the accident-involved riders and passenger.

Table 10.2.9: Rider statement about when helmet is usually worn

Helmet use conditions	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Never uses	199	55.4	128	79.0
Long trip	26	7.2	3	1.9
Always	61	17.0	5	3.1
Other	62	17.3	22	13.6
Unknown	11	3.1	4	2.5
Total	359		162	

10.3 Helmet characteristics

Over half of the helmets worn by riders and passengers were the partial coverage type, similar to those worn by police. Full facial coverage helmets, which cover the face as well as the head, were rare. Table 10.3.1 shows the type of helmet coverage worn by the motorcycle riders and passengers.

Table 10.3.1: Rider and passenger helmet coverage

Helmet type	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Partial coverage	43		1	
Full coverage	34		6	
Full facial, no face shield	2		0	
Total	79		7	

Helmet manufacturer

Table 10.3.2 shows the distribution of the manufacturers of helmets worn by the motorcycle rider and passenger of the 359 on-scene, in-depth accident cases. The manufacturers of the majority of helmets were unknown 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, Safety-met, Pretty Lady and Million Stars were found frequently in the data set.

Table 10.3.2: Helmet manufacturer, rider and passenger

Helmet manufacturer	Code	Rider helmet		Passenger helmet	
		Frequency	Percent	Frequency	Percent
Safetymet	S9	7	8.9	2	28.6
Other*	98	27	34.2	2	28.6
Unknown	99	45	57.0	3	42.9
Total		79	100.0	7	100.0

* "Other" included Avex, Pretty Lady, Safety helmet, Star, etc.

Helmet qualification

Table 10.3.3 shows the qualification of the motorcycle rider helmet collected as part of this study. The majority of accident-involved helmets showed no standard labeled and therefore were coded as having no indication of qualification. Helmets with TIS (Thai Industry Standard) were present on 30% of the accident-involved helmets.

Table 10.3.3: Helmet qualification, rider and passenger

Helmet standard certification	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No standard labeled	53	67.1	5	71.4
Thai Industrial Standard	24	30.4	2	28.6
Unknown	2	2.5	0	0.0
Total	79		7	

Helmet mass

The data collected during this study clearly indicate that the higher weight helmets correspond to more shell and liner, for more coverage and, presumably, greater protection. Table 10.3.4 shows the weight distribution of the helmets worn by the motorcycle riders and passengers in our series. In general it was found that those helmets weighing up to 700 grams were half helmet type helmets, and those helmets that weighed between 800-1100 grams were open face helmets. Full-face helmets usually weighed between 1200-1500 grams.

Table 10.3.4: Helmet weight, rider and passenger

Helmet weight (grams)	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
< 600	1	1.3	0	0.0
600 – 700	44	55.7	2	28.6
700 – 800	6	7.6	0	0.0
800 – 1000	24	30.4	5	71.4
1000 – 1300	2	2.5	0	0.0
1300 – 1500	1	1.3	0	0.0
Unknown	1	1.3	0	0.0
Total	79		7	

Helmet pre-crash condition

Most of the helmets worn in upcountry accidents had little or no prior damage. In most cases, the prior damage to the shell of the helmets was innocuous and had no effect upon accident performance. However, 20% of the helmets showed damage to the retention system that made the retention system inoperable prior to the time of collision. One passenger's helmet had no retention system. As noted earlier, a helmet with an inoperable, missing or unused retention system will almost surely eject from the wearer's head during an accident. Table 10.3.5 shows the pre-crash condition of the motorcycle rider helmets involved in the 359 on-scene, in-depth accident cases.

Table 10.3.5: Rider helmet pre-crash condition

Any helmet damage before accident	Rider helmet	
	Frequency	Percent
No significant prior damage	15	19.0
Minor damage from handling and use	46	58.2
Moderate, to exterior finish or comfort pad	1	1.3
Other *	17	21.5
Total	79	

Note: "Other" also included no retention system and/or more than one category of damage.

Helmet colour

Blue helmets predominated among the riders. The helmet colour was considered to be a minor factor affecting conspicuity because the greatest portion of the helmet presented to the other vehicle involved in collision was often the facial region and front portion of the helmet rather than the side or rear of the helmet. Therefore, only a small part of the helmet surface was conspicuous to the other vehicle driver. Table 10.3.6 shows the frequency and distribution of the predominating colour of the helmets worn by the accident-involved motorcycle riders and passengers.

Table 10.3.6: Helmet colour

Helmet colour	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Multi-coloured	1	1.3	0	0.0
White	11	13.9	2	28.6
Yellow	2	2.5	0	0.0
Black	10	12.7	1	14.3
Red	12	15.2	1	14.3
Blue	16	20.3	1	14.3
Green	9	11.4	0	0.0
Silver	4	5.1	2	28.6
Brown, tan	3	3.8	0	0.0
Purple	5	6.3	0	0.0
Gold	3	3.8	0	0.0
Pink	3	3.8	0	0.0
Total	79		7	

10.4 Helmet retention system design and performance

In order protect the wearer, the helmet must remain in place on the head at least until the end of the collision sequence. Several factors are critical to retention system performance, including helmet fit and whether it was worn properly and fastened properly. The retention straps and buckles must be strong enough, and attached to the helmet shell strongly enough to withstand high tensile loads during an accident. The shell must maintain its integrity, because fracturing may allow for complete helmet ejection. Finally, the straps and coverage must work together to prevent the helmet from moving excessively or rotating forward off the wearer's head, thus exposing parts of the head to direct impact.

Table 10.4.1 shows the evaluation of helmet fit. Based upon the analysis of the investigators, about 9% of the rider helmets were considered too large or too loose. None of the passenger helmets were considered too loose, however the sample size was extremely low.

Table 10.4.1: Helmet fit evaluation.

Helmet fit	Motorcycle rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Acceptable fit	71	89.9	7	100.0
Too large	7	8.9	0	0.0
Unknown	1	1.3	0	0.0
Total	79		7	

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 10.4.2 shows riders owned their helmet nearly 90% of the time, while passengers owned the helmet they wore almost three-fourths of the time.

Table 10.4.2: Helmet owner

Owned by wearer	Motorcycle Rider		Motorcycle Passenger	
	Frequency	Percent	Frequency	Percent
No	8	10.1	2	28.6
Yes	70	88.6	5	71.4
Unknown	1	1.3	0	0.0
Total	79		7	

Helmet adjustment

"Helmet adjustment" refers to how the helmet is worn on the head. A helmet that was pushed back so far that the rider's entire forehead and hairline was considered to be improperly adjusted. In the upcountry cases, the investigators were unable to detect any cases where the helmet was improperly worn prior to the crash. The data are reported in Table 10.4.3.

Table 10.4.3: Helmet properly adjusted

Helmet adjustment	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
Improper	0	0.0	0	0.0
Proper	78	98.7	7	100.0
Unknown	1	1.3	0	0.0
Total	79		7	

Retention system

"Quick-release" retention systems, i.e. those secured by some kind of buckle, were the most common retention system found in this study, 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 (similar to airplane safety belts (23%). Fifteen helmets had no retention system because of prior damage. Passenger helmets showed similar findings. Table 10.4.4 shows the type of retention systems found on rider and passenger helmets evaluated during this study.

Table 10.4.4: Type of helmet retention system

Retention system type	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No retention system	15		1	
Double D-ring	2		0	
Slide bar	1		0	
Quick release, Barb sides	42		4	
Quick release, D-blade	18		2	
Other	1		0	
Total	79		7	

Helmet fastening

Nearly one-third (25/79) of the helmeted riders and two of the helmeted passengers wore helmets that were not fastened securely at the time of the accident. Table 10.4.5 shows the majority of the helmets worn by the motorcycle rider and passenger were also securely fastened.

Table 10.4.5: Helmet fastened by rider and passenger.

Helmet fastened	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
No	25	31.6	2	28.6
Yes	54	68.4	5	71.4
Total	79		7	

Helmet ejection

Nearly one-third of the helmets worn by riders and passengers were ejected during the collision events, as shown in Table 10.4.6. There were 20 cases in which the helmet ejected from the head during crash and 3 cases in which the helmet ejected after the initial collision but before the rider came to rest. Only one passenger's helmet ejected during a crash.

Table 10.4.6: Rider helmet retention system performance

Helmet retention performance	Frequency	
Helmet retained	51	64.6
Helmet moved on head but not ejected	5	6.3
Helmet ejected during crash	20	25.3
Helmet ejected after collision	3	3.8
Total	79	

Causes of helmet ejection

Of 24 helmets that came off of the head, only four helmet ejections (17%) were due to some type of helmet failure, but the remaining 83% were due to rider error. In the case of rider error, the helmet was fastened loosely, or was not fastened at all. Failure of the retention system straps was found in only one case. It was associated with a severe forces applied to a previously damaged retention system. Data are shown in Table 10.4.7

Table 10.4.7: Causes of helmet ejection

Helmet ejection cause	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
Helmet not ejected	56	70.9	6	85.7
Due to loose fastening	3	3.8	1	14.3
Ejected due to shell failure	4	5.1	0	0.0
Strap failure	1	1.2	0	0.0
Other*	15	19.0	0	0.0
Total	79		7	

***** "Other" was usually coded when no retention straps were present or the straps were not fastened at all.

10.5 Safety helmet impact analysis

Forty-five of the 79 (57%) safety helmets worn by the accident-involved rider were acquired for later detailed examination. Acquisition was primarily through the offer of a replacement helmet with some form of financial compensation. In those cases where the helmet was not obtained, the accident-involved helmet was visually examined for evidence of external impact damage.

Abrasion was the dominant type of damage to the shell, accounting for 41% of all helmets collected. Nearly one-fourth of accident-involved helmets sustained some type of fracture, usually to the face shield, and sometimes to the helmet shell. There were 21 cases where the helmet was significantly damaged when they were ejected sometime during the crash. About one-third of all helmets showed no evidence of damage. With respect to the passenger helmets, only one helmet showed abrasion. Table 10.5.1 shows the types of impact damage found on those helmets that were examined.

Table 10.5.1: Helmet impact damage type

Helmet impact damage	Rider helmet		Passenger helmet	
	Frequency	Percent	Frequency	Percent
No damage	33	36.3	6	85.7
Abrasion	37	40.7	1	14.3
Fracture through	19	20.9	0	0.0
Crack	2	2.2	0	0.0
Total	91		7	

Helmet damage location

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

Damage was found more often on the right than on the left side of the helmet (53% versus 40%). The upper front region was impacted 30% of the time, the upper rear 25% of the time. Impacts to the lower front and lower rear both were about 12%. Because a helmet could be impacted in more than one region, and all impact locations were recorded, the number of impacts listed is not the same as the number of helmets worn.

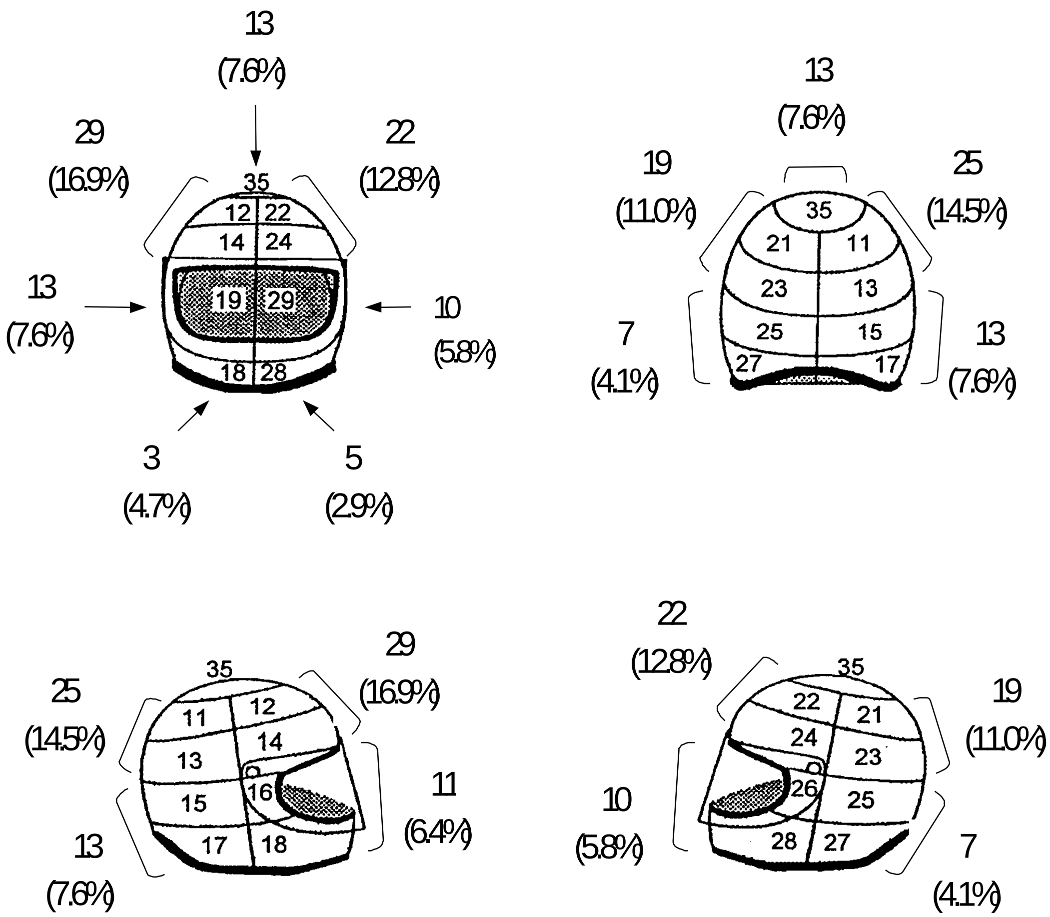


Figure 10.5.1: Designation of helmet regions used to code impact locations

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 cannot prevent crushing injuries. In other cases, impact severity was found to be far beyond the capacity of any helmet to protect the wearer.

Helmet protection was 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. The biggest problems seen in helmet performance in these upcountry 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. 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 shields and facial injuries

The majority of the injuries in the orbital region were found to be abrasions and lacerations to the skin. Fractures of the orbital bones or loss of the eye itself were found only among the fatal cases. The data in Table 10.6.1 show that riders with a face shield had fewer face injuries at all injury severity levels.

Table 10.6.1: Face shield use and face injury severity

Face shield	Severity of face injury						Total
	No injury		Minor		Moderate		
No face shield	34	68%	15	30%	1	2%	50
Yes	22	76%	7	24%	0	0%	29
Total	56		22		1		79

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 30 cases (3.3%) wore some sort of eye protection, usually prescription eyeglasses, or in a few cases, sunglasses. Table 10.6.2 shows the type of eye coverage in use at the time of the accident.

Table 10.6.2: Eye coverage

Eye coverage type	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
None	347	96.7	160	98.8
Prescription clear glasses	8	2.2	2	1.2
Non-prescription sunglasses	3	0.8	0	0.0
Prescription sunglasses	1	0.3	0	0.0
Total	359		162	

10.7 Clothing

Clothing worn by motorcyclists in the upcountry sampling regions reflects the tropical climate of Thailand. When people plan to go only a few kilometres, they may not wish to change into heavy protective clothing, particularly if the clothing will be cumbersome at the destination.

Upper torso coverage

Most riders and passengers wore only light cloth such as a T-shirt, or shirt. About one-eighth wore medium clothes (light jacket) while riding, usually at night or during rainy weather. Only one rider did not wear any upper torso garment, as shown in Table 10.7.1.

Table 10.7.1: Rider and passenger upper torso coverage

Upper torso coverage	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
None	1	0.3	0	0.0
Light cloth	311	86.6	142	87.7
Medium cloth	47	13.1	20	12.3
Total	359		162	

Lower torso coverage

Riders and passengers tended to wear lightweight lower torso coverage. Short pants were very common, and were coded as "light cloth," as were lightweight long pants. Medium cloth was usually a denim jean. The data are shown in Table 10.7.2.

Table 10.7.2: Lower torso garment, motorcycle rider and passenger

Lower torso coverage	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
Light cloth	228		121	
Medium cloth	131		41	
Total	359		162	

Gloves

Only one rider was wearing gloves, which were heavy leather. None of the passengers wore gloves. Abrasion damage on the rider's gloves was considered evidence of injury reduction.

Footwear

Two-thirds of the riders and 80% of the passengers were wearing sandals when they crashed. Only 10 accident-involved riders were wearing boots at the time of collision. Table 10.7.3 shows the type of footwear worn by the accident-involved riders and passengers.

Table 10.7.3: Footwear coverage, motorcycle rider and passenger.

Foot coverage	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
Light sandal	247	68.8	129	79.6
Medium street shoes	60	16.7	23	14.2
Athletic shoes	42	11.7	8	4.9
Heavy shoe or boot	10	2.8	2	1.2
Total	359		162	

10.8 Injury reduction by clothing

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.

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 as to 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 10.8.3.

Upper torso

Coverage worn by the riders was considered to have prevented upper torso injury in only 15 of 218 riders (7%) and nine of 77 passengers (12%). Data are shown in Table 10.8.1.

Table 10.8.1: Upper torso garment effectiveness

Upper torso coverage effectiveness	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
NA, no coverage	1	0.3	0	0.0
No effect	203	56.5	67	41.4
Reduced injury	13	3.6	8	4.9
Prevented injury	2	0.6	1	0.6
No injury contact	140	39.0	86	53.1
Total	359		162	

Lower torso coverage

Lower torso coverage was judged to have reduced injury in 54 of 242 cases of lower torso contact (22%) to the rider, and 16 of 100 passenger contacts as shown in Table 10.8.2.

Table 10.8.2: Lower torso garment effectiveness

Coverage effect on injuries	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
No effect	188	52.4	84	51.9
Reduced injury	48	13.4	15	9.3
Prevented injury	6	1.7	1	0.6
No contact	117	32.6	62	38.3
Total	359		162	

Footwear effectiveness

As expected, the light sandals worn by both riders and passengers could neither prevent nor reduce any kinds of injury in about one-third of the riders and one-fourth of passengers. Evaluations of footwear effectiveness are shown in Table 10.8.3.

Table 10.8.3: Footwear effectiveness

Footwear effect on injuries	Motorcycle rider		Motorcycle passenger	
	Frequency	Percent	Frequency	Percent
No effect	113	31.5	41	25.3
Reduced injury	5	1.4	1	0.6
Prevented injury	5	1.4	0	0.0
No contact	236	65.7	120	74.1
Total	359		162	

11.0 Contributing Factors in Accident Causation

Throughout the 359 on-scene, in-depth accident investigation cases, each accident was thoroughly investigated in order to identify clearly all environmental, vehicle and human factors that may be related to the accident events, accident characteristics and the accident causation. It was, therefore, essential to evaluate these three factors in detail in order to establish their relative contributions and to provide culpability apportionment of each accident.

11.1 Environmental factors

Roadway design defects

Roadways can be defective in a variety of ways that can be classified as design, maintenance or control defects. Design defects are those that involve traffic engineering designs that create problems for motorists. These can include failure to provide positive guidance (such as a lack of signs or confusing signs), poorly designed traffic controls, poor intersection design, improper hardware, etc. Probably the biggest single problem observed was the lack of “positive guidance” at night to alert and guide the motorist along the proper path. The following are some examples of design defects that caused or contributed to accidents in the 359 upcountry cases.

1. Curves on unlighted rural roads need adequate signing on the approach and through the curve, to provide proper guidance to the driver. Also needed are speed advisory signs.

2. Traffic control signals at intersections in urban areas that are set to blink yellow in both directions at night. Drivers approaching on perpendicular paths are not required to stop or even to slow down, and buildings may obstruct the view between them until they are nearly in the intersection and going too fast to avoid a collision.

3. Pavement reflectors that are too large caused several accidents when they were impacted by the front tyre, causing loss of tyre pressure, denting of the front wheel rim and subsequently causing a fall to the roadway.

4. Inadequate marking and guidance in 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. Construction vehicles were sometimes left immediately adjacent to the traffic flow at night, again with no reflectors or lighting and no markers to divert traffic around the hazard.

5. Lane markings, usually paint stripes, may disappear during heavy rain, so that drivers cannot tell exactly where they should be on the roadway. In other cases, upcountry accidents occurred on very wide streets (10 to 15 metres wide in each direction) that lacked any kind of lane stripes to mark where drivers should drive.

6. Bridges narrower than the roadway, so that the motorcycle-only lane directed the rider into collision with the raised sidewalk on the edge of the bridge at night.

7. Intersections of a small road with a larger road that lacked any stop sign or yield sign to discourage drivers on the smaller road from entering the intersection at full speed.

8. Center medians with vegetation taller than one metre above pavement level blocked the view of car drivers, whose eyes are usually one metre above the pavement.

There was no clear roadway design defect present in any of the 322 crashes investigated. A roadway design defect was present but did not contribute in only three cases. Design defects caused or contributed to almost 10% (34) of upcountry accidents. The data regarding design defects are shown in Table 11.1.1

Table 11.1.1: Roadway design defect and accident causation

Design defect contribution	Defect on other vehicle path				Total
Defect on motorcycle path	No OV or no defect	Present, no contribution	Defect was PE	Defect contributed	
No design defects	322	0	0	5	327
Defect, not contributed	1	2	1	1	5
Defect was PE	1	0	0	0	1
Defect was primary cause	2	0	0	0	2
Defect contributed	10	0	0	14	24
Total	336	2	1	20	359

Roadway maintenance defects

Maintenance defects were considered to be items such as potholes, dirt from construction sites left in the roadway, worn and nearly invisible paint stripes. Ten of the accidents reported here (3%) were due at least in part to maintenance defects. No maintenance defects were noted in 327 cases, and maintenance defects were present but did not contribute in another 19 cases. The data for motorcycle and other vehicle path defects are shown in Table 11.1.2.

Table 11.1.2: Maintenance defect contributions to accident causation

Maintenance defect contribution	Defect on other vehicle path			Total
Defect on motorcycle path	No OV or no defects	Present, no contribution	Defect contributed	
No defects	327	2	0	329
Present, no contribution	10	7	0	17
Defect was PE	3	0	0	3
Defect was primary cause	2	0	0	2
Defect contributed	7	0	1	8
Total	349	9	1	359

Traffic control defect or malfunction

A traffic control defect was coded only if traffic control device was present but was operating improperly. Earlier mention was made of traffic control signals that were set to blink yellow in both directions at night. Although this is a defect involving a traffic control, it was coded as a design defect because the problem was considered to be due to unwise programming of traffic lights, not due to a malfunction of the light.

Traffic control malfunction was considered to be the primary cause factor in one case when a motorcycle rider entered the intersection when cross-traffic had a green light because the red light for the motorcycle direction was burned out and no colour was presented. Table 11.1.3 shows that traffic control problems caused or contributed to 12 of the upcountry accidents (3.3%).

Table 11.1.3: Traffic control defect contribution to accident causation

Traffic control defect contribution	Defect on other vehicle path				Total
Defect on motorcycle path	No OV or no defects	Present, no contribution	Primary cause	Defect contributed	
No defects	346	0	1	1	348
Present, no contribution	0	1	0	0	1
Primary cause	0	0	1	0	1
Defect contributed	1	0	0	8	9
Total	347	1	2	9	359

Temporary traffic obstructions

Examples of temporary traffic obstructions included unmarked, unreflectorized barriers around construction sites. In some cases, temporary traffic obstructions blocked the view between the motorcycle and other vehicle. In one case, a temporary barrier placed next to a parked police vehicle, in the traffic flow at nighttime without warning reflectors. It was considered as a primary cause factor because the rider could not detect the hazard along his path. Table 11.1.4 shows 3 cases where a temporary traffic obstruction was present and contributed directly to accident causation.

Table 11.1.4: Contribution of traffic hazards to accident causation

Traffic hazard defect contribution	Defect on other vehicle path			Total
Defect on motorcycle path	No OV or no defects	Present, no contribution	Primary cause	
No defects	350	0	0	350
Present, no contribution	3	3	0	6
Defect was PE	1	0	0	1
Primary cause	1	0	1	2
Total	355	3	1	359

Contribution of roadway defects

Together, these various roadway defects were cited in 17% (59 of 359 upcountry crashes). It is important to note that these 59 cases represented those cases where the roadway defect was a clear problem. There were many other cases found by the investigators where there were other unsafe design conditions, yet these conditions did not contributed directly to accident causation.

Visual obstructions

No visual obstructions were found on the motorcycle path in three-fourths of the accidents (278/359). Stationary obstructions (such as building or trees) were present in 46 cases (13%) and mobile view obstructions were found in 31 cases (9%). Only two cases involved both mobile and stationary obstructions on the motorcycle path.

The other vehicle path was free of view obstructions in nearly three-fourths of the cases. The mobile obstructions were mostly cars (13) or small trucks (12) while the 54 stationary obstructions were usually buildings (18), vegetation such as trees and bushes (13) or parked vehicles (13).

For both motorcycles and the other vehicle, view obstructions were a contributing factor in about 57% of the cases in which an obstruction was present. The data are shown in Table 11.1.5.

Table 11.1.5: Visual obstruction contribution

View obstruction	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No view obstruction	274	76.3	219	71.1
No contribution	35	9.7	31	10.1
Contributed to accident cause	50	13.9	58	18.8
Total	359		308	

Weather related problems

In general, the weather was not a major accident cause factor in this research because most riders simply stopped riding during rain. Weather was a contributing factor in 14 cases and the precipitating factor another case, usually because precipitation limited rider visibility. In Chiang Rai, the visibility problem in rain caused one passenger to hold an umbrella, which blocked the rider's view ahead. In another case, rain reduced the visibility of the lane stripes and caused a vehicle to drift into the adjacent lane and collide with other traffic. Weather conditions were considered to be a contributing factor for the other vehicle in three cases.

11.2 Motorcycle vehicle problems

The evaluation and inspection of the motorcycle revealed no evidence of a motorcycle design defect that caused or contributed to the crash.

The mechanical problems we found were due to faulty maintenance. Although maintenance problems were reported in 32 cases, vehicle problems were actually a contributing factor in only six cases (2%). There was one documented case in which a rear tyre blew out after five hours of riding at highway speeds. In three night crashes, the motorcycle had no headlamp at all; however, this was not considered to be a design defect but rather a maintenance related problem.

Cargo/luggage contribution to accident causation

Cargo or luggage was present in 67 cases (19%), but contributed to accident causation in only four cases (1%), as shown in Table 11.2.1. In two cases, part of the cargo impacted another vehicle. In another case, the cargo interfered with motorcycle controls and prevented successful collision avoidance action. In the fourth case, the cargo came loose, causing loss of control.

Table 11.2.1: Cargo/luggage and accident causation, motorcycle

Cargo contribution	Frequency	
Not applicable, no cargo/luggage	292	81.3
No contribution	62	17.3
Cargo/luggage came loose	1	0.3
Cargo/luggage interfered with controls	1	0.3
Other	2	0.6
Unknown	1	0.3
Total	359	

Other vehicle failures related to the accident

Failure of the other vehicle was reported in 13 cases. All were pre-existing maintenance-related problems stemming from human errors (Table 11.2.2). Often the other vehicle with a mechanical problem was another motorcycle. Whether a contributory defect was present but was unknown in 39 cases, usually when the other vehicle fled the scene.

Table 11.2.2: Other vehicle failure and accident causation

Other vehicle mechanical failure type	Frequency	
None	256	
Other	13	
Unknown	39	
Total	308	

11.3 Rider alcohol

Alcohol was considered to be the single most outstanding contributing factor in these upcountry accidents. Alcohol-involved accidents occur more often near the weekend and in the few hours before midnight. Alcohol-involved riders were found to be more likely to be in a single vehicle accident, to run off the road, to violate traffic control signals and to be going faster when crash. Alcohol-involved riders were less likely to be female or to be wearing a helmet. They were more likely to be the primary or even sole contributing factor in causing the accident.

Day of week

Alcohol was present in 30% of the upcountry accidents, but was present in nearly 60% of the accidents that occurred on Sunday. The data are presented in Table 11.3.1 for the 358 riders whose alcohol involvement was known.

Table 11.3.1: Alcohol involvement by day of week

Day of week	No alcohol		Alcohol use	
	Frequency	Row %	Frequency	Row %
Monday	39	78	11	22
Tuesday	40	77	12	23
Wednesday	45	76	14	24
Thursday	45	73	17	27
Friday	36	68	17	32
Saturday	34	71	14	29
Sunday	14	42	20	59
Total	253		105	

Accident time of day

As in Bangkok, alcohol-involved accidents in the upcountry sampling region tended to occur mostly at night. However, in upcountry accidents, the peak frequency was found to occur in the few hours around 10 p.m. where 65 of 105 cases (62%) happened between 8 p.m. and 1 a.m. Figure 11.3.1 shows the time distribution of alcohol and non-alcohol accidents. The data are shown in Table 11.3.2 in the Appendix.

Alcohol and Hour of Accident

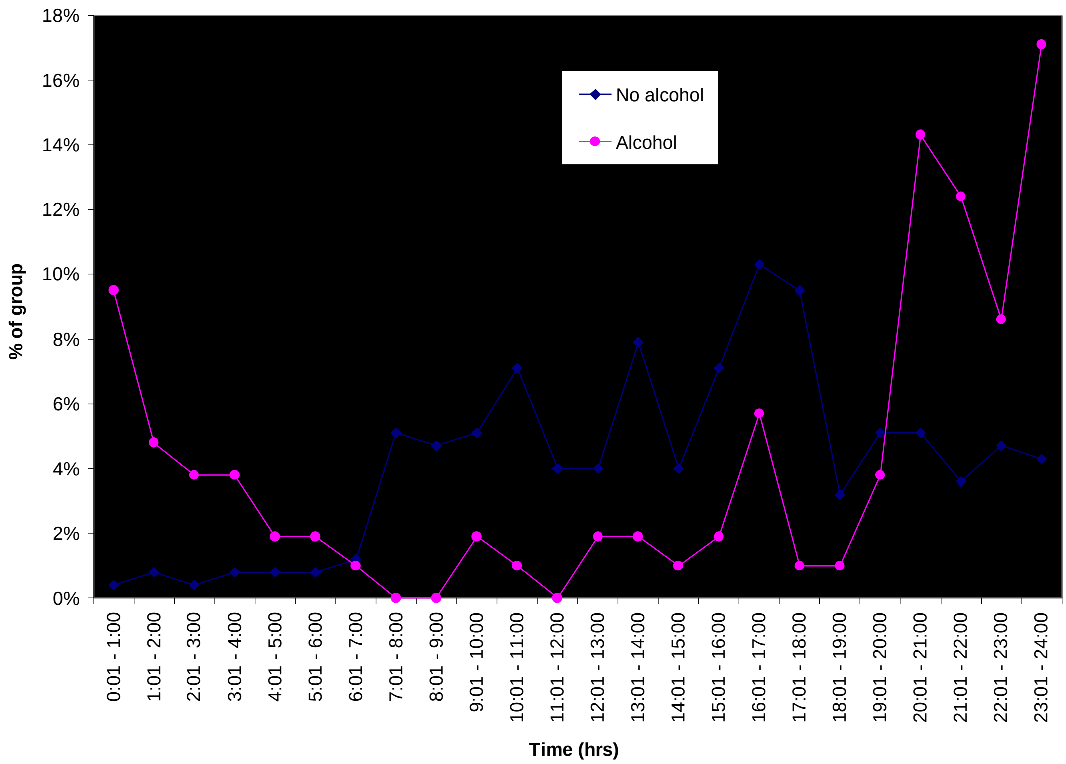


Figure 11.3.1: Percent distribution of accident times in alcohol and non-alcohol accidents

Accident type

When riders have been drinking alcohol, there is a higher probability that they will have a single vehicle crash, that it will involve a loss of control, and that the loss of control will involve falling on or running off the road.

Alcohol-involved riders were twice as likely to get into single vehicle accidents (Table 11.3.3). Only 14% of non-alcohol accidents (36 of 253) were single-vehicle crashes, compared to 30% of alcohol-involved cases (31 of 105).

Table 11.3.3: Alcohol and other vehicle involvement

Other vehicle involved	No alcohol		Alcohol use		Total	
	Frequency	%	Frequency	%	Frequency	%
No other vehicle	36		31		67	
Other vehicle involved	217		74		291	
Total	253		105		358	

Loss of control was found to be three times greater among alcohol-involved riders. Only 12% of non-alcohol drinkers (32 of 253) lost control of the motorcycle, compared to 40% (42 of 105) of alcohol-involved riders.

The most common loss of control among impaired riders was simply riding off the edge of the roadway. Of 32 non-alcohol drinkers who lost control of the motorcycle, only 7 (22%) ran off the roadway, compared to half of the alcohol-involved riders (21 of 42) as shown in Table 11.3.4.

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	221	87.4	63	60.0
Loss of control	32	12.6	42	40.0
Total	253		105	
Loss of control mode				
Ran off road	7	21.9	21	50.0
Other loss of control mode	25	78.1	21	50.0
Total	32		42	

Alcohol and traffic controls

If a traffic control was present, alcohol-involved riders were far more likely to violate it when they crashed. Non-alcohol-involved riders violated a traffic control 20% of the time (8 of 40 cases) that a control was present, compared to 55% (11 of 20) for alcohol-involved 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	%	Frequency	%	Frequency	%
No	32		9		41	
Yes	8		11		19	
Total	40		20		60	

Alcohol and gender

Females were found to represent 22% of accident -involved riders overall (77 of 358), and 28% of the riders in non-alcohol-involved accidents. They accounted for only 5 of the 105 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	Frequency	Percent
Male	181		100		281	
Female	72		5		77	
Total	253		105		358	

Alcohol, education and occupation

Alcohol use actually varied very little as a function of education or occupation in the upcountry data. For both alcohol-involved riders and non-drinkers the median number of years of formal schooling was 9 years.

Alcohol use was also found to be fairly consistent across occupational categories, with one exception. This study found that students were far less likely to have been drinking before they got into a crash. While about 30% of the overall riding population were found to have been drinking alcohol, only 16% of students (15 of 95) had been consuming alcohol prior to the collision.

Alcohol and trip plans

Half of the alcohol-involved riders were on their way home from a friend's house or a bar or restaurant when they crashed (52 of 105), and another 14 were on their way home from work. Nine riders were going to work, and three riders were drinking alcohol while driving as part of their work. In contrast, non-alcohol-involved riders were found to be most likely to be going home from friends, work or running errands (85 of 253) or the opposite direction, from home to work, friends or errands (76 of 253 cases).

Alcohol and speed

Alcohol-involved riders in the upcountry accidents were usually going faster when they crashed when compared to their non-drinking counterparts. Table 11.3.7 shows the mean and standard deviation of pre-crash and crash speeds for alcohol-involved and non-alcohol-involved populations.

Table 11.3.7: Mean and standard deviation of speeds, by alcohol use

Speed distribution	No alcohol		Alcohol use	
	Mean	S.D.	Mean	S.D.
Pre-crash speed	34 (km/hr)	18 (km/hr)	46 (km/hr)	18 (km/hr)
Crash speed	30 (km/hr)	16 (km/hr)	40 (km/hr)	18 (km/hr)

Alcohol and attention

Alcohol affects drinkers by slowing down information processing during divided-attention tasks, and driving a vehicle is a divided-attention task. That is, the driver (or rider) must divide his attention between vehicle speed and other controls (lights, turn signals, etc.), his lane position, position relative to other traffic and following the proper route to his chosen destination. The more one consumes alcohol, the more the ability to process information slows down.

Therefore, it was expected that alcohol-involved accidents would show more attention failures than accidents that did not involve alcohol. Table 11.3.8 compares attention failures in accidents between riders who had been consuming alcohol and those who had not.

Table 11.3.8: Alcohol and rider attention

Rider attention	Alcohol use				Total
	No		Yes		
	Freq	Percent	Freq	Percent	
Inattentive mode, daydreaming	4		57		61
Attention tasks not a factor	226		35		261
Diverted to surrounding traffic	4		2		6
Diverted to non-traffic item	9		3		12
Diverted to passenger activities	4		1		5
Other	2		1		3
Total	249		99		348

Alcohol-involved riders were present in about 30% of the accident population, but they accounted for over 90% of the accidents in which "day-dreaming" 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 90% of non-alcohol involved riders.

Inattention does not always cause or contribute to a crash. Table 11.3.9 suggests that for 100 accident-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 fourteen accidents.

At the investigation level, it was not uncommon for alcohol-involved riders to be unable to provide any information at all about how their accident had happened.

Table 11.3.9: Alcohol and attention failure contribution to accident cause

Attention failure	Alcohol use				Total
	No		Yes		
	Freq	Percent	Freq	Percent	
Not applicable	227	91.5	34	34.0	261
No	2	0.8	12	12.0	14
Yes	19	7.7	54	54.0	73
Total	248		100		348

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 as many as three contributing factors could be listed, in order of their contribution. For example, an accident might involve a primary contribution of OV driver error, a less serious contributing error by the motorcycle rider and perhaps a third factor such as a view obstruction. The first factor listed was considered the primary cause factor. If no second factor was listed, then the primary cause was considered the sole cause of the accident. In 68 cases, only one cause factor was listed with no other contributing factor.

In non-alcohol-involved accidents, the rider was coded as the primary cause in 40% of the cases (101 of 253 cases). In contrast, alcohol-involved riders were the primary cause in nearly 75% of their crashes (76 of 105).

One-third of alcohol-involved riders (34 of 105) were listed as the sole cause factor in their accident, compared to only about one in eight of non-alcohol-involved riders (34 of 253). The comparisons of rider error as primary or sole contributing factor are shown in Table 11.3.10.

Table 11.3.10: Alcohol and primary contributing cause factors

Accident contributing factors	No alcohol		Alcohol use	
	Frequency	Percent	Frequency	Percent
<u>Primary contributing factor</u>				
Rider error	101	39.9	76	72.4
Other than rider error	152	60.1	29	27.6
Total	253		105	
<u>Sole contributing factor</u>				
Rider error	34	13.4	34	32.4
Other than rider error	219	86.6	71	67.6
Total	253		105	

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 of the accident. For example, if an alcohol-involved rider was stopped waiting in traffic at a red traffic signal and was struck from behind by another vehicle, then alcohol was not considered to be a contributing factor. On the other hand, if an impaired rider fell asleep while riding or ran a red light, alcohol was considered to be a contributing factor.

In each alcohol-involved accident, investigators made a subjective decision as to whether alcohol had contributed to causing the accident. Table 11.3.11 shows that alcohol was considered to be a contributing factor for the motorcycle rider in about 86% (91/106) cases in which the rider had been drinking and for 31% of cases in which the other vehicle driver had been drinking.

Table 11.3.11: Alcohol contribution to accident causation

Alcohol contribution	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
Present, but no contribution	14		3	
Contributed to accident cause	91		24	
Unknown	1		51	
Total	106		78	

Alcohol summary

Alcohol was found to have a profound effect on accidents, and the characteristics of alcohol-involved accidents were very different from non-alcohol crashes. Alcohol-involved accidents occurred most often at night, in the few hours around 10 p.m. They were found to involve higher speeds, inattention, running off the road, and traffic control violations. Alcohol-involved accidents in the upcountry sampling regions were found less likely to involve a female rider or a student. Also, as shown in sections 10.2 and 8.9, alcohol-involved accidents had lower levels of helmet use (12% vs. 26%) and more fatal crashes (about one per 13 accidents versus one per 63 non-alcohol accidents.)

11.4 Risk-taking behavior by riders

The on-scene, in-depth accident investigation data collected during this study clearly show that there was a high frequency of human errors 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.

Actions that were considered to be “major” unsafe acts included traveling in the wrong direction, riding at night without a headlamp, failure to yield the right of way to other vehicles, street racing, violation of traffic control signals, improper passing maneuver, excessive speed, and reckless riding which clearly contributed to the accident causation. It should be noted that the act of leaving a vehicle abandoned in a travel lane was also considered to be a major unsafe act. Although riding after drinking alcohol was unsafe, alcohol use was coded separately in order to distinguish its contribution from that of unsafe riding behaviors.

Actions that were regarded as “moderate” unsafe acts included following too closely, and improper turn maneuvers. Failure to travel along curb lane was coded as a "moderate" unsafe act only because it was a violation of the traffic laws.

Riding without a license was coded as a "minor" unsafe act that had no clear contribution to accident causation.

About one-third of the accident-involved riders were engaged in some sort of major unsafe act just before the accident occurred. Another one-fourth were coded as having committed a moderately unsafe act, while 22% committed some minor unsafe acts such as riding without a license or without turn signals.

Not all unsafe acts were found to cause or contribute to a crash, so a separate evaluation was made to determine whether the unsafe act caused or contributed to the accident. The evaluation showed that the unsafe acts contributed differently, depending on the severity of the unsafe act. Table 11.4.1shows the frequency of unsafe acts committed by the accident-involved motorcycle rider before the accident sequence began, and their contribution to accident causation. Note that the more unsafe the rider’s actions, the more likely they were to have contributed to causing the accident.

Table 11.4.1: Motorcycle rider unsafe acts

Rider unsafe acts	Unsafe act occurred		Unsafe act contributed	
	Frequency	Percent	Frequency	Percent
No unsafe acts	59	16	-	-
Major unsafe acts	117	33	109	92
Moderate unsafe acts	102	28	54	53
Minor unsafe acts	81		11	14
Total	359		174	

A similar evaluation of the unsafe acts committed by the other vehicle drivers showed that 188 of 308 (61%) other vehicle drivers committed an unsafe act that contributed to the accident causation. It should be noted that drivers who abandoned a large truck at roadside without proper warning to drivers approaching from behind were considered to have committed an unsafe act, even though they were not in the vehicle at the time of the accident (i.e., the vehicle had no driver). Data are shown in Table 11.4.2.

Table 11.4.2: Evaluation of other vehicle driver risk taking

Unsafe act contribution	Frequency	
No unsafe act	76	25
Unsafe act did not contribute	40	13
Unsafe act contributed	188	61
Unknown	4	1
Total	308	

Lane choice errors

Traveling the wrong way opposite the traffic flow was the most obvious and the most common of the various lane choice errors riders and other vehicle drivers made, and this was regarded as 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 11.4.3 shows that in 31 cases (9%) of the cases, the rider's choice of lane contributed to causing the crash. In 22 of the 31 cases (71%) the motorcycle was traveling in the opposing lanes of traffic. The other vehicle driver's lane choice contributed to accident causation in 29 of 292 cases (10%), and 22 of those (76%) involved driving in the wrong lane.

Table 11.4.3: Lane choice and accident causation.

Contribution of lane choice	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No lane choice available	164	45.7	163	52.9
No contribution	163	45.4	115	37.3
Contributed to causation	31	8.6	30	9.7
Other	1	0.3	0	0.0
Total	359		308	

Traffic scanning errors

Traffic scanning errors were coded when the rider or other vehicle driver made unsafe actions due to his or her failure to see other traffic. Table 11.4.4 shows traffic scanning errors acted as a contributing factor for the rider in 146 cases (40%) and for the other vehicle driver in 50% of the cases. It should be noted that there was a view obstruction in about half those cases. An example of a case in which both view obstruction contribution and scanning error were coded was an accident in which an OV driver attempted to make a right turn onto a major street at an intersection where a parked tour bus badly obstructed his view of traffic approaching from his right. Despite the view obstruction by the bus, the other vehicle driver did not bother to scan for cross traffic, and entered the intersection without stopping.

Table 11.4.4: Traffic scanning errors and accident causation

Contribution of faulty traffic scanning	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
NA, no other traffic	46	12.8	19	6.2
No contribution	167	46.5	129	41.9
Contributed to causation	146	40.7	155	50.3
Unknown	0	0.0	5	1.6
Total	359		308	

Temporary traffic obstruction detection failure

Failure to detect any traffic hazards on roadway such as a pedestrian, an animal crossing the roadway or the presence of a broken sign post lying in roadway was coded as a contributing factor to accident causation. It should be noted that blame or fault was 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 they could not have seen the obstruction. Both situations were treated the same; the rider failed to see the obstruction and that failure was part of what caused the accident. This failure was reported for the rider in 9% of the cases and only twice for the other vehicle driver, as shown in Table 11.4.5.

Table 11.4.5: Temporary traffic obstructions

Traffic obstruction contribution	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No obstruction	324	90.3	306	99.4
No contribution	2	0.6	0	0.0
Contributed to causation	32	8.9	2	0.6
Unknown	1	0.3	0	0.0
Total	359		308	

Faulty traffic strategy

Following another vehicle too closely and going into opposing lanes to pass stopped traffic were considered to be two examples of faulty traffic strategy. Such faulty strategies on the part of the motorcycle rider and other vehicle driver were a major problem and contributed to about half of all cases as shown in Table 11.4.6.

Table 11.4.6: Faulty traffic strategy of rider and other vehicle driver

Faulty strategy contribution	Motorcycle rider		Other vehicle driver	
	Frequency	%	Frequency	%
NA, no fault or no other vehicle	56		14	
Faulty strategy, no contribution	160		116	
Faulty strategy contributed	143		175	
Unknown	0		3	
Total	359		308	

Speed compared to surrounding traffic

Excessively high speed relative to surrounding traffic was considered to be a contributing factor to accident causation. Other situations were also coded as unsafe speed, compared to surrounding traffic such as riding at a very low speed along the fast lane and/or going into opposing lanes to pass adjacent vehicles that are stopped waiting in traffic. Lane splitting was considered to be unsafe only if the rider was going much faster than the traffic that was present in adjacent lanes.

Unusual speed was a contributing factor for 12% of both motorcycles and other vehicles. These data showed speed contribution to accident causation in equal measure for both types of vehicles. The frequency of cases in which unusual speed caused or contributed to accident causation is shown in Table 11.4.7.

Table 11.4.7: Speed compared to surrounding traffic

Speed contribution to accident cause	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No unusual speed	280	78.0	223	72.4
Speed did not contribute	35	9.7	30	9.7
Contributed to causation	43	12.0	36	11.7
Unknown	1	.3	19	6.2
Total	359		308	

Safe position with respect to other traffic

Traveling the wrong way, or attempting to make a U-turn in the middle of roadway or following too closely were considered to be the typical examples of an unsafe vehicle position that could contribute to accident causation. The unsafe position of the motorcycle rider and other vehicle driver accounted for 20% and 32% of all cases as shown in Table 11.4.8.

Table 11.4.8: Safe position relative to other traffic

Contribution of unsafe position in traffic	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No other traffic	67	18.7	7	2.3
No contribution	220	61.3	202	65.6
Contributed to causation	72	20.1	99	32.1
Total	359		308	

Skills deficiency and vehicle unfamiliarity

Twelve accident-involved riders were found to be inexperienced, at the time of the collision, but this deficiency was considered to be a contributing factor in only five cases. Only one other vehicle driver was found to have a skill deficiency that contributed to an accident.

Twenty-five motorcycle riders and 11 other vehicle drivers were considered to be unfamiliar with their vehicles, but vehicle unfamiliarity was a factor in only six motorcycle riders and one other vehicle driver.

Aggressive riding

In the current study, certain rider motions such as running through a red light or street racing or going into opposing lanes to pass stopped traffic were considered to represent aggressive riding practices. These actions usually contributed to accident causation when they occurred. Twenty-two accident-involved riders and 21 other vehicle drivers were considered to have engaged in aggressive driving that contributed to accident causation, as shown in Table 11.4.9.

Table 11.4.9: Aggressive driving contribution to accident causation

Contribution of aggressive driving	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No aggressive driving	315	88	225	73
Present but no contribution	10	3	8	3
Contributed to accident	22	6	21	7
Unknown	12	3	54	18
Total	359		308	

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 OV driver was faced with an imminent collision and there was no action that could have possibly prevented the 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 was a case where a motorcycle (M1) made a right turn from a driveway to the far side of a wide roadway, taking about 8-10 seconds to complete the turn. A rider on another motorcycle (M2) traveling the same direction as the M1 motorcycle was heading saw M1 turning but didn't slow down, speed up, go around, honk the horn or take any kind of action, and instead sideswiped M1 and then fell on the curb. The rider of the M2 motorcycle failed to compensate for the M1 motorcycle 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 13% of all cases and for 20 other vehicle drivers (7%), six of whom were riding a motorcycle. That is, 14 other vehicle drivers and 46 motorcycle riders made some kind of compensation failure. Data are shown in Table 11.4.10.

Table 11.4.10: Compensation failure

Compensation failure	Motorcycle rider		Other vehicle driver	
	Frequency	Percent	Frequency	Percent
No compensation failure	306	85	279	91
No contribution	5	1	4	1
Contributed to accident cause	46	13	20	7
Unknown	2	1	5	2
Total	359		308	

11.5 Other vehicle contribution to accident causation

Most of these upcountry accidents involved another vehicle, and most of those were non-motorcycles such as cars, trucks, buses, 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 cars and truck may well be different than those of motorcycles, so this section will examine other vehicle accident cause factors in more depth.

About 80% of the accidents reported here involved another vehicle. When another vehicle was present, other vehicle driver error was the only accident cause factor in 16 % (48 of 292 cases) as shown in Table 11.5.1. Other vehicle driver error was identified as the primary cause factor along with other contributing factors in another 103 cases (35%).

Table 11.5.1: Other vehicle contribution to accident causation

Other vehicle contribution to cause	Frequency	Total %	% of OV
No OV	67	19	-
No OV contribution	74	21	25
OV was sole cause	48	13	16
OV was primary cause	103	29	35
OV contributed, not primary cause	67	19	23
Total	359	100	100

Alcohol

Alcohol use was lower among non-motorcycle drivers than motorcyclists. Table 11.5.2 shows a cross-tabulation of other vehicle driver alcohol involvement as a function of the type of other vehicle (motorcycle or non-motorcycle). When the other vehicle was another motorcycle, 16% of the other vehicle riders had been drinking alcohol before the accident. When the other vehicle was a non-motorcycle, only 6% of those drivers were known to have been consuming 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 11.5.2: Alcohol involvement and other vehicle type

Alcohol involvement	Other vehicle type				Total
	Motorcycle		Non-MC		
	Frequency	Percent	Frequency	Percent	
No alcohol	85	73	115	68	200
Alcohol use	18	16	9	5	27
Unknown	12	10	32	19	44
No driver	1	1	13	8	14
Total	116	100	169	100	285

Other vehicle causation and accident type

The most common collision configurations are shown in Table 11.5.3 and are summarized in Table 11.5.4. When the other vehicle was a non-motorcycle, the OV tended to be rear-ended, to involve in the perpendicular intersection crashes or to violate the motorcycle right-of-way by making U-turn.

Table 11.5.3: Accident configuration by other vehicle type

Collision configuration	Other vehicle type				Total
	No OV	Motorcycle	Non-MC	Unknown	
1	0	2	12	0	14
2&3	0	14	22	0	36
4	0	2	3	0	5
5	0	7	12	0	19
6&7	0	11	6	0	17
8	0	2	1	0	3
9	0	5	6	0	11
10	0	0	8	0	8
11	0	6	4	0	10
12	0	6	12	1	19
13	0	6	26	1	33
14	0	14	7	1	22
15	0	12	12	2	26
16	0	3	19	0	22
17	0	22	9	1	32
18	23	0	0	0	23
19	22	0	2	0	24
20	0	3	7	0	10
21	0	0	0	1	1
23	18	1	0	0	19
24	2	0	0	0	2
98	2	0	1	0	3
Total	67	116	169	7	359

Table 11.5.4: Most common collision configurations when other vehicle was not a motorcycle

Collision configuration	Motorcycle		Non-MC	
	Freq	%	Freq	%
13 – MC strikes OV rear end	6	5	26	15
2&3 – Perpendicular intersection collisions	14	12	22	13
16 – OV U-turn	3	3	19	11

Other vehicle driver as primary or sole cause of collision

When the other vehicle driver error was the primary or sole cause of the accident, the most common type of accident configurations differed depending on whether the other vehicle was a motorcycle or not. The data are shown in Table 11.5.5 and the most common configurations are highlighted.

Table 11.5.5 : Accident configuration when other vehicle driver error is primary or sole cause

Accident configuration	Other vehicle type		Total
	Motorcycle	Non-motorcycle	
1	1	2	3
2&3	7	12	19
4	2	2	4
5	7	12	19
6&7	10	2	12
8	1	0	1
9	0	2	2
10	0	6	6
11	5	2	7
12	3	3	6
13	4	10	14
14	7	3	10
15	6	6	12
16	3	17	20
17	4	5	9
20	3	1	4
Total	63	85	148

. When the other vehicle was not a motorcycle, the accident most often involved the car making a U-turn. The four most common collision configurations are listed in Table 11.5.6. Interestingly, the other vehicle was at fault when it was rear-ended by the motorcycle. Many of those cases were night crashes in which the cars or trucks were parked or abandoned in the curb lane with inadequate marking or warning and not to be seen by the rider approaching from the rear.

Table 11.5.6: Most common collision type when OV driver is primary cause

Collision configuration	Frequency	
16 - OV U-turn	17	10
2&3 - Perpendicular intersection collision	12	7
5 - OV right turn, MC coming in perpendicular direction	12	7
13 - MC hits OV rear end	10	6

11.6 Accident contributing factors

In each accident, the investigators ranked the relative contribution of as many as three 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, even if a rider was impaired, speeding and driving 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 blocking the view between the two vehicles (view obstruction). Both vehicles were on or across the centerline of the roadway as they rounded the curve (rider & other vehicle driver error). The motorcycle rider swerved and skidded, causing a slide-out (braking error) on the road 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 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 359 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: Accident contributing factors and ranking of importance

Contribution to accident causation	Ranking of importance			
	1	2	3	4
Motorcycle rider error	181	105	3	0
Other vehicle driver error	150	66	7	0
Vehicle failure	1	6	9	0
Environmental factors*	24	51	26	1
Motorcycle passenger	3	4	1	0

Note: Environmental factors included roadway defects, traffic control problems, roadside environment, animals and pedestrians and adverse weather. OV driver error includes an OV that made some maneuver that precipitated the crash but was not actually struck.

In the 120 crashes in which only one cause factor was identified, that cause was found to be the rider in 68 cases (57%) and the OV driver in 48 cases (40%). Of these 120 crashes, 21 (17%) were single vehicle motorcycle crashes. Rider error was found to be the cause of 17 of the 21 single vehicle motorcycle crashes (81%), but environmental problems caused two crashes and a rear tyre blowout caused a third crash. There were 99 multiple vehicle crashes in which only one cause factor was identified and these cases were evenly split between rider error (51 cases) and other vehicle driver error (48 cases).

Environmental factors were assigned as a contributing factor whenever some irregularity of the roadway surface, malfunctioning traffic control, broken sign post lying in the roadway, roadway contamination, stationary view obstruction, etc. were present. Inadequate or non-existing signing, poor lighting, of construction zones and curves, abandoned or illegally parked-unlighted trucks were noted as contributing cause factors in the upcountry cases accounting for 28% of all cases (102/359 cases). Pedestrians and animals were also included and coded under environmental factors. Pedestrian action was selected whenever the pedestrian made some unsafe act, i.e. jaywalking, or a darting move into the path of the motorcycle. Some form of environmental problem was the primary cause factor in about one in every fifteen (7%) accidents.

Motorcycle passengers were assigned culpability in the accident when their motions distracted the motorcycle rider or caused loss of control of the motorcycle. The motorcycle passenger was the primary cause in only three cases, in one case by jumping off the motorcycle and causing it to fall, or in another case by carrying an umbrella that blocked rider's view ahead. The motorcycle passenger was ranked as the second most culpable contributor to the accident in four cases and one case each in which the passenger was ranked as the third and fourth most culpable.

Finally, vehicle problems were infrequently 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 which were the responsibility of the motorcycle rider. There was only one example in which the rear tyre blew out while riding and this was subsequently was coded as the primary accident cause factor. A vehicle failure was ranked second in 6 cases and these consisted of either a braking failure resulting in a rear-ended collision or a failure to equip with headlamp at nighttime. The vehicle was also ranked as third culpable contribute in 9 cases.

Summary of accident causation factors

Based on the data collected in this study, human error is the greatest cause in these motorcycle accidents. Consumption of alcohol and riding a motorcycle appears to be the most prominent of the human errors. Many riders engage in risky behavior with and without alcohol involvement. The data collected in this study also show that many problems of roadway design exist in upcountry and that these problems do contribute to motorcycle accident s. Large structures that crate view obstruction and poorly maintained and marked construction sites represent preventable hazards, which can be eliminated.

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 very similar risks of accident and injury as those who were 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 same time of day to observe motorcycle and vehicle traffic. Information was collected for both the motorcycle and other vehicle paths of travel. The 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, type (step-through, sport, etc.) headlamp use, passengers, cargo, etc., was collected. These data are referred to here as the on-scene exposure (OSE) data.

Visual observation does provide vehicle information; however, it does not provide any human factors information. It was dangerous or impossible to interview motorcycle riders passing the on-scene exposure data collection sites, therefore, investigators later went to petrol stations located near the accident site at the same time of day and same day of week as the accident and interviewed riders as they stopped for petrol. The interviews are referred to here as the petrol station exposure (PSE) data.

12.1 Environmental factors

Traffic flow

The number of vehicles traveling along the motorcycle and other vehicle pre-crash paths of travel at each accident location was counted for a one-hour duration (30 minutes before and 30 minutes after the reference accident time). For example, if the reference accident involved a motorcycle going east along lane 2 and a westbound car turning right from lane 1 in front of the motorcycle, then all east bound vehicles were counted as part of the motorcycle traffic flow, and all westbound vehicles that turned right were counted as part of the other vehicle traffic flow.

Vehicles were also classified as motorcycles of various types, passenger cars (which included subcompact, compact, intermediate, saloon, mini-light trucks (pick-up), minivans, full-size van, sport utility vehicles), trucks, buses, articulated coach, special vehicles, tuk-tuks and others.

The traffic count data shows that on the motorcycle path, half of the vehicles that passed by were motorcycles and 45% were cars (all sizes, including pickup trucks and SUVs). The remaining vehicles were large trucks and buses.

On the other vehicle path, passenger cars accounted for 51% of the traffic, motorcycles accounted for 42% of the traffic, all buses 3.2%, big trucks 1.7% and tuk-tuks 3.9%. Table 12.1.1 shows the number of vehicles passing the OSE scene in one hour in the five selected provinces along the motorcycle and other vehicle paths of travel for each category. There were 57,221 vehicles counted along the motorcycle direction and 36,668 counted on the other vehicle path.

Table 12.1.1: Vehicle type and frequency (OSE data)

Vehicle type	Motorcycle path		Other vehicle path	
	Frequency	Percent	Frequency	Percent
Standard motorcycles	2,724	4.76	1,610	4.39
Step-through motorcycles	25,273	44.17	13,719	37.41
Saloon/sedan cars	9	0.02	4	0.01
Intermediate cars	182	0.32	149	0.41
Compact size cars	5877	10.27	4,302	11.73
Subcompact cars	459	0.80	327	0.89
Mini light truck	17,777	31.07	12,721	34.69
Full size light truck	188	0.33	189	0.52
Sport utility vehicles	524	0.92	406	1.11
Commercial trucks	1,604	2.80	1,215	3.31
Trailer towing truck	278	0.49	215	0.59
Full size van	526	0.92	488	1.33
Minivan	364	0.64	214	0.58
Bus	751	1.31	614	1.67
Articulated coach	11	0.02	11	0.03
Trolley bus	0	0.00	0	0.00
Special vehicle	49	0.09	78	0.21
Other	195	0.34	135	0.37
Tuk-Tuk	430	0.75	271	0.74
Total	57,221		36,668	

Weather

As in the accident cases, clear weather conditions predominated in the great majority of the OSE cases. Rain accounted for only 4% of all exposure data collections and was therefore not considered to have a significant effect upon the vehicle counts. Rain occurred more often in the Chiang Rai sampling area than other selected provinces largely because data collection in Chiang Rai occurred during mid-August to mid-September, the peak of the rainy season.

12.2 Motorcycle factors

Honda motorcycles accounted for about half of the motorcycles passing the exposure data sites followed by Suzuki motorcycles (22%), Yamaha motorcycles (22%), and Kawasaki motorcycles (4%) as shown in Table 12.2.1

Table12.2.1: Motorcycle manufacturers

Motorcycle manufacturer	Frequency	
Honda	14,332	51.2
Kawasaki	1,199	4.3
Suzuki	6,191	22.1
Yamaha	6,110	21.8
Piaggio - Vespa	48	0.2
Other	5	0.0
Unknown	112	0.4
Total	27,997	

Motorcycle type

Motorcycles passing each OSE location were immediately counted and identified as well as videotaped for later confirmation. The motorcycles were then classified according to motorcycle type and manufacturer. As in the accident data, step-through type motorcycles predominated. About 90% of the 27,997 motorcycles were step-through, 5% were standard street motorcycles and 3% were sport-bike design. The data are shown in Table 12.2.2.

Table 12.2.2: Motorcycle type in exposure data

Motorcycle type	Code	Frequency	
Standard street OEM	00	1,439	5.14
Standard street, modified	01	2	0.01
Sport, race replica design	03	894	3.19
Cruiser design	04	70	0.25
Chopper, semi-chopper	05	1	0.00
Touring design	06	4	0.01
Scooter	07	298	1.06
Step-through	09	25,273	90.27
Street MC plus sidecar on left	11	1	0.00
Off road, enduro, trials	13	15	0.05
Total		27997	

Headlamp usage

The motorcycle headlamp was operating for 31% of the motorcycles passing the OSE locations (Table 12.2.3). The headlamp use varied with the time of day. The distribution of motorcycle observations was divided into daytime (daylight-bright and not bright) night (night-lighted and night-not lighted), dusk and dawn. The OSE data revealed that the highest percentage of headlamp use was at night (91%) and lowest usage was during day (2%).

Table 12.2.3 : Motorcycle headlamp use at exposure sites

Ambient light	Headlamp on		Headlamp off		Total	
	Frequency	%	Frequency	%	Frequency	%
Daylight	392	2.3	16,969	97.8	17,361	100.0
Night	7,725	90.7	788	9.3	8,513	100.0
Dusk	512	25.4	1,505	74.6	2,017	100.0
Dawn	15	14.2	91	85.9	106	100.0
Total	8,644		19,353		27,997	

12.3 Human factors at on-scene exposure data sites

The human factors data reported in this section come from observations of motorcycles and riders that passed the on-scene exposure data collection sites one week after each accident. Data from interviews at petrol stations are reported in sections 12.4 through 12.14.

Gender

The gender of riders and passengers who passed the OSE data collection sites is shown in Table 12.3.1. Female riders accounted for over one-fourth of all riders and represented 56% of all passengers. The percentage of female riders varied from 15% in Saraburi to 35% in Phetchburi. More than half of motorcycle passengers were female in 4 provinces but was 47% in the Saraburi data set.

Table 12.3.1: Motorcycle rider and passenger gender at OSE sites

Gender	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Male	20,478		5,661	
Female	7,519		7,262	
Total	27,997		13,923	

Motorcycle cargo/luggage

Cargo or luggage was identified on 13% of the nearly 28,000 motorcycles passing the OSE sites. About 15% of motorcycles were carrying some sort of cargo or luggage on a rear rack. The cargo was carried by the passenger 29% of the time, 15% of the time it was carried in the rider's backpack and 8% of the time it was carried on the seat or tank ahead of rider. Data are shown in Table 12.3.2.

Table 12.3.2: OSE data, cargo/luggage on motorcycle

Cargo luggage location	Frequency	
No cargo/luggage	24,351	87.0
Carried on rear rack	554	2.0
Carried in saddle bag	99	0.4
Carried by passenger	1072	3.8
Carried on seat or front of rider	303	1.1
Between rider legs (step-through or scooter)	86	0.3
Carried between rider arms	278	1.0
Carried in backpack on rider	566	2.0
Other	687	2.5
Unknown	1	0.0
Total	27,997	

Number of passengers on motorcycle

The number of passengers riding on the motorcycles at the OSE sites was counted directly by the investigators and then confirmed from videotapes. There was no passenger present on 58% of the motorcycles passing the OSE locations. The data are shown in Table 12.3.3.

Table 12.3.3: Number of passengers on motorcycle, OSE data

Number of passengers on motorcycle	Frequency	
None	16,421	58.7
One	10,327	36.9
Two	1,156	4.1
Three	88	0.3
Four	5	0.0
Total	27,997	

Helmet use

Over 40% of the riders passing the OSE sites were helmeted. Helmet use for passengers was found to be much lower than for riders (10%) (see Table 12.3.4). The majority of helmets worn by the rider and passenger appeared to be securely fastened. It should be noted that the number of helmets fastened poorly was underestimated because the investigators could only clearly identify those cases where the helmet was worn so far back the straps could not be fastened or those cases in which the straps were obviously flapping freely and blowing in the wind. It was not possible to determine the number of cases in which the helmet was fastened too loose or not present at all.

Table 12.3.4: OSE data, helmet use by rider and passenger.

Helmet use	Rider		Passenger	
	Frequency	Percent	Frequency	
No helmet wearing	16,717		11,542	
Yes, but not securely fastened	1,353		141	
Yes, and securely fastened	9,927		1,240	
Total	27,997		12,923	

The distribution of rider helmet types is shown in Table 12.3.5. About haft of the riders and passengers seen passing the OSE sites were wearing the partial coverage type and were least likely to be wearing a full-face helmet.

Table 12.3.5: Rider and passenger helmet type at OSE sites

Helmet type	Rider		Passenger	
	Frequency	Percent	Frequency	Percent
Not motorcycle helmet	44	0.4	2	0.1
Haft/police type helmet	5,517	48.9	774	56.1
Open face MC helmet	4,740	42.0	570	41.3
Full face M helmet	979	8.7	33	2.4
Other	0	0.0	2	0.1
Total	11,280		1,381	

Helmet use sharply declined at night and dusk-dawn, among both riders and passengers. Helmet use at night was roughly one-third as much as during daylight. Table 12.3.6 shows a cross-tabulation of helmet use and ambient lighting condition.

Table 12.3.6: Helmet use at different times of day, OSE data

Helmet use by ambient light		Rider		Passenger	
Ambient lighting condition	Helmet use	Frequency		Frequency	
Daylight	No	8,272	47.7	6,312	85.3
	Yes	9,089	52.4	1,086	14.7
Total		17,361		7,398	
Night	No	7,002	82.3	4,264	94.2
	Yes	1,511	17.75	262	5.8
Total		8,513		4,526	
Dusk	No	1,352	67.0	915	96.8
	Yes	665	33.0	30	3.2
Total		2,017		945	
Dawn	No	91	85.9	51	94.4
	Yes	15	14.1	3	5.6
Total		106		54	

12.4 Petrol station exposure data

During February to March, 2001, investigators returned to the study areas to collect additional human factors information by interviewing motorcycle riders at a petrol station located as near as possible to the accident. This data collection was based on the assumption that riders using that petrol station were likely part of the same population as those who passed OSE sites and those who were involved in accidents at the OSE sites.

During the petrol station interviews, riders were asked many of the same questions that were asked of accident-involved motorcycle riders, including background information such as education and occupation, as well as their experience riding motorcycles, and their familiarity with the roadway where the reference accident occurred, etc. Some elements of the data came from simple observation, such as clothing, helmet use, gender and motorcycle information.

Motorcycle types

The distribution of motorcycle types ridden by 1,060 riders participating in the petrol station exposure (PSE) study is shown in Table 12.4.1. As in the on-scene exposure data collected one week after the accident, step-through motorcycles predominated, accounting for 92% of the exposure populations.

Table 12.4.1: Motorcycle type in petrol station interviews

Motorcycle type, PSE data	Frequency	
Standard street, no significant modifications	20	1.9
Standard street, with modifications	3	0.3
Sport, race-replica design	51	4.8
Scooter	11	1.0
Step-through	974	91.9
Other	1	0.1
Total	1060	

12.5 General characteristics of riders in petrol station interviews

Rider gender

Female motorcycle riders accounted for 26% of all riders interviewed at the petrol stations as shown in Table 12.5.1. In both exposure studies, male rider represented nearly three-fourths of the riders on the street.

Table 12.5.1: Rider gender in petrol station interview data

Rider gender	Frequency	
Male	784	
Female	276	
Total	1,060	

Rider Age

The youngest rider interviewed was found to be 12 years and the oldest rider was 72 years. The median age was 26 years. Approximately 27% of those responding riders were under the age of 21 years and 60% were 21-30 years. The age distribution of motorcycle riders interviewed is shown in Table 12.5.2.

Table 12.5.2 : PSE data, rider age

Rider age (years)	Frequency	
11 – 20	285	26.9
21 – 30	403	38.0
31 – 40	236	22.3
41 – 50	94	8.9
51 – 60	32	3.0
> 60	10	0.9
Total	1060	

Rider height

Table 12.5.3 shows the height of participating riders in the PSE data. Rider height varied from 143 to 183 cm. with a median height of 166 cm.

Table 12.5.3: PSE data, rider height

Rider height (cm)	Frequency	
0 - 145	3	0.3
146 -150	20	1.9
151 -155	59	5.6
156 - 160	172	16.2
161 - 165	266	25.1
166 - 170	400	37.7
171 - 175	116	10.9
176 - 180	22	2.1
> 180	2	0.2
Total	1060	

Rider weight

Table 12.5.4 shows the distribution of rider weights. Rider weight ranged from 40 to 105 kilograms with a median weight of 60 kilograms.

Table 12.5.4: PSE data, rider weight

Rider weight (kg)	Frequency	
31 - 40	12	1.1
41 - 50	224	21.1
51 - 60	461	43.5
61 - 70	286	27.0
71 - 80	59	5.6
> 80	18	1.7
Total	1060	

Rider education

Nearly 70% of riders interviewed had a formal education that ended prior to college. Twenty one percent of the interviewees were found to have a partial college education, while 5.5% of those interviewed were college graduates. The data are shown in Table 12.5.5.

Table 12.5.5 : Rider's highest level of education, PSE interviews

Rider education	Frequency	Percent
No formal school	17	1.6
Formal education, prior to college	734	69.2
Partial college/university training	218	20.6
Specialty technical school graduate	30	2.8
College/university graduate	58	5.5
Graduate school, advanced degree, professional degree	3	0.3
Total	1060	100.0

Rider occupation

Elementary occupations (such as ordinary laborers) made up nearly one-third of those interviewed. Students represented about one-fourth of those interviewed and service workers were about 10% of those interviewed. The data are shown in Table 12.5.6.

Table 12.5.6 : Rider occupation in petrol station interview data

Rider occupation	Code	Frequency	
Unemployed	1	60	5.7
Senior officials and managers	2	4	0.4
Technicians and associate professionals	4	10	0.9
Clerical, office worker	5	73	6.9
Service, shop and market sales workers	6	97	9.2
skilled agricultural and fishery workers	7	74	7.0
Craft and related trades workers	8	6	0.6
Transport equipment operative, driver	9	57	5.4
Plant and machine operators and assemblers	10	3	0.3
Elementary occupations	11	335	31.6
Housewife, homemaker	12	36	3.4
Military, active duty	13	18	1.7
Military, reserve duty	14	1	0.1
Student, full time	15	279	26.3
Retired, civilian	16	3	0.3
Retired, government service or military	17	1	0.1
Other	98	3	0.3
Total		1060	

12.6 Licensing and training of riders in petrol station interviews

About one-third of riders interviewed in the PSE data had no driver license as shown in Table 12.6.1.

Table 12.6.1: Rider license in PSE interview data

Rider license held	Frequency	
No license held	352	33.2
Motorcycle license	706	66.6
Automobile license	2	0.2
Total	1060	

Rider training

Approximately 80% of responding riders were self-taught and 20% learned to ride from family and friends (Table 12.6.2). None of the riders interviewed reported that they had received any formal motorcycle training.

Table 12.6.2: PSE data, rider training experience

Rider motorcycle training	Frequency	
Self taught	850	
Taught by friends or family	210	
Total	1060	

12.7 Rider experience

Nearly 90% of riders interviewed claimed to ride daily. The median distance estimated by the riders interviewed was 5,000 kilometres per year. The data are show in Tables 12.7.1 and 12.7.2.

Table 12.7.1: PSE data, days per year riding motorcycle

Days per year riding	Frequency	
0 - 50	2	0.2
51 - 100	14	1.3
101 - 150	32	3.0
151 - 200	19	1.8
201 - 250	19	1.8
251 - 300	36	3.4
301 - 365	938	88.5
Total	1060	

Table 12.7.2: PSE data, distance motorcycle is ridden per year

Distance per year riding (km)	Frequency	
1 - 3000	290	27.4
3001 - 6000	313	29.5
6001 - 9000	216	20.4
9001 - 12000	74	7.0
12001 - 15000	42	4.0
15001 - 18000	2	0.2
18001 - 21000	66	6.2
> 21000	57	5.4
Total	1060	

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 the time and rode a motorcycle half the time, and that half his motorcycle use was recreational, his use was coded 50% "does not ride," 25% "motorcycle - basic transportation" and 25% "motorcycle - recreation."

The responses of all interviewees were averaged and the results are shown in Table 12.7.3. The results showed that 84% (five-sixths) of motorcycle riders use the motorcycle for basic transportation and 14% use the motorcycle for recreation purposes. Younger riders tended to have more recreational use, while older riders tended to use the motorcycle as basic transportation.

Table 12.7.3: PSE data, purposes of motorcycle use

Vehicle operation	
Non-motorcycle	3.9
Motorcycle - recreation	11.7
Motorcycle - basic transportation	84.5
Total	

Rider experience riding with passenger(s)

Approximately 60% of all participating riders carried no passenger at the time of the interview. This was nearly identical to the proportion seen in the on-scene exposure surveys conducted one week after the reference accident. Of those who were carrying a passenger, about 70% (300/431) of the responding riders said they had moderate experience riding with a passenger and 21% (91/431) had extensive experience. Only 9% of PSE interviewees (40/431) said they had little experience carrying a passenger (Table 12.7.4).

Table 12.7.4: Riding experience with passenger, PSE data

Experience carrying a passenger	Frequency	
No passenger	629	59.3
Very little experience	40	3.8
Moderate experience	300	28.3
Extensive experience	91	8.6
Total	1060	

Rider experience carrying similar cargo

Of 1,060 riders interviewed, 83% carried no cargo or luggage (compared to 87% in the on-scene exposure surveys). Among those observed to be carrying some sort of cargo, three-fourths said they frequently or always carried similar cargo. The data are shown in Table 12.7.5.

Table 12.7.5:Rider experience with similar cargo/luggage, PSE data

Experience carrying cargo	Frequency	
No cargo/luggage	877	82.7
No previous experience	1	0.1
Seldom carries similar cargo	43	4.1
Frequently carries similar cargo	112	10.6
Always carries similar cargo	27	2.5
Total	1060	

12.8 Rider's previous traffic violations and accidents

Nearly 70% of riders denied any previous traffic citations or tickets during the past 5 years and 17% claimed to have received only one citation. Fifteen riders claimed to have been ticketed at least five times. It was not possible to verify rider reports because no official records of citations were available. The data are shown in Table 12.8.1.

Table 12.8.1: PSE data, previous traffic violation

Citation in past 5 years	Frequency	
None	731	69.0
One	184	17.4
Two	83	7.8
Three	38	3.6
Four	9	0.8
Five	7	0.7
Six	3	0.3
Seven	1	0.1
Eight	3	0.3
Ten	1	0.1
Total	1060	

Rider's previous traffic accidents

Responding riders in the PSE study reported a relatively low incidence of previous motorcycle traffic accidents during the past 5 years. About two-thirds of riders interviewed in the PSE data denied any previous motorcycle accident and about one-third reported that they had at least one previous accident (Table 12.8.2). With respect to any previous non-motorcycle traffic accidents, about 91% of responding riders denied previous non-motorcycle traffic accident experience.

Table 12.8.2: PSE data, previous traffic accidents

Previous crashes, last 5 years	Motorcycle		Non-motorcycle	
	Frequency		Frequency	
None	707	66.7	965	91.0
One	222	20.9	66	6.2
Two	86	8.1	20	1.9
Three	26	2.5	6	0.6
Four	5	0.5	2	0.2
Five	9	0.8	1	0.1
Six	1	0.1	0	0
Seven	2	0.2	0	0
Eight	2	0.2	0	0
Total	1,060		1,060	

12.9 Rider trip

A large percentage of the riders interviewed showed a high level of familiarity with the area. About 78% of 1,060 riders interviewed reported traveling on the same roadway daily and another 15% said they traveled the same roadway at least weekly as shown in Table 12.9.1.

Table 12.9.1: Rider familiarity with roadway, PSE data

Roadway familiarity	Frequency	
Daily use	829	78.2
Weekly use	159	15.0
Monthly use	48	4.5
Quarterly	5	0.5
Annually	5	0.5
Never used this roadway before	14	1.3
Total	1060	

Rider trip plan

According to the riders interviewed in the PSE study, home was the most frequent response as both origin and destination of the intended trip (Table 12.9.2). Two-thirds of responding riders reported they were going five kilometres or less (Table 12.9.3); the average distance of the intended trip was four kilometres. About 70% of riders had traveled only 6 minutes or less from the departure to the petrol station where they were interviewed. The median value of the riding time was 0.1 hour or 6 minutes (Table 12.9.4).

Table 12.9.2: Trip origin and destination, PSE data

Location	Trip origin		Trip destination	
	Frequency	Percent	Frequency	Percent
Home	400	37.7	431	40.7
Work, business	260	24.5	226	21.3
Recreation	18	1.7	35	3.3
School, university	82	7.7	36	3.4
Errand, shopping	143	13.5	175	16.5
Friends, relatives	114	10.8	100	9.4
Bar, restaurant, café	43	4.1	57	5.4
Total	1060		1060	

Table 12.9.3: Length of intended trip, PSE data

Length of intended trip (km)	Frequency	
0.1 - 1.0	130	12.3
1.1 - 2.0	201	19.0
2.1 - 3.0	137	12.9
3.1 - 5.0	231	21.8
5.1 - 10.0	196	18.5
> 10.0	165	15.6
Total	1060	

Table 12.9.4: Time riding before interview, PSE data

Time riding (hours)	Frequency	
0	233	22.0
0.1	496	46.8
0.2	165	15.6
0.3	79	7.5
0.4	22	2.1
0.5	42	4.0
0.6 - 0.7	8	0.8
0.8 - 1.0	7	0.7
> 1.0	8	0.8
Total	1060	

12.10 Rider physiological impairments

The majority of riders interviewed at the petrol stations reported no physical problems or stress. About 6% (61) of responding riders reported vision problem but only 31 of these riders were wearing eyeglasses at the time of the interview and one used contact lens. Although one accident-involved rider crashed due to epileptic seizure, none of riders interviewed in petrol stations reported a history of epilepsy.

Transient physiological impairment was extremely uncommon. Only one participating rider reported that he was fatigued at the time of the interview.

Six riders admitted to significant stress at the time of interview. One was in conflict with friend, four had work-related problems and one rider was involved in a traffic conflict.

12.11 Alcohol use

Table 12.11.1 shows 3.3% of 1,060 riders had been drinking alcohol prior to the time they were interviewed. Of those 35 riders who had consumed alcohol, four riders showed subjective evidence of alcohol impairment as directly observed by the interviewers (Table 12.11.2). Although questions regarding drug use came late in the interview to minimize any perceived threat, none of participating riders admitted to any kind of drug use. Participating riders were reluctant to admit drug involvement.

Table 12.11.1: Alcohol use in petrol station interviews

Alcohol use	Frequency	
No Yes	1025 35	
Total	1060	

Table 12.11.2: Apparent alcohol impairment in PSE data

Apparent impairment	Frequency	
None Not significantly impaired Significantly impaired	1025 31 4	
Total	1060	

12.12 Helmet use

About 46% of the 1,060 participating riders were helmeted. Another 77 riders had a helmet with them, but were not wearing it when they entered the petrol station. Nearly half of the riders interviewed (496) had no helmet, either on their head or on the motorcycle (Table 12.12.1).

Table 12.12.1: Helmet use by riders in PSE data

Helmet use	Frequency	
No helmet present No, helmet present, but not on head Helmet worn on head	496 77 487	
Total	1060	

The helmet was securely fastened 86% of the time (419/487) one was worn as shown in Table 12.12.2.

Table 12.12.2: Helmet securely fastened in PSE data

Helmet securely fastened	Frequency	
Poorly fastened Fastened properly	68 419	
Total	487	

The distribution of helmet types is shown in Table 12.12.3. Half-helmets represented 70% of those helmets worn, while the open face (three-quarter coverage) style accounted for another one-fourth of helmets worn. The full-face motorcycle helmets, which completely cover the head and face and offer the most protection, were worn by only 4% of those interviewed.

Table 12.12.3: Type of helmet worn in PSE interviews

Helmet coverage	Frequency	
Not motorcycle helmet Half-helmet, police-type Open face, three-quarter coverage Full face coverage	1 337 130 19	
Total	487	

About 97% of helmets were owned by riders interviewed rather than being borrowed helmets. The data are shown in Table 12.12.4.

Table 12.12.4: Helmet owner in PSE data

Helmet owner	Frequency	
Other than rider Rider	15 472	
Total	487	

Helmets were most often blue, black, red, white or green. Only 20% of the riders interviewed wore a face shield, which was usually clear or grey. The data are shown in Tables 12.12.5 and 12.12.6.

Table 12.12.5: Helmet colour in PSE data

Colour	Frequency	
No dominant colour	5	1.0
White	64	13.1
Yellow	12	2.5
Black	81	16.6
Red	77	15.8
Blue	90	18.5
Green	63	12.9
Silver, grey	42	8.6
Orange	6	1.2
Brown, tan	4	0.8
Purple	29	6.0
Gold	4	0.8
Chrome, metallic	1	0.2
Pink	9	1.8
Total	487	

Table 12.12.6: Colour of face shield when worn in PSE data

Face shield colour	Frequency	
Clear	162	
Grey, smoke	58	
Reflective	1	
Total	221	

12.13 Factors affecting helmet use

Helmet use by gender and age

Female motorcycle riders were found to wear a helmet more often than males (51% to 44%) as shown in Table 12.13.1. Helmet use was also found to increase with rider age, from a low of 25% among riders under age 21years, to 67% helmet use among riders over 40 years of age (Table 12.13.2).

Table 12.13.1: Helmet use by rider gender in PSE data

Gender	Helmet on head				Total	
	No		Yes			
	Frequency	%	Frequency	%	Frequency	%
Male	439		345		784	
Female	134		142		276	
Total	573		487		1060	

Table 12.13.2: Helmet use by rider age, PSE data

Rider age (years)	Helmet use				Total	
	No		Yes			
	Frequency	%	Frequency	%	Frequency	%
11 – 20	217	76	68	24	285	27
21 – 30	218	54	185	46	403	38
31 – 40	93	40	143	60	236	22
41 – 50	34	36	60	64	94	9
51 – 60	9	28	23	72	32	3
> 60	2	20	8	80	10	1
Total	573		487		1060	

Helmet use by education

Helmet use varied with level of education, and appeared to increase with education level (Table 12.13.3). About half of the riders interviewed whose education ended before college wore a helmet, while about two-thirds of college graduates wore a helmet. Those riders with partial college education had a lower rate of helmet use.

Table 12.13.3: Helmet use by rider's highest level of education, PSE data

Highest level of education	Helmet was on head		Row Total
	Frequency	% of row total	
No formal schooling	4	24	17
Grade school or high school	353	48	734
Partial college	80	37	218
Technical school graduate	11	37	30
College/university graduate	37	64	58
Graduate or professional degree	2	67	3
Total	487		1060

Helmet use by occupation

Table 12.13.4 shows the helmet use among various types of occupation. Helmet use was lowest among students (24%), while about two-thirds of office and service workers wore head protection at the time of the petrol station interview.

Table 12.13.4: Helmet use by rider occupation, PSE data

Occupation	Code	Helmet on head				Total
		No		Yes		
		Freq	%	Freq	%	
Unemployed	1	36	60	24	40	60
Legislators, senior officials	2	2	50	2	50	4
Technicians and professional	4	5	50	5	50	10
Clerical, office worker	5	21	29	52	71	73
Service worker	6	32	33	65	67	97
Skilled agricultural	7	40	54	34	46	74
Skilled craft workers	8	4	67	2	33	6
Driver, vehicle operator	9	18	32	39	68	57
Machine operators	10	0	0	3	100	3
Elementary jobs, laborers	11	180	54	155	46	335
Housewife, homemaker	12	14	39	22	61	36
Military, active duty	13	6	33	12	67	18
Military, reserve	14	1	100	0	0	1
Student	15	212	76	67	24	279
Retired, civilian	16	0	0	3	100	3
Retired, gov't or military	17	1	100	0	0	1
Other	98	1	33	2	67	3
Total		573		487		1060

Helmet use by trip length

Helmet use was found to increase with increasing trip length. Helmet use was the lowest (33%) for trips of one and two kilometres and increased to 57% for trips longer than 10 kilometres (Table 12.13.5).

Table 12.13.5: Helmet use by trip length, PSE data

Length of intended trip (km)	Helmet on head				Total
	No		Yes		
	Frequency	Percent	Frequency	Percent	
0 - 1.0	76	58.5	54	41.5	130
1.1 - 2.0	134	66.7	67	33.3	201
2.1 - 3.0	72	52.6	65	47.4	137
3.1 - 5.0	114	49.4	117	50.6	231
5.1 - 10.0	106	54.1	90	45.9	196
> 10.0	71	43.0	94	57.0	165
Total	573		487		1060

Helmet use by trip plan

Table 12.13.6 shows the relationship between helmet use and trip plan. Helmet use was found to be very high when work was the origin or the destination (68%). On the other hand, when bar, restaurant was either the origin or destination, helmet use was as low as 17% of the riders interviewed. When home was an origin or destination, helmet use was just approximately 40%.

Table 12.13.6: Helmet use by trip plan in PSE data

Location	Helmet on head				Total
	No		Yes		
	Frequency	Percent	Frequency	Percent	
Origin					
Home	243	60.8	157	39.3	400
Work, business	84	32.3	176	67.7	260
Recreation	14	77.8	4	22.2	18
School, university	49	59.8	33	40.2	82
Errand, shopping	70	49.0	73	51.0	143
Friends, relatives	77	67.5	37	32.5	114
Bar, pub	36	83.7	7	16.3	43
Total	573		487		1060
Destination					
Home	253	58.7	178	41.3	431
Work, business	72	31.9	154	68.1	226
Recreation	23	65.7	12	34.3	35
School, university	24	66.7	12	33.3	36
Errand, shopping	88	50.3	87	49.7	175
Friends, relatives	66	66.0	34	34.0	100
Bar, pub	47	82.5	10	17.5	57
Total	573		487		1060

Helmet use and rider license

Table 12.13.7 shows that those riders with a motorcycle license had a higher percentage of helmet use than those without a license.

Table 12.13.7: Helmet use by rider license in PSE data

License type	Helmet on head				Total
	No		Yes		
	Frequency	Percent	Frequency	Percent	
No license	242	68.8	110	31.3	352
Motorcycle license	329	46.6	377	53.4	706
Automobile license	2	100.0	0	0.0	2
Total	573		487		1060

Helmet use by alcohol involvement

Alcohol-involved riders were far less likely to wear a helmet than non-alcohol-involved riders (14% versus 47%) as shown in Table 12.13.8.

Table 12.13.8: Helmet use by rider alcohol involvement in PSE data

Alcohol use	Helmet on head				Total
	No		Yes		
	Frequency	Percent	Frequency	Percent	
No	543		482		1025
Yes	30		5		35
Total	573		487		1060

Summary of helmet use factors

In the petrol station exposure data interviews, helmet use was found to be the lowest among younger riders, students, those without a motorcycle license, and particularly alcohol-involved riders. Helmet use was also found to be very low at night or when the intended trip was a short one. These helmet use patterns provide useful information regarding population-at-risk groups, which should be targeted to receive additional safety information regarding the benefits of helmets.

12.14 Clothing

Upper torso coverage

Riders in the petrol station interviews usually wore light upper torso garments such as T-shirts. At night and in bad weather, the clothing tended to be a little heavier. None of the riders wore leather or clothing made specifically to provide protection while riding a motorcycle (Table 12.14.1).

Table 12.14.1: Upper torso coverage in PSE interviews

Upper torso coverage	Frequency	
T-shirts, tank tops, light shirts	911	
Sweatshirt, jacket	149	
Total	1060	

Lower torso coverage

About 60% of riders interviewed wore light cloth lower torso garments, and 40% wore medium cloth garment (denim, nylon) as shown in Table 12.14.2. Lower torso coverage tended to be more extensive and a bit heavier weight when compared to the upper torso coverage.

Table 12.14.2: Lower torso garment in PSE data

Lower torso coverage	Frequency	
Short pants, light-weight pants	626	
Jeans, medium weight pants	434	
Total	1060	

Foot coverage

About three-quarters of riders interviewed wore light sandals. Only 2 riders did not wear footwear. Data are reported in Table 12.14.3.

Table 12.14.3: Footwear coverage in PSE data

Footwear	Frequency	
None, barefoot	2	0.2
Light sandal	778	73.4
Medium street shoe, loafer	190	17.9
Athletic, training shoe	78	7.4
Heavy shoe or boot	12	1.1
Total	1060	

Gloves

Only four riders wore gloves. Three riders wore gloves of medium cloth, one with light cloth. None wore leather gloves (Table 12.14.4).

Table 12.14.4: Gloves worn by riders in PSE data

Glove type	Frequency	
None	1056	
Light cloth	1	
Medium cloth	3	
Total	1060	

Eye coverage worn

Among 1,060 riders interviewed, 61 riders reported that they were required to wear eye correction, however, only 24 chose to wear prescription clear eyeglasses and six riders wore prescription sunglasses. Contact lenses were considered to be vision correction, but were not considered eye protection. There were eight riders who had reported no vision problem but used non-prescription sunglasses at the time of interview (Table 12.14.5).

Table 12.14.5: Eye coverage in use in PSE data

Eye coverage	Frequency	
None	1021	
Prescription clear glasses	24	
Non-prescription sunglasses	8	
Prescription sunglasses	6	
Total	1060	

12.15 Passengers

Number of passengers

Passengers were present on about 40% of the motorcycles stopped at the PSE sites as shown in Table 12.15.1. The distribution was nearly identical to the data from on-scene exposure surveys done a week after the reference accidents. Only two motorcycles carried three passengers at the time of entering the petrol station.

Table 12.15.1: PSE data, number of passenger (s)

Number of passengers on MC	Frequency	
None	629	59.3
One	406	38.3
Two	23	2.2
Three	2	0.2
Total	1060	

Riding experience as a motorcycle passenger

The majority of the motorcycle passengers interviewed in the PSE study (70%) claimed to have a moderate amount of passenger experience. About one for every six passengers said they had extensive experience, while only 13% of passengers said they had little experience. Only one passenger had never ridden a motorcycle before. The data are shown in Table 12.15.2.

Table 12.15.2: PSE data, riding experience as passenger

Prior passenger experience	Frequency	
Never before as passenger	1	0.2
Very little experience	57	13.2
Moderate experience	298	69.1
Extensive experience	75	17.4
Total	431	

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 those who are 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 found to be lowest during daylight hours and nearly doubled at night. Table 13.1.1 shows the ratio of motorcycles passing exposure sites when compared to the number of accident motorcycles for the different lighting conditions. The percentage of nighttime riding was found to be significantly over-represented in the accident population when compared to the exposure population (42.6% of the accident data versus 30.4% of the exposure data, chi-square test = 25.30, 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	181	17,361	1 : 96
Dusk - dawn	25	2,123	1 : 85
Night	153	8,513	1 : 56

13.2 Motorcycle characteristics

Motorcycle type

Step-through motorcycles were found to be the overwhelming majority of motorcycles in the upcountry area, and they dominated all three portions of this study: the accident investigations, the on-scene exposure (OSE) data and the petrol station exposure (PSE) studies, as shown in Table 13.2.1. The results obtained from the on-scene exposure and petrol station interview data were found to be very similar. However, the percentage of sport bike motorcycles was found to be significantly over-represented in the accident population when compared to the OSE population (7.2% of the accident data against 3.2% of the OSE data, chi-square test = 19.03, df = 1, p-value < 0.0001, ? = 0.05).

This finding 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.

In fact, a comparison of sport bike riders to those on other types of motorcycles shows that sport bike riders were more likely to be male (96% versus 77%), under 30 years of age (96% versus 64%) and unlicensed (65% versus 49%). Sport bike riders were also more likely to have been consuming alcohol (46% versus 25% for riders of other motorcycle types). Sport bike riders also were found to have higher pre-crash speeds (median of 45 km/hr versus 35 km/hr) and crash speeds (44 versus 30) when compared to riders on other types of motorcycles.

Table 13.2.1: Motorcycle type in accident and exposure data.

Motorcycle type	Accident data		OSE data		PSE data	
	Freq	%	Freq	%	Freq	%
Standard street	14	3.9	1,441	5.2	23	2.2
Sport, race replica	26	7.2	894	3.2	51	4.8
Cruiser design	2	0.6	70	0.3	0	0.0
Scooter	5	1.4	298	1.1	11	1.0
Step-through	312	86.9	25,273	90.3	974	91.9
Off road, dual use	0	0.0	15	0.1	0	0.0
Other	0	0.0	6	0.0	1	0.1
Total	359		27,997		1,060	

Motorcycle manufacturer

Half of the motorcycles in the exposure data were Honda motorcycles, but Honda made up less than half of the accident population. Suzuki and Yamaha each made up about one-fifth of the exposure population. Suzuki was somewhat over-represented in the accident data. Table 13.2.2 provides a comparison of motorcycle manufacturers in the accident and on-scene exposure data.

Table 13.2.2: Motorcycle manufacturers

Manufacturer	Accident data		OSE data	
	Frequency	Percent	Frequency	Percent
Honda	164	45.7	14,332	51.2
Kawasaki	19	5.3	1,199	4.3
Piaggio	2	0.6	48	0.2
Suzuki	97	27.0	6,191	22.1
Yamaha	77	21.4	6,110	21.8
Other	0	0.0	5	0.0
Unknown	0	0.0	112	0.4
Total	359		27,997	

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 showed no statistically significant difference in the accident population when compared to the OSE population (11.5% of the accident data versus 9.3% of the exposure data, chi-square test = 1.21, df = 1, p-value > 0.05, ? = 0.05).

Table 13.2.3 Headlamp use in accident and on-scene exposure data

Ambient lighting	Accident data			On-scene exposure data		
	Off	On	Total	Off	On	Total
Daylight	171	10	181	16,969	392	17,361
	95%	5%	100%	98%	2%	100%
Night	18	134	152	788	7,725	8,513
	12%	88%	100%	9%	91%	100%
Dusk	18	0	18	1,505	512	2,017
	100%	0%	100%	75%	25%	100%
Dawn	4	3	7	91	15	106
	57%	43%	100%	86%	14%	100%

Headlamp use when other vehicle violates motorcycle right-of-way

Headlamp use was considered to be most important in those cases where the other vehicle made a maneuver across the motorcycle path, with the potential of violating the motorcycle right-of-way. In order to examine the role of headlamp use more closely, accident configurations that involved the other vehicle crossing the motorcycle path were examined to compare headlamp use in accidents and exposure data. (Specifically, the configurations are listed in Table 5.2.7 as codes 2 - 7and 16)

The data suggest, though not conclusively, that the risk of colliding with an OV at night was higher when the motorcycle headlamp was off. That is, 9% of motorcycles passing on-scene exposure sites had the headlamp off, but 16% of those in night accidents that involved other vehicle violation of the motorcycle right of way had the headlamp off (Table 13.2.4).

Similarly, motorcycles with the headlamp illuminated at the time of the accident represent a smaller proportion of dusk-dawn accidents that involve OV violation of the motorcycle right-of-way. Eight dusk-dawn accidents involved the OV pulling out in front of the motorcycle, and not one of those motorcycles had the headlamp illuminated. Exposure data collected at those sites showed that one-fourth of the motorcycles passing by had the headlamp operating.

Table 13.2.4 MC headlamp use when OV violates MC right-of-way

Headlamp use at night	Accident data		OSE data	
	Frequency	Percent	Frequency	Percent
Off	6	16	788	9
On	31	84	7725	91
Total	37		8513	

13.3 Human factors in accident causation

Rider alcohol involvement

Alcohol use data from the accident and petrol station interview populations are shown in Table 13.3.1. The percentage of riders who had been drinking in the accident data set was found to be significantly different from the exposure population and over-represented in the accident population when compared to the population-at-risk (29.3% of the accident data versus 3.3% of the exposure data, chi-square test = 759.58, df = 1, p-value < 0.0001, ? = 0.05).

Alcohol was a major contributing factor in these upcountry accidents. Alcohol-involved riders were seen in accidents nearly nine times as often as they were seen in exposure interviews. 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, to be single-vehicle accidents, to involve rider inattention and running off the road, or violating a traffic control device. Alcohol-involved accidents often involved a trip home after drinking at a bar or at the home of friends or relatives. In contrast, non-alcohol-involved accidents tended to occur during daylight hours, to involve another vehicle, and were more likely to occur while running errands or going to work.

Table 13.3.1: Rider alcohol use impairment in accident and PSE data

Alcohol	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
<u>Alcohol use</u>				
No	253	70.5	1025	96.7
Yes	105	29.2	35	3.3
Unknown	1	0.3	0	0.0
Total	359		1060	
<u>Alcohol impairment</u>				
Not seriously impaired	11	10.4	31	88.6
Seriously impaired	94	88.7	4	11.4
Unknown	1	0.9	0	0.0
Total	106		1060	

Table 13.3.1 also shows the results of the investigators' evaluations of whether riders appeared to be seriously impaired or not. In the accident data, nearly 90% of those who crashed after consuming alcohol appeared to be seriously impaired. In comparison, only about 10% of riders who had been consuming alcohol in the exposure population appeared to be seriously impaired.

13.4 Rider license qualification

Table 13.4.1 shows a comparison of the license qualification for the motorcycle rider in the accident and the PSE data. The percentage of unlicensed riders was found to be significantly over-represented in the accident population compared to the population-at-risk (49.86% of the accident data versus 33.21% of the exposure data, chi-square test = 44.89, 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: Rider license in accident and PSE data

License	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No license held	179		352	
Learner’s permit, only	1		0	
Motorcycle license	173		706	
Automobile license	6		2	
Total	359		1060	

13.5 Rider general characteristics

Rider gender

Table 13.5.1 shows the rider gender in the accident, OSE and PSE data. Female riders were found to be significantly under-represented in accidents when compared to PSE and OSE data (21% of the accident data versus 26% of the PSE data, chi-square test = 3.93, df = 1, p-value < 0.05, ? = 0.05, and 21% of the accident data versus 27% of the OSE data, chi-square test = 5.34, p-value < 0.05, ? = 0.05).

Table 13.5.1: Motorcycle rider gender in accident and exposure data

Rider gender	Accident data		OSE data		PSE data	
	Frequency	%	Frequency	%	Frequency	%
Male	282		20,478		784	
Female	77		7,519		276	
Total	359	100.0	27,997		1,060	

Rider age

Table 13.5.2 shows a comparison of accident and PSE data for rider age. The percentage of motorcycle riders under 21 years showed no statistically difference in the accident population when compared to the population-at-risk (31.2% of the accident data versus 26.9% of the exposure data, chi-square test = 3.39, df = 1, p-value > 0.05, ? = 0.05).

Table 13.5.2: Motorcycle rider age in accident and PSE data

Rider age (years)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
11 – 20	112	31.2	285	26.9
21 – 30	127	35.4	403	38.0
31 – 40	64	17.8	236	22.3
41 – 50	36	10.0	94	8.9
51 – 60	12	3.3	32	3.0
> 60	8	2.2	10	0.9
Total	359		1060	

Rider height and weight

A comparison of accident and PSE data for motorcycle rider height and weight showed essentially no differences between the two groups as shown Tables 13.5.3 and 13.5.4.

Table 13.5.3: Motorcycle rider height in accident and PSE data

Rider height (cm)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0 - 140	1	0.3	0	0.0
141 – 145	2	0.6	3	0.3
146 - 150	9	2.5	20	1.9
151 - 155	21	5.8	59	5.6
156 - 160	70	19.5	172	16.2
161 - 165	99	27.6	266	25.1
166 - 170	99	27.6	400	37.7
171 - 175	46	12.8	116	10.9
176 - 180	11	3.1	22	2.1
> 180	1	0.3	2	0.2
Total	359		1060	

Table 13.5.4: Motorcycle rider weight in accident and PSE data

Rider weight (kg)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
31 - 40	10	2.8	12	1.1
41 - 50	76	21.2	224	21.1
51 - 60	162	45.1	461	43.5
61 - 70	89	24.8	286	27.0
71 - 80	21	5.8	59	5.6
> 80	1	0.3	18	1.7
Total	359		1060	

Rider education

Table 13.5.5 shows the educational background of the motorcycle riders in the accident and PSE data.

Table 13.5.5: Motorcycle rider education in accident and PSE data

Rider educational level	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No formal school	5	1.4	17	1.6
Less than college/university	282	78.6	734	69.2
Partial college training	40	11.1	218	20.6
Technical school graduate	13	3.6	30	2.8
College/university graduate	18	5.0	58	5.5
Graduate degree	0	0.0	3	0.3
Unknown	1	0.3	0	0.0
Total	359		1060	

The percentage of riders with formal education prior to college (grade 1-12) was found to be significantly over-represented in the accident population when compared to the population-at-risk (80.17% of the accident data versus 70.85% of the exposure data, chi-square test = 15.05, df = 1, p-value < 0.001, ? = 0.05). Riders with a partial college education (who were mostly students) were under-represented in the accidents: their accident rate (11%) was barely half their exposure rate (20.6%).

Rider occupation

Table 13.5.6 shows the occupations for the motorcycle riders in the accident and PSE data. The percentage of riders in "elementary occupations" (such as ordinary laborers) and unemployed riders was significantly over-represented in the accident population when compared to the population-at-risk (53.07% of the accident data versus 37.26% of the exposure data, chi-square test = 38.27, df = 1, p-value < 0.0001, ? = 0.05).

Therefore, this comparison would suggest that elementary workers would be an excellent target group for safety education and countermeasures.

Table 13.5.6: Motorcycle rider occupation in accident and PSE data

Occupation category	Code	Accident data		PSE data	
		Freq	%	Freq	%
Unemployed	1	27	7.5	60	5.7
Senior officials, managers	2	1	0.3	4	0.4
Professionals	3	3	0.8	0	0.0
Technicians, minor professional	4	3	0.8	10	0.9
Clerical, office worker	5	12	3.3	73	6.9
Service workers shop sales	6	20	5.6	97	9.2
Skilled agricultural and fishery	7	2	0.6	74	7.0
Craft and related trades workers	8	0	0.0	6	0.6
Transport equipment driver	9	15	4.2	57	5.4
Machine operators, assemblers	10	2	0.6	3	0.3
Elementary, laborers	11	163	45.4	335	31.6
Housewife, homemaker	12	4	1.1	36	3.4
Military, active duty	13	5	1.4	18	1.7
Military, reserve duty	14	0	0.0	1	0.1
Student, full time	15	96	26.7	279	26.3
Retired, civilian	16	4	1.1	3	0.3
Retired, gov't service or military	17	0	0.0	1	0.1
Other	98	1	0.3	3	0.3
Unknown	99	1	0.3	0	0.0
Total		359		1060	

13.6 Rider training

There was no difference in rider training between the accident and exposure data (Table 13.6.1), probably because almost no training programs were available in the upcountry area. Most riders were either self-taught, or were taught by family or friends. Not one single rider in either the accident or exposure data reported having any formal training.

Table 13.6.1: Rider training in accident and PSE data

Training	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
No training	2		0	
Self taught	274	76.3	850	80.2
Taught by friends or family	79	22.0	210	19.8
Unknown	4	1.1	0	0.0
Total	359		1060	

The most common method of acquiring riding skills is through experience. Essentially in Thailand, riders go onto the roads with little or no training and, it is hoped that they somehow acquire the knowledge and skills that will prepare them to develop a traffic strategy and deal with traffic hazards before they get into an accident. The data collected in this study strongly indicate that the riders do not gather this knowledge and therefore, formal rider training would represent a great improvement in the manner in which riders in the upcountry region learn the proper skills to avoid motorcycle accidents.

13.7 Riding experience

Riders who rode daily were found to be the same proportion for both accident and exposure data populations. Thus, riding daily appears to neither increase nor decrease accident risk. Table 13.7.1 compares number of days per year that motorcycles are ridden in the accident and exposure populations.

Table 13.7.1: Comparison of motorcycle riding frequency

Days per year riding	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0 – 50	4	1.1	2	0.2
51 – 100	3	0.8	14	1.3
101 – 150	7	1.9	32	3.0
151 – 200	6	1.7	19	1.8
201 – 250	0	0.0	19	1.8
251 – 300	14	3.9	36	3.4
301 – 365	323	90.0	938	88.5
Unknown	2	0.6	0	0.0
Total	359		1060	

Table 13.7.2 compares the distance that motorcycles are ridden per year. There appears to be no consistent trend in the data. Those who rode 9,000 to 12,000 km/yr showed a large increase in accidents, but riders who rode less and some who rode more showed lower accident involvement.

Table 13.7.2: Distance per year motorcycle is ridden

Distance ridden per year (km)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
< 1	2	0.6	0	0.0
1 – 3000	77	21.4	290	27.4
3001 – 6000	109	30.4	313	29.5
6001 – 9000	54	15.0	216	20.4
9001 – 12000	65	18.1	74	7.0
12001 – 15000	15	4.2	42	4.0
15000 – 18000	3	0.8	2	0.2
18001 – 21000	22	6.1	66	6.2
> 21000	7	1.9	57	5.4
Unknown	5	1.4	0	0.0
Total	359		1060	

Cargo and luggage carrying

Table 13.7.3 provides a comparison of riding experience with similar cargo/luggage for riders in both the accident and PSE data. The percentage of riders who seldom carried cargo or luggage was significantly over-represented in the accident population when compared to the population-at-risk (49.25% of the accident data versus 24.04% of the exposure data, chi-square test = 23.32, df = 1, p-value < 0.0001, ? = 0.05). Therefore, it appears that accident risk increases when the rider has little experience carrying cargo.

Table 13.7.3: Rider experience with cargo in accident and PSE data

Experience with similar cargo or luggage	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
NA, no cargo or luggage	292	81.3	877	82.7
No previous experience	1	0.3	1	0.1
Seldom	32	8.9	43	4.1
Frequently	25	7.0	112	10.6
Always	9	2.5	27	2.5
Total	359		1060	

13.8 Rider previous traffic violations and accidents

Tables 13.8.1 and 13.8.2 show the data on accident and violation experience in the previous five years for accident and exposure populations. The percentage of riders without prior motorcycle traffic accident was found to be over-represented in the accident population when compared to the population-at-risk (74.29% of the accident data versus 66.70% of the exposure data, chi-square test = 9.20, df = 1, p-value < 0.01, ? = 0.05). Regarding the previous motorcycle traffic violation, the percentage of riders without prior traffic violation was also found to be significantly over-represented in the accident population compared to the population-at-risk (90.11% of the accident data versus 69.96% of the exposure data, chi-square test = 73.99, df = 1, p-value < 0.0001, ? = 0.05).

It is important to note that information about prior traffic accidents and violations in both the accident and exposure data was based on rider statements only, rather than an examination of official records. In the upcountry sampling region, many riders had no license (one-third of PSE riders and approximately half of the accident population); hence there were no records to check. Also, many riders were unwilling to provide a license number to allow a check of their driving records.

Table 13.8.1: Rider traffic accidents in previous five years

Number of prior accidents	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Motorcycle accidents				
None	263	73.3	707	66.7
One	57	15.9	222	20.9
Two	19	5.3	86	8.1
Three	7	1.9	26	2.5
Four	1	0.3	5	0.5
Five	5	1.4	9	0.8
> Five	2	0.6	5	0.5
Unknown	5	1.4	0	0.0
Total	359		1060	
Non-motorcycle accidents				
None	345	96.1	965	91.0
One	8	2.2	66	6.2
Two	0	0.0	20	1.9
Three	1	0.3	6	0.6
Four	0	0.0	2	0.2
Five	0	0.0	1	0.1
Unknown	5	1.4	0	0.0
Total	359		1060	

Table 13.8.2: Comparison of rider previous motorcycle traffic violation

Rider traffic violations in last 5 years	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
None	319	88.9	731	69.0
One	24	6.7	184	17.4
Two	5	1.4	83	7.8
Three	4	1.1	38	3.6
Four	1	0.3	9	0.8
Five	1	0.3	7	0.7
> Five	0	0.0	8	0.8
Unknown	5	1.4	0	0.0
Total	359		1060	

13.9 Rider trip

Rider familiarity with the roadway

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 roadway users showed no statistically significant difference in the accident population when compared to the PSE data (7.32% of the accident data versus 6.79% of the PSE data, chi-square test = 0.16, df = 1, p-value > 0.1, ? = 0.05). Therefore, roadway familiarity has no effect on accident involvement.

Table 13.9.1: Rider familiarity with roadway in accident and PSE data

Roadway use	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
Daily use	295	82.2	829	78.2
Weekly use	34	9.5	159	15.0
Monthly use	10	2.8	48	4.5
Quarterly use	1	0.3	5	0.5
Annually use	1	0.3	5	0.5
Less than annually	1	0.3	0	0.0
Never before	13	3.6	14	1.3
Unknown	4	1.1	0	0.0
Total	359		1060	

Trip plan

Points of origin that are over-represented in the accident data were found to include recreation sites, friends-family and bars and restaurants (Table 13.9.2). All were frequent points of origin in alcohol accidents. Home was somewhat over-represented as a destination, likely due to the fact that so many alcohol-involved riders were heading home after a night of drinking. (70% of alcohol-involved riders compared to 40% of non-alcohol-involved riders) as shown in Table 13.9.3.

Table 13.9.2: Rider trip origin in the accident and PSE data

Location	Code	Accident data		PSE data	
		Frequency	Percent	Frequency	Percent
Home	1	116	32.3	400	37.7
Work, business	2	75	20.9	260	24.5
Recreation	3	20	5.6	18	1.7
School, university	4	10	2.8	82	7.7
Errand, shopping	5	42	11.7	143	13.5
Friends, relatives	6	66	18.4	114	10.8
Bar, restaurant	7	27	7.5	43	4.1
Unknown	9	3	0.8	0	0.0
Total		359		1060	

Table 13.9.3: Rider trip destination in the accident and PSE data

Location	Code	Accident data		PSE data	
		Frequency	Percent	Frequency	Percent
Home	1	175	48.7	431	40.7
Work, business	2	68	18.9	226	21.3
Recreation	3	9	2.5	35	3.3
School, university	4	16	4.5	36	3.4
Errand, shopping	5	33	9.2	175	16.5
Friends, relatives	6	46	12.8	100	9.4
Bar, restaurant	7	9	2.5	57	5.4
Unknown	9	3	0.8	0	0.0
Total		359		1060	

Length of intended trip

Table 13.9.4 provides a comparison of trip distance for the intended trip in the accident and PSE data. The percentage of riders who traveled less than 5 kilometres showed no statistically significant difference in the accident population when compared to the PSE data (64.90% of the accident data versus 65.94% of the PSE data, chi-square test = 0.17, df = 1, p-value > 0.1, ? = 0.05)

Table 13.9.4: Rider intended trip length in accident and PSE data

Length of intended trip (km)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
< 0.1	5	1.4	0	0.0
0.1 - 1.0	47	13.1	130	12.3
1.1 - 2.0	67	18.7	201	19.0
2.1 - 3.0	44	12.3	137	12.9
3.1 - 5.0	70	19.5	231	21.8
5.1 - 10.0	56	15.6	196	18.5
> 10.0	62	17.3	165	15.6
Unknown	8	2.2	0	0.0
Total	359		1060	

Time riding since departure

The length of time spent riding before the accident (or interview) was very similar for both accident and exposure data. No consistent trend of under- or over-representation was found. However, it is important to note that riding for long periods does not appear to be a factor in these data since 98% of riders in both data sets had been riding for less than one-half hour as shown in Table 13.9.5.

Table 13.9.5: Time riding in accident and PSE data

Time riding (hours)	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
0	51	14.2	233	22.0
0.1	163	45.4	496	46.8
0.2	68	18.9	165	15.6
0.3	44	12.3	79	7.5
0.4	0	0.0	22	2.1
0.5	13	3.6	42	4.0
0.6 - 0.7	0	0.0	8	0.8
0.8 - 1.0	4	1.1	7	0.7
> 1.0	3	.8	8	0.8
Unknown	13	3.6	0	0.0
Total	359		1060	

13.10 Rider physical impairments and stress

Fatigue was found to occur more frequently in the accident data however, the frequency is too small for any statistical analysis. No other transient or permanent problems appear to affect accident involvement. Epilepsy was not a common problem, but two accidents in Bangkok and one upcountry accident occurred when the riders had a seizure while operating the motorcycle. 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: Rider physiological impairment in accident and PSE data

Physiological impairments	Accident data		PSE data	
	Frequency	Percent	Frequency	
Permanent impairments,				
None	332	92.5	999	94.2
Vision	19	5.3	61	5.8
Respiratory, cardiovascular	2	0.6	0	0.0
Neurological, epilepsy, stroke	1	0.3	0	0.0
Unknown	5	1.4	0	0.0
Total	359		1060	
Temporary impairments				
None	330	91.9	1059	99.9
Fatigue	14	3.9	1	0.1
Thirst	1	0.3	0	0.0
Headache, fever, minor illness	1	0.3	0	0.0
Unknown	13	3.6	0	0.0
Total	359		1060	

Rider stress

Stress appears to increase the risk of accident involvement, even though the numbers are far too small to conduct any statistical analysis. In the exposure data, less than one percent of the riders admitted to some kind of stress, compared to slightly more than two percent of the 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: Rider stress in accident and PSE data

Source of stress	Accident data		PSE data	
	Frequency	Percent	Frequency	Percent
None observed or noted	337	93.9	1054	99.4
Conflict with friends, family	4	1.1	1	0.1
Work related problems	2	0.6	4	0.4
Traffic conflict, road rage	0	0.0	1	0.1
Other	2	0.6	0	0.0
Unknown	14	3.9	0	0.0
Total	359		1060	

13.11 Rider protective equipment

Helmet use

Table 13.11.1 provides a comparison of the on-scene accident data, and the 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 (78% of the accident data versus 60% of the OSE data, chi-square test = 49.89, df = 1, p-value < 0.0001, ? = 0.05). Unhelmeted riders were also found to be over-represented in the accident population when compared to the PSE population (78% of the accident data versus 54% of the PSE data, chi-square test = 82.83, df = 1, p-value < 0.0001, ? = 0.05).

The OSE data appear to be more accurate than PSE data for several reasons: 1) OSE data was collected usually one week after the accident occurred, compared to several months later 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. 27997 riders versus 1060 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: Rider helmet use in accident and exposure data

Helmet use by rider	Accident data		OSE data		PSE data	
	Frequency	%	Frequency	%	Frequency	%
No	280		16,717		573	
Yes	79		11,280		487	
Total	359		27,997		1,060	

Among those riders who did wear a helmet, partial coverage half-helmets were the most popular in both the accident and exposure populations (Table 13.11.2). However, there was no statistically significant difference in the accident population compared to the OSE data (53.16% of the accident data versus 48.91% of the OSE data, chi-square test = 0.57, df = 1, p-value > 0.1, ? = 0.05).

Table 13.11.2: Rider helmet type in accident and exposure data

Helmet type	Accident data		OSE data	
	Frequency	Percent	Frequency	Percent
Not motorcycle helmet	2	2.5	44	0.4
Half-helmet	42	53	5,517	49
Open-face	33	42	4,740	42
Full-face helmet	2	2.5	979	9
Total	79		11,280	

13.12 Motorcycle passengers

Table 13.12.1 shows a comparison of number of passengers involved in the accident relative to the OSE and PSE data. The percentage of motorcycles with no passengers showed no statistically difference in the accident population when compared to the population-at-risk (61.28% of the accident data versus 58.65% of the exposure data, chi-square test = 1.02, df = 1, p-value > 0.05, significance level ? = 0.05).

Carrying a passenger, or even multiple passengers, appears to have little or no effect on accident involvement. Motorcycles without passengers made up about 60% of the accident population and both exposure populations. Motorcycles with multiple passengers were 5.8% of the accident population, 4.5% of the OSE population, but only 2.4% of the petrol station interview population. However, the proportion of motorcycles with multiple passengers in the accident population and PSE data is too small to conduct a meaningful statistical analysis.

Table 13.12.1: Number of passengers in accident and exposure data

Number of passengers	Accident data		OSE data		PSE data	
	Frequency	%	Frequency	%	Frequency	%
No passenger	220	61.3	16,421	58.7	629	59.3
1	118	32.9	10,327	36.9	406	38.3
2	19	5.3	1,156	4.1	23	2.2
3	2	0.6	88	0.3	2	0.2
4	0	0.0	5	0.0	0	0.0
Total	359		27,997		1,060	

13.13 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 were found to be significantly over-represented in the accident population. Accident risk also was found to decline, as riders grow older. Therefore, younger motorcycle riders should be targeted as a group for the application of countermeasures.

Other factors were found to affect accident rates, but their proportion of the accident population was often small, and the benefits of countermeasures were less clear. Rider experience with similar cargo appears to be a contributing factor in those riders unaccustomed to the cargo they were carrying were more likely to get into an accident.

Female motorcycle riders were far less likely to be alcohol-involved. Students were half as likely to be in alcohol accidents as non-students (16% vs. 34%), but they were found to be over-represented in non-alcohol accidents (32%) with the net effect that their proportion of the exposure population (26.3%) equals their accident involvement (26.7%). Failure to use the headlamp at night was twice as common in night accidents that involved other vehicle violation of the motorcycle right of way.

A number of factors reported here were found to have no apparent effect on accident involvement. Rider level of education, trip length, riding experience, rider height and weight all had no affect on either increasing or reducing accident risk. Carrying passengers, or even multiple passengers, seemed to have no effect on accident risk; however, very few of these cases appeared in this study. It is rare that passenger action caused or contributed to a crash,

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 and 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 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
<u>Motorcycle path</u>				
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	
<u>Other vehicle path</u>				
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 sampling regions and the upcountry sampling regions 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 Major Findings

The data obtained from all 359 on-scene, in-depth accident investigation cases reveal several important findings related to accident causation, injury information and accident characteristics of motorcycle accidents in the upcountry regions. 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 359 upcountry motorcycle accidents.

2. Alcohol was a key factor in the upcountry accidents. Only 3.3% of riders interviewed in the petrol station exposure study had been drinking alcohol compared to 29% of upcountry crashes. 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. Impaired riders were also less likely to be wearing a helmet and more likely to be killed.

3. Roadway design and maintenance problems were a contributing factor in at least one-sixth of these accidents.

4. Motorcycle problems were nearly non-existent as a contributing factor, and the only motorcycle problems found in this study were related to poor vehicle maintenance, and not to poor design or manufacturing.

5. The most frequent motorcycle-related problem was riding at night without the headlamp illuminated. The lack of headlamp use at night doubled the risk of being involved in a right-of-way collision with another vehicle.

6. Adverse weather (i.e., rain) was not found to be a major cause factor, because most riders stop riding while it is raining. However, when rain was present in an accident, it usually contributed to causing the accident.

7. None of the riders involved in crashes 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 half of the riders took evasive action. Of those who took action, only one in seven 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. Many helmets in Thailand are used improperly or not used at all.

11. 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.

12. 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, 30% of the helmets worn were ejected from the rider's head at sometime during the collision sequence.

13. Unhelmeted riders were more likely to get into a crash than those wearing a helmet. About 40% of the riders passing upcountry exposure sites were wearing a helmet, but only 20% of the accident-involved riders had any kind of head protection.

14. Helmets tend to be used less often in the very situations where an accident is more likely.

15. Three-fourths of these motorcycle accidents involved collisions with other vehicles, usually a passenger car. Sixty-nine of the 303 crashes reported (23%) here involved two motorcycles.

16. Accident rate nearly doubled at night when compared to the daytime accident rate.

17. The most frequent accident configuration in the upcountry series was a solo crash in which the motorcycle ran off the road or fell on the road with no other vehicle involved. The next most common configuration was the motorcycle impacting the rear of the other vehicle. Both configurations were typical alcohol-involved crashes.

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 upcountry study. This accident situation accounted for one-third of the rear-end collisions (11 of 33 cases); the other two-thirds of the rear-end collisions were the typical result of following too closely in traffic.

19. Most accidents occurred when traffic conditions were light or moderate.

20. Nearly half (48%) of the accidents reported here occurred at intersections. Most intersection accidents involved a crossing-path collision with the other vehicle.

21. Non-intersection accidents were more varied than intersection collisions, with more pedestrians, animals and motorcycle-solo crashes, but the majority still involved another vehicle -- U-turn, sideswipe, rear-end and head-on collisions.

22. Running over raised pavement reflectors caused fewer accidents upcountry than in Bangkok, probably because raised reflectors were far less common upcountry. These large reflectors sometimes caused immediate loss of front tyre pressure and dented front rim, 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 tires, a loose steering stem or swing arm pivot or an unwieldy cargo can contribute to dynamic instability problems. Although these factors were coded as being present on some motorcycles, they did not cause or contribute to uncontrollable to any instability problems.

24. No fires and no fuel burn injuries were seen in the upcountry accidents. Although most motorcycles (68%) 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 90% of the motorcycles in these upcountry accidents were the step-through frame type. However, sport-bikes (race replica design) models were over-represented in 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 one-third 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 identified as a contributing cause factor in 34 crashes (9.5%). Besides the large pavement reflectors, other design problems included traffic lights that blink yellow in both directions at night, inadequate signing and guidance at curves, and view obstructions

28. Roadway maintenance defects (i.e. potholes, debris, etc.) were present in 30 cases but were the accident cause factor in only 13 (3.6%) of all accidents.

29. Traffic control malfunction was a contributing factor in 10 cases (2.8%) for the motorcycle and 11 cases for the other vehicle.

30. The rear position lamp and stop lamp were missing or inoperable in 10 cases. In two of those, the motorcycle was rear-ended by another vehicle at night.

31. In non-fatal accidents, the median pre-crash speed of the motorcycle was 35 kilometers per hour and the median crash speed was 30 kilometers per hour.

32. Crash speeds in fatal accidents were, on average, about 20 km/hr higher than in non-fatal crashes. The mean pre-crash and crash speeds for the fatal motorcycle accidents were 52 and 50 kilometers per hour.

33. About 20% of these upcountry accidents involved motorcycle loss of control, usually by running off the road or a braking slide-out during collision avoidance. Alcohol-involved riders were especially prone to loss of control (40% of impaired riders versus 13% of non-impaired riders).

34. The median rider age was 25 years. Motorcycle riders under the age of 21 accounted for 31%, while 53% fell into the 21 to 40 age bracket.

35. Female motorcycle riders accounted for 21% of the accident population. They were also under-represented when compared to the expose data.

36. Three fourths of accident-involved riders had no education beyond 12th grade, and only 5% were college graduates. Half had only a 9th grade education.

37. Unlicensed riders were over-represented in the accident data. They were one-third of those interviewed in petrol stations, but half of the accident population.

38. Among physiological impairments, only fatigue seems to be over-represented in accidents. One rider had an epileptic seizure while riding.

39. Motorcycles with passengers (or even multiple passengers) were not over-represented in accidents. However, in individual cases passengers did contribute to accident causation by distracting the rider or interfering with motorcycle balance.

40. None of the accident-involved drivers reported having any formal vehicle training. This suggests that many drivers lacked knowledge of defensive strategies to avoid potential collision situation.

41. About 61% of other vehicle drivers committed an unsafe act that contributed to the accident causation.

42. When another vehicle was involved and the type of other vehicle was known, it was a motorcycle nearly one-third of the time.

43. If the other vehicle was not a motorcycle, it tended to be rear-ended by the motorcycle or tended to violate the motorcycle right-of-way by making a U-turn in front of the motorcycle. When other vehicle driver error was identified as the primary or sole cause of the accident, it mainly involved the other vehicle making a turn across the motorcycle path, i.e., U-turn, right turn - either in front of a motorcycle coming from the opposite or perpendicular direction.

44. If the other vehicle was a motorcycle and the other vehicle driver error was identified as the primary cause factor, the collision was likely to be a perpendicular intersection crash, or sideswipe - either another motorcycle approaching from the opposite or same direction.

45. Pedestrians were involved in 11 collisions, half during daylight hours. When the motorcycle struck a pedestrian at night, the motorcycle headlamp was off in two of five cases. None of the pedestrians were in a crosswalk.

46. Twelve accidents (3%) involved collisions with animals (9 dogs, 2 cows and one hen). Five crashes were daylight accidents.

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 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. Defensive driving practices for motorcycle, alcohol risks, proper helmet use and proper collision avoidance maneuvers and rider training courses could be a primary means of doing this.

In Thailand, only the Honda Safety Training 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 of 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 upcountry 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. 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

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 upon the data 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 8 p.m. and 1 a.m., 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. Nearly 10% of upcountry riders failed to use their headlamp and their risk of colliding with a car that violated their right-of-way nearly doubled. Legislation and law enforcement action is needed to require motorcycle riders to use a headlamp at night so that other drivers can see them.

4. Requirements for 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 from 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 curb-lane law rear-ended poorly marked vehicles that were left parked illegally along the roadside.

5. A large 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 reflected almost no light and 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 upcountry 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

Nearly one in six accidents, particularly those at night, were caused entirely or in part, by environmental deficiencies that can by improved or eliminated by better engineering or better maintenance. The most outstanding needs were for better signing and guidance along unlighted curves and for better signing, reflectorization and traffic flow safety at construction sites. Additional changes that are needed include:

1. Stationary view obstructions such as telephone booths, advertising signs, trees, etc. should be relocated away from the mouth of the intersection and busy driveways (i.e., at petrol stations) to minimize effect of view obstruction.

2. Many preventable accidents occurred at intersections because a traffic control signal, stop sign or yield sign was needed to regulate the flow of traffic going from a soi onto a larger roadway

3. Many roadways allow drivers, especially small motorcycles, to make dangerous turns across traffic. Better-designed physical barriers are necessary to prevent such dangerous maneuvers.

4. The center medians need to be low and need to be maintained properly to avoid view obstruction problems. Shrubs should not extend more than one meter above pavement level since this is the nominal the height of car drivers' eyes.

5. At intersections where traffic control signals blink at night, they should be adjusted to blink red in one direction and yellow in the other so that one driver will stop and yield to the other instead of both entering the intersection at full speed.

6. Traffic control signs must be easily visible and placed in locations where drivers expect to see them, or they will not be obeyed.

7. The large raised pavement reflectors with a sharp edge currently in use in Thailand (i.e., in Bangkok and upcountry as well) cause motorcycles to lose control and fall. They should be replaced by smaller, less aggressive reflectors.

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. Many crashes involved one vehicle turning right across the path of another vehicle approaching from the opposite direction. Right turn-only lanes with a right-turn-only traffic light could nearly eliminate this collision problem.

10. Many construction sites were badly designed and badly marked especially at night, with uneven pavement, view obstructions, unmarked vehicles and obstacles such as moveable and 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 safety standards are applied and enforced.

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 upcountry accidents. Less than half the 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. and are currently available.

16.6 Protective equipment

A proper motorcycle safety helmet can prevent or reduce head injury in many accident situations.

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 be ejected immediately in an accident and leave the rider completely unprotected.

It is essential that all motorcycle helmets sold to the public must 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 tested to make sure that manufacturers maintain adequate quality control. In addition, helmet legislation must assure that riders wear a motorcycle helmet (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 some place where the police would see them. This may be the reason helmet use was far higher in Bangkok than in the upcountry regions.

It is recommended 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. These efforts will reduce the toll 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 noticeably under-represented in the accident data, it appears that eye protection may very well reduce accident involvement.

Education 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 information regarding proper helmet use, alcohol involvement in accidents, the importance of motorcycle headlamp and tail lamp visibility and other important motorcycle safety messages.

17.0 References

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Appendix A

Table 7.12.1: Motorcycle pre-crash and crash speeds

Speed (km/hr)	Pre-crash speed		Crash speed	
	Frequency	Percent	Frequency	Percent
Stop	16	4.5	3	0.8
1 – 10	2	0.6	20	5.6
11 – 20	46	12.8	73	20.3
21 – 30	73	20.3	88	24.5
31 – 40	85	23.7	71	19.8
41 – 50	53	14.8	50	13.9
51 – 60	32	8.9	20	5.6
61 – 70	19	5.3	18	5.0
71 – 80	12	3.3	8	2.2
81 – 90	4	1.1	2	0.6
91 – 100	1	0.3	1	0.3
> 100	1	0.3	1	0.3
Unknown	15	4.2	4	1.1
Total	359	100.0	359	100.0

Table 7.12.1: Other vehicle pre-crash and crash speeds

Speed (km/hr)	Pre-crash speed		Crash speed	
	Frequency	Percent	Frequency	Percent
Stop in traffic	48	15.6	37	12.0
<10	9	2.9	21	6.8
11 - 20	62	20.1	75	24.4
21 - 30	44	14.3	49	15.9
31 - 40	40	13.0	39	12.7
41 - 50	25	8.1	26	8.4
51 - 60	10	3.2	12	3.9
61 - 70	14	4.5	13	4.2
71 - 80	7	2.3	3	1.0
81 - 90	7	2.3	2	0.6
91 - 100	4	1.3	1	0.3
> 100	1	0.3	NOC 15*	4.9
Unknown	37	12.0	15	4.9
Total	308	100.0	308	100.0

* NOC = No impact speed because no impact occurred

Table 7.15.1: Points of collision contact, other vehicle

First contact on other vehicle	Code	Frequency	Percent
<u>Automobile, Van, Bus, Truck</u>			
Front bumper	F01X	44	14.3
Front push bar	F02X	1	0.3
Front corner	F04X	8	2.6
Front undercarriage	U01X	2	0.6
Front unknown	F99X	6	1.9
Rear bumper	R01X	8	2.6
Rear step bumper	R02X	1	0.3
Trailer hitch	R05X	1	0.3
Rear lamp	R06X	5	1.6
Tailgate	R08X	1	0.3
Rear door panel, center	R10X	1	0.3
Rear corner	R13X	2	0.6
Lower rear corner, van	R16X	3	1.0
Accessory lights, light bar	R29X	1	0.3
Rear, unknown	R99X	3	1.0
Side of front bumper	S01X	12	3.9
Front mudguard fender	S03X	3	1.0
Front mudguard, wheel house	S04X	5	1.6
Front tire	S05X	15	4.9
Rocker panel	S07X	4	1.3
Front door, front	S10X	8	2.6
Front door, rear	S11X	5	1.6
Front door, side glass	S13X	1	0.3
Rear door, rear	S20X	1	0.3
Center panel (van, bus)	S25X	1	0.3
Rear mudguard, wheel house	S28X	2	0.6
Rear tire	S29X	5	1.6
Rear mudguard (fender)	S30X	2	0.6
Upper rear corner	S33X	1	0.3
Side of rear bumper	S34X	1	0.3
Battery box, tool box, fire extinguishers	S36X	1	0.3
Side other	S98X	1	0.3
Side unknown	S99X	7	2.3
Left rear unknown	LR99	1	0.3
No collision contact	OVNC	15	4.9
Unknown	9999	4	1.3
<u>Motorcycle</u>			
Unknown	MC99	4	1.3
Center front	MCCF	27	8.8
Center rear	MCCR	1	0.3
Left center	MCLC	8	2.6
Left front	MCLF	29	9.4
Left rear	MCLR	4	1.3

First contact on other vehicle	Code	Frequency	
Right center	MCRC	13	4.2
Right front	MCRF	21	6.8
Right rear	MCRR	9	2.9
Top center	MCTC	1	0.3
Undercarriage center	MCUC	1	0.3
Tuk-Tuk			
Lower B-pillar	TT17	1	0.3
Unknown	TT99	1	0.3
Bicycle			
Left rear	BCLR	1	0.3
Right center	BCRC	1	0.3
Right rear	BCRR	1	0.3
Tricycle			
Right front	TCRF	1	0.3
Steel buffalo			
Right rear	SBRR	2	0.6
Total		308	100.0

Table 8.1.1: Age distribution

Age	MC rider		MC passenger		OV driver	
	Frequency	%	Frequency	%	Frequency	%
N/A	0	0	-	-	40	13
0 – 10	0	0	15	9	0	0
11 – 20	112	31	72	44	73	24
21 – 30	127	35	44	27	53	17
31 – 40	64	18	18	11	38	12
41 – 50	36	10	8	5	19	6
51 – 60	12	3	1	0.6	8	3
> 60	8	2	3	2	19	6
Unknown	0	0	1	0.6	58	19
Total	359	100	162	100	308	100

Table 9.12.2: Motorcycle injury contact surfaces

Motorcycle contact surface	Code	Frequency	
Brake lever, Clutch lever	MC01	10	2.9
Handlebars	MC02	67	19.8
Mirrors, mirror posts	MC03	7	2.1
Instruments	MC06	12	3.5
Front forks, front suspension	MC08	16	4.7
Fairing	MC09	45	13.3
Front fender	MC10	12	3.5
Headlamp, nacelle	MC11	1	0.3
Fuel tank	MC14	2	0.6
Steering head assembly	MC17	7	2.1
Frame tube, Frame element	MC23	18	5.3
Engine - cylinders, cylinder head	MC24	2	0.6
Engine - transmission cases	MC25	16	4.7
Radiator, lines, coolant	MC28	2	0.6
Shifter	MC29	33	9.7
Rear brake pedal	MC31	17	5.0
Exhaust headers, pipes	MC33	2	0.6
Mufflers	MC35	2	0.6
Rider foot pegs, foot rests	MC37	32	9.4
Passenger foot pegs, foot rests	MC39	2	0.6
Rear wheel assembly	MC40	1	0.3
Rear suspension, shocks, swing arm	MC41	4	1.2
Rear fender	MC42	2	0.6
License plate	MC43	1	0.3
Side stand	MC49	1	0.3
Center stand	MC51	1	0.3
Luggage rack, parcel rack	MC55	4	1.2
Rider	MC59	11	3.2
Passenger	MC60	2	0.6
MC other	MC98	1	0.3
MC Unknown	MC99	6	1.8
Total		339	100.0

Table 9.12.3: Environment contact surface

Environment contact surfaces	Code	Frequency	
Asphalt pavement	EA01	658	59.5
Concrete pavement	EC01	246	22.2
Concrete pole or post	EC02	17	1.5
Concrete Embankment	EC03	6	0.5
Concrete structure	EC05	7	0.6
Concrete curb	EC06	12	1.1
Concrete unpaved shoulder	EC07	5	0.5
Concrete sharp edge	EC11	1	0.1
Concrete flat surface	EC13	6	0.5
Glass sharp edge	EG11	4	0.4
Glass (debris of bottle)	EG98	1	0.1
Hard-packed soil, embankment	EL03	3	0.3
Hard-packed soil, unpaved shoulder	EL07	5	0.5
Metal, yielding pole or post	EM02	1	0.1
Metal, yielding sharp edge	EM11	1	0.1
Pedestrian, animal	EP14	2	0.2
Gravel, soil pavement	ES01	17	1.5
Gravel, soil embankment	ES03	1	0.1
Gravel, soil unpaved shoulder	ES07	40	3.6
Gravel flat surface	ES13	3	0.3
Wood pole or post	EW02	10	0.9
Wood structure	EW05	2	0.2
Wood shrubbery	EW09	57	5.2
Cow	EX13	1	0.1
Total		1106	100.0

Table 9.12.4: Other vehicle injury contact surfaces

Injury contact surfaces on other vehicle	Code	Frequency	
Vehicle Front and Front Corner			
Front bumper	F01X	42	10.4
Front push bar	F02X	7	1.7
Front grille	F03X	3	0.7
Front corner, headlamp nacelle	F04X	22	5.5
Side of front bumper	S01X	6	1.5
Side corner, headlamp nacelle	S02X	6	1.5
Front unknown part	F99X	5	1.2
Front of undercarriage	U01X	3	0.7
Front others	F98X	2	0.5
Vehicle Side Front			
Front mudguard (fender)	S03X	10	2.5
Front mudguard (fender) wheel house	S04X	7	1.7
Front tyres	S05X	25	6.2
Side of hood edge	S06X	6	1.5
Rocker panel, sill beam, steps	S07X	3	0.7
Lower A-pillar	S08X	2	0.5
Upper A-pillar	S09X	1	0.2
Front door, front	S10X	10	2.5
Front door, rear	S11X	2	0.5
Front door, belt line	S12X	3	0.7
Front door side glass (window)	S13X	12	3.0
Front door handle	S14X	3	0.7
Front roof rail	S15X	3	0.7
Front edge of hood	F05X	13	3.2
External rear view mirror	S43X	13	3.2
Vehicle Side Rear			
Lower B-pillar	S17X	5	1.2
Upper B-pillar	S18X	1	0.2
Rear door, front	S19X	3	0.7
Rear door, rear	S20X	2	0.5
Rear door, handle	S22X	2	0.5
Center panel (van, bus)	S25X	5	1.2
Rear mudguard (fender) wheel house	S28X	1	0.2
Rear tyres	S29X	1	0.2
Rear mudguard (fender), rear bed side panel	S30X	6	1.5
Side of trunk lid, edge	S31X	3	0.7
Other side	S98X	12	3.0
Side parts, unknown	S99X	1	0.2
Vehicle Rear and Rear Corner			
Lower rear corner (truck, van, bus, car)	S32X	1	0.2
Side of rear bumper	S34X	1	0.2
Rear bumper	R01X	4	1.0
Rear lamp, sub-boot (sub trunk) panel	R06X	13	3.2

Injury contact surfaces on other vehicle	Code	Frequency	
Tailgate	R08X	35	8.7
Rear door panel, top	R09X	1	0.2
Rear door panel, bottom	R11X	1	0.2
Rear corner, truck bed	R13X	3	0.7
Lower rear corner, van	R16X	4	1.0
Upper rear corner, van	R17X	12	3.0
Rear door or window, frame sill	R26X	1	0.2
Rear door side frame posts, hinges	R27X	1	0.2
Other rear	R98X	1	0.2
Rear unknown part	R99X	4	1.0
Rear of undercarriage	U02X	4	1.0
Vehicle Top Surface			
Top of bonnet, front	F06X	9	2.2
Top of bonnet, center	T02X	1	0.2
Top of bonnet, rear	T03X	12	3.0
Windshield surface	F10X	25	6.2
Windshield header	F11X	4	1.0
Roof top, front	T05X	1	0.2
Unknown OV part	9999	11	2.7
Tricycle rider	TC59	2	0.5
Total		402	100.0

Table 11.3.2: Alcohol involvement and time of accident

Time of accident	No alcohol	Alcohol use	Total
0:01 - 1:00	1	10	11
1:01 - 2:00	2	5	7
2:01 - 3:00	1	4	5
3:01 - 4:00	2	4	6
4:01 - 5:00	2	2	4
5:01 - 6:00	2	2	4
6:01 - 7:00	3	1	4
7:01 - 8:00	13	0	13
8:01 - 9:00	12	0	12
9:01 - 10:00	13	2	15
10:01 - 11:00	18	1	19
11:01 - 12:00	10	0	10
12:01 - 13:00	10	2	12
13:01 - 14:00	20	2	22
14:01 - 15:00	10	1	11
15:01 - 16:00	18	2	20
16:01 - 17:00	26	6	32
17:01 - 18:00	24	1	25
18:01 - 19:00	8	1	9
19:01 - 20:00	13	4	17
20:01 - 21:00	13	15	28
21:01 - 22:00	9	13	22
22:01 - 23:00	12	9	21
23:01 - 24:00	11	18	29
Total	253	105	358

Appendix B (Statistical analysis)

Table 13.1.1: Accident-to-exposure rates by ambient lighting

Ambient Lighting	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Night	153	109.16	8513	42.62	30.41
Others	206	249.84	19484	57.38	69.59
Total	359	249.84	27997	100.00	100.00
	X^2 =	25.30	P - Value < 0.0001		Reject H_0

Table 13.2.1: Motorcycle type in accident and exposure data

Motorcycle Type	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Sport	26	11.47	894	7.24	3.19
Others	333	347.53	27097	92.76	96.81
Total	359	359.00	27991	100.00	100.00
	X^2 =	19.03	P - Value < 0.0001		Reject H_0

Table 13.2.3 Headlamp use in accident and on-scene exposure data at night

Ambient Lighting at night	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Headlamp off	18	14.07	788	11.84	9.26
Headlamp on	134	137.93	7725	88.16	90.74
Total	152	152.00	8513	100.00	100.00
	X^2 =	1.21	P - Value > 0.05		Accept H_0

Table 13.3.1: Rider alcohol use impairment in accident and PSE data

Alcohol Involvement	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Alcohol use	253	346.18	1025	70.67	96.70
No alcohol use	105	11.82	35	29.33	3.30
Total	358	358.00	1060	100.00	100.00
	X^2 =	759.58	P - Value < 0.0001		Reject H_0

Table 13.4.1: Rider license in accident and PSE data

License Held	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No license held	179	119.22	352	49.86	33.21
Others	180	239.78	708	50.14	66.79
Total	359	359.00	1060	100.00	100.00
	X^2 =	44.89	P - Value < 0.0001		Reject H_0

Table 13.5.1: Motorcycle rider gender in accident and PSE

Gender	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Female	77	93.48	276	21.45	26.04
Male	282	265.52	784	78.55	73.96
Total	359	359.00	1060	100.00	100.00
	X^2 =	3.93	P - Value < 0.05		Reject H_0

Table 13.5.1: Motorcycle rider gender in accident and OSE

Gender	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Female	77	96.41	7519	21.45	26.86
Male	282	262.59	20478	78.55	73.14
Total	359	359.00	27997	100.00	100.00
	X^2 =	5.34	P - Value < 0.05		Reject H_0

Table 13.5.2: Motorcycle rider age in accident and PSE data

Rider age, years	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Under 21	112	96.52	285	31.20	26.89
Over 20	247	262.48	775	68.80	73.11
Total	359	359.00	1060	100.00	100.00
	X^2 =	3.39	P - Value > 0.05		Accept H_0

Table 13.5.5: Motorcycle rider education in accident and PSE data

Education Level	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Less than Grade 12th	287	253.64	751	80.17	70.85
More than Grade 12th	71	104.36	309	19.83	29.15
Total	358	358.00	1060	100.00	100.00
	X^2 =	15.05	P - Value < 0.001		Reject H_0

Table 13.5.6: Motorcycle rider occupation in accident and PSE data

Rider Occupation	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Unemployed&Elementary	190	133.41	395	53.07	37.26
Others	168	224.59	665	46.93	62.74
Total	358	358.00	1060	100.00	100.00
	X^2 =	38.27	P - Value < 0.0001		Reject H_0

Table 13.7.3: Rider experience with cargo in accident and PSE data

Length of intended trip	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Infrequent carrying cargo	33	16.11	44	49.25	24.04
Frequenct carrying cargo	34	50.89	139	50.75	75.96
Total	67	67.00	183	100.00	100.00
	X^2 =	23.32	P - Value < 0.0001		Reject H_0

Table 13.8.1: Rider traffic accidents in previous five years

Previous MC accident	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
None	263	236.11	707	74.29	66.70
Others	91	117.89	353	25.71	33.30
Total	354	354.00	1060	100.00	100.00
	X^2 =	9.20	P - Value < 0.01		Reject H_0

Table 13.8.2: Comparison of rider previous motorcycle traffic violation

Previous traffic violation	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
None	319	244.13	731	90.11	68.96
Others	35	109.87	329	9.89	31.04
Total	354	354.00	1060	100.00	100.00
	X^2 =	73.99	P - Value < 0.0001		Reject H_0

Table 13.9.1: Rider familiarity with roadway in accident and PSE data

Rider familiarity	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Infrequent	26	24.11	72	7.32	6.79
Frequent	329	330.89	988	92.68	93.21
Total	355	355.00	1060	100.00	100.00
	X^2 =	0.16	P - Value > 0.1		Accept H_0

Table 13.9.4: Rider intended trip length in accident PSE data

Length of intended trip	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Less than 5 km	233	236.74	699	64.90	65.94
More than 5 km	126	122.26	361	35.10	34.06
Total	359	359.00	1060	100.00	100.00
	X^2 =	0.17	P - Value > 0.1		Accept H_0

Table 13.11.2: Rider helmet use in accident and OSE

Helmet use	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No	280	214.36	16717	77.99	59.71
Yes	79	144.64	11280	22.01	40.29
Total	359	359.00	27997	100.00	100.00
	X^2 =	49.89	P - Value < 0.0001		Reject H_0

Table 13.11.2: Rider helmet use in accident and PSE

Helmet use	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No	280	194.06	573	77.99	54.06
Yes	79	164.94	487	22.01	45.94
Total	359	359.00	1060	100.00	100.00
	X^2 =	82.83	P - Value < 0.0001		Reject H_0

Table 13.11.3: Rider helmet type in accident and exposure data

Helmet type	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
Half helmet	42	38.64	5517	53.16	48.91
Others	37	40.36	5763	46.84	51.09
Total	79	79.00	11280	100.00	100.00
	X^2 =	0.57	P - Value > 0.1		Accept H_0

Table 13.12.1: Number of passengers in accident and exposure data

Number of passenger(s)	Observed Accident	Expected value	Exposure	Observed percentage	Exposure percentage
No passenger	220	210.56	16421	61.28	58.65
1 - 4 passengers	139	148.44	11576	38.72	41.35
Total	359	359.00	27997	100.00	100.00
	X^2 =	1.02	P - Value > 0.05		Accept H_0

Appendix C (Motorcycle components)

Rear crash bar

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Windscreen

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	216	60.2	60.2	60.2
	2	143	39.8	39.8	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	216	60.2	60.2	60.2
	1	142	39.6	39.6	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	216	60.2	60.2	60.2
	1	143	39.8	39.8	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	216	60.2	60.2	60.2
	1	54	15.0	15.0	75.2
	2	89	24.8	24.8	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Fairing

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	33	9.2	9.2	9.2
	2	326	90.8	90.8	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	33	9.2	9.2	9.2
	1	325	90.5	90.5	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	33	9.2	9.2	9.2
	1	326	90.8	90.8	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	33	9.2	9.2	9.2
	1	85	23.7	23.7	32.9
	2	241	67.1	67.1	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Headlamps

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	3	.8	.8	.8
	2	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	3	.8	.8	.8
	1	353	98.3	98.3	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	3	.8	.8	.8
	2	355	98.9	98.9	99.7
	9	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	3	.8	.8	.8
	1	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	3	.8	.8	.8
	1	271	75.5	75.5	76.3
	2	85	23.7	23.7	100.0
	Total	359	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	336	93.6	93.6	93.6
	2	23	6.4	6.4	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	336	93.6	93.6	93.6
	1	21	5.8	5.8	99.4
	2	2	.6	.6	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	336	93.6	93.6	93.6
	1	23	6.4	6.4	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	336	93.6	93.6	93.6
	1	11	3.1	3.1	96.7
	2	12	3.3	3.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front reflectors

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front turn signals

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	26	7.2	7.2	7.2
	2	333	92.8	92.8	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	26	7.2	7.2	7.2
	1	333	92.8	92.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	26	7.2	7.2	7.2
	1	3	.8	.8	8.1
	2	330	91.9	91.9	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	26	7.2	7.2	7.2
	1	333	92.8	92.8	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	26	7.2	7.2	7.2
	1	202	56.3	56.3	63.5
	2	131	36.5	36.5	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Speedometer

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	16	4.5	4.5	4.5
	2	343	95.5	95.5	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	4.5	4.5	4.5
	1	340	94.7	94.7	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	4.5	4.5	4.5
	1	21	5.8	5.8	10.3
	2	320	89.1	89.1	99.4
	9	2	.6	.6	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	4.5	4.5	4.5
	1	343	95.5	95.5	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	16	4.5	4.5	4.5
	1	309	86.1	86.1	90.5
	2	34	9.5	9.5	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Tachometer

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	317	88.3	88.3	88.3
	2	42	11.7	11.7	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	88.3	88.3	88.3
	1	41	11.4	11.4	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	88.3	88.3	88.3
	1	2	.6	.6	88.9
	2	40	11.1	11.1	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	88.3	88.3	88.3
	1	42	11.7	11.7	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	317	88.3	88.3	88.3
	1	33	9.2	9.2	97.5
	2	9	2.5	2.5	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Handlebars

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	352	98.1	98.1	98.1
	2	7	1.9	1.9	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	170	47.4	47.4	47.4
	2	189	52.6	52.6	100.0
	Total	359	100.0	100.0	

Note:
0-not applicable
1-No
2-Yes
9-unknown

Throttle

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	352	98.1	98.1	98.1
	2	7	1.9	1.9	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	3	.8	.8	.8
	2	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	346	96.4	96.4	96.4
	2	13	3.6	3.6	100.0
	Total	359	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	233	64.9	64.9	64.9
	2	126	35.1	35.1	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	233	64.9	64.9	64.9
	1	123	34.3	34.3	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	233	64.9	64.9	64.9
	1	1	.3	.3	65.2
	2	125	34.8	34.8	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	233	64.9	64.9	64.9
	1	126	35.1	35.1	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	233	64.9	64.9	64.9
	1	69	19.2	19.2	84.1
	2	57	15.9	15.9	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Brake lever

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	2.5	2.5	2.5
	2	350	97.5	97.5	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	9	2.5	2.5	2.5
	1	347	96.7	96.7	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	9	2.5	2.5	2.5
	1	7	1.9	1.9	4.5
	2	343	95.5	95.5	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	9	2.5	2.5	2.5
	1	350	97.5	97.5	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	9	2.5	2.5	2.5
	1	191	53.2	53.2	55.7
	2	159	44.3	44.3	100.0
	Total	359	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	Cumulative Percent
Valid	1	127	35.4	35.4	35.4
	2	232	64.6	64.6	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	127	35.4	35.4	35.4
	1	198	55.2	55.2	90.5
	2	34	9.5	9.5	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	127	35.4	35.4	35.4
	1	1	.3	.3	35.7
	2	231	64.3	64.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	127	35.4	35.4	35.4
	1	231	64.3	64.3	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	127	35.4	35.4	35.4
	1	117	32.6	32.6	68.0
	2	115	32.0	32.0	100.0
	Total	359	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	131	36.5	36.5	36.5
	2	228	63.5	63.5	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	131	36.5	36.5	36.5
	1	195	54.3	54.3	90.8
	2	33	9.2	9.2	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	131	36.5	36.5	36.5
	1	1	.3	.3	36.8
	2	227	63.2	63.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	131	36.5	36.5	36.5
	1	228	63.5	63.5	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	131	36.5	36.5	36.5
	1	133	37.0	37.0	73.5
	2	95	26.5	26.5	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front suspension

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	359	100.0	100.0	100.0

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	.6	.6	.6
	2	357	99.4	99.4	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	352	98.1	98.1	98.1
	2	7	1.9	1.9	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	224	62.4	62.4	62.4
	2	135	37.6	37.6	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front tyre/wheel

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	181	50.4	50.4	50.4
	2	178	49.6	49.6	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	243	67.7	67.7	67.7
	2	116	32.3	32.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front fender

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	.8	.8	.8
	2	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	.8	.8	.8
	1	352	98.1	98.1	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	.8	.8	.8
	2	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	.8	.8	.8
	1	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	.8	.8	.8
	1	140	39.0	39.0	39.8
	2	216	60.2	60.2	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Front brakes

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	22	6.1	6.1	6.1
	2	337	93.9	93.9	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	22	6.1	6.1	6.1
	1	333	92.8	92.8	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	22	6.1	6.1	6.1
	1	6	1.7	1.7	7.8
	2	330	91.9	91.9	99.7
	9	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	22	6.1	6.1	6.1
	1	334	93.0	93.0	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	22	6.1	6.1	6.1
	1	319	88.9	88.9	95.0
	2	18	5.0	5.0	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Seat

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	311	86.6	86.6	86.6
	2	48	13.4	13.4	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	303	84.4	84.4	84.4
	2	56	15.6	15.6	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Sissy bar/passenger back rest

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	357	99.4	99.4	99.4
	2	2	.6	.6	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	357	99.4	99.4	99.4
	1	2	.6	.6	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	357	99.4	99.4	99.4
	2	2	.6	.6	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	357	99.4	99.4	99.4
	1	2	.6	.6	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	357	99.4	99.4	99.4
	1	2	.6	.6	100.0
	Total	359	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	293	81.6	81.6	81.6
	2	66	18.4	18.4	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	293	81.6	81.6	81.6
	1	65	18.1	18.1	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	293	81.6	81.6	81.6
	2	66	18.4	18.4	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	293	81.6	81.6	81.6
	1	66	18.4	18.4	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	293	81.6	81.6	81.6
	1	54	15.0	15.0	96.7
	2	12	3.3	3.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Frame

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	345	96.1	96.1	96.1
	2	14	3.9	3.9	100.0
	Total	359	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	64	17.8	17.8	17.8
	2	295	82.2	82.2	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	64	17.8	17.8	17.8
	1	293	81.6	81.6	99.4
	2	2	.6	.6	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	64	17.8	17.8	17.8
	1	295	82.2	82.2	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	64	17.8	17.8	17.8
	1	181	50.4	50.4	68.2
	2	114	31.8	31.8	100.0
	Total	359	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	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	330	91.9	91.9	91.9
	2	29	8.1	8.1	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Auxiliary fuel tank

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	358	99.7	99.7	99.7
	1	1	.3	.3	100.0
	Total	359	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	358	99.7	99.7	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	343	95.5	95.5	95.5
	2	16	4.5	4.5	100.0
	Total	359	100.0	100.0	

Transmission case

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	341	95.0	95.0	95.0
	2	18	5.0	5.0	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Oil tank

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	40	11.1	11.1	11.1
	2	319	88.9	88.9	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	40	11.1	11.1	11.1
	1	319	88.9	88.9	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	40	11.1	11.1	11.1
	1	318	88.6	88.6	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	40	11.1	11.1	11.1
	1	300	83.6	83.6	94.7
	2	19	5.3	5.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Battery, battery box

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	6	1.7	1.7	1.7
	2	353	98.3	98.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	1.7	1.7	1.7
	1	353	98.3	98.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	1.7	1.7	1.7
	1	353	98.3	98.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	1.7	1.7	1.7
	1	347	96.7	96.7	98.3
	2	6	1.7	1.7	100.0
	Total	359	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	2	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	359	100.0	100.0	100.0

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	.3	.3	.3
	2	358	99.7	99.7	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	248	69.1	69.1	69.1
	2	111	30.9	30.9	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Shift lever

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	5	1.4	1.4	1.4
	2	354	98.6	98.6	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	1.4	1.4	1.4
	1	353	98.3	98.3	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	1.4	1.4	1.4
	1	1	.3	.3	1.7
	2	353	98.3	98.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	1.4	1.4	1.4
	1	354	98.6	98.6	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	5	1.4	1.4	1.4
	1	268	74.7	74.7	76.0
	2	86	24.0	24.0	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Foot pegs, footrests

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	1.1	1.1	1.1
	2	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	1.1	1.1	1.1
	1	349	97.2	97.2	98.3
	2	6	1.7	1.7	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	1.1	1.1	1.1
	2	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	1.1	1.1	1.1
	1	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	1.1	1.1	1.1
	1	39	10.9	10.9	12.0
	2	316	88.0	88.0	100.0
	Total	359	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	11	3.1	3.1	3.1
	2	348	96.9	96.9	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	3.1	3.1	3.1
	1	348	96.9	96.9	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	3.1	3.1	3.1
	1	1	.3	.3	3.3
	2	347	96.7	96.7	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	3.1	3.1	3.1
	1	348	96.9	96.9	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	11	3.1	3.1	3.1
	1	336	93.6	93.6	96.7
	2	12	3.3	3.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Center stand

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	35	9.7	9.7	9.7
	2	324	90.3	90.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	35	9.7	9.7	9.7
	1	324	90.3	90.3	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	35	9.7	9.7	9.7
	1	2	.6	.6	10.3
	2	322	89.7	89.7	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	35	9.7	9.7	9.7
	1	323	90.0	90.0	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	35	9.7	9.7	9.7
	1	307	85.5	85.5	95.3
	2	17	4.7	4.7	100.0
	Total	359	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	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	351	97.8	97.8	97.8
	2	8	2.2	2.2	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	1	.3	.3	.3
	2	358	99.7	99.7	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	348	96.9	96.9	96.9
	2	11	3.1	3.1	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	197	54.9	54.9	54.9
	2	162	45.1	45.1	100.0
	Total	359	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	354	98.6	98.6	98.6
	2	5	1.4	1.4	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	354	98.6	98.6	98.6
	1	2	.6	.6	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	354	98.6	98.6	98.6
	1	4	1.1	1.1	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	354	98.6	98.6	98.6
	1	4	1.1	1.1	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Parcel rack

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	213	59.3	59.3	59.3
	2	146	40.7	40.7	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	213	59.3	59.3	59.3
	1	142	39.6	39.6	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	213	59.3	59.3	59.3
	1	146	40.7	40.7	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	213	59.3	59.3	59.3
	1	41	11.4	11.4	70.8
	2	105	29.2	29.2	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear position lamps

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	7	1.9	1.9	1.9
	2	352	98.1	98.1	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	1.9	1.9	1.9
	1	348	96.9	96.9	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	1.9	1.9	1.9
	1	4	1.1	1.1	3.1
	2	347	96.7	96.7	99.7
	9	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	1.9	1.9	1.9
	1	352	98.1	98.1	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	1.9	1.9	1.9
	1	329	91.6	91.6	93.6
	2	23	6.4	6.4	100.0
	Total	359	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	7	1.9	1.9	1.9
	2	352	98.1	98.1	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	7	1.9	1.9	1.9
	1	348	96.9	96.9	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	7	1.9	1.9	1.9
	1	3	.8	.8	2.8
	2	349	97.2	97.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	7	1.9	1.9	1.9
	1	352	98.1	98.1	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	7	1.9	1.9	1.9
	1	332	92.5	92.5	94.4
	2	20	5.6	5.6	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear reflectors

Equipped

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	193	53.8	53.8	53.8
	2	166	46.2	46.2	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	193	53.8	53.8	53.8
	1	162	45.1	45.1	98.9
	2	4	1.1	1.1	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	193	53.8	53.8	53.8
	2	166	46.2	46.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	193	53.8	53.8	53.8
	1	166	46.2	46.2	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	193	53.8	53.8	53.8
	1	161	44.8	44.8	98.6
	2	5	1.4	1.4	100.0
	Total	359	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	39	10.9	10.9	10.9
	2	320	89.1	89.1	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	39	10.9	10.9	10.9
	1	317	88.3	88.3	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	39	10.9	10.9	10.9
	1	4	1.1	1.1	12.0
	2	316	88.0	88.0	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	39	10.9	10.9	10.9
	1	320	89.1	89.1	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	39	10.9	10.9	10.9
	1	263	73.3	73.3	84.1
	2	57	15.9	15.9	100.0
	Total	359	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	359	100.0	100.0	100.0

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	346	96.4	96.4	96.4
	2	13	3.6	3.6	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	1	.3	.3	.3
	2	357	99.4	99.4	99.7
	9	1	.3	.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	347	96.7	96.7	96.7
	2	12	3.3	3.3	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear tyre/wheel

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	158	44.0	44.0	44.0
	2	201	56.0	56.0	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	2	359	100.0	100.0	100.0

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	359	100.0	100.0	100.0

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	1	347	96.7	96.7	96.7
	2	12	3.3	3.3	100.0
	Total	359	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	4	1.1	1.1	1.1
	2	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	4	1.1	1.1	1.1
	1	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	4	1.1	1.1	1.1
	2	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	4	1.1	1.1	1.1
	1	355	98.9	98.9	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	mulative Perce
Valid	0	4	1.1	1.1	1.1
	1	317	88.3	88.3	89.4
	2	38	10.6	10.6	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Rear brakes

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	.3	.3	.3
	2	358	99.7	99.7	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.3	.3	.3
	1	358	99.7	99.7	100.0
	Total	359	100.0	100.0	

Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.3	.3	.3
	1	2	.6	.6	.8
	2	356	99.2	99.2	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.3	.3	.3
	1	357	99.4	99.4	99.7
	2	1	.3	.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	.3	.3	.3
	1	356	99.2	99.2	99.4
	2	2	.6	.6	100.0
	Total	359	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	175	48.7	48.7	48.7
	2	184	51.3	51.3	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	175	48.7	48.7	48.7
	1	184	51.3	51.3	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	175	48.7	48.7	48.7
	1	184	51.3	51.3	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	175	48.7	48.7	48.7
	1	181	50.4	50.4	99.2
	2	3	.8	.8	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown

Side covers

Equipped

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	1.4	1.4	1.4
	2	354	98.6	98.6	100.0
	Total	359	100.0	100.0	

Aftermarket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	1.4	1.4	1.4
	1	354	98.6	98.6	100.0
	Total	359	100.0	100.0	

Modified

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	1.4	1.4	1.4
	1	354	98.6	98.6	100.0
	Total	359	100.0	100.0	

Damage in accident

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	1.4	1.4	1.4
	1	254	70.8	70.8	72.1
	2	100	27.9	27.9	100.0
	Total	359	100.0	100.0	

Note: 0-not applicable
1-No
2-Yes
9-unknown