Bicycle Crashes and Injuries in Western Australia, 1987-2000

RR131

injury research centre

The University of Western Australia

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INJURY RESEARCH CENTRE

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Abstract

The purpose of this study was to analyse police and hospital data relating to bicycle crashes in Western Australia for the period 1987-2000. It is the continuation of a previous report which examined bicycle crashes from 1987 to 1996. Data on bicycle crashes and injuries were obtained from two sources: police reports and hospital admissions data. The results of the analyses were presented using the following broad subject areas: size of the problem, cyclist profile, injury characteristics, helmet wearing, other vehicle characteristics and crash characteristics. The findings were generally consistent with other Australian and overseas studies that have investigated bicycle crashes and injuries. However, some important differences were found in the information obtained from the police and hospital data. The hospitalised cyclists were considerably younger than the police-reported group; the hospital data showed cyclists accounting for a much greater proportion of road casualties, and motorists for a much smaller proportion, than the police data; and the number of cyclists involved in bicycle crashes in the police data decreased between 1987 to 2000 while the hospital data shows a significant increase in the number of hospitalised cyclists. These differences need to be considered in the development of road safety policy relating to cyclists. More in-depth analysis of the police and hospital data, and the examination of additional sources of data such as the data bases maintained by hospital emergency departments, could provide more information relating to the magnitude and nature of the bicycle crash and injury problem in WA.

Keywords
Bicycle, Cyclist, Injury Severity

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Introduction

The objectives of this study were (i) to examine current research into bicycle safety, and (ii) to analyse police and hospital data relating to bicycle crashes in Western Australia for the period from 1987 to 2000. This report is a continuation of a report which documented bicycle crashes from 1987 to 1996.

The rationale for undertaking the study was to determine the past and current status of bicycle safety in WA and provide information about the characteristics of bicycle crashes and injuries to use in developing bicycle safety initiatives.

Brief Review of Current Research on Bicycle Safety

Five main areas of research were identified in the literature -

1. Factors associated with bicycle crashes such as cyclist characteristics, crash circumstances, and temporal factors.
2. The under-reporting of bicycle crashes in the police records which are evident when comparing police data with hospital and other sources of data relating to bicycle crashes and injuries.
3. The extent of injuries to cyclists in terms of injury severity and body region of injury.
4. Bicycle usage and traffic exposure, and the relative risk of cycling compared with other modes of transport.
5. Measures to reduce bicycle crash and injury rates, which can be grouped into engineering countermeasures, vehicle safety features, education and enforcement.

A brief review of current research in each of these areas is provided in the report.

Method

Data on bicycle crashes and injuries for the years from 1987 to 2000 were obtained from two sources, namely police reports and hospital admission records. Linked police and hospital data were used to examine the reporting rate to the police of road crashes involving cyclists admitted to hospital. The study used descriptive statistical methods to analyse these different data sources.

Summary of Major Findings

Police-reported Road Crash Data

Size of the Problem

- The number of bicycle crashes reported to the police in Western Australia significantly decreased from 1,012 in 1987 to 612 in 2000 (p=0.001). Over this period, the share of bicycle crashes as a percentage of all reported crashes decreased from 2.5% to 1.4 %.

Cyclist Profile

- The majority of cyclists involved in police-reported crashes were young and predominantly male.

- Cyclists involved in police reported crashes were relatively younger than other road users involved in road crashes.

- 30% of cyclists involved in police-reported crashes were 16 years or less compared with 24% of pedestrians and 2% of other road users. On the other hand, relatively few older cyclists were involved in police-reported bicycle crashes. Only 10% of cyclists involved in police-reported crashes were 40 years or older compared with 22% and 25% of pedestrians and other road users respectively.

Injury Severity

- Over the 14 year study period, an analysis of total Police-reported crashes reveals that, 81 (1%) cyclists were killed in road crashes, 1,851 (16%) were reported to have been admitted to hospital, 4,486 (39%) required medical attention, 1,250 (11%) were injured but did not require treatment, and 3,717 (33%) were involved in property damage only crashes or crashes of unknown severity.

Helmet Wearing

- In 2000, helmet wearing status was unknown for 56% of cyclists involved in police-reported crashes, 34% were known to have been wearing a helmet, and 11% were known not to have been wearing a helmet. This implies a helmet-wearing rate of 76% for cyclists whose helmet wearing status was known.

Other Vehicle Characteristics

- Most bicycle crashes (93%) reported to the police involved a cyclist and at least one other vehicle.

Crash Type

- Right-angled crashes and sideswipe same direction crashes accounted for almost 60% of all police-reported bicycle crashes.

- The proportion of sideswipe same direction crashes as a percentage of all crashes decreased over the 14-year period, while in recent years the proportion of indirect right-angled crashes has also decreased.

- Right-angled crashes, rear end crashes, sideswipe same direction crashes and sideswipe opposite direction crashes accounted for 85% of all fatalities and 70% of police-reported hospital admissions. Indirect right-angled crashes accounted for 11% of hospital admissions.

Traffic Control

- Over the 14-year period, 72% of bicycle crashes occurred where there were no traffic signs or controls, 11% where there were stop signs, 10% where there were traffic lights and 5% where there were give way signs.

- In recent years, relatively fewer crashes occurred at stop signs and relatively more at give way signs.

Road Type

- The majority (94%) of police-reported crashes occurred on-road. Eighty-six percent occurred on urban-arterial and local roads, 12% on highways and 2% on main roads.

Crash Location

- Using the Main Roads WA regions, 84% of police-reported crashes occurred in the Perth metropolitan region, 7% in the South West, and 2% in each of the Goldfields-Esperance and Great Southern regions.

Temporal Factors

- The peak times for bicycle crashes were 6am to 9am and 3pm to 6pm. There were differences in the distribution of crashes by time of day for different age groups.

- Weekend crashes had a different time distribution to weekday crashes with proportionately more weekend crashes in the 9am to 12 noon period and 12pm to 3pm period.

Hospital Admissions Data

Size of the Problem

- There has been a significant increase (p=0.001) in the number of cyclists admitted to hospital with injuries resulting from road crashes during the 14 year study period.

- Over the 14-year period, hospital admissions of cyclists as a percentage of all road crash casualties increased from12% in 1989 to 16% in 2000.

Cyclist Profile

- The majority of cyclists admitted to hospital were young and predominantly male. Fifty percent of cyclist casualties were young males aged 16 years or less and 18% were young females aged 16 years or less.

- Compared with other road users, cyclists admitted to hospital were relatively younger. Sixty-seven percent of cyclists admitted to hospital were 16 years or less, compared with 32% of pedestrians and 13% of other road users.

- Young males in the 13 to 16 year age group and the 6 to 12 year age group had the highest rates of hospital admission.

Injury Severity

- Injury severity was coded using the Abbreviated Injury Scale (AIS). According to this scale, from 1988 to 1999 in WA, 51 cyclists were admitted to hospital each year in WA with critical injuries (AIS=5), 171 with severe injuries (AIS=4), 811 with serious injuries (AIS=3), 5,130 with moderate injuries (AIS=2) and 1,371 with minor injuries (AIS=1).

- Cyclists had fewer critical, severe and serious injuries (13%) compared with pedestrians (32%), motorcyclists (26%) and motor vehicle occupants (26%). Cyclists had the highest proportion of moderate injuries (65%).

Body Region of Injury

- The most frequently occurring injuries to cyclists were upper extremity injuries (29%), followed by head injuries (23%), external injuries (16%) and injuries to the lower extremities (15%).

- Injuries to the upper extremities have shown a steady increase from 17% of all cyclist injuries in 1988 to 37% in 1999.

- Head injuries accounted for the highest proportion of critical injuries (69%) and severe injuries (80%) to cyclists. Injuries to the lower extremities accounted for almost half of all serious injuries (49%).

Common Injury Types

- Injuries were also classified by common injury type. The common injury types that cyclists sustained most frequently were head injuries (28%), upper limb fractures (27%), open wounds (18%), lower limb fractures (12%) and bruises and abrasions (5%).

- Head injuries were the most common injury type, but in recent years the proportion of head injuries has decreased and the most common injury types were upper limb fractures.

Length of Stay in Hospital

- The majority of cyclists (57%) spent only one day in hospital, while 35% spent between two and seven days in hospital. The length of hospital stay has decreased over the period.

- Younger cyclists had shorter lengths of stay in hospital than adult cyclists.

- The injuries requiring longer stays in hospital were those to the lower extremities, the head and the spine. Cyclists who stayed in hospital for only one day had upper extremity injuries (36%), head injuries (29%), and external injuries (16%).

Crash Type

- Most bicycle crashes (82%) resulting in a hospital admission were non-motor vehicle crashes (i.e., did not involve a collision with a motor vehicle).

Road Type

- Forty percent of bicycle crashes resulting in a cyclist casualty being admitted to hospital occurred on-road, 59% occurred off-road, and the place of occurrence was unknown for the remainder.

- A large majority of bicycle crashes involving collisions with motor vehicles (82%) occurred on-road, while only 31% of non-motor vehicle crashes occurred on-road.

Place of Residence of Cyclist

- Seventy-one percent of cyclists admitted to hospital with road injuries lived in the metropolitan region.

Reporting Rate to the Police of Crashes Involving Hospital Admissions

- The number of cyclists recorded as being hospitalised in the police data was 21% of the number actually admitted to hospital over this period.

- Over the 12.5 year period from 1987 to June 30, 1999, between 14% and 24% of hospital records had a matching (linked) police record.

- The linkage rate of hospital records to a police report was lower for cyclists than for pedestrians and other road users.

- In general, the linkage rate of hospital records to a police record for cyclists was higher for individuals living in the metropolitan region, males, older cyclists and for those with more severe injuries and longer stays in hospital.

Discussion

The results of this study were found to be generally consistent with other Australian and international studies in terms of the findings relating to the profile of cyclists, crash characteristics, injury severity and the most common types of injury. The majority of cyclists involved in crashes were young (30% were 16 years or less) and predominantly male (81% excluding unknown category). With regard to crash circumstances, almost all police-reported bicycle crashes involved a motor vehicle and occurred on-road, while a high proportion of cyclists admitted to hospital following a bicycle crash were involved in crashes not involving a motor vehicle with only half occurring on-road. In the police data, the most common crash types resulting in fatalities or hospital admissions were right-angled crashes, rear end crashes and sideswipe crashes. Most cyclists admitted to hospital had moderate or minor injuries, with the most frequently occurring injuries being those to the head and upper extremities.

Some important differences were found in the information obtained from the police-reported data and the hospital admissions data. These were -

1. Hospitalised cyclists were considerably younger than cyclists in the police-reported data.
2. The two data sources revealed very different distributions across road user groups. The police data showed cyclists accounting for 1% of crash involvement compared to 14% of the hospital data (see Table A6 and Table B4).
3. The number of cyclists involved in crashes in the police data significantly decreased between 1987 and 2000, while the hospital data showed a significant increase in the number of admissions.

This report has important implications for the development of bicycle safety policy in Western Australia. The descriptive data - relating to the size of the bicycle safety problem, cyclist characteristics, injury details and crash characteristics - provide information that can be used to identify the crash and injury problem and develop strategies and programs for bicycle safety. In addition, the report has found some important differences between the police and hospital data that need to be recognised when decisions relating to bicycle safety issues are being made.

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1. INTRODUCTION

Over the 14 years from 1987 to 2000 in Western Australia, there has been 11,114 Police reported road crashes involving cyclists. This represents an average of six cyclists fatally injured per year and approximately 700 cyclists being admitted to hospital following injuries sustained in road crashes. Cyclists were involved in approximately 2% of all road crashes reported to the police and 5% of the reported crashes involving serious injury.

The information presented in this report is a continuation of a previous report that examined bicycle crash and injury data for both the police reported data and hospital admissions data from 1987 to 1996. Due to updates in The Western Australian Road Injury Database numbers may be different to what was previously reported.

Therefore the objectives of this study are to:

1. Examine current research into bicycle safety.
2. Analyse police-reported and hospital admissions data relating to bicycle crashes and injuries in WA for the period 1987-2000.

The reason for undertaking the study is to assess the magnitude of the bicycle crash and injury problem using available police and hospital data, and to provide information about the characteristics of bicycle crashes and injuries to use in developing bicycle safety strategies and programs in WA. The data will also provide information that can be used to evaluate new and current initiatives for reducing crashes and injuries to cyclists. In addition, the data will be made widely available to all stakeholders and other groups with an interest in bicycle safety.

Section 2 of this report provides an overview of current research into bicycle safety. Section 3 describes the data and methods used in the study. Sections 4 and 5 present the results of the analyses of the police and hospital data respectively, and Section 6 examines the reporting rate to police of crashes involving hospital admission. Section 7 summarises the major findings of the study, and the discussion is presented in Section 8.

2. BRIEF REVIEW OF CURRENT RESEARCH ON BICYCLE SAFETY

Bicycle riding is one of the most popular recreational activities in Australia and is fast becoming an increasingly popular form of transportation. However cyclists have a higher risk of being injured more than any other group of road users (Petersson et al., 1997; Wahlberg et al., 1995). They are "unprotected" in traffic, despite being capable (on the multi-geared bicycles of today) of reaching high speeds. Because of the serious nature of injuries and deaths among cyclists there exists a sizable body of published literature describing bicycle related injury and patterns.

Five main research areas can be identified in the literature on bicycle safety: factors associated with bicycle crashes; the under-reporting of bicycle crashes in the police records; the extent of injuries to cyclists; bicycle usage and the relative risk of cycling; and measures to reduce bicycle crash and injury rates.

2.1 Factors Associated with Bicycle Crashes

Factors that have been investigated for association with bicycle crashes include the following:-

1. Cyclist characteristics such as age and gender, riding/driving experience and alcohol consumption.
2. Crash circumstances such as type and mechanisms of crash, crash location and road type.
3. Temporal characteristics such as time of day, day of week and seasonal variations.

2.1.1 Cyclist Characteristics

Most studies investigating the age and gender distribution of people involved in bicycle crashes have found that the majority of casualties are less than 20 years old and are predominantly male. In a study of bicycle crashes in New Zealand, Collins, Langley and Marshall (1993) identified young males and children in the 5 to 14 year age group as having the highest rates of injury. In Western Australia, Piggott (1993) showed injury rates of police-reported and hospitalised casualties were highest for young cyclists, although there were variations in rates by age in the police and hospital data. In a Swedish study Petersson et al. (1997) found that it was the age group from 0-24 who were more frequently injured. They found that bicycle injury was often caused by environmental factors in combination with behaviours such as excessive speed, lack of attention, breach of traffic regulations or a co-ordination problem. Colwell & Culverwell (2002) examined the relationship between cycling accidents, attitudes and behaviour among 336 children (age 13 to 16 years) in London, England. Girls displayed "safer attitudes" but safe behaviour related to gender differences did not reach significance.

Other studies in Europe found that while children dominated cyclist casualties, adult casualties were also common (e.g., Ostrom, Bjornstig, Nasllund & Eriksson, 1993). This is most likely a result of more cycling by adults in these countries. A study by Rodgers (1997) investigated the crash risk of adult bicyclists. The results showed that bicycle crash risk is related to the driver's age, riding distance, riding surface, bicycle type and geographical region of residence. Risk was higher for males than females and was lower for cyclists in the 25-64 year age group categories than for cyclists 18-25 and over age 64.

The role of alcohol involvement in bicycle crashes has been documented in several studies. A study in the US by Li and Baker (1994) that examined fatally injured cyclists aged 15 years and older found 32% had a positive blood alcohol concentration (BAC) and 23% had a BAC over the legal limit. Males were 3.3 times more likely to have a positive BAC and 3.9 times more likely to be legally intoxicated than females. A more recent study by Li et al. (2001) examined 124 cases of seriously injured cyclists (which included 34 fatalities) to assess the relative risk of fatal and serious bicycling injury according to BAC. A positive BAC (>=0.02g/dl) was detected in 12.9% fatally and seriously injured cyclists compared with 2.9% of the control group. They concluded that alcohol use while bicycle riding is associated with a substantially increased risk of fatal or serious injury. Cyclists dying in crashes at night were also found to have a significantly increased likelihood of having a positive BAC and being legally intoxicated. In a case-control study in Helsinki, Olkkonen and Honkanen (1990) found the injury risk estimate (i.e., odds ratio) of an inebriated cyclist was at least 10 times at BACs of 0.100 gm % compared with a sober cyclist. Alcohol was found to increase the cyclist's risk of injury from falling more than from a collision.

Cyclists can also be involved in an alcohol related crash even when they are not drinking. Margolis et al. (2000) examined the association between alcohol use by drivers and the mortality of children who were passengers, pedestrians and cyclists using data obtained from the Fatality Analysis Reporting System for 1991-1996 (a nationwide registry of motor vehicle deaths used in the United States). Twenty percent of the alcohol related deaths involved children as either pedestrians or cyclists. The distribution of deaths for children as pedestrians and cyclists was 52% for males mainly due to the substantial overrepresentation among this group.

2.1.2 Crash Circumstances

The crash circumstances reported in studies of bicycle crashes and injuries vary according to the source of data. Several studies using data from emergency departments and hospital admission records found a high proportion of bicycle crashes did not involve a motor vehicle. Olkkonen, Lahenranta, Slatis and Honkanen (1993) in a study in a semi-rural region in Finland found non-motor vehicle bicycle crashes accounted for 58% of hospital admissions and 93% of outpatient visits. In a US study, Stutts, Williamson, Whitely and Sheldon (1990) reported only 18% of bicycle injuries treated in emergency departments were a result of crashes involving a motor vehicle, whereas almost all police-reported crashes involved a motor vehicle. In WA, over one half (54%) of the casualties who attended an emergency department at the children's hospital sustained their injuries at off-road locations (MacKellar & Hilbers, 1986). A more recent study of bicycle crashes in WA from 1987 to 1996 using both police and hospital data found some important differences in the information obtained from them. The police data showed cyclists accounted for a much smaller share of road casualties, and motorists for a much greater share, than the hospital data (Hendrie et al., 1998).

Jacobson et al. (1998) found that the 599 bicycle injury presentations to an emergency department from 1991 to 1995 in Tasmania represented more than 2% of all injury related presentations. Seventy-nine percent of these presentations were rider only injuries such as falls or collisions with stationary objects with only 5.2% due to collisions on a public road or footpath with other moving traffic. The majority of bicycling injuries resulting from an accident (62%) occurred in off-road locations. These results are similar to a study by Stutts et al., (1999) who collected information from eight emergency departments over a year in the U.S. The results showed that over 70% of the reported bicycle injury events did not involve a motor vehicle with 31% of the bicyclists being injured in non-road locations such as sidewalks, parking lots or off-road trails. These results are also consistent with a Swedish study which found that cyclists were mostly injured on pavements, pedestrian malls and cycle tracks (Petersson et al, 1997).

The greatest number of crashes in police-reported data occurred on arterial roads, with the second most common site of crashes being driveways (e.g., Piggott, 1993; Collins et al., 1993). Whately (1996) found the following crash types accounted for the majority of fatalities and serious injuries in Victoria: intersection crashes, rear end crashes, driveway crashes, bicycle rideout crashes occurring midblock, and ‘out of control on carriageway on straight’ crashes. In WA, approximately half of the reported crashes occurred at intersections or where cyclists enter a road (Piggott, Knuiman & Rosman, 1994). Of intersection crashes involving cyclists and motor vehicles, Piggott (1993) found the main crash types to be right-angle (47%), sideswipe (27%), rear end (8%) and head on (2%). An analysis of police recorded cycling crashes in the U.K from 1990 to 1999 found over 70% of the crashes occurred at or within 20m of a junction with over half of them at a T-junction. In just over half of those that occur more than 20 m from a junction, the bicycle was struck by the front of the vehicle. The study also found that 75% of serious and fatal cycle accidents occurred on 30 mph roads, but that fatality rises markedly with speed limit (Stone & Broughton 2002). These results are consistent with an analysis of the injury of road users involved in road traffic accidents in Germany from 1985 to 1998. Severe injuries occurred in 20% of bicyclists and pedestrians at a collision speed less than 30 km/hr and 80% at more than 50km/hr.

Some studies of bicycle crashes using police data have investigated who was at fault in the crash. A prospective study examining the crash circumstances of approximately 2,000 injured cyclists found that, in the 0 to 7 and 8 to 12 year age groups, 88% and 66% respectively were due to cyclist error (Simpson & Mineiro, 1992). The 8 to 12 year old cyclists were twice as likely to have caused the crash if they had had no formal training. For cyclists over the age of 18 years, 41% were due to another road user. Although fatal collisions between pedestrians and bicyclists are relatively rare Graw & Konig (2002) found that the person causing the accident is usually the cyclist while the pedestrian generally suffers more severe injuries. The cyclists involved are mainly younger people on mountain bikes while injured pedestrians are more likely to be frail, and/or elderly with a lower tolerance of trauma.

2.1.3 Temporal Factors

Several studies have reported that the majority of crashes occurred in the summer months (Ostrom et al., 1993; Piggott, 1993; Hoque, 1990). Hoque (1990) reported this seasonal variation has not changed in Australia since investigations into bicycle crashes began in 1960.

Most bicycle crashes occurred in daylight and clear weather. Weather or lighting conditions were found not to be related to fatal bicycle crashes (Piggott, 1993).

More bicycle crashes occurred on weekdays than weekend days, with the majority of weekday crashes involving children occurring in the afternoon or early evening (Piggott, 1993; Ostrom et al., 1993; Larson, 1994).

2.2 Under-reporting of Bicycle Crashes in the Police Records

Information about factors associated with bicycle crashes is mainly derived from police reports of crashes. These data are known to under-estimate the actual number of bicycle crashes as certain types of crashes involving bicyclists are not reported to the police such as when cyclists collide with pedestrians on pavements. There is evidence of inaccuracy of accident databases involving cyclists in many countries. For example, Stutts et al. (1990) found that only 11% of crashes involving cyclists receiving treatment at hospital emergency rooms in North Carolina (US) were reported to the police. This study also found that the police-reporting rate for crashes involving a motor vehicle was 60%, while for those not involving a motor vehicle the reporting rate was less than 1%. In Australia, studies of the reporting rate of bicycle crashes to the police have also shown under-reporting. In Western Australia, Hendrie and Ryan (1994) found the reporting rate of injury crashes involving a cyclist was 2.2% if all injured cyclists were used for the denominator, and 3.5% if only cyclists injured on-road were used for the calculation. Aultman-Hall & Hall

(1998) also found that only 15% of bicycle collisions had been reported to the police in Ottawa, Canada and the authors argue strongly for the use of self-report accident data in cycling accident research. In developing countries bicycle injuries are also seriously underreported. In Colombo, Sri Lanka 92% of children and 54 % of adults who were hospitalized for bicycling injuries were not included in police reports (Barss et al, 1998).

2.3 Extent of Injuries to Cyclists

The majority of injuries sustained in bicycle crashes are minor (Stutts et al., 1990; Piggott, 1993). Hendrie and Ryan (1994) estimated that in Western Australia 34% of cyclists injured in crashes required medical treatment and 2% required hospital admission. Of cyclist casualties who attended emergency departments, the hospital admission rate in Australian states ranged from 10% (Armson & Pollard, 1986) to 20% (Cass & Gray, 1989; MacKellar & Hilbers, 1986).

Length of hospital stay has been found to vary with the type of crash. In a study in Melbourne, Drummond and Ozanne-Smith (1991) found approximately 90% of cyclists admitted to hospital after non-motor vehicle collisions were discharged from hospital within 3 to 4 days. For all cyclists admitted to hospital in WA, Piggott (1993) found 14% had a length of stay of more than a week.

Injuries to the head and extremities were the most common types of injury for cyclists who are admitted to hospital. Collins et al. (1993) found intracranial injuries and skull fractures accounted for 46% of cyclists admitted to hospital in New Zealand, and these injuries had the highest score on the Abbreviated Injury Scale (AIS). The AIS is a consensus derived, anatomically based system that was developed to provide researchers with a simple numerical method for ranking and comparing injuries by severity. A similar result was reported by Piggott (1993) who found 40% of cyclist casualties in WA had head injuries as the principal cause of hospital admission. Superficial injuries to the external part of the body and fractures of bones or dislocations of joints of the extremities were found to be the principal injuries of the majority of cyclist casualties attending hospital emergency departments (Stutts et al., 1990; Olkkonen et al., 1993).

2.4 Bicycle Usage and the Relative Risk of Cycling

Several studies have been conducted to obtain data for assessing bicycle usage and traffic exposure. For some Australian states, the Australian Bureau of Statistics (ABS) has conducted bicycle usage and safety surveys that have collected exposure data for cyclists (e.g., ABS, 1989). Data relating to bicycle usage have also been collected as part of general travel surveys (e.g., Adena & Montesia, 1988).

Exposure estimates have also been obtained from in-depth observational studies of bicycle usage. A frequently cited study of the exposure patterns of children and young adults is that conducted by Drummond and Ozanne-Smith (1991) in Melbourne. Some findings from this study were -

1. Cyclist exposure was heavily weighted towards the local street environment which accounted for 80% of total exposure. Primary school children (5 to 11 years) divided their exposure evenly between road and footpath, while 12 to 17 year olds had a road exposure more than 70% greater than their exposure on footpaths.
2. There were strong gender differences in the proportion of road and footpath cycling. In the 5 to 11 year age group, males did 1.5 times more cycling on the road than on the footpath, whereas females did almost 4 times more of their cycling on the footpath. Adolescent males (12 to 17 years old) did twice as much cycling on the road than the footpath; while 12 to 17 year old girls used the road and footpath equally.
3. Cycling in the arterial environment was almost five times more dangerous than cycling on a local street. The highest risk group was the 12 to 17 year olds, mainly because of their elevated risk in arterial environments.

A number of studies of bicycle safety have attempted to measure the relative risk associated with bicycle crashes to compare with that of other road user groups. There has been considerable debate about whether distance travelled or time taken is the appropriate denominator (Katz & Smith, 1993). Mathieson (1984) estimated cyclist fatalities were 1.4 to 2.7 times more likely per kilometre travelled than motorist fatalities. Rates of injury requiring hospitalisation were estimated at 2.5 to 5 times more likely for cyclists than motorists.

2.5 Measures to Reduce Bicycle Crashes and Injuries

Strategies to reduce road crashes and injuries are generally grouped into those addressing the following areas: engineering, vehicle safety features, education, and enforcement.

Studies into the engineering aspects of bicycle safety have addressed a wide range of design issues relating to the road environment such as improving cyclist safety at intersections, the appropriate width of bicycle lanes, and on-road markings and signage (e.g., Daff, 1992; Wisdom, 1992). Katz and Smith (1993) reported there is relatively little published work in Australia on testing of different engineering treatments in an experimental sense, possibly due to the limited number of such treatments and the conduct of such work, either within road authorities or on behalf of road authorities, by engineering consultants on an unpublished basis.

Possible features to improve the safety of bicycles have also been investigated. Many studies have reviewed ways of increasing the visibility and conspicuity of cyclists by improving bicycle lighting systems, the use of bicycle reflectors, and reflective or more brightly coloured clothing (e.g., Cairney, 1992; Boyd, 1986; Kwan et al., 2002). Cycling safety features that have received less attention in published research are brakes, rear view mirrors, and design changes in the basic frame and components of bicycles. However, the US Consumer Product Safety Commission is considering handlebar regulation regarding impact performance to address the risk of abdominal and pelvic organ injuries in cyclists (Winston et al., 2002). It is anticipated that requirements for safer handlebar designs may provide an avenue to achieve a health benefit for the cyclist.

The education of cyclists, particularly children, is an area that has received a lot of attention. Several studies have examined the effectiveness of bicycle education programs such as the Australian Bike-Ed course (e.g., Trotter & Kearns, 1983; Kearns & Rothman, 1983). Because of the difficulty of using reduction in crash involvement as an outcome measure studies generally measured effectiveness in terms of observed changes in riding behaviour or subjective assessment of the course by participants. In a review of evaluations into the effectiveness of a number of children's bicycle skills training programs, Bailey (1994) concluded that current cycle training programs have some educational advantages, particularly in the case of the on-road program content. Another area receiving attention is bicycle helmet wearing among teenagers (Lajunen & Rasanen, 2001). Recent research shows that few teenagers wear helmets when riding a bicycle. They suggest that the most efficient way of increasing bicycle helmet wearing rates among teenagers is to influence peer opinion and to inform students' parents about the safety benefits of bicycle helmets.

Enforcement of road rules has also been examined, mainly in observational studies estimating the levels of law compliance. In WA, these studies have included those conducted on the level of helmet wearing amongst different groups of cyclists (e.g., Dobbs & Maisey, 1991; Healy & Maisey, 1992), and earlier studies conducted by the Royal Automobile Club of WA on the failure to use bicycle lights at night.

Different aspects relating to helmet wearing have been widely investigated both in Australia and overseas. Katz and Smith (1993) identified five main areas covered by these studies. These areas together with selected references are listed below.

1. Injury comparisons for crashes where the cyclist was wearing a helmet and crashes where the cyclist was not wearing a helmet (e.g., McDermott, Lane, Brazenor & Debney, 1993; Thomas, Acton, Nixon, Battistutta, Pitt, & Clark, 1994; Thompson et al., 2000).
2. Time series analysis to examine the change in levels of head injury as a function of increased helmet-wearing rates (e.g., Cameron, Vulcan, Finch & Newstead, 1994; Robinson, 1996a; Robinson, 1996b; Scuffham & Langley, 1997; Cook et al., 2000; Curnow, 2003).
3. Crash lab testing, biomechanical analyses and Standard setting (e.g., Hodgson, 1990).
4. Analysis of the impact of compulsory helmet wearing legislation on helmet-wearing rates (Walker, 1992; Cameron et al., 1994; Finch, Newstead, Cameron & Vulcan, 1993; LeBlanc et al., 2002; Ichikawa et al., 2003).
5. Analysis of the impact of helmet wearing on bicycle use (Katz et Smith, 1993).

In countries where helmet wearing is not mandatory, the effectiveness of different strategies promoting helmet wearing has been extensively examined (e.g., Dannenberg, Gielen, Beilenson, Wilson & Joffe, 1993; Rourke, 1994; Farley, Haddad, & Brown, 1996).

In conclusion, the literature has shown the need for policy makers, educators, transportation experts and health and injury professionals to advocate for safer cycling facilities as the protection of these vulnerable road users is a public health priority.

3. METHOD

The study covers the 14-year period from 1987 to 2000. Data on bicycle crashes and injuries in WA were obtained from two sources: police reports and hospital admission records. This report is an update on Hendrie, Kirov and Gibbs (1998) which analysed 1987 to 1996 and follows a similar format.

Data from police reports are held in the Western Australian Road Injury Database jointly maintained by the WA Police Service and Main Roads WA. The database contains detailed information on the characteristics of the people and vehicles involved in road crashes, crash circumstances and Police reported injury severity. Crashes involving cyclists (and other road user types where relevant) were identified using the unit type variable. While the police-reported data are known to be a biased sample of bicycle crashes because of the level of under-reporting (Hendrie & Ryan, 1994), they provide the only available information on many important crash factors.

The hospital admission records are held in the Hospital Inpatient Morbidity System, which is operated by the Health Department of Western Australia. Data from the hospital admission records and the police reports contain some common information such as the characteristics of casualties. However, the hospital admission data provides very limited information on crash and vehicle characteristics but detailed information about the injuries sustained by casualties. The injury data are coded according to the *International Classification of Diseases* (ICD9-CM and ICD10-AM). Admissions of road crash casualties were identified using the codes for external causes of injury (E-codes) of the ICD9-CM for the period 1987 to June 30, 1999. The E-codes used to identify cyclists were -

1. E810.6 to E819.6, which include cyclists involved in motor vehicle traffic crashes (i.e, collisions between motor vehicles and cyclists on a public road).
2. E820.6 to E825.6, which include cyclists involved in motor vehicle non-traffic crashes (i.e., collisions between motor vehicles and cyclists not on a public road).
3. E826.1, which include cyclists involved in non-motor vehicle traffic crashes (i.e., crashes involving a cyclist but no motor vehicle).

Admissions of road casualties using ICD10-AM which came into effect July 1,1999 were identified using V10.0 to V19.9 excludingV10.3 to V18.3 (includes both traffic and non-traffic crashes and cyclists involved in other specified transport crashes).

Injuries were grouped into seven categories on the basis of the ICD9-CM codes, and by injury severity level and body region using the Abbreviated Injury Scale (AIS). The AIS is a numerical severity scoring scale ranging from 1 (minor injury) to 6 (maximum injury - virtually unsurvivable), that also groups injuries by nine body regions. The body regions are head, spine, lower extremities, upper extremities, chest, abdomen, external (skin and nails unless specified elsewhere), face and neck. A computerised conversion table was used to convert inpatient injury information coded by ICD9-CM into AIS severity codes and body regions. If casualties had more than one recorded injury, the higher AIS score was used to describe the severity of injury. If casualties had more than one injury of equal severity to different body regions, the following hierarchy of body regions was used for classification: head, spine, lower extremities, chest, abdomen, upper extremities, neck, face and external.

The Injury Research Centre has a Road Injury Database that consists of linked data from four different sources: police reports, hospital admissions records, ambulance records and death certificates. The database currently has linked data for the years 1987 to June 30, 1999. The linked data were used to examine the reporting rate to police of road crashes involving cyclists (and, for comparison, other road user groups) admitted to hospital.

The study used descriptive statistical methods to analyse the data from the different sources. Frequency tables and cross-tabulations were generated using the *SAS Statistical Package,* and charts were drawn using *Microsoft Excel*. The results of the data analyses are presented in Sections 4, 5 and 6 as charts. The data are shown in two main ways – on a year-by-year basis when trends are being examined and for the combined 14-year period when more than one variable is being examined. The supporting numerical data are provided in tables in Appendix A (police-reported road crash data), Appendix B (hospital admissions data) and Appendix C (reporting rate to police of crashes involving hospital admissions).

4. POLICE-REPORTED ROAD CRASH DATA

The results of the analysis of the bicycle crashes reported to the police are presented using the following subject areas: size of the problem, cyclist profile, injury severity, helmet wearing, other vehicle characteristics and crash characteristics.

4.1 Size of the Problem

Figure 4.1 (see Table A1 for numerical data in Appendix A) shows the number of bicycle crashes reported to the police each year from 1987 to 2000, and the percentage of all crashes reported to the police that involved cyclists. Over the 14-year period, 11,114 crashes involving cyclists were reported to the police. The number of police-reported crashes decreased each year from 1,131 in 1988 to 559 in 1993, and then averaged approximately 700 until 1998 following which a further decline in crashes was reported. This represents a significant decrease (p=0.001) in crashes in 2000 compared to 1987 with a decrease of approximately 32 crashes per year. The proportion of police-reported bicycle crashes as a percentage of all road crashes has fallen over the decade. In the late-1980s, bicycle crashes accounted for about 2.5% of crashes reported to the police; this decreased to 1.4% in 2000.

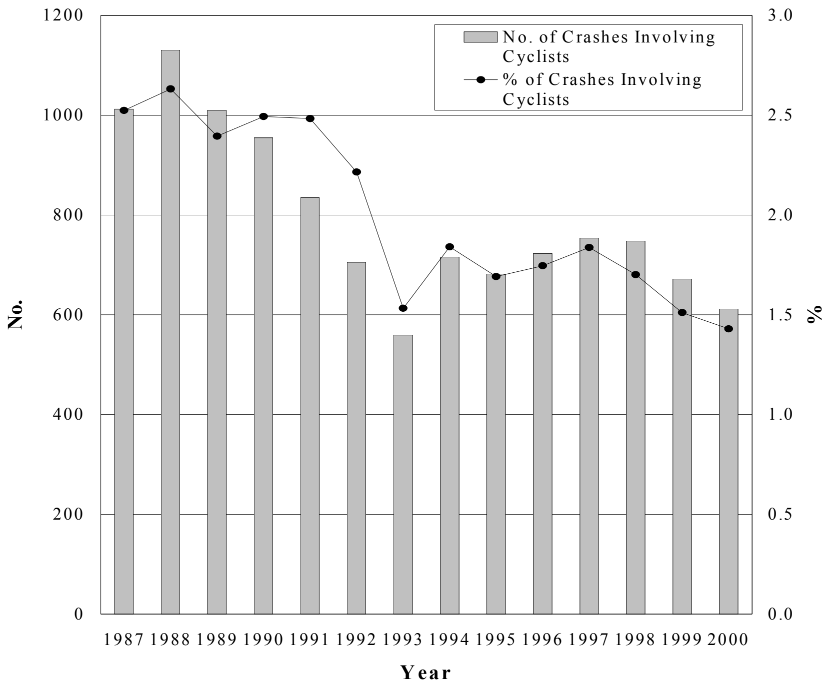

Figure 4.1 Police Reported Crashes: Number and Percentage Involving Cyclists, WA, 1987-2000 (14-year period)

Motor vehicle occupants accounted for the major share of crash casualties to road users (90%), with (pedal) cyclists and pedestrians each accounting for 1%, and motor cyclists for 1.7% (see Table A2). Over the 14 years from 1987, cyclists accounted for a decreasing proportion of people involved in crashes reported to the police until 1993 then stabilised until 1998 where a further decrease has since been reported. The proportion of motor cyclists involved in crashes reported to Police has been decreasing since 1987 however a small increase has been evident since 1998. The proportion of pedestrians involved in a crash has more or less remained constant. Figure 4.2 illustrates the trend in the number of vulnerable road users - namely cyclists, pedestrians and motor cyclists - involved in police-reported crashes over the period.

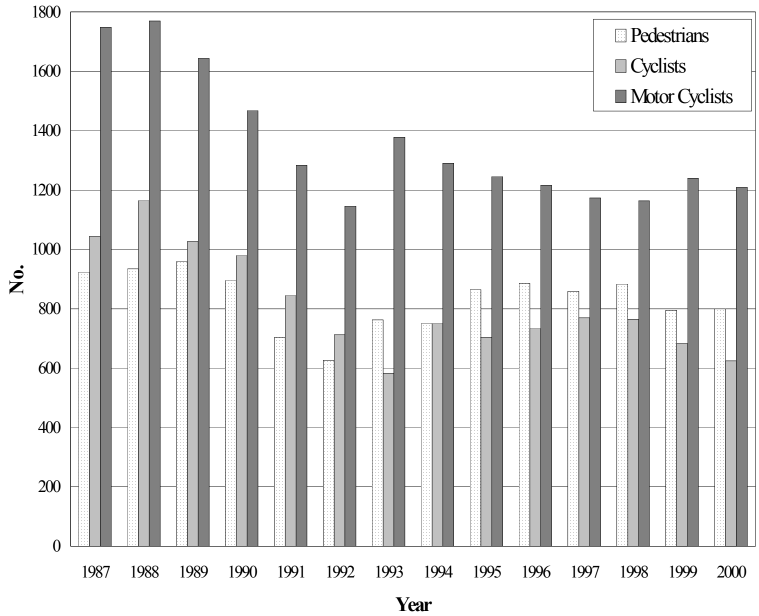

Figure 4.2 Police Reported Crashes: Number of People Involved by Selected Road User Groups, WA, 1987-2000 (single years)

4.2 Cyclist Profile

This section examines the age and gender distribution of cyclists involved in crashes reported to the police. Two sets of age groups were used - a life cycle grouping (1 to 5 years, 6 to 12 years, 13 to 16 years, 17 to 24 years, 25 to 39 years, 40 to 59 years and 60 years and over) and an alternative age grouping used by the ABS (1989) (1 to 4 years, 5 to 14 years, 15 to 24 years, 25 to 44 years, 45 years and over). Only results using the life cycle set of ages are discussed in the text; tables showing the alternative grouping are included in the appendices.

Figure 4.3 (see Table A3) shows the distribution of cyclists involved in police-reported crashes by age group (life cycle) and gender for the 14-year period. Age was not recorded for 28% of cyclists and gender was not recorded for 9%. Overall, excluding the cyclists whose gender was not recorded, 81% of cyclists involved in crashes were males, and considerably more males than females were involved in crashes in every age group. The age group with the highest male to female proportion was 1 to 5 year olds (88% males) and the lowest was 6 to 12 year olds (76%).

Excluding the unknown category, 83% of males and 88% of female cyclists involved in police-reported crashes were aged between 6 and 39 years old. Thirty three percent of cyclists of known age and gender were young males aged 16 years or less.

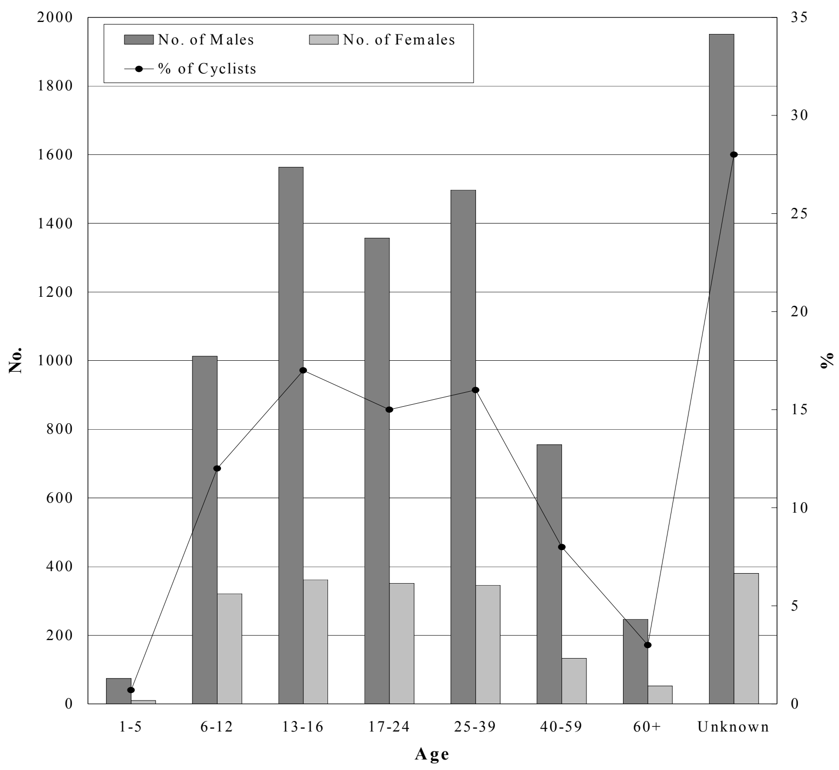

Figure 4.3 Police Reported Crashes: Number and Percentage of Cyclists by Age Group (Life Cycle) and Gender, WA, 1987-2000 (14-year period)

Figure 4.4 (see Table A5) compares the age distribution of different road user groups involved in road crashes reported to the police. Cyclists involved in crashes were relatively younger than other road users. For example, 30% of cyclists involved in police-reported crashes were 16 years or less compared with 24% of pedestrians and 2% of other road users. On the other hand, relatively few older cyclists were involved in police-reported bicycle crashes. Only 10% of cyclists involved in police-reported crashes were 40 years or older compared with 22% and 25% of pedestrians and other road users respectively.

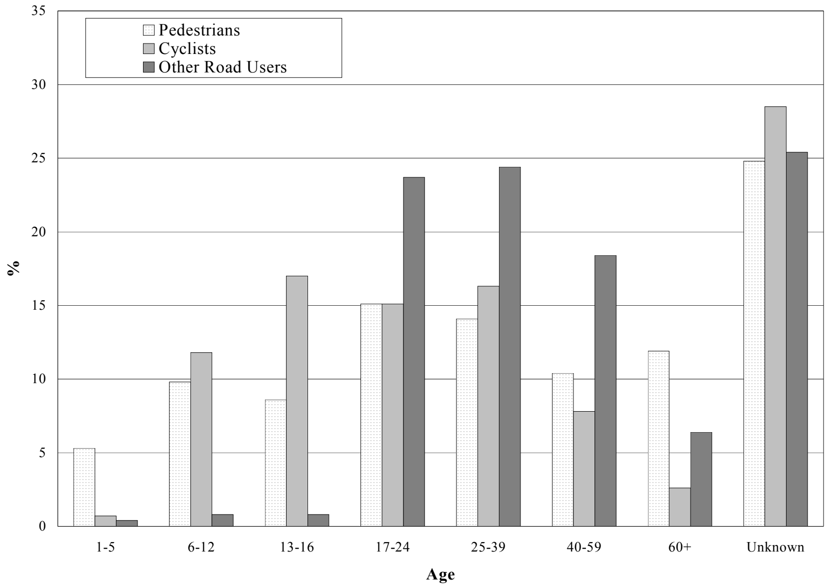

Figure 4.4 Police Reported Crashes: Comparison of the Percentage Distribution of Cyclists and Selected Other Road Users by Age Group (Life Cycle), WA, 1987-2000 (14-year period)

4.3 Injury Severity

The police records have five levels of injury severity - death within 30 days, hospital admission, medical treatment with no hospital admission, injured with no medical treatment, and property damage only. Figure 4.5 (see Table A7) shows the injury severity of cyclists involved in bicycle crashes reported to the police. Over the 14-year period, 81 (1%) cyclists were killed in road crashes, 1,851 (16%) were reported to have been admitted to hospital, 4,486 (39%) required medical attention, 1,250 (11%) were injured but required no treatment, and 3,717 (33%) were involved in property damage only crashes or crashes of unknown injury severity. The number of fatalities varied each year from one in 1992, 11 in 1996 and 2 in 2000. For every injury severity level, the number of cyclists involved in bicycle crashes reported to the police has declined, although there were fluctuations on a year-to-year basis. The average annual number of cyclists reported to have been admitted to hospital was 166 for 1987 to 1991, 120 for 1992 to 1996 compared with 106 for 1997 to 2000. The average annual number requiring medical treatment was 444 for 1987 to 1990 compared with 272 for 1991 to 1996 and 269 for 1997 to 2000. The average number injured but requiring no treatment fell from 100 in 1987 to 1991 compared to 94 in 1997 to 2000. The average number of property damage only crashes fell from 317 in 1987 to 1991 compared to 238 in 1997 to 2000.

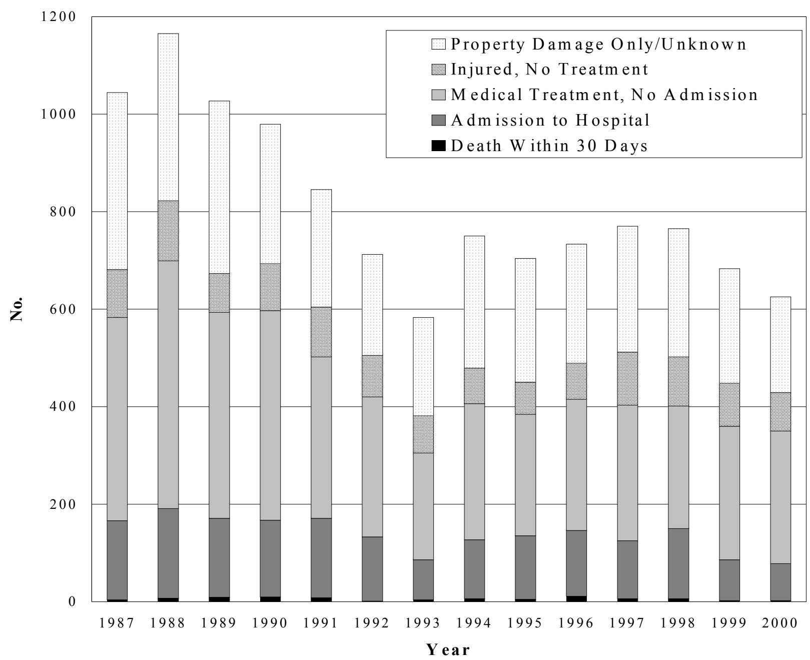

Figure 4.5 Police Reported Crashes: Number of Cyclists by Injury Severity Level, WA, 1987-2000 (single years)

Figure 4.6 (see Table A8) compares the severity of injury for different road user groups. The most severely injured groups were: (i) pedestrians (4% of pedestrians involved in police-reported crashes were fatally injured and 32% were admitted to hospital), and (ii) motor cyclists (2% of motorcyclists involved in police-reported crashes were fatally injured and 23% were admitted to hospital). The severity level of injury to cyclists was less than for pedestrians and motorcyclists, but was considerably greater than for motor vehicle occupants. Fatalities accounted for 1% of cyclists involved in police-reported crashes and hospital admissions for 16%, while fatalities accounted for 0.2% of motor vehicle occupants involved in police-reported crashes and hospital admissions accounted for 3%.

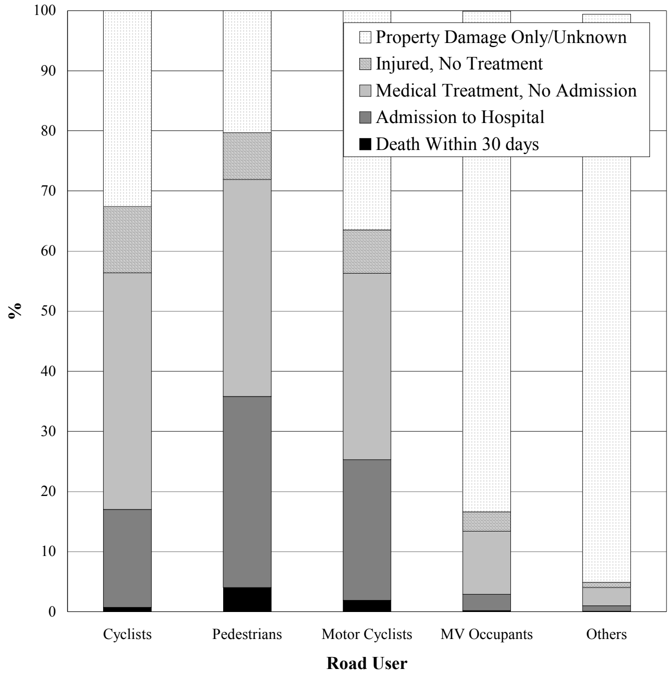

Figure 4.6 Police Reported Crashes: Comparison of the Percentage Distribution of Cyclists and Other Road Users by Injury Severity Level, WA, 1987-2000 (14-year period)

Table A9 in Appendix A11 shows the injury severity level by age group. Relatively more very young cyclists were reported to have been admitted to hospital - 35% of the 1 to 5 year age group and 25% of the 6 to 12 year age group compared with the average across all age groups of 16%. The majority (72%) of the cyclists whose age was not recorded were either not injured or their injury severity level was unknown.

4.4 Helmet Wearing

Figure 4.7 (see Table A10) presents the helmet wearing status of cyclists. The police crash data does not record helmet wearing status for the majority of cyclists, although this information has been available for a higher percentage of cyclists in recent years. In 2000, helmet wearing status was unknown for 56% of cyclists involved in police-reported crashes compared to 63% in 1996 and 100% in 1987. In

1992 - the year that compulsory helmet wearing was introduced - helmet wearing status was unknown for 76% of cyclists involved in police-reported crashes, 14% were known to have been wearing a helmet , and 9% were known not to have been wearing a helmet. This implies a helmet wearing rate of 61% for cyclists, whose helmet wearing status was known. In 2000, 34% were known to have been wearing a helmet, and 11% were known not to have been wearing a helmet. For the cyclists whose helmet wearing status was known, this implies a helmet-wearing rate of 76%, which is a significant increase (p=0.002).

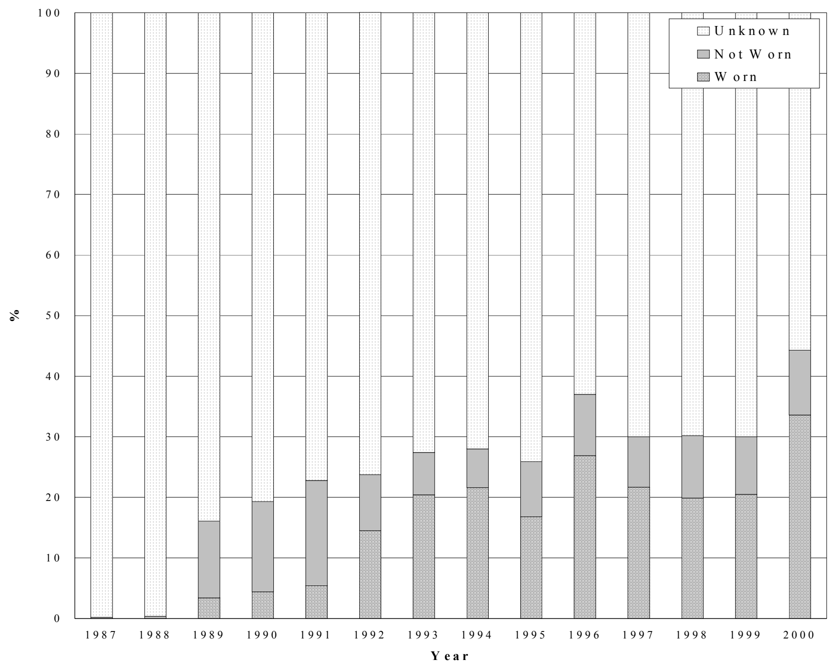

Figure 4.7 Police Reported Crashes: Percentage of Cyclists by Helmet Wearing Status, WA, 1987-2000 (single years)

4.5 Other Vehicle Characteristics

Over the 14-year period, most police-reported bicycle crashes (93%) involved a cyclist and one other vehicle (see Table A11in Appendix A13). Four percent were single vehicle crashes (i.e., involving only a cyclist and no other vehicle), and 4% involved a cyclist and at least two other vehicles.

Table A12 *(*see Appendix A14) examines the involvement of different age groups in single and multi- vehicle crashes. Compared with older cyclists (those 25 years and older), more younger cyclists (63%) were involved in crashes that involved another vehicle.

Table A13 (see Appendix A15) shows the type of other vehicle involved in crashes with cyclists. Passenger vehicles (85%) constituted the majority of “other” vehicles, 2% were trucks, and 2% were buses from 1987 to 2000.

Table A14 (see Appendix A16) compares the age and gender of the driver of the other vehicle for crashes involving cyclists, and pedestrians. It appears that: (i) fewer male drivers in the 17 to 24 year age group were involved in collisions with cyclists (21%) compared to pedestrians (28%) and similarly (ii) fewer drivers in the 25 to 39 year age groups were involved in collisions with cyclists (27%) compared to pedestrians (28%). However, the unknown categories for the age and gender of drivers are high, and this could confound these results.

4.6 Crash Characteristics

Several crash characteristics are discussed in this section: crash type, posted speed limit, traffic control, road type, crash location, temporal factors and weather conditions.

4.6.1 Crash Type

Type of crash was identified using the ‘accident nature’ variable in the Western Australia Road Injury database. This identifies 10 crash types: rear end, head on, sideswipe opposite direction, sideswipe same direction, right-angled, indirect right-angled, hit pedestrian, hit animal, hit object and non-collision.

Figure 4.8 (see Table A15) shows the types of crashes involving cyclists that are reported to the police. Two crash types accounted for 60% of crashes - right-angled crashes (43%) and sideswipe same direction crashes (17%). The next most frequently occurring crash types were indirect right-angled crashes (9%) and rear end crashes (8%). There appears to have been some trends in the percentage distribution of types of crash. Sideswipe same direction crashes as a percentage of all crashes decreased over the 14-year period. Indirect right-angled crashes have decreased in more recent years. No consistent trend was evident in the percentage of right-angled crashes and rear end crashes while non collision crashes, though fluctuating, have remained relatively unchanged since 1987.

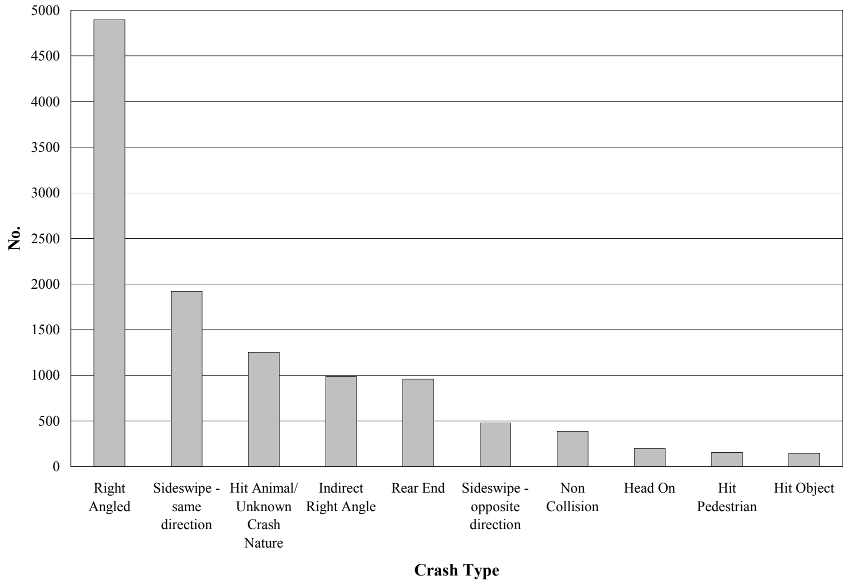

Figure 4.8 Police Reported Crashes: Number and Percentage of Cyclists by Type of Crash, WA, 1987-2000 (14-year period)

Figure 4.9 (Table A16) compares the type of crash involving cyclists for different age groups. For all age groups, right-angled crashes were the most common type of crash. However, there were some differences by age in the relative share of crash types. More younger cyclists (less than 12 years old) were involved in right-angled crashes (54% vs the average of 43%). Older cyclists (17 to 59 year olds) were more likely than the younger 1 to 16 year olds to be involved in sideswipe same direction crashes, indirect right-angled crashes, rear end crashes, non-collision crashes and right angled crashes. For the other two age groups - namely younger cyclists in the 13 to 16 year group and older cyclists in the 60 years and older group - the relative proportions of crash type were similar to the average for all age groups.

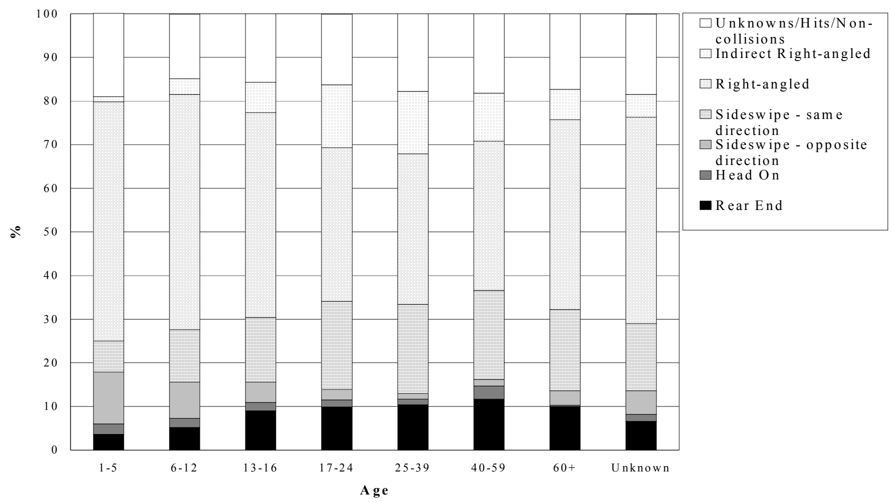

Figure 4.9 Police Reported Crashes: Percentage Distribution of Cyclists by Police Crash Type and Age Group (Life Cycle), WA, 1987-2000 (14-year period)

Figure 4.10 (see Table A17) examines the injury severity level of cyclists by crash type. Four crash types accounted for 85% of the 81 fatalities - right-angled crashes (38%), rear ends (22%), sideswipe same direction crashes (16%) and sideswipe opposite direction crashes (9%). These four crash types also accounted for 70% of Police reported hospital admissions. Sideswipe same direction crashes accounted for 14%, right-angled crashes accounted for 11%, rear end crashes 10%, and sideswipe opposite direction crashes 5% of Police reported crashes requiring hospital admission.

If the percentage of Police-reported crashes resulting in a hospital admission or fatality are examined by crash type, then non-collision and rear end crashes were the most serious types of crash with 29% and 22% respectively resulting in a fatality or reported hospital admission, (compared with the average of 17% for all crashes). Crash types with a higher than average number of cyclists requiring medical treatment but not hospital admission were hit animal crashes (74%), non-collision (49%), indirect right-angle crashes (45%) and head on (43%).

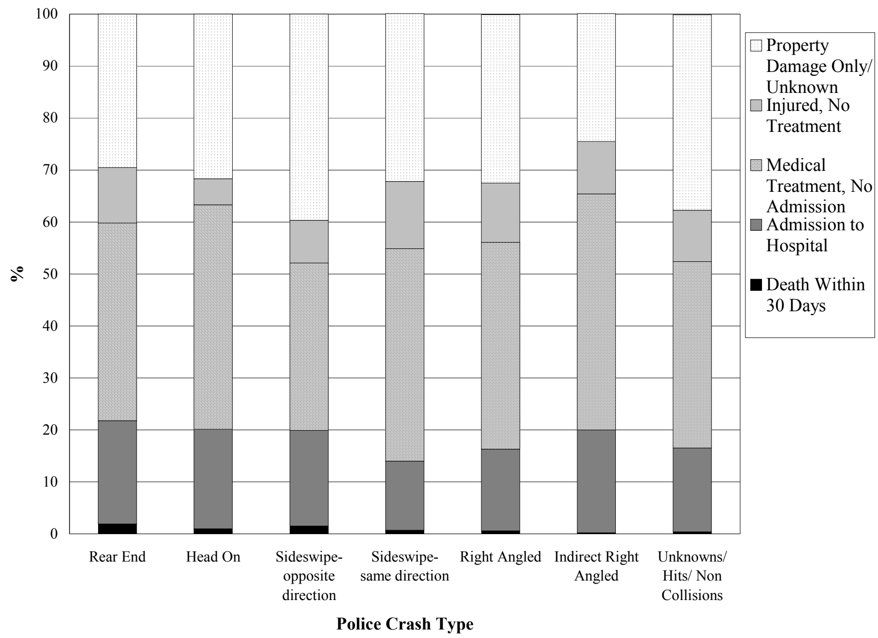

Figure 4.10 Police Reported Crashes: Percentage Distribution of Cyclists by Injury Severity and Selected Crash Type, WA, 1987-2000 (14-year period)

Table A18 examines the posted speed limit by type of crash. Fifty-seven percent of police-reported crashes involving cyclists occurred on roads with a speed limit between 60km/h and 70 km/h. Forty seven percent of crashes occurring on roads with a speed limit between 60km/h and 70km/h were right angle crashes and 16% were the result of a sideswipe-same direction crash. Cyclists involved in rear end crashes were more likely to sustain serious injuries followed closely by sideswipe-opposite direction than cyclists involved in many other types of crash (see Table A17).

4.6.2 Traffic Control

Figure 4.11 (see Table A19) compares the type of traffic control in police-reported crashes involving cyclists. Overall, 72% of crashes occurred where there were no traffic signs or controls, 11% where there were stop signs, 10% where there were traffic lights, and 5% where there were give way signs. Since 1992, the trend in the distribution of crashes by type of traffic control shows a decreasing proportion of crashes occurred at stop signs and an increasing proportion at give way signs.

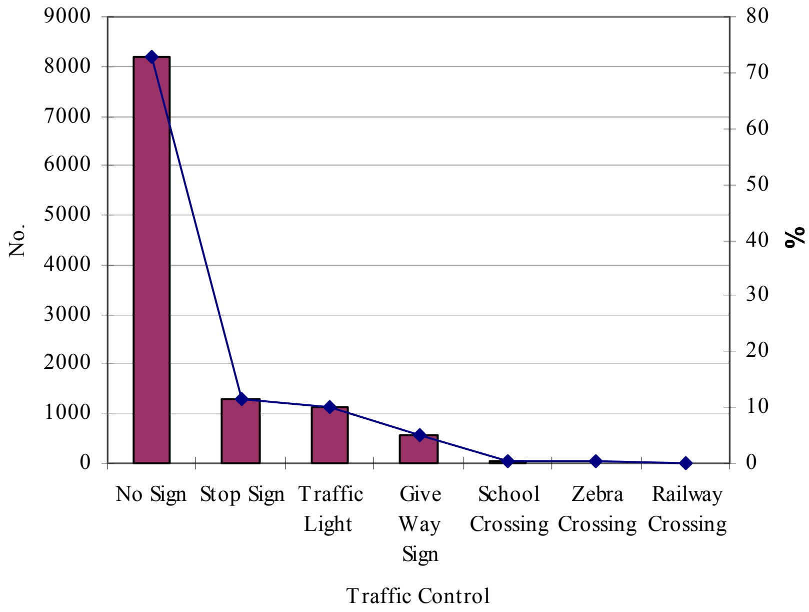

Figure 4.11 Police Reported Crashes: Percentage of Cyclists Involved by Type of Traffic Control, WA, 1987-2000 (14-year period)

Table A20 examines the type of traffic control in police-reported crashes involving cyclists of different ages. For all age groups (including unknown), the majority (72%) of crashes occurred where there was no traffic sign or control. However, older cyclists (17 years and older) were involved in more crashes where there was no sign or control when compared to younger cyclists (45%). Crashes occurring where there was no sign include those occurring at unsigned intersections and where the cyclist enters the road midblock.

4.6.3 Road Type

Table A21 shows that the majority of police-reported crashes involving cyclists (94%) occurred on-road. The percentage fluctuated on a year-to-year basis with a 42% decrease in reported crashes occurring on road in 2000 compared to 1987. Off-road crashes involving cyclists fluctuated over the 13 year period beginning at 54 in 1987, peaking 103 in 1997 and returning to 54 in 2000.

There were differences by age in the percentage of cyclists involved in on-road and off-road crashes. Table A22 shows that younger cyclists (1 to 16 year old) were involved in relatively more off-road crashes than older cyclists.

The type of road on which bicycle crashes occurred was also examined (Table A23). Three road types are identified in the Traffic Accident System database (TAS): (i) highways, (ii) main roads, and (iii) urban-arterial, local and other roads. Most police-reported bicycle crashes (86%) occurred on urban-arterial, local and other roads. A further 12% of bicycle crashes occurred on highways and 2% on main roads. A comparison of police-reported bicycle crashes reported in 1987 and 2000 reveals a 38% decrease in urban-arterial, local and other roads and a 52% decrease in highways.

Figure 4.12 (see Table A24) examines age differences by road type on which the crash occurred. Younger cyclist (less than 13 years old) had a higher percentage of their crashes on urban-arterial, local and other roads (91%) than older cyclists (84%).

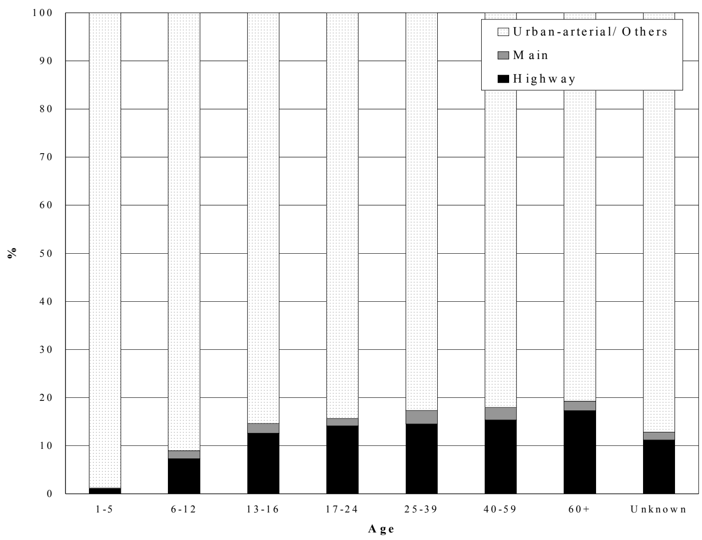

Figure 4.12 Police Reported Crashes: Percentage Distribution of Cyclists by Age Group (Life Cycle) and Road Type, WA, 1987-2000 (14-year period)

4.6.4 Crash Location

Table A25 presents the number of cyclists involved in crashes by Main Roads WA regions during the study period. This breakdown shows 84% of crashes occurred in the metropolitan region, 7% in the South West, and 2% in each of the Goldfields-Esperance region and the Great Southern region.

4.6.5 Temporal Factors

This section examines the time of day and day of week of police-reported crashes involving cyclists.

Figure 4.13 (see Table A26) presents the time of day of crashes by age group. Overall, the two peak times for bicycle crashes were 3pm to 6pm when 38% of crashes occurred, and 6am to 9am when 20% of crashes occurred. In the morning peak period more crashes involved cyclists in the 25 to 59 year age groups and, in the afternoon peak period, more crashes involved cyclists in the 6 to 16 year age groups. This afternoon period is the time that children would be cycling after school either on their way home, on their way to after-school activities, visiting friends or just riding around. Other times of day that show a higher crash involvement for particular age groups were the 6am to 9pm period when very young children (5 years and younger) and the 9am to noon period when older cyclists (60 years and older) were involved in crashes.

Figure 4.14 (see Table A27) shows the differences in the distribution of bicycle crashes by time of day for weekdays and weekends. Crashes occurring during the week had the same two peak periods discussed above, namely 6am to 9am (23%) and 3pm to 6pm (40%). On the weekend, proportionately more crashes occurred between 3pm to 6pm (29.3%) and during the 9am to 12-noon period (25% vs 10% for weekday crashes). Crashes involving cyclists of different age groups had different time of day and day of week distributions (see Table A28). For example, relatively more cyclists in the 25 to 39 year age group had crashes in the 6pm to 3am time period on weekends (21%) and relatively more cyclists in the 60 years and over age group (35%) had crashes in the 9am to 12 noon time period on weekends.

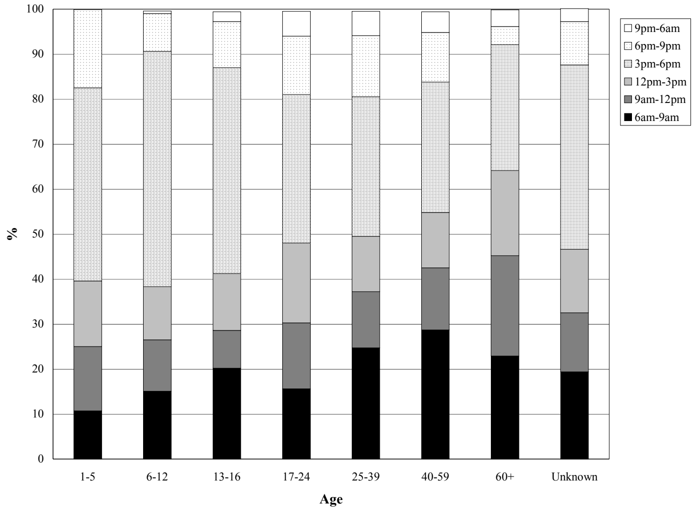

Figure 4.13 Police Reported Crashes: Percentage Distribution of Cyclists by Age Group (Life Cycle) and Time of Day, WA, 1987-2000 (14-year period)

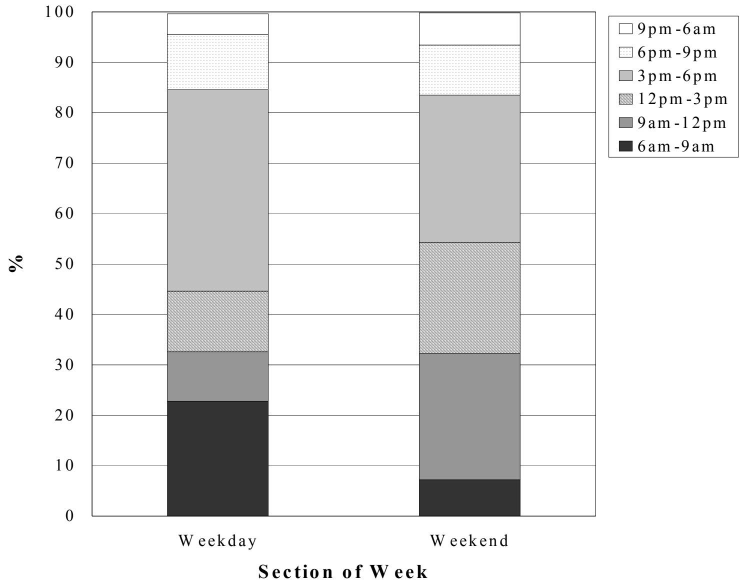

Figure 4.14 Police Reported Crashes: Percentage Distribution of Cyclists by Weekday/Weekend and Time of Day, WA, 1987-2000 (14-year period)

4.6.6 Weather Conditions

Table A29 shows the weather conditions when bicycle crashes occur. Most crashes (88%) occurred when the weather conditions were clear and 4% occurred in rainy weather.

4. HOSPITAL ADMISSIONS DATA

The following subject areas are used to present the data relating to cyclists admitted to hospital: size of the problem, cyclist profile, injury severity, body region of injury, common injury type, crash type, road type and place of occurrence.

5.1 Size of the Problem

Figure 5.1 (see Table B1) shows the number of hospitalised cyclists admitted to hospital between 1987 and 2000. Over this period, 9,897 cyclists were admitted to hospital. The number of hospitalised cyclists has shown a significant increasing trend (p=0.001) since 1992 with 913 cyclists admitted in 2000 compared to 574 in 1992. This number most likely underestimates the true number of cyclists admitted to hospital since road user type is unknown for a significant number of road crash casualties in the hospital admissions data (and some of these would probably have been cyclists). Cyclist admissions as a proportion of all road crash casualties admitted to hospital have shown no clear trend, varying between 12% in 1989 to 16% in 2000.

Table B1 also shows the number of other road users admitted to hospital. The number of pedestrians (396 in 1987 compared to 569 in 2000) and motorcyclists (831 in 1987 compared to 1083 in 2000) admitted to hospital has also shown a significant increasing trend during the study period (p=0.011 and p=0.009 respectively), while the number of motor vehicle occupants has significantly increased (p=0.000) from around 1,500 in the late 1980s to over 2,400 in more recent years. This may reflect better coding of the external causes of injury. The ‘other’ category (i.e., mostly road users of unknown type) has fallen from approximately 1,500 in the late 1980s to 815 in 2000.

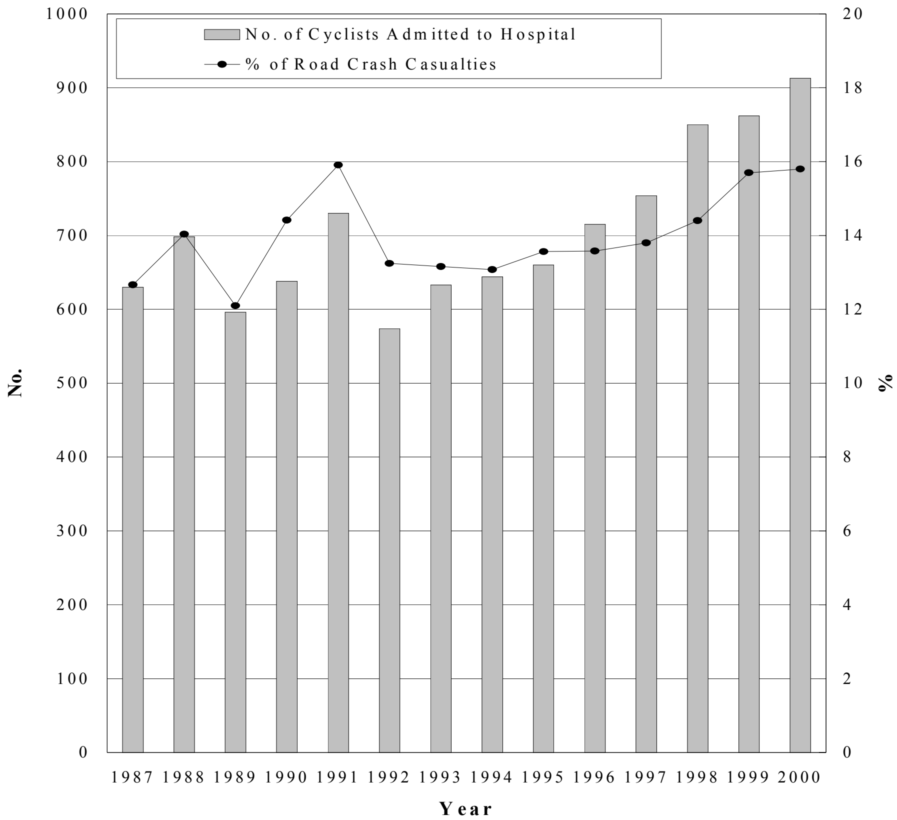

Figure 5.1 Hospital Admissions Data: Number and Percentage of Cyclists Admitted, WA, 1987-2000 (single years)

5.2 Cyclist Profile

Figure 5.2 (see Table B2) shows the distribution of cyclists admitted to hospital by age group (life cycle) and gender for the 14-year period. Seventy-six percent of cyclists admitted to hospital were male, with considerably more male cyclists admitted to hospital than female cyclists in each age group. Young cyclists in the 6 to 12 year age group accounted for the highest proportion of hospital admissions (35%), followed by 13 to 16 year olds (22%) , 25 to 39 year olds (11%) and 1 to 5 year olds (10%).

Figure 5.3 (see Table B4) compares the age distribution of different road user groups. Cyclists admitted to hospital with road injuries were relatively younger than other road users. Sixty-seven percent of cyclists admitted to hospital were less than 17 years old, compared with 32% of pedestrians and 13% of all other road users. The latter include motor vehicle drivers and occupants, motor cycle riders and pillion riders, and all other (mainly unknown) road users.

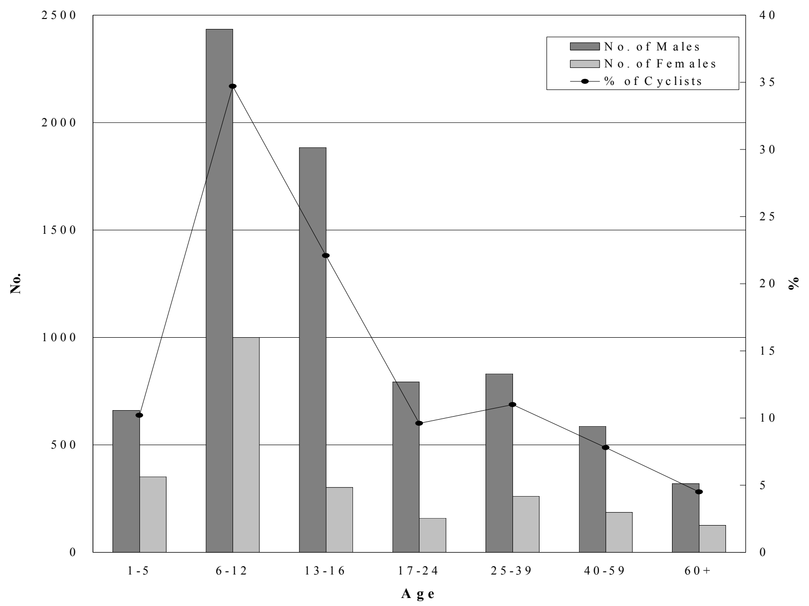

Figure 5.2 Hospital Admissions Data: Number and Percentage of Cyclists Admitted by Age (Life Cycle) and Gender, WA, 1987-2000 (14-year period)

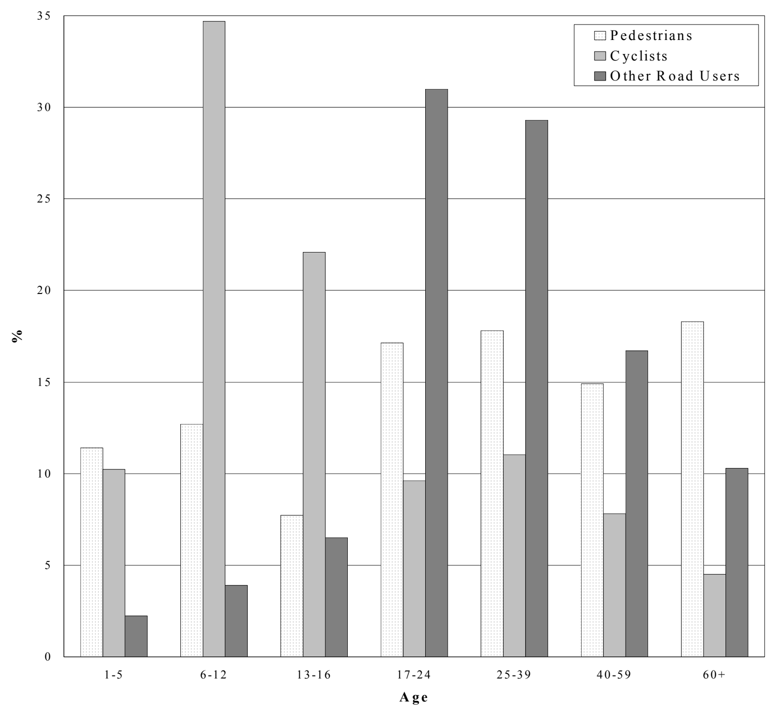

Figure 5.3 Hospital Admissions Data: Distribution of Cyclists and Other Selected Road Users Admitted by Age (Life Cycle), WA, 1987-2000 (14-year period)

5.3 Injury Severity

Injury severity for the years 1988 to June 30, 1999 was coded using the Abbreviated Injury Scale (AIS) as data was only available for this time period. Casualties were counted (coded) once by their most severe injury.

Figure 5.4 (see Table B6) shows the severity of injuries of cyclists admitted to hospital. According to this scale from 1988 to 1999 in WA, 51 cyclists were admitted to hospital with critical injuries (AIS=5), 171 with severe injuries (AIS=4), 811 with serious injuries (AIS=3), 5,130 with moderate injuries (AIS=2) and 1,371 with minor injuries (AIS=1). The percentage distribution of injuries by severity level remained more or less constant over the 12.5 year period (up to June 31, 1999).

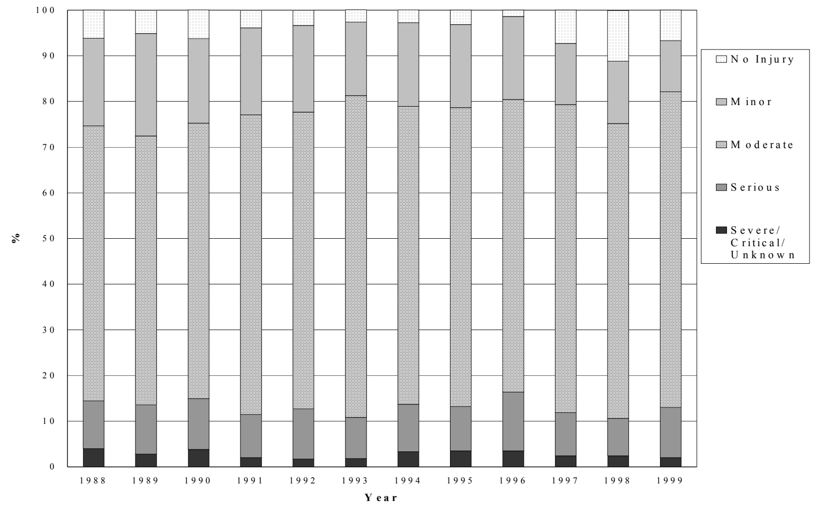

Figure 5.4 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by AIS, WA, 1988- June 30,1999 (single years)

Figure 5.5 (see Table B7) compares the injury severity for different road user groups. Pedestrians were the most severely injured with 32% having critical, severe or serious injuries. Motor cyclists and motor vehicle occupants were the next most severely injured groups, each having 26% of critical, severe or serious injuries, while 13% of cyclists had critical, severe or serious injuries. Cyclists had the highest proportion of moderate injuries (65%).

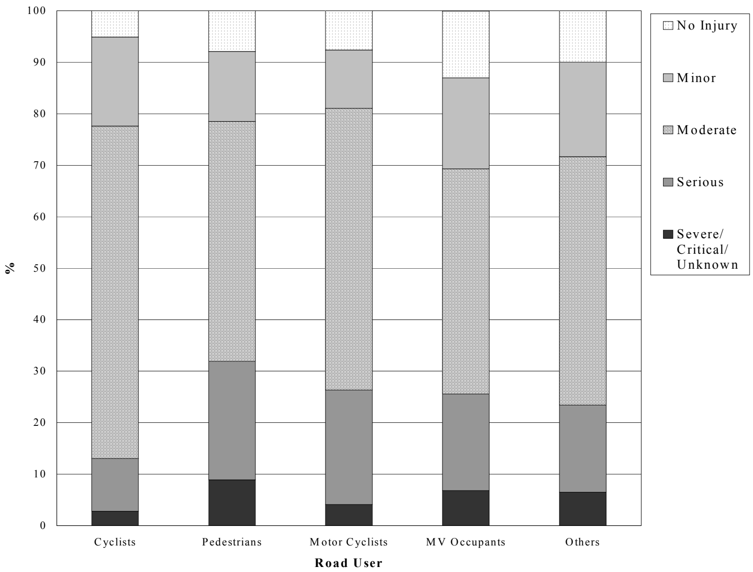

Figure 5.5 Hospital Admissions Data: Percentage Distribution of Cyclists and Selected Other Road Users Admitted by AIS, WA, 1988- June 30, 1999 (12.5-year period)

Figure 5.6 (see Table B8) shows the injury severity level of cyclists admitted to hospital by age group (life cycle) over the 13 year period. In general, the severity of injury appears to increase with age. Of cyclists aged 17 years and older, 54% had critical, severe or serious injuries compared with 46% for the less than 17-year-olds.

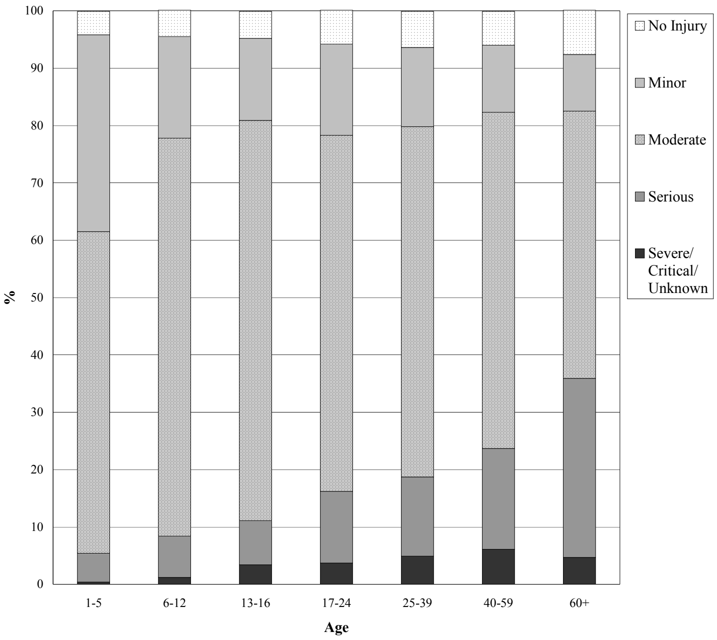

Figure 5.6 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by AIS and Age (Life Cycle), WA, 1988- June 30, 1999 (12.5-year period)

5.4 Body Region of Injury

The AIS groups injuries into the following body regions: head, spine, upper extremities, lower extremities, abdomen, chest, face and external. A small number of casualties who were admitted for observation are classified as having no injury. In the case of multiple injuries, the body region with the highest level of injury severity was used to code the body region of injury.

Figure 5.7 (see Table B9) presents the percentage distribution of cyclists admitted to hospital by body region of injury. The most frequently occurring injuries are upper extremity injuries (29%), followed by head injuries (23%), external injuries (16%) and injuries to the lower extremities (15%). Injuries to the upper extremities has shown an almost steady increase from 118 (17%) in 1988 to 163 (37%) in 1999. External injuries have fluctuated but have fallen from 19% to 12% over the study period. Face injuries has also fallen slightly from 7% to 6% whereas the relative share of injuries to all other body regions has not shown a clear trend in either direction.

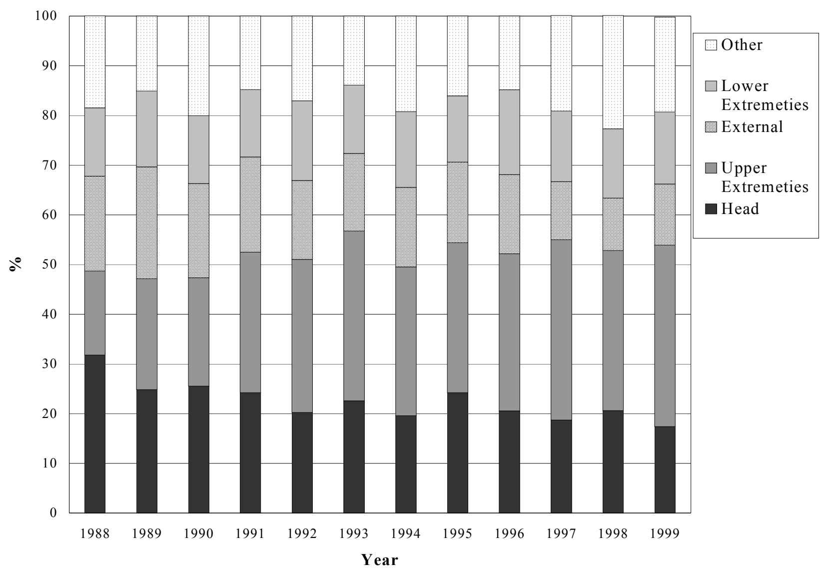

Figure 5.7 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Body Region of Injury, WA, 1988- June 30, 1999 (single years)

Figure 5.8 (see Table B10) shows the distribution of injuries to cyclists by body region of injury and injury severity. Head injuries accounted for the highest proportion of severe (80%) and critical (69%) injuries. Most remaining critical injuries were spinal injuries (22%) and severe injuries were injuries to the abdomen (12%). Serious injuries consisted mainly of those to the lower extremities (49%), the head (15%), upper extremities (15%), the chest (11%) and spine (10%), while injuries of moderate severity mainly comprised upper extremity injuries (41%), head injuries (29%), and injuries to the lower extremities (14%). The majority of minor injuries (62%) involved external injuries followed by facial injuries (25%).

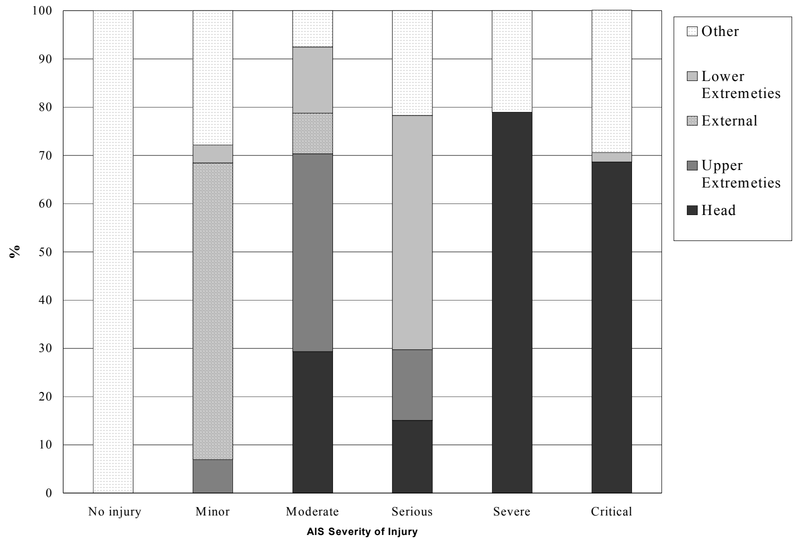

Figure 5.8 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Body Region of Injury and AIS, WA, 1988- June 30, 1999 (12.5-year period)

Figure 5.9 (see Table B11) shows the distribution of cyclists by body region of injury and age group (life cycle). There were some differences in the injury patterns of the different age groups. For example, cyclists in the 1 to 5 year age group had more external injuries (33%) than the other age groups; cyclists in the 6 to 12 and 13 to 16 year age group had more upper extremity injuries (35% and 30% respectively); and older cyclists in the 60 years and older groups had more lower extremity injuries (37%) and fewer head injuries (12%) than the other age groups.

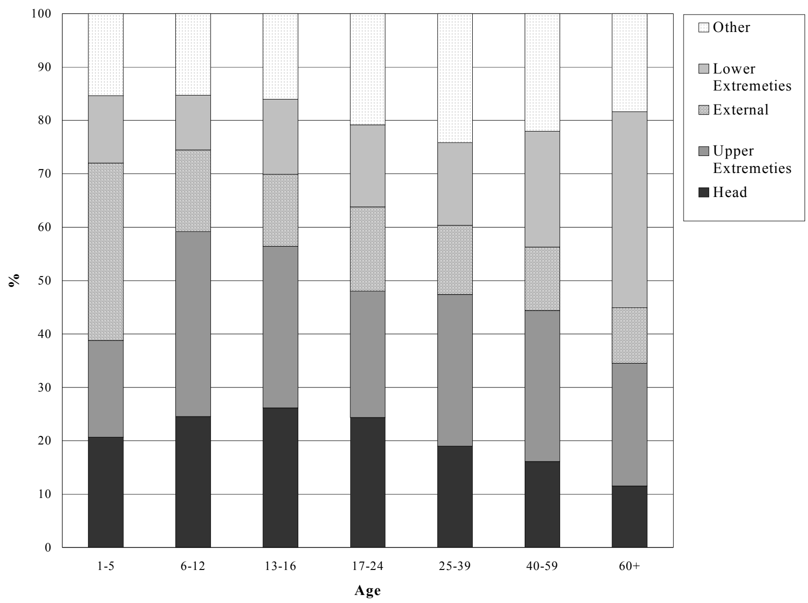

Figure 5.9 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Body Region of Injury and Age, WA, 1988- June 30, 1999 (12.5-year period)

5.5 Common Injury Types

Injuries were also classified into common injury types directly from the ICD diagnostic codes. The common injury types identified were head injuries, upper limb fractures, lower limb fractures, neck/trunk fractures, open wounds, bruises and abrasions, and other injuries. In applying this classification, all injuries to cyclists were counted (not only the most severe injury).

Over the 13.5 year period, the common injuries that cyclists sustained most frequently, based on the principal diagnosis upon presentation to the hospital, were head injuries (28%), upper limb fractures (27%), open wounds (18%) lower limb fractures (12%), bruises and abrasions (5%), and neck/trunk fractures (2%) (see Figure 5.10 and Table B12). The total number of recorded injuries to cyclists increased from 590 in 1987 to 819 in 1998 with 420 injuries recorded in the first six months of 1999. Head injuries have been the most common injury, but in recent years the share of head injuries has decreased (209 in 1987 to 195 in 1998). However upper limb fractures have increased by 147% in 1998 compared to 1987.

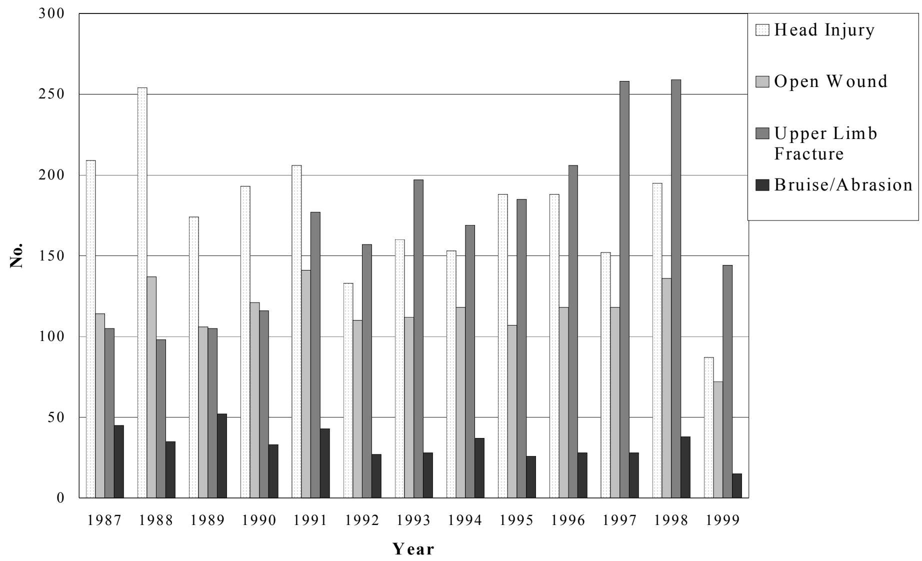

Figure 5.10 Hospital Admissions Data: Number of Cyclists Admitted by Common Injury Types, WA, 1987- June 30, 1999 (single years)

Figure 5.11 (see Table B13) shows the distribution of common injury types by age. Compared with other cyclists, cyclists in the 1 to 5 year age group had more open wounds (44%); cyclists in the 6 to 12 year age group had more upper limb fractures (33%); those in the 13 to 16 year age group had more head injuries (33%); and older cyclists in the 60 years and older group had more lower limb fractures (31%) and fewer head injuries (15%) than the other age groups.

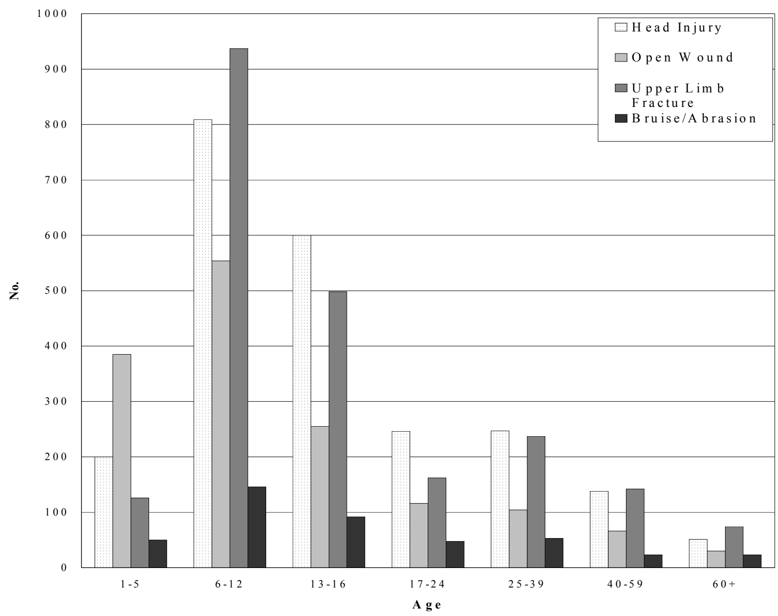

Figure 5.11 Hospital Admissions Data: Number of Cyclists Admitted by Common Injury Types and Age, WA, 1987- June 30, 1999 (13.5-year period)

5.6 Length of Stay in Hospital

Figure 5.12 (see Table B14) shows the length of stay in hospital for cyclists each year. Over the 14-year period, 57% of cyclists spent one day in hospital, 33% spent between two and seven days in hospital, 8% spent between eight and 30 days in hospital, and 1% spent more than 30 days in hospital. The length of hospital stay for cyclists appears to be decreasing. This is consistent with general trends of shorter lengths of stay in hospital for all medical conditions. In the later years of this 14-year period, a higher proportion of cyclists had lengths of stay of one day, and fewer had lengths of stay of more than one day. There has been a fairly consistent decrease in the proportion of cyclists with hospital stays of eight to 30 days.

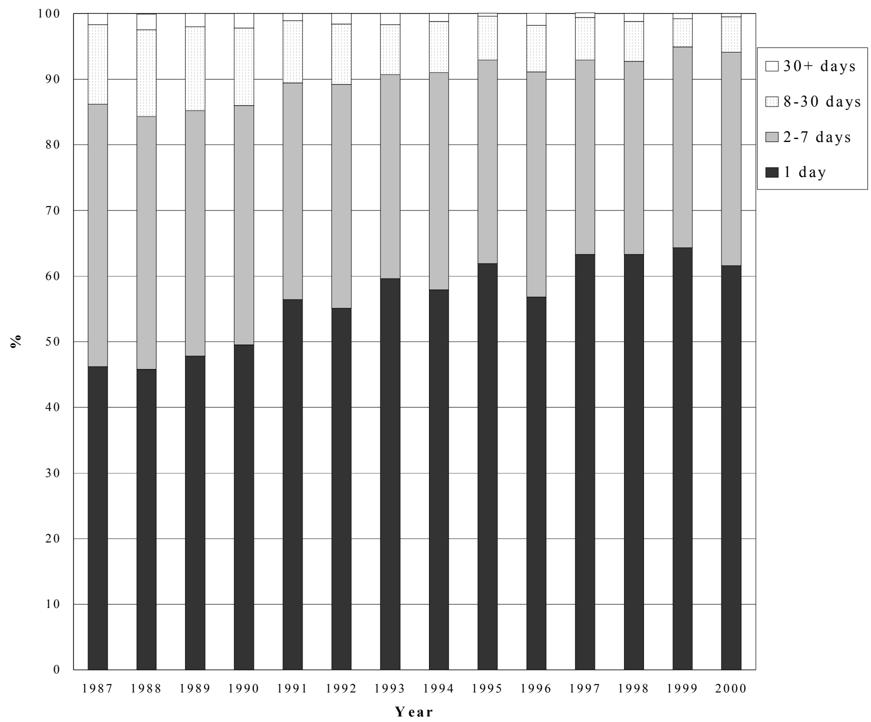

Figure 5.12 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Length of Stay in Hospital, WA, 1987-2000 (single years)

Figure 5.13 (see Table B15) examines length of stay by age group. Seventy-six percent of cyclists age 1 to 16 had shorter lengths of stay (1 day) in hospital than adults. The percentage of casualties with lengths of stay of one day or less decreased with age from 68% for cyclists aged 6 to 12 years to 28% for cyclists in the 60 years and older group. On the other hand, 27% of cyclists aged 60 years and older stayed in hospital between eight and 30 days compared with 5% of cyclists in 6 to 12 year age group.

Figure 5.14 (see Table B16) shows the differences in the length of hospital stay for cyclists with injuries to different body regions. The injuries requiring longer stays (more than 30 days) in hospital were those to the lower extremities, the head and the spine. Of the 113 cyclists who spent more than 30 days in hospital, 53 had lower extremity injuries, 22 had head injuries and 16 had spinal injuries. Injuries to the lower extremities (283), external injuries (107) and the head (101) also accounted for a significant share of the casualties staying in hospital for between eight and 30 days.

Cyclists who stayed in hospital for one day had mainly upper extremity injuries (36%), followed by head injuries (29%) and external injuries (16%).

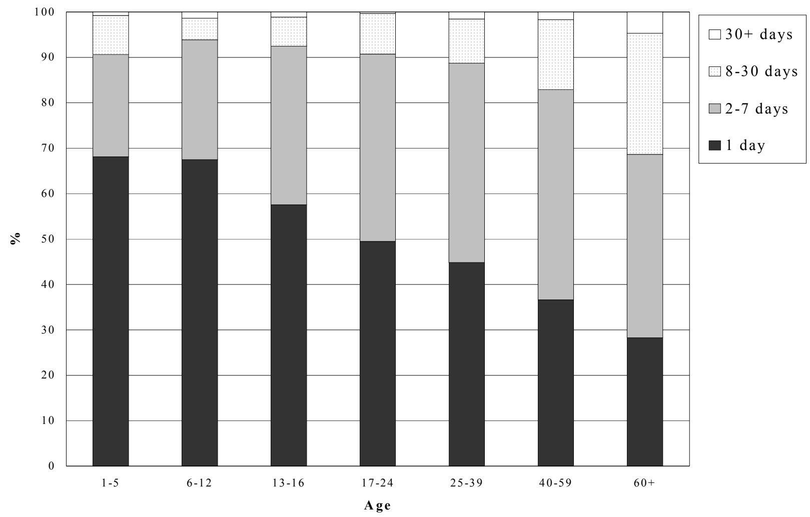

Figure 5.13 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Age and Length of Hospital Stay, WA, 1987-2000 (14-year period)

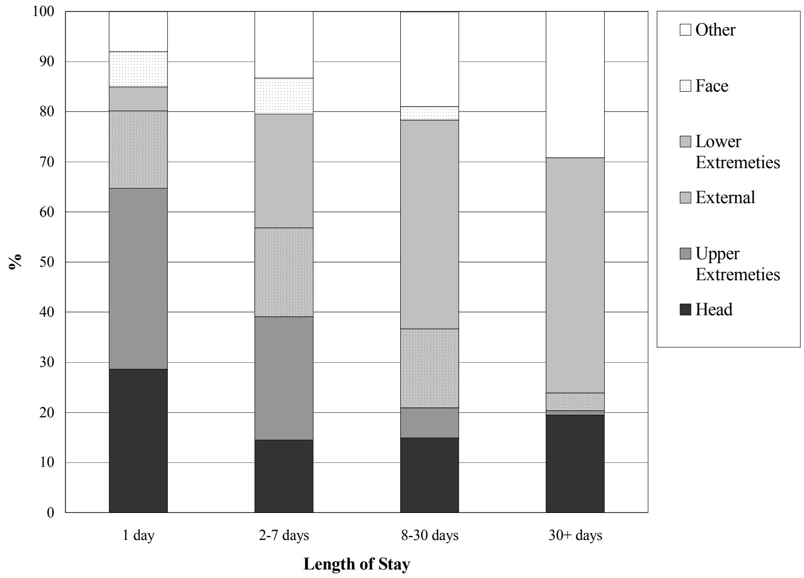

Figure 5.14 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Body Region of Injury and Length of Hospital Stay, WA, 1988- June 30, 1999 (12.5-year period)

5.7 Crash Characteristics

Three crash characteristics that were available from the hospital admissions data are discussed in this section: crash type, road type and place of residence of cyclist.

5.7.1 Crash Type

The hospital records distinguish three types of bicycle crashes:

(i) motor vehicle traffic crashes - collisions between motor vehicles and cyclists on a public road;
(ii) motor vehicle non-traffic crashes - collisions between motor vehicles and cyclists not on a public road; and
(iii) non-motor vehicle crashes - crashes involving a cyclist but no motor vehicle.

Figure 5.15 (see Table B17) shows crash type by year. By far the majority of bicycle crashes were non-motor vehicle crashes (82%).

Figure 5.16 (see Table B18) shows crash type for different age groups. Non-motor vehicle crashes accounted for the greatest percentage of crashes for all age groups. However, proportionately more younger cyclists were involved in non-motor vehicle traffic crashes and more older cyclists were involved in motor vehicle crashes.

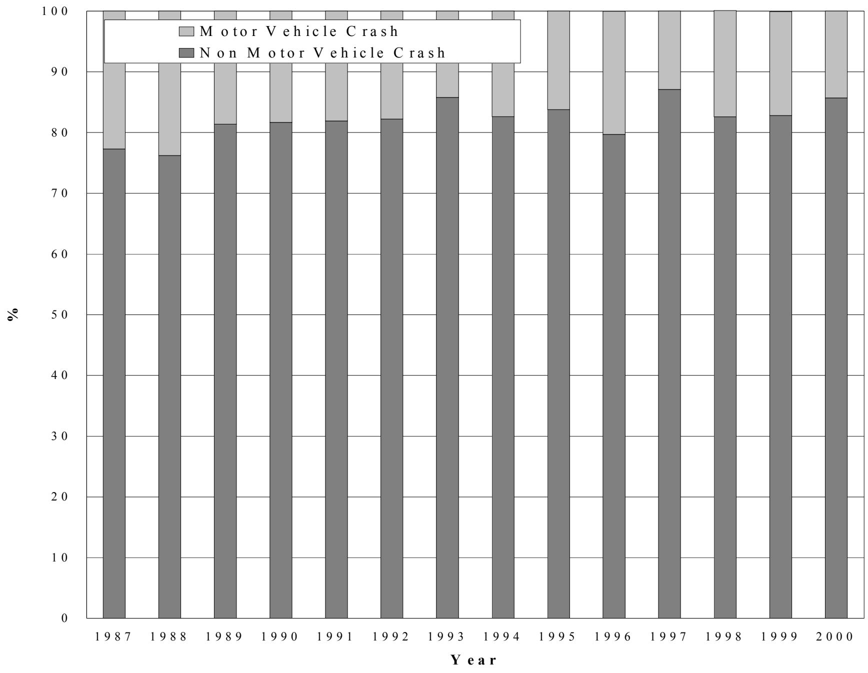

Figure 5.15 Hospital Admissions Data: Percentage Distribution Cyclists Admitted by Crash Type, WA, 1987-2000 (single years)

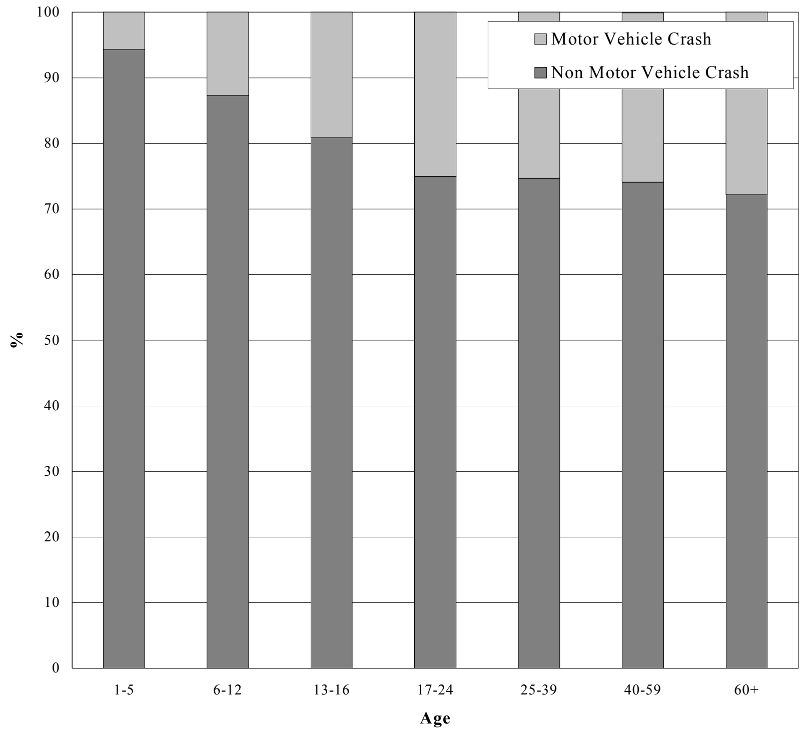

Figure 5.16 Hospital Admissions Data: Percentage Distribution of Cyclists Admitted by Crash Type and Age, WA, 1987-2000 (14-year period)

5.7.2 Road Type

Figure 5.17 (see Table B19) investigates for each crash type whether the bicycle crash occurred on-road or off-road. On-road is defined as occurring on a street or highway. Data for this variable are only available from 1993. For the period from 1993 to 2000, 40% of bicycle crashes resulting in a cyclist being admitted to hospital occurred on-road, 59% occurred off-road, and the place of occurrence was unknown for the remainder (1%). The proportion of motor vehicle and non-motor vehicle crashes occurring on-road and off-road were very different. While almost all motor vehicle crashes (82%) occurred on-road, only 31% of non-motor vehicle crashes occurred on-road.

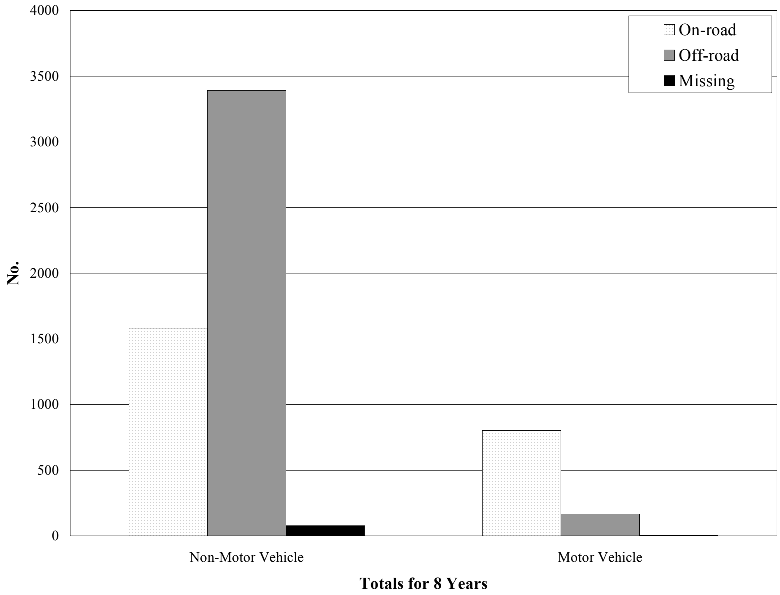

Figure 5.17 Hospital Admissions Data: Number of Cyclists Admitted by Road Type, WA, 1993-2000 (8-year period)

5.7.3 Place of Residence of Cyclist

Figure 5.18 (see Table B20) presents the region (i.e., metropolitan or country) of the cyclists' home residence. The distribution of cyclists' home residence is similar to that of the population with 71% of cyclists admitted to hospital living in the metropolitan region and the remainder living in the country (29%). In recent years, slightly more cyclists admitted to hospital were from country regions (33% in 2000 compared to 21% in 1987).

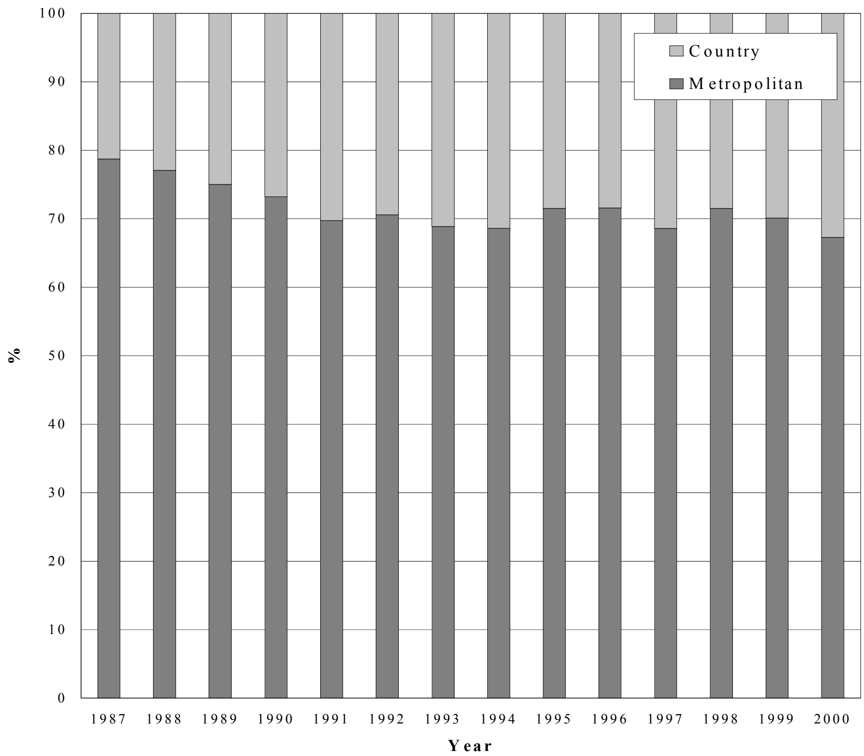

Figure 5.18 Hospital Admissions Data: Number of Cyclists Admitted by Region, WA, 1987-2000 (single years)

6. REPORTING RATE TO POLICE OF CRASHES INVOLVING HOSPITAL ADMISSIONS

This section compares the police and hospital data in two ways. First, the actual number of hospital admissions each year is compared with the number reported in the police data. Second, the linkage rate of hospital admission records to police records is examined both over time and for selected variables in the hospital data. The linkage rate is the percentage of hospital admissions records that have a matching police record. A link is said to be present if the hospital record has a matching police record regardless of the injury severity coded on the police report form.

Figure 6.1 (see Table C1) shows (i) the reported number of hospital admissions recorded in the police data, and (ii) the number of cyclists admitted to hospital as recorded in the hospital data from 1987 to June 30,1998. Over the 12.5 year period, the number of cyclists recorded as being hospitalised in the police data was 21% of the number recorded in the hospital admissions data. The number of hospital admissions in the police data as a percentage of the number in the hospital data fluctuated between 13% in 1993 and 27% in 1989

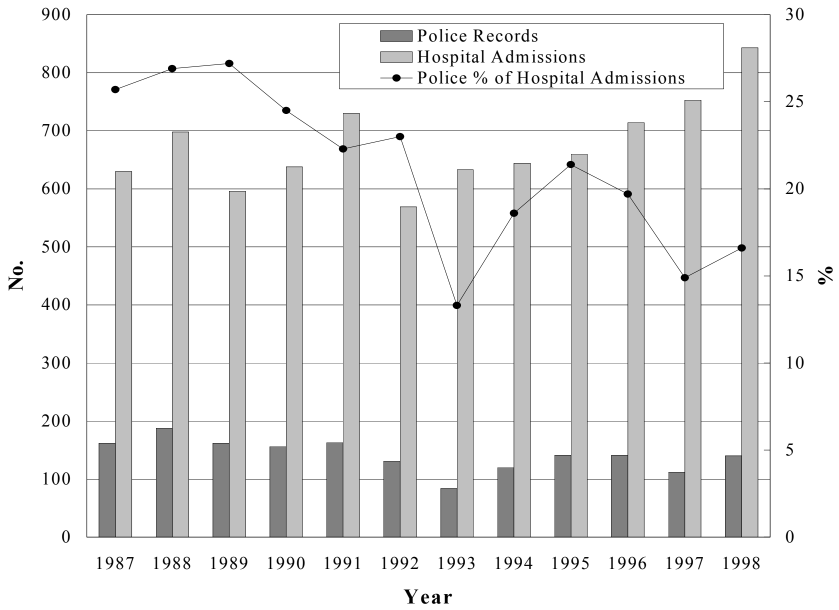

Figure 6.1 Number of Hospitalised Cyclists in the Police-reported Data and the Hospital Admissions Data, WA, 1987- June 30, 1999 (single years)

Table C2 shows the linkage rate of hospital admission records to a police record for cyclist casualties. The linked data are only available for the years 1987 to June 30, 1999. Over this period, between 13% (1999) and 24% (1988) of hospital records had a matching police record.

Figures 6.2 to 6.5 (see Table C3) compare the linkage rate of cyclists, pedestrians and other road users for selected variables. These were casualty residence (i.e., metropolitan or country), gender, age, length of stay and injury severity. The linkage rates for cyclists were consistently lower than for pedestrians or other road casualties which may indicate a smaller proportion of cyclist's casualties were reported to police than other road users. Overall, the linkage rate was 19% for cyclists and 61% and 55% for pedestrians and other road users respectively. Cyclists living in country regions linked less often than their metropolitan counterparts.

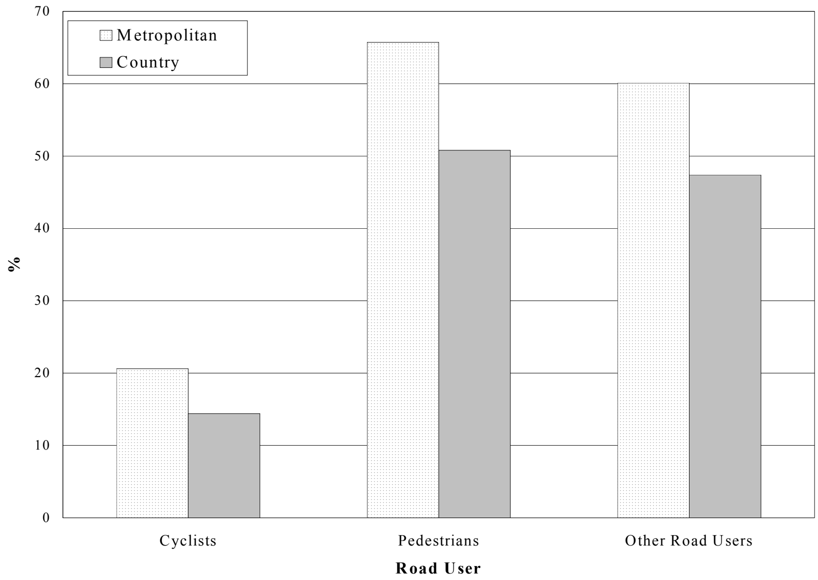

Figure 6.2 Linked Data: Police Linkage Rates for Cyclists, Pedestrians and Other Road Users by Casualty Residence, WA 1987-June 30, 1999 (13.5-year period)

Figure 6.3 shows that for cyclists proportionately more male hospital casualties (20%) than females (14%) were linked to a police report. This was reversed for pedestrian and other road user casualties with more female hospital casualties than males linking to a police report.

For cyclists and other road users (non pedestrians), Figure 6.4 shows that the linkage rate was lower for hospital casualties who were 16 years or younger (between 5% and 22% for cyclists and 27% and 31% for other road users) compared to those 17 years and older (between 27% and 33% for cyclists and 57% and 61% for other road users). However for pedestrians, only the 1 to 5 year olds had a lower linkage rate than pedestrians aged 6 years or more.

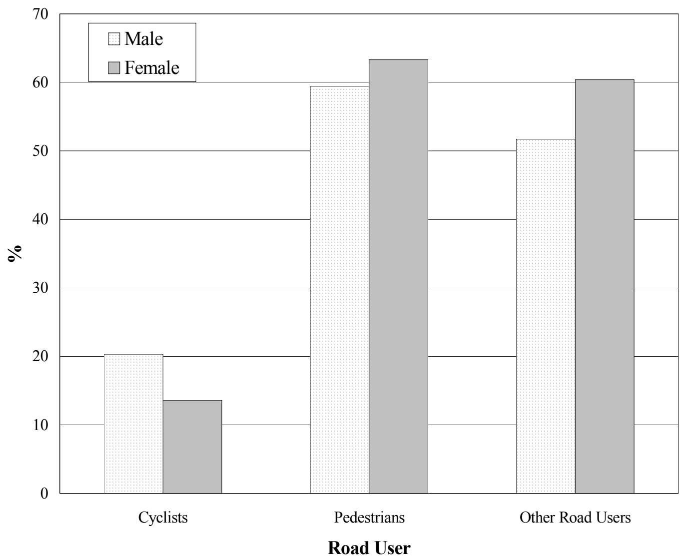

Figure 6.3 Linked Data: Police Linkage Rates for Cyclists, Pedestrians and Other Road Users by Gender, WA, 1987- June 30, 1999 (13.5 year period)

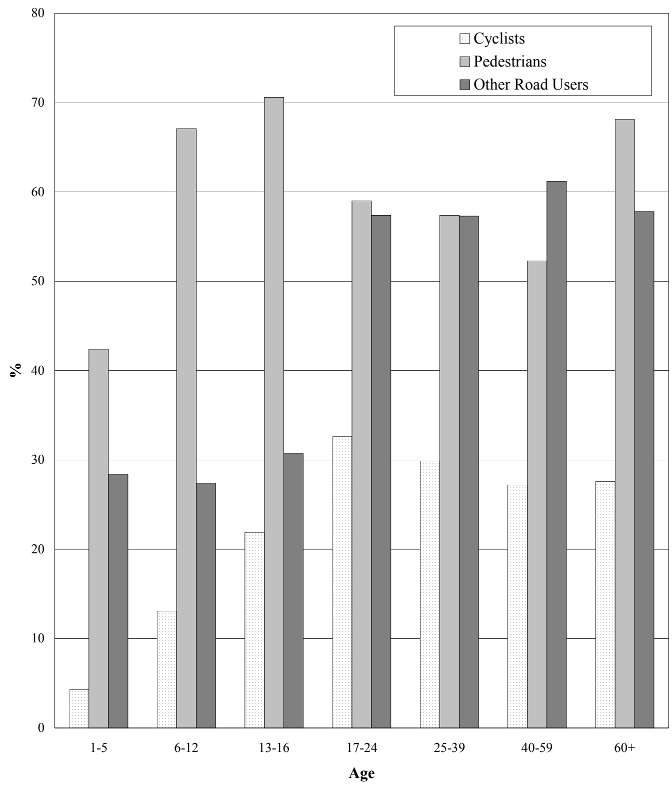

Figure 6.4 Linked Data: Police Linkage Rates by Age Group (Life Cycle) for Cyclists, Pedestrians and Other Road Users, WA, 1987- June 30, 1999 (13.5 year period)

Figure 6.5 shows that linkage rates increased with length of stay in hospital. This was particularly marked for cyclists - 12% of cyclists whose length of stay in hospital was one day linked to a police record and this increased to 62% for those whose length of stay was 30 days or more.

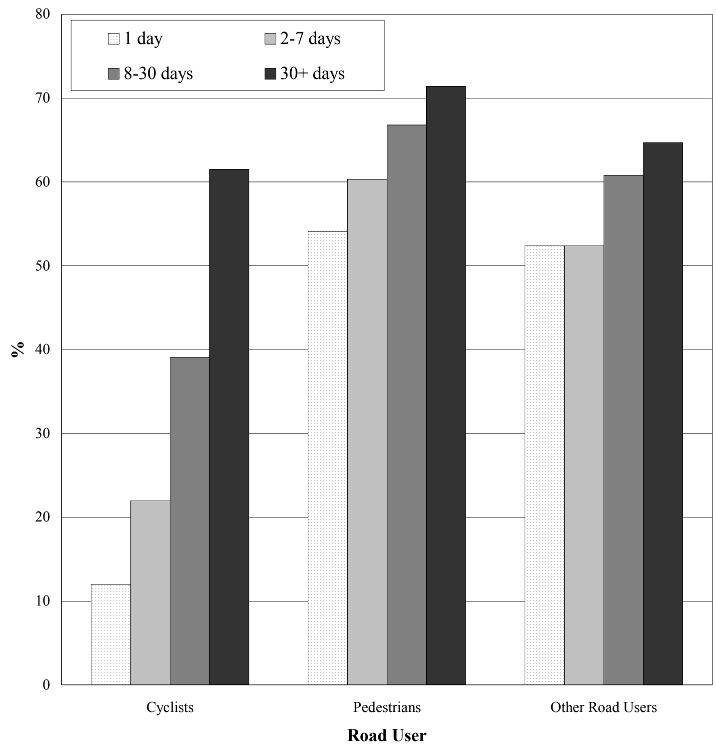

Figure 6.5 Linked Data: Police Linkage Rates for Cyclists, Pedestrians and Other Road Users by Length of Stay, WA, 1987- June 30, 1999 (13.5 year period)

7. SUMMARY OF MAJOR FINDINGS

7.1 Police-reported Road Crash Data

7.1.1 Size of the Problem

- The number of bicycle crashes reported to the police in Western Australia significantly decreased from 1,012 in 1987 to 612 in 2000 (p=0.001) which represents a decrease of approximately 32 crashes per year. Over this period, the share of bicycle crashes as a percentage of all reported crashes decreased from 2.5% to 1.4% in 2000.

7.1.2 Cyclist Profile

- The majority of cyclists involved in police-reported crashes were young and predominantly male.

- Cyclists involved in police-reported crashes were relatively younger than other road users involved in road crashes.

- 30% of cyclists involved in police-reported crashes were 16 years or less compared with 24% of pedestrians and 2% of other road users. On the other hand, relatively few older cyclists were involved in police-reported bicycle crashes. Only 10% of cyclists involved in police-reported crashes were 40 years or older compared with 22% and 25% of pedestrians and other road users respectively.

7.1.3 Injury Severity

- Over the 14 year study period 81 (1%) cyclists were killed in road crashes, 1851 (16%) were reported to have been admitted to hospital, 4,486 (39%) required medical attention, 1,250 (11%) were injured but did not require treatment, and 3,717 (33%) were involved in property damage only crashes or crashes of unknown severity.

7.1.4 Helmet Wearing

- In 2000, helmet wearing status was unknown for 56% of cyclists involved in police-reported crashes, 34% were known to have been wearing a helmet, and 11% were known not to have been wearing a helmet. This implies a helmet-wearing rate of 76% for cyclists whose helmet wearing status was known.

7.1.5 Other Vehicle Characteristics

- Most bicycle crashes (93%) reported to the police involved a cyclist and at least one other vehicle during the study period.

7.1.6 Crash Type

- Right-angled crashes and sideswipe same direction crashes accounted 60% of all police-reported bicycle crashes.

- The proportion of sideswipe same direction crashes as a percentage of all crashes decreased over the 14-year period, while in recent years the proportion of indirect right-angled crashes has also decreased.

- Right-angled crashes, rear end crashes, sideswipe same direction crashes and sideswipe opposite direction crashes accounted for 85% of all fatalities and 70% of police-reported hospital admissions. Indirect right-angled crashes accounted for 11% of hospital admissions.

7.1.7 Traffic Control

- Over the 14-year period, 72% of bicycle crashes occurred where there were no traffic signs or controls, 11% where there were stop signs, 10% where there were traffic lights and 5% where there were give way signs.

- In recent years, relatively fewer crashes occurred at stop signs and relatively more at give way signs.

7.1.8 Road Type

- The majority (94%) of police-reported crashes occurred on-road. Eighty-six percent occurred on urban-arterial, local and other roads, 12% on highways and 2% on main roads.

7.1.9 Crash Location

- Using the Main Roads WA regions, 84% of police-reported crashes occurred in the Perth metropolitan region, 7% in the South West, and 2% in each of the Goldfields-Esperance region and the Great Southern region.

7.1.10 Temporal Factors

- The peak times for bicycle crashes were 3pm to 6pm (38%) and 6am to 9am (20%). There were differences in the distribution of crashes by time of day for different age groups.

- On the weekend, proportionately more crashes occurred between 3pm to 6pm (29.3%) and during the 9am to 12-noon period (25% vs 10% for weekday crashes).

7.2 Hospital Admissions Data

7.2.1 Size of the Problem

- There has been a significant increase ($p=0.001$) in the number of cyclists admitted to the hospital resulting from road crashes during the 14 year study period.

- Over the 14-year period, hospital admissions of cyclists as a percentage of all road crash casualties varied between 12% in 1989 and 16% in 2000.

7.2.2 Cyclist Profile

- The majority of cyclists admitted to hospital were young and predominantly male. Seventy-six percent of cyclist casualties were young males. Young males in the 6 to 12 year age group accounted for the highest proportion of hospital admissions (35%) followed by 13 to 16 year olds (22%).
- Compared with other road users, cyclists admitted to hospital were relatively younger. Sixty-seven percent of cyclists admitted to hospital were 16 years or less, compared with 32% of pedestrians and 13% of other road users.

7.2.3 Injury Severity

- Injury severity was coded using the Abbreviated Injury Scale (AIS). According to this scale from 1988 to 1999 in WA, 51 cyclists were admitted to hospital with critical injuries (AIS=5), 171 with severe injuries (AIS=4), 811 with serious injuries (AIS=3), 5,130 with moderate injuries (AIS=2) and 1,371 with minor injuries (AIS=1).

- Cyclists had fewer critical, severe and serious injuries (13%) compared with pedestrians (32%), motorcyclists (26%) and motor vehicle occupants (26%). Cyclists had the highest proportion of moderate injuries (65%).

7.2.4 Body Region of Injury

- The most frequently occurring injuries to cyclists were upper extremity injuries (29%), followed by head injuries (23%) external injuries (16%) and injuries to the lower extremities (15%).

- Injuries to the upper extremities have shown an almost steady increase from 17% of all cyclist injuries in 1988 to 37% in 1999.

- Head injuries accounted for the highest proportion of critical injuries (69%) and severe injuries (80%) to cyclists. Injuries to the lower extremities accounted for almost half of all serious injuries (49%).

7.2.5 Common Injury Types

- Injuries were also classified by common injury type. The common injury types that cyclists sustained most frequently were head injuries (28%), upper limb fractures (27%), open wounds (18%), lower limb fractures (12%), and bruises and abrasions (5%).
- Head injuries were the most common injury type, but in recent years the proportion of head injuries has decreased and the most common injury type was upper limb fractures.

7.2.6 Length of Stay in Hospital

- The majority of cyclists (57%) spent only one day in hospital, while 33% spent between two and seven days in hospital. The length of hospital stay has decreased over the period.

- Younger cyclists had shorter lengths of stay in hospital than adult cyclists.

- The injuries requiring longer stays in hospital were those to the lower extremities, the head and the spine. Cyclists who stayed in hospital for only one day had mainly upper extremity injuries (36%), head injuries (29%) and external injuries (16%).

7.2.7 Crash Type

- Most bicycle crashes (82%) resulting in a hospital admission were non-motor vehicle crashes (i.e., did not involve a collision with a motor vehicle).

7.2.8 Road Type

- Forty percent of bicycle crashes resulting in a cyclist casualty being admitted to hospital occurred on-road, 59% occurred off-road, and the place of occurrence was unknown for the remainder.

- A large majority of bicycle crashes involving collisions with motor vehicles (82%) occurred on-road, while only 31% of non-motor vehicle crashes occurred on-road.

7.2.9 Place of Residence of Cyclist

- Seventy-one percent of cyclists admitted to hospital with road injuries lived in the metropolitan region.

7.3 Reporting Rate to the Police of Crashes Involving Hospital Admissions

- The number of cyclists recorded as being hospitalised in the police data was 21% of the number actually admitted to hospital over this period.

- Over the 12.5 year period (1987 to June 30, 1999), between 13% (1999) and 24% (1988) of hospital records had a matching (linked) police record.

- The linkage rate of hospital records to a police report was lower for cyclists than for pedestrians and other road users.

- In general, the linkage rate of hospital records to a police record for cyclists was higher for individuals living in the metropolitan region, males, older cyclists and for those with longer stays in hospital.

8. DISCUSSION

The main purpose of this study was to analyse police and hospital data relating to bicycle crashes and injuries in Western Australia over the period 1987-2000. The police data are the official source of information on road crashes and contain detailed information on the characteristics of the people and vehicles involved in road crashes and the crash circumstances. Hospital admissions data are an alternative source of information on bicycle crashes and injuries, and provide limited information on crash and vehicle characteristics but detailed information about the injuries sustained by cyclist casualties.

The results of the study are generally consistent with other Australian and international studies that have investigated bicycle crashes and injuries. The majority of cyclists involved in crashes were found to be young and predominantly male. The greatest number of bicycle crashes reported in the police data occurred on arterial and local roads, and the most commonly occurring crash types were right-angled crashes and sideswipe same direction crashes. The two peak times for bicycle crashes reported to the police were 3pm to 6pm and 6am to 9am. In the hospital data, the most frequently occurring injuries were head injuries and upper extremity injuries. The majority of hospitalised cyclists only spent a few days in hospital.

The analysis of the police data shows that reported crashes were mainly collisions with motor vehicles occurring on-road. In comparison, the hospital data show that the majority of cyclist casualties admitted to hospital had been involved in single vehicle (i.e., bicycle only or non-motor vehicle crash) crashes with only 31% occurring on-road.

Several other differences were found in the information provided in the police and hospital data. The hospitalised cyclists were considerably younger than the police-reported group. In the hospital data, sixty-seven percent of the cyclist casualties admitted to hospital were 16 years or younger compared with 41% of the cyclists involved in police-reported crashes. The two data sources also show very different distributions across road user groups. The hospital data show cyclists accounting for almost 14% of hospital admissions of road casualties compared with the police records where cyclists accounted for approximately 1% of all people involved in police-reported crashes and 5% of people in the police data recorded as having been admitted to hospital. The relative shares for other road user groups are shown below:

- Pedestrians accounted for 9% of hospital admissions in the hospital data, 1% of all people involved in police-reported crashes and 10% of people in the police data recorded as having been admitted to hospital.
- Motor cyclists accounted for 16% of hospital admissions in the hospital data, 2% of all people involved in police-reported crashes and 12% of people in the police data recorded as having been admitted to hospital.
- Motor vehicle occupants accounted for 38% of hospital admissions in the hospital data, 90% of all people involved in police-reported crashes and 72% of people in the police data recorded as having been admitted to hospital.

Another important difference between the police and hospital data is the trends shown in bicycle crashes and injuries. The number of cyclists involved in crashes in the police data has significantly declined over the 14-year period from 1,012 cyclists in 1987 to 612 in 2000. This decline has resulted in a decrease in the number of cyclists as a percentage of all road users from 1.3% in 1987 to 0.7% in 2000. On the other hand, the hospital data showed a significant increase in the number of admissions since 1992 (from 574 to 913). Approximately 700 (range 574 to 913) cyclists were admitted to hospital each year and these admissions accounted for between 12% and 16% of road injuries recorded in the hospital data.

9. RECOMMENDATIONS

These findings have important implications for the development of road safety policy relating to cyclists.

1) Both the police data and the hospital data contain valuable information on bicycle crashes and injuries and both data sources should be consulted in developing bicycle safety strategies and programs.

2) In assigning priority to cyclists as a target group in road safety programs, the under-reporting of serious injuries involving cyclists to the police should be recognised. The extent of this under-reporting of serious injuries to cyclists is considerable, and is greater for cyclists than for other types of road users. A capture-recapture methodology is a potentially useful method for evaluating the completeness of data sources and identifying biases within datasets. When several sources of case ascertainment are available capture-recapture can be employed under certain assumptions, to estimate the number of individuals not identified by the sources used and to derive a more comprehensive "ascertainment corrected" incidence measure. It would be interesting to apply this methodology to analyse bicycle accidents.

3) The reduction in the number of bicycle crashes reported in the police data should be examined since the hospital data show no reduction but actually a significant increase in the number of cyclists who are admitted to hospital.

4) Cycling safety programs particularly targeting helmet wearing should be aimed at children aged 16 or younger as this group constitutes 67% of cyclists admitted to hospital.

In conclusion, the analysis of the police and hospital data presented in this report provides information that can be used as the basis for developing bicycle safety strategies in Western Australia. Data have been provided on the past and current status of the bicycle crash and injury problem, the characteristics of cyclists involved in crashes, crash and vehicle characteristics, and the injuries sustained by cyclists. However, the report provides no more than an overview of the available data, and more in-depth analyses can be undertaken on both the police and hospital data if additional information is required on specific areas of interest within either data set. Furthermore, additional data sources such as those maintained by some of the hospital emergency departments could be explored in order to provide more information relating to the magnitude and nature of the bicycle crash and injury problem in Western Australia.

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