Hospital admission rates and the rate of fractures of the femur in non-fatal traffic crashes in Victoria

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Abstract

Injuries following road traffic crashes are seen to vary according to age, roaduser type and collision partner. This is a consequence of differing injury tolerances due to age and gender, and vulnerability to vehicle-to-body contact among roaduser groups such as pedestrians and cyclists in collisions with vehicles. This paper presents hospital admission rates by roaduser type, age and gender in Victoria. Analysis showed that young persons (18 – 39 years) were over-represented in terms of admissions per head of population across all roaduser categories. Rates of femur fracture by age, gender and roaduser class were presented. Odds ratios for sustaining fractures of the femur for passengers, pedestrians and cyclists relative to drivers of the same age and gender were determined to examine the concept of vulnerability. The odds of sustaining fractures of the femur were high for pedestrians and cyclists relative to drivers of the same age and gender. Age and gender appeared to interact such that the odds of sustaining fractures of the femur increased with age, with the effect more pronounced for females.

KEYWORDS

Hospital admissions, Pedestrians, Cyclists, Injury, Odds Ratios, Fractures, Femur

Road crashes are an everyday occurrence in modern society. The World Health Organisation (WHO) estimate that approximately 1.2 million people are killed and 39 million people are injured annually around the world from road traffic crashes [1]. Road traffic crashes represent the 10th leading cause of death and the 9th leading cause of burden of disease to humans [2], costing OECD nations an estimated US$450 billion annually, or approximately 2% GDP [3]. In Australia, 1759 persons were killed in 1999 [4] and an estimated 22,000 persons were hospitalised as a consequence of road crashes[1] [5]. To further underlie the cost of road crashes to the Australian community, the BTE estimated that road crashes cost Australian society $15 billion annually [6]. There is also an enormous personal cost to individuals involved in road crashes. Road crashes are violent with injuries resulting as a consequence of exposure to forces that exceed human injury tolerances [7]. In addition to the physical injuries sustained, road crashes often carry enormous psychological and social costs for the individual [8-13].

Previous research in the UK and New Zealand has reported hospital admission rates and associated injuries according to roaduser type [14, 15]. In a study of inpatient costs in New Zealand, it was reported that vehicle occupants represented an estimated 50% of national in-patient cases, followed by motorcyclists (26%), pedestrians (10%), pedal cyclists (4%) and 'other road users' (9%) [14]. In the UK, a national hospital study of road accident casualties reported that car occupants represented 58% of casualties, followed by cyclists (15%), pedestrians (12%), motorcyclists (8%), bus occupants (3%) and occupants of goods vehicles (3%) [15]. In the UK study, 57% of patients were male and 43% were female, and casualties were predominately young with approximately one-third being under 20 years of age and nearly 75% of casualties being aged under 40 years old [15]. The UK study also reported the age and gender distribution among roaduser class [15]. For car occupants, persons aged 16-19 years represented 13% of casualties followed by persons age 20 –29 years (34%), 30-39 years (18%), and 40-49 years (11%). For pedestrians, persons aged 0-15 years represented 43% of casualties followed by persons aged 20 –29 years (15%), and 60 years and older (14%). For cyclists, persons aged 0 –15 years comprised 42% of all cyclist admissions, followed by cyclists aged 20 – 29 years of age (20%). Finally for motorcyclists, persons aged 20-29 years represented 39% of casualties followed by persons age 30–39 years (22%), 16-19 years (20%), and 40-49 years (9%). Unfortunately, the UK report did not report casualty rates per head of population [15].

In a study of hospitalisations resulting from motorcycle traffic crashes in New Zealand, it was reported that the overall incidence rate was 68.1 per 100,000 persons per year, that males represented 87% of the hospitalisations, and that the hospitalisation rate for males was 119.6 per 100,000 persons per year compared to 17.6 per 100,000 persons

[1] Note: Exact figures unavailable, estimate based on 1990-1996 figures

per year for females [16]. Motorcyclist hospitalisation rates showed a strong age and gender effect with highest hospitalisation rates for male motorcyclists being for persons aged 15-19 years and 20-24 years of age with 409 and 416 per 100,000 persons per year respectively, followed by a dramatic decrease in rates for older age groups [16].

A recent study of trauma-related hospitalisations of urban adolescents aged 10–19 years of age in New Zealand reported that adolescent males were on average almost two times as likely as females to be hospitalised for trauma, with the rate ratio increasing from 1.4 at 10 years to 3.1 by 19 years of age [17]. A total of 70% of admissions were male while overall 16% of persons sustained lower limb fractures. The study also reported that the admission rate for car occupants aged 15-19 years of age was 181 per 100,000 population per annum, 103 for motorcyclists, 45 for cyclists, and 28 per 100,000 persons per annum for pedestrians [17].

A study of bicycle injuries and risk factors for serious injury, though not reporting admission rates or fracture rates, did reveal that motor vehicle involvement was an important predictor of severe and fatal injury, as did a study of childhood pedestrian injuries [18,19]. These results further underline the inadequate nature of the current road transport system to cope with the needs and demand of vulnerable roadusers.

Fractures of the lower extremity (femur, tibia, fiblua) are reported to be frequent, severe, and costly to society and to the individual [14,20,21,22]. A study by Levine examining the effects of lower limb injuries reported that a high proportion of severe musculoskeletal trauma was related to motor vehicle crashes, and that traffic crashes were a significant cause of lower limb injury such as femoral shaft fractures [23]. The same study also reported that the length of stay associated with femoral fractures ranged from 16 – 40 days depending on the exact nature of the injury and treatment type, and that the time to return to work was, on average, 11 months [23].

The MAA published figures regarding the administration of the compulsory third party scheme in NSW and reported that lower limb fractures represent 9.5% of the total number of claims yet accounted for 24% of the total cost of the Scheme [20]. In a study of inpatient costs in New Zealand due to motor vehicle traffic crashes, Langley, Phillips and Marshall [14] reported that fractures of the lower limb contributed the highest amount (24%) of any single injury to the total costs of motor vehicle traffic crashes, while representing 18% of the six leading causes of injury. Langley et al [14] reported that 17% of vehicle occupants sustained a lower limb fracture, while 27% of pedestrians, 34% of motorcyclists and 20% of cyclists sustained a fracture of the lower limb [14]. In another study, Langley et al report that 43% of motorcyclists sustained an injury to the lower limb of which 71% were fractures, equating to 30% of all motorcyclists [16]. The abovementioned UK study of road accident casualties did not provide explicit breakdowns of fracture type or lower limb injuries by roaduser class [15].

The influence of age and gender in fractures has been examined in a number of studies, however these studies are usually in the context of fractures due to all external causes or report limited samples, such as children or persons aged 65 years and older [22, 24, 25, 26, 27]. A prospective study of 15000 persons aged 15 years and above with fractures conducted in the UK provides invaluable insights of the effect of age and gender on fracture patterns [24]. When examining the incidence rates of all fractures it was reported that young males, older females, and older males had high incidence of fractures relative to other age groups. The effect for older females was more pronounced than for older males of the same age [24]. The same age and gender trend was seen to apply in the instance of fractures of the femur. It was reported that there was no difference in gender until age 75 years and older with the incidence rate ranging from 0.00 – 5 per 10,000 population for both males and females, and accelerated to 10.7, 16.39 and 37.14 in females aged 80-84, 85-89, & 90-94 respectively [24]. While the incidence of femur fractures in older males increases, it was not of the same order of magnitude as seen for females [24]. Similarly, in a cohort of persons aged over 65 years of age where fractures of the upper and lower extremity due to all causes were studied, it was reported that women had higher rates for all types of fractures than males and that the rate of fractures increased with age for both males and female [27].

With the exception of the study of motorcyclists by Langley and colleagues, the studies of fractures reviewed here do not examine non-fatal motor vehicle crashes alone [14]. The studies reviewed were mixed samples and as such may not be directly relevant to the fracture patterns associated with non-fatal motor-vehicle crashes. In fact, there appears to be a relative paucity of information regarding fracture rates from an admitted hospital sample as a consequence of motor vehicle traffic crashes. The studies reviewed do however report that age and gender are important factors in limb fracture rates. The study by Langley is important as it provides an extremely good base for comparisons for the present study in terms of the percentage of roadusers sustaining fractures of the lower limb. Given that the present study focuses purely on fractures of the femur, the comparison is unfortunately not ideal.

The brief review of literature presented above indicates age and gender difference in motor vehicle crash involvement, and further that this involvement varies according to roaduser class. It was also reported that fractures of the femur are common and costly. However, it was found that there is a relative dearth of studies purely examining the rates of non-fatal admissions due to traffic crashes and the epidemiology of femur fractures in this type of sample. This study aims to go some way in examining these issues. Such a paper is necessary as the reporting of injury outcomes is of epidemiological importance in terms of health planning, vehicle design and the development of appropriately focussed road infrastructure countermeasures. Hence the two key aims of this paper are:

1. To determine rates of admission to hospital by roaduser group, age and gender,
2. To examine the incidence of fractures of the femur as a consequence of non-fatal traffic crashes;

METHOD

To achieve the stated aims of the paper, all non-fatal traffic accident admissions to public hospitals in Victoria will be examined for the 1998-1999 financial year. The dataset to be used is the Victorian Admitted Episodes Database (VAED) held by the Victorian Injury Surveillance and Applied Research System (VISAR) at MUARC.

Description of the VAED

The Victorian Admitted Episodes Dataset (VAED) is a dataset of acute patient hospital admissions in Victoria, Australia, representing 100% coverage of hospital admissions in Victoria. The VAED was developed and is currently maintained by the Victorian Department of Human Services (DHS) in order to fulfil health-reporting requirements to the Government of Victoria [28].

Data available for analysis included age, gender, length of stay, number of ICU hours, injuries and injury cause coded in ICD-10-AM format. The first episode of care relating each person was examined therefore ensuring each person is represented once per event. Re-admissions within 30 days of the first episode of care were excluded.

Description of ICD-10-AM

The International Statistical Classification of Diseases and Related Health Problems was developed by the World Health Organisation (WHO) as a classification system so that diseases and injuries are defined into categories in accordance with established criteria [29]. ICD-10-AM refers to the Australian modification of the 10th Edition of ICD. ICD-10-AM external injury codes are assigned to each admission and "reflect the victim's mode of transportation and are subdivided to identify the victim's 'counterpart' struck by or the type of event" [29, p.444]. ICD-10-AM also distinguishes between traffic and non-traffic distinction, where a traffic accident "is any vehicle accident occurring on the public highway…", and where a "non-traffic accident is any vehicle accident that occurs entirely in other than a public highway" [29, p.444]. This paper focuses only on traffic accidents.

Data Analysis

Admissions with non-fatal outcomes involved in traffic crashes were examined with respect to age and gender differences across roaduser groups. Rates of admission and femur fractures were derived using estimated resident population for Victoria from the ABS for the 1998/1999 financial year [30]. Femur fractures were defined as injuries coded S72 in ICD-10-AM format. Analysis was performed in SPSS Version 10.

RESULTS

Non-Fatal Traffic Crashes

A total of 5276 persons were admitted to hospital and discharged to either the home or some other formal care service, representing 74% (7117) of all admissions due to land transport crashes in the 1998/1999 financial year. This represents a ratio of approximately 13:1 of admissions to deaths in Victoria, a figure that is similar to the ratio of 12.5:1 admissions to deaths for Australia in 1999. A total of 9.9% (523 of 5276) of persons admitted were treated in ICU for some period of time, of which 66% were male.

Occupants of cars (passenger cars / vans / 4WD) accounted for 61.8% of all hospital admissions, followed by motorcyclists (13.1%), pedestrians (13%) and pedal cyclists (10%). Occupants of other modes of transport, such as heavy vehicles, pick-up trucks / vans, buses and 3-wheeled motor vehicles accounted for less then 3% of all hospital admissions.

Overall, males accounted for 61.2% of all admissions to Victorian Hospitals in the 1998 / 1999 financial year. With the exception of car occupants, males out-numbered females in terms of hospital admissions. The male-to-female admission ratio for car occupants was split evenly. The male-to-female ratio for pedestrians reflected the overall rate of admissions with males comprising 62% of all pedestrian admissions, while males represented 92.2% of all admissions due to motorcycle crashes, 78.6% of pedal cyclists, 94.6% of heavy vehicle transport admissions, and 85.7% of all admissions due to crashes involving pick-up trucks / vans. The low number of bus occupants and occupants of three-wheeled motor vehicles precludes any meaningful comments to be made in relation to gender differences.

Figure 1 shows the percent of admissions by age group within roaduser categories. It is evident, although not surprising, that the younger age groups dominate admissions within each category. Persons aged less than 40 years of age represent at least 57% of admissions within each category, and as high at 82% in the case of motorcyclists. The pattern is however slightly different within each roaduser category and thus worthy of discussion.

With respect to car occupants, approximately 30% of all admissions were persons aged 20-29 years of age while an additional 16% were persons aged 30-39 years. Of note was the finding that 10% of all car occupant admissions were persons aged 18 or 19 years of age and yet represent 2.7% of the Victorian population. Persons aged 70 years and older formed approximately 10% of all car occupant admissions, and is representative of the population in Victoria.

The age pattern of pedestrian admissions is somewhat different from all other categories in that there are three peaks, a plateau in the middle age groups (30 – 69) and a nadir in adolescents (16 – 19 years). Children aged 0 – 15 years represent approximately 20% of all pedestrian admissions, followed by persons aged 20 – 29 years (~18%) and persons aged 70 years and older (15%). The antecedents of the involvement of these three groups may be different and therefore important in guiding road countermeasure and injury prevention efforts.

Pedal cyclist hospital admissions due to traffic crashes were dominated by children (38.4% cf. 21% in population), followed by young adults aged 20 – 29 years of age (21.2%). As with pedestrian admissions, persons aged 16 – 19 years of age represent a low proportion of admissions, yet are twice that expected based on population distribution. The proportion of cyclist admissions decreases with age such that persons aged 60 years and above represent 4% of all cyclist admissions while representing 15% of the population.

The age distribution of motorcyclist hospital admissions indicates that persons aged 20 – 29 years of age represent 43.4% of all motorcyclist admissions, followed by persons aged 30 – 39 years of age (22.3%). It is noteworthy to mention that these age groups each represent 15% of the population, indicating the magnitude of over-involvement. As with cyclists, the proportion of motorcycle admissions decreases with age.

The pattern of admissions for occupants of pick-up trucks and heavy transport vehicles is similar, and are both dominated by persons aged 20 – 49 years of age. Persons less than 20 years of age and over 60 years of age form a small proportion of admissions in these two categories.

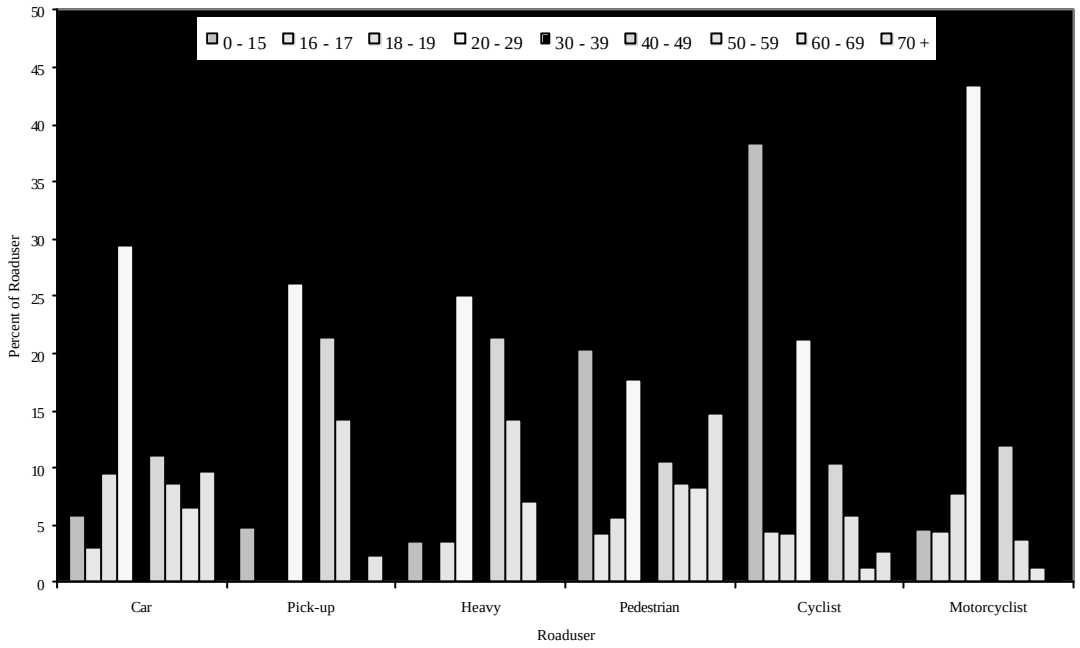

Figure 1. Percent of admissions per age group by roaduser category

Admission rates adjusted for population are important as they provide a more accurate reflection of accident involvement than simply percentages and allow for comparison with other jurisdictions. In presenting admission rates, the categories of pick-up trucks and heavy transport vehicles will be excluded due to very low numbers. Consequently, the remainder of the paper will focus on occupants of cars, pedestrians, cyclists and motorcyclists.

Figure 2 shows the admission rate (per 100,000 population) of car occupants, pedestrians, cyclists, and motorcyclists by age-group and gender. The overall admission rate for occupants of cars, pedestrians, cyclists, pedal cyclists, and motorcyclists was 135.4 per 100,000 males in the population and 85.7 admissions per 100,000 females in the population.

The admission rate for car occupants, both male and female, was significantly greater than pedestrians, cyclists, and motorcyclists. Overall, the admission rate for male car occupants was 71.7 per 100,000 in the population and 67.6 per 100,000 females in the population. Male and female car occupants aged 18 – 19 years of age had the highest admission rate following traffic crashes, at 266 and 210 admissions per 100,000 persons in the population respectively, followed by males and females aged 20 – 29 years. The admission rate for males and female aged 20 – 29 years of age was 144 and 124 per 100,000 in the population respectively. Interestingly, the admission rate for males aged 40 – 69 years was lower than that of females of the same age, however males aged 70 and older demonstrate an increased admission rate (87 per 100,000 population) compared to their younger male counterparts and females of the same age (68 per 100,000 population).

The pedestrian admission rates presented in Figure 2 demonstrate that young males have higher rates of admission compared to females of the same age, and that admission rates increase from age 60 years for both males and females. The overall admission rate for male and female pedestrians was 18.4 and 11.1 per 100,000 in the population respectively. The admission rate for male pedestrians aged 16 – 17 years and 18 – 19 years was approximately twice that of females of the same age. Admission rates for persons aged 30 and above were low for male and female pedestrians until rising to a further peak in males (26 per 100,000) and females (23 per 100,000) aged 70 years and older.

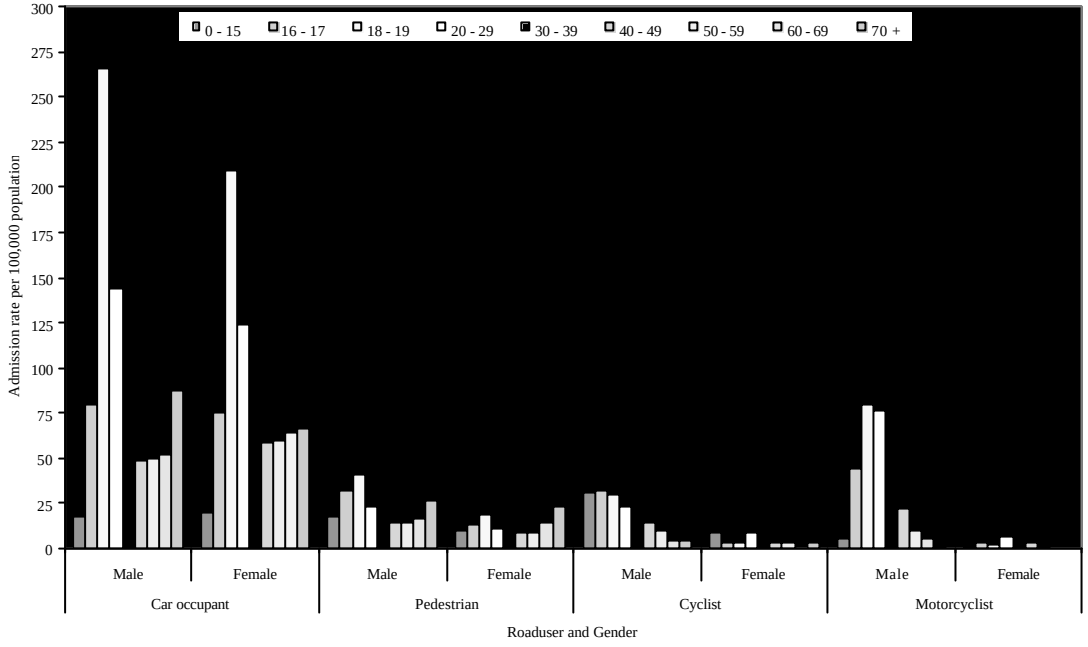

Figure 2. Admission rates per head of population by age-group, gender and roaduser

The admission rates for male cyclists and motorcyclists are significantly greater than female motorcyclists at every age group, particularly at the younger age groups. With respect to cyclists, the overall admission rate for male and female cyclists was 17.8 and 4.7 per 100,000 in the population respectively. Notably, male admission rates range from 1.4 times (70 years and older) to 10 times (Persons aged 16 – 17 years; 18-19 years of age) that of females. In persons aged 19 years or less, the admission rate for male cyclists was approximately 30 per 100,000 compared to the admission rate for females of the same age groups, being on average, 5 per 100,000.

Motorcyclist admissions demonstrate a clear differential between males and females as seen in the overall admission rates for males and females and decrease dramatically with age. The admission rate for male motorcyclists was 27.5 per 100,000 males compared to 2.3 per 100,000 females in the population. Male admission rates were found to be as low as 7 times that of female admission rates and as great as 50 times that of female admissions. The admission rate for males age 60 years and older and females of all ages is minimal, perhaps reflecting low use of motorcycles. On the other hand, admission rates of young male motorcyclists were found to be have admission rates that are extremely high and comparable to admission rates of 16 - 17 year old and 30 – 39 year old male car occupants. The admission rate for male motorcyclists aged 18 – 19 years and 20 – 29 years of age was 79.8 per 100,000 head of population and 76.61 per 100,000 head of population, representing 50 times and 11 times, respectively, greater than female motorcyclists of the same age.

The incidence of fractures of the femur as a consequence of traffic crashes

As noted in the Introduction, fractures of the femur often result from severe musculoskeletal trauma following exposure to violent forces that exceed the injury tolerance of the human. This section examines the incidence of femur fractures among car drivers, car passengers, pedestrians, cyclists and motorcyclists. Injury data was known and complete for 96.8% (N=4933) of cases.

Table 2 presents the number and percentage of fractures of the femur by gender and roaduser class. A total of 257 persons sustained a fracture of the femur (S72), representing 5.2% of all car drivers, passengers, pedestrians, motorcyclists and cyclists. A slightly higher proportion of males' sustained fractures of the femur (6%) compared to

females (5.2%). Motorcyclists had the highest proportion of femur fractures (9.3%) followed by pedestrians (7.6%). Approximately 10% of male motorcyclists and 7.4% of female motorcyclists sustained a fracture of the femur. A high proportion of female pedestrians sustained a fracture of the femur (8.8%) while 6.9% of male pedestrians sustained a femur fracture. A higher proportion of male drivers and passengers of cars sustained fractures of the femur compared to females. Finally, approximately a similar proportion of male (6.1%) and female (5.5%) cyclists sustained fractures of the femur

Table 2. Number and percent of fractures of the femur by roaduser and gender

Roaduser	Males			Females			All		
	Number of fractures	%	Total	Number of fractures	%	Total	Number of fractures	%	Total
Driver	54	4.7	1158	26	2.9	886	80	3.9	2044
Passenger	15	3.6	416	15	2.6	587	30	3.0	1003
Pedestrian	29	6.9	420	23	8.8	262	52	7.6	682
Cyclist	25	6.1	408	6	5.5	109	31	6.0	517
Motorcyclist	60	9.5	633	4	7.4	54	64	9.3	687
Total	183	6.0	3035	74	3.9	1898	257	5.2	4933

Figure 3A and 3B shows the rate of femur fracture for drivers and passengers of cars and pedestrians, cyclists and motorcyclists involved in traffic crashes by age group per 100,000 persons in the Victorian population. Examination of Figure 3A and 3B shows that motorcyclists aged 20 –24 years of age had the highest rate of femur fractures of all age groups across roadusers at 5.27 per 100,000 persons in the population, followed by drivers aged 15 – 19 years (4.98), drivers aged 20-24 (4.38), and motorcyclists aged 25-29 years of age (4.03 per 100,000).

The rate of fractures of the femur for drivers of cars per head of population (see Figure 3A) demonstrates two key points. Firstly, the peak in the rate occurs in young adults aged 15-24 years of age, falls until age group 55-59 years whereupon the rate rises to a second peak at age 75-79 years of age. The fracture rate falls away in persons 80 and above due to low numbers in the population and presumably due to the low numbers of this age using vehicles either as a driver or passenger. A similar trend in fracture rates is seen in passengers, although the rates are lower.

The equivalent pattern of femur fracture rates for motorcyclists is shown in Figure 3B. As noted above, motorcyclists aged 20-24 years had the highest rate of femur fractures, followed by motorcyclists aged 25-29 years of age while no persons aged 50 and older sustained fractures of the femur. These results clearly indicate the exposure difference in, and perhaps inherent vulnerability of, motorcycle use. It must be noted that if licensing rates rather than population was used to determine fracture rates, the values for motorcyclists would be considerably higher for motorcyclists than for car occupants.

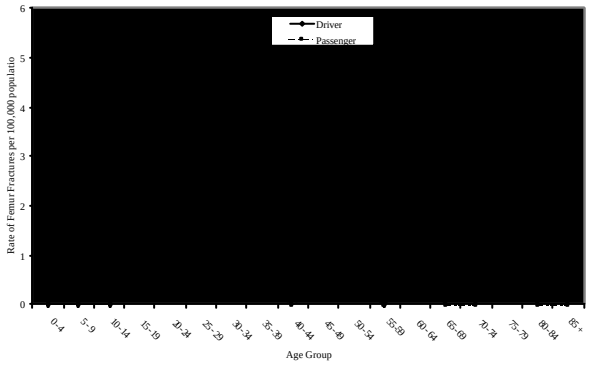

Figure 3A. Rate of femur fracture for drivers and passengers of cars involved in traffic crashes

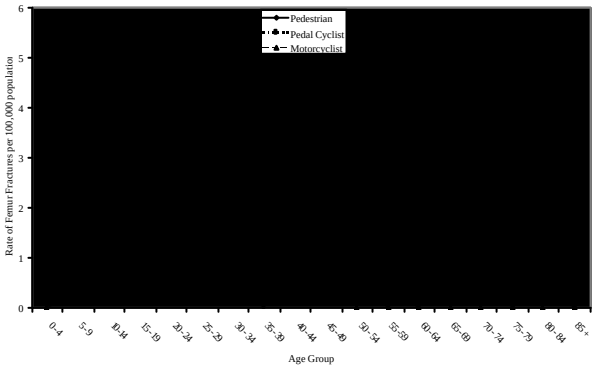

Figure 3B. Rate of femur fracture for pedestrians, cyclists and motorcyclists involved in traffic crashes

The pattern of femur fractures for cyclists and pedestrians are similar in that they are bimodal and share a similar magnitude of fracture rates across each age group. The fracture rates for pedestrians are highest amongst children (0-9 years) and are again relatively high in persons aged 55-59 years (2.69) and 70 – 74 years (2.51) of age. The fracture rate for cyclists is highest for persons aged 10 – 14 years (2.53 per 100,000), for persons aged 15-29 years of age (1.25), and for older adults aged 65-69 years (1.14) and 70-74 years of age (1.88).

Figure 4 shows the rate of femur fracture for all roadusers involved in non-fatal traffic crashes by age-group and gender. There are two major points to be made in relation to Figure 4. Firstly, the fracture rate is bimodal for both males and females in that it is high in young adults, falls in the middle age groups and then rises from age 60 years and older. This rise in fracture rates in older adults is best seen in the combined rate of males and females. Secondly, the fracture rate for males is consistently higher than for females with the notable exception of females aged between 75-79 years of age. Also noteworthy is the difference in the magnitude of peak fracture rates and at which age they occur. For instance, the peak rate for males occurs at age 15-19 (~21 per 100,000), 20-24 years of age (~22 per 100,000), and remains high for persons aged 25-29 yeas of age (~16 per 100,000). Young females of the same age group have significantly lower values with the corresponding value of approximately 7 femur fractures per 100,000 for the age group 20-24 years of age. The peak in fracture rates for females occurred in the 70-74 year old age group at approximately 10 fractures per 100,000 persons with the corresponding male value being slightly lower at approximately 8 per 100,000 in the population.

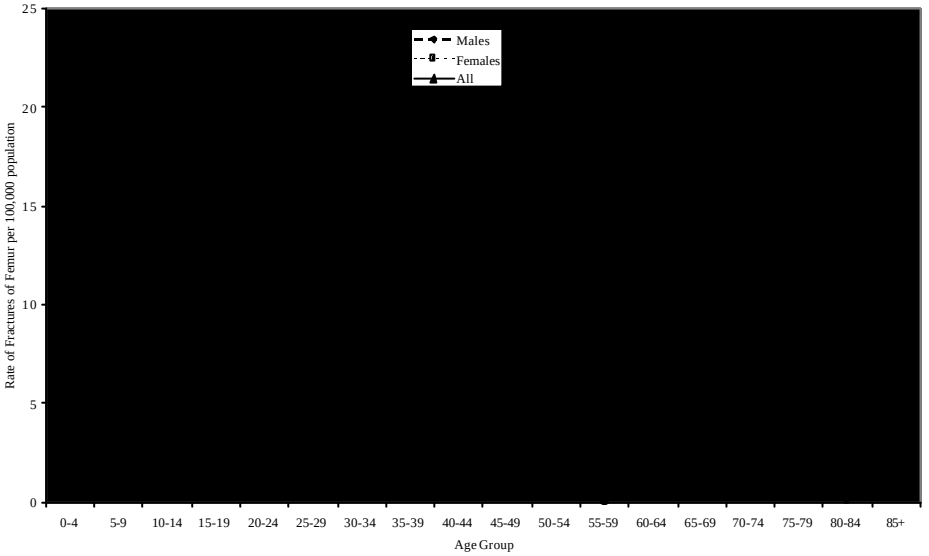

Figure 4. Rate of femur fracture for roadusers involved in non-fatal traffic crashes by age group and gender

Femur fracture rates by age-group and gender were examined within roaduser categories. There are a number of differences in the fracture rates for males and females within each category but they consistent such that males have higher fracture rates compared to females at most age groups. The most noteworthy of these differences are in the higher femur fracture rates of young male car occupants compared to females of the same age, older male cyclists compared to female cyclists, and the high fracture rates among male motorcyclists aged between 15 – 39 years compared to the almost non-existence of femur fractures in female motorcyclists of the same age.

CONCLUSIONS

This paper presented the demographic characteristics, hospital admission rates, and femur fracture rates by roaduser, age and gender as a consequence of involvement in non-fatal traffic crashes in Victoria, Australia.

The distribution of admissions by roaduser groups was similar to that reported the study of UK admissions, although motorcyclists in the UK represented a slightly greater proportion of admissions than the current study, while the converse was true of cyclists [15]. The distribution of roaduser types in this study, and the UK study, were somewhat

dissimilar to those reported by Langley et al who reported a higher proportion of motorcyclists (26% cf. 13%) and a lower proportion of car occupants (50% cf. 61.8%) and pedal cyclists (4% cf. 10%) [14]. The differences in agreement may simply rest in sampling frames with the present study relying on all public hospitals in Victoria, the UK study was based on 18 hospitals while the NZ study based national estimates on a single hospital sample.

The examination of hospital admission data revealed that persons aged 20 – 29 years represented a significant percentage of admission across all roaduser categories, followed closely by persons aged 30 – 39 years of age. Notably, person's aged 0 – 15 represented a large percentage of cyclist admissions, while persons aged 70 years and above represented 15% of all pedestrian admissions. The age distribution is remarkably similar to casualties presenting to UK hospitals as reviewed in the Introduction of this paper. The over-representation of male admissions compared to females given particular roaduser categories data may simply reflect the gender distribution of vehicle use and / or differences in risk-taking behaviour.

When admissions were examined on a population rate basis it was evident that car occupants aged 18 and 19 years of age were admitted at a rate almost three times that of the overall average. Pedestrians aged 70 years and older demonstrated higher admission rates than persons aged 30-69 years of age. Notably, males had a significantly higher admission rate than females overall, perhaps reflecting involvement in more frequent and serious collisions compared to females. The high proportion of male admissions reported in the present study is consistent with previous studies. A study of motorcycle crashes resulting in hospitalisation in NZ provides a useful comparison for present study [16]. The present study reports an overall admission rate for male motorcyclists of 27.5 per 100,000 persons per annum comparing favourably to that reported for male motorcyclists in NZ of 119.6 per 100,000 persons per annum. The peak rates of motorcyclists in the present study are significantly lower than that reported in the NZ study (79.8 per 100,000 persons per annum cf. 416 per 100,000 persons per annum) [16]. Similarly, the admission rate for persons aged 15 – 19 are lower than those reported in a study of trauma among urban adolescents in NZ, although due to the age group structure the studies are not directly comparable [17].

The present study also reports the number and percentage of fractures of the femur by roaduser for males and females, and rates of femur fractures per 100,000 persons per annum. A total of 257 persons sustained a fracture of the femur, representing 5% of all admissions. Motorcyclists sustained the highest proportion of femur fractures of any roaduser class (9.3%) followed by pedestrians (7.6%), cyclists (6%), car drivers (4%), and passengers (3%). In comparison with other studies, the proportion of roadusers sustaining fractures is low as was also the case for fracture rates, although these studies are not directly comparable. Consistent with other studies is the bimodal nature of fracture rates, peaking in young and older adults. The gender effect reported in this study is also consistent with earlier studies that examined the effect of age and gender on fracture rates.

The present study has a number of limitations that need to be acknowledged. With respect to the sample, using a single year of admission data may mean that data is not representative of the injury profile over a period of years and that estimates may lack precision for rare events. This was seen in the instance of the occupants of heavy transport vehicles, buses, and three-wheeled motor vehicles. Future analysis could use a number of years combined to counteract these potential problems. A further potential limitation of the sample was the private hospitals were not included in the analysis. This is a potential problem as there are a large number of private hospitals in Melbourne with large and fully equipped A&E Departments. The use of traffic crashes on public roads only in the analysis potentially excludes large numbers of cyclists and motorcyclists who may have crashed and sustained injuries off public roads. Finally, it must be noted that a concerted effort was ensure the first episode of care only was examined by using cases presenting through A&E departments and excluding readmissions within 30 days of initial presentation. Having mentioned these data limitations, the data quality is a strength of the present study given that the data entry, coding and error checking procedures are an integral part of governmental monitoring of hospitals and is guided by Acts of Parliament. In the production of admission rates and femur fracture rates, the Victorian population was used as the denominator. Future analysis could also use licensing rates for cars, motorcyclists and other vehicles to obtain more accurate, and less underestimated rates. Finally, in the formulation of admission and fracture rates it was not possible to control for accident type (front, side etc…) or severity (impact speed). For analysis it was decided that persons must have been in traffic crashes involving a collision with the ICD-10-AM category of cars / vans / 4WD, and that patients must have been discharged home or to another care type. These principles of inclusion provide some degree of uniformity, albeit poor, over accident circumstances given that there was no information in the VAED indicating accident type or severity. In conducting this analysis it was felt that the ICD-10-AM category is over-inclusive by categorising car, vans and 4WD vehicles together despite large differences in mass and geometry, and reported differences in aggressivity [31]. It is recommended that future revisions of ICD

separate cars, vans and 4WD vehicle into single categories so as to allow for appropriate examination of vehicle types on injury outcomes.

While such results are not particularly surprising it is, however, important that such evidence is presented as it underlies the vulnerability of unprotected roadusers to serious and potentially long-term debilitating injuries. Despite the limitations mentioned, the implications are clear. It is apparent that the current road transport system does not tolerate well vulnerable roadusers as indicated by high rates of involvement and serious injury. Particular roaduser groups are at increased risk and represent key targets for injury prevention efforts. Renewed efforts should be made to improve the compatibility of vehicles and vulnerable roadusers in an attempt to minimise injury outcomes in the event of a collision. In addition, effective pedestrian and cyclist countermeasures, such as improved separation of cyclists and vehicles and appropriate speed limits in high density pedestrian and cyclist areas, should be implemented as a matter of urgency. Given the increased risk for older adults to sustain injuries in the event of a collision, attention should be paid to effective education campaigns designed to highlight the potential dangers of being a pedestrian or other forms of road use that might place them in a 'vulnerable' position. This is particularly pertinent for older adults who do not renew their licence or have it removed and seek alternative transport solutions. With respect to motorcyclists, countermeasures might include differential speed limits and more rigorous licensing and rider training requirements. The implications for vehicle engineering are also evident. Given the incidence of fractures of the femur among car occupants, regulatory tests for vehicles might include lower limb loading measures for occupants and potential collis ion counterparts. A step in this direction has been taken with the recent introduction of pedestrian NCAP tests in Europe. Finally, the presentation of the magnitude of traffic crashes to the public and governments requires revisiting. It may be the case that renewed momentum towards a crashworthy system would be achieved if the public and government were informed on the number and types of injuries sustained on our roads as opposed to simply the number of fatalities on a daily basis.

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