Paediatric Spinal Injuries in Traffic-Related Incidents

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Abstract

Spinal trauma in children is not common, but the cost is high – both financially and emotionally, and is most commonly seen as a result of traffic related events. This study aimed to characterise the types and numbers of injuries to the spinal region among children (0-16 years) resulting from traffic incidents. This included motor vehicle occupants, pedestrians, bicyclists, and motorcyclists. A retrospective case review methodology was used. All children 16 years of age and under, treated at the major children's hospitals in Sydney after sustaining any spinal trauma from a traffic related cause over a five year period, were included. Injury type, severity, and mechanisms were analysed and the changes with age investigated. Data was collected for 101 children. Descriptive analytical techniques were used.

Occupants made up approximately 60% of all spinal injury cases, pedestrians accounted for 17%, and bicycle and motor cycle riders approximately 8% and 15% respectively. There were, however, significant variations in the type of traffic incident leading to spinal injury depending on age. There were also differences in the pattern of injury with age. Minor injuries accounted for 44% of the sample, spinal cord injuries 13%, fractures without cord injury 31% and serious soft tissue injuries (without fracture or cord injury) 12%. Children under 5 years were more likely to sustain serious injuries than older children.

This study demonstrates that in order to reduce traffic-related paediatric spinal injury, addressing protection in child occupants should be the highest priority. There is a particular need for further examination of injury mechanisms in children too big for booster seats. Pedestrians would be the next priority, specifically children less than 5 years. Motorbike crashes accounted for more serious spinal injuries than pedal cycle incidents. Furthermore, the findings suggest that different injury prevention strategies may be required for younger (<10 years) and older children (>10 years), and crash factor studies in this area are recommended. In particular there may be a need to examine the relationship between motor coordination development and motorcycle handling in off-road situations.

Keywords

Spinal injury, child, occupant, pedestrian, motorcycle

Introduction

Spinal trauma in children is often reported to be relatively rare, however, the significance of these types of injuries is high, both in terms of medical costs and social impacts to the child and family.

Epidemiological studies have demonstrated that spinal injuries to children account for somewhere between 1 and 10% of all spinal trauma [1-4] and for approximately 5% of all trauma to children (Cirak et al, 2004). As is the case for adults, the most common cause of spinal trauma in children is motor vehicle crashes [3, 5].

While there have been a number of recent investigations into the incidence and mechanisms of spinal injury in children in other jurisdictions [1, 3, 6, 7], there has been no similar study in Australia. Evidence from these studies suggests that the frequency of spinal trauma varies depending on the type of motor vehicle crash leading to spinal injury, i.e. car to car, pedestrian, motorcycle or bicycle, and the age of the child. Many of these studies have looked at spinal cord trauma and vertebral column injuries [3, 4, 7-9], or a specific region of the spinal column [10-13]. Very few have looked at the entire spectrum of spinal trauma in children in motor vehicle crashes. In addition, very few, if any, have separated out the different types of motor vehicle related mechanisms and examined differences in the frequency and nature of spinal trauma occurring as a result of these different but related mechanisms of injury. Further, there has been no broad comparison of the spinal injury experience of children injured in transport related incidents in Australia compared to other countries.

The aim of this study was to characterise the types and numbers of significant injuries to the spinal column sustained by children aged 0-16 years inclusive as a result of traffic incidents. This included motor vehicle occupants, pedestrians, bicyclists, and motorcyclists.

Methods

Data collection

Subjects included all children who attended either the Sydney Children's Hospital or the Children's Hospital at Westmead, subsequent to any traffic related accident, who sustained any injury or pain to the spine or neck. As these two hospitals contain the only paediatric spinal units in NSW, the vast majority of serious paediatric spinal injuries are treated at one of these hospitals. A five-year period (1999-2004) was selected. These cases were identified using a search of medical records for all relevant ICD codes. These codes were selected to include injuries to the spinal cord, vertebral column and surrounding soft tissues. Hereafter, we refer to spinal injuries as "injuries".

Medical data related to the spinal injury and any other concomitant injuries sustained during the injury event were entered in a custom database. Information on the injury event contained in the medical record or ambulance sheet (when present) was also recorded. For occupants, restraint use was noted. For cyclists, helmet use was also noted if known.

The study methodology was approved by the Human Ethics Committees at the Children's Hospital at Westmead and the South Eastern Area Health Service, and ratified by UNSW.

Data analysis

After entry into the database, a series of custom codes were used to describe the type of spinal injury. The injury type categories included are shown in Table 1.

Table 1:. Injury categories used to classify data

Injury category
Spinal cord injury without radiographic abnormality (SCIWORA)
Fracture only
Fracture plus spinal cord injury
Fracture plus soft tissue injury
Fracture plus transient neurological symptoms
Major soft tissue only
Minor soft tissue only
Pain only
Soft tissue plus spinal cord injury
Soft tissue plus transient neurological symptoms
Transient neurological symptoms only

These were further categorised as serious or not serious, where the serious injuries were defined as SCIWORA, fracture only, fracture plus soft tissue, fracture plus cord injury, fracture plus transient neurological symptoms, soft tissue plus spinal cord injury, or major soft tissue only. The spinal level was also coded as cervical, thoracic, lumbar or sacral. Where injuries to more than one level were present, these were coded as the level of the most serious injury, or the highest spinal level if two equal severity injuries occurred. For example, in a subject who sustained a soft tissue injury at T5, but a fracture at C4, the injury would be coded as a cervical injury. Aetiology descriptors coded the type of precipitating event (occupant, pedestrian, bicyclist, motorcycle, other traffic). Within each of these broad categories, the mechanism was further coded as shown in Table 2.

Table 2: **Mechanisms of injury codes for traffic related spinal injuries**

Event	Mechanism
Occupants	Restrained adult belt Unrestrained Restrained CRS Restrained booster Restraint status unknown
Pedestrians	Pedestrian hit by car travelling <30km/hr Pedestrian hit by car travelling >30km/hr Pedestrian hit by car by car unknown speed Pedestrian hit by another vehicle (not car)
Bicyclists	Cyclist hit by car travelling <30km/hr Cyclist hit by car travelling >30km/hr Cyclist hit by car by car unknown speed Cyclist hit by another vehicle (not car)
Motorcycle (driver or passenger)	Ran into stationary object (e.g. fence) Hit by vehicle Hit by another object Lost control and fell off

The presence of injuries in addition to any spinal injury was also coded, in order to assess how often spinal-injured patients sustained multiple injuries.

Statistical analysis included the use of chi-squared and, where relevant, Fisher's exact test to determine significance. $P<0.05$ was set as the significance level. Post-hoc analysis was done using standardised residual analysis to identify the cell(s) with significant associations [14].

Results

General characteristics

One hundred and one motor vehicle and traffic-related spinal injuries among children aged 0-16 years (inclusive) who attended either the Sydney Children's Hospital or the Children's Hospital at Westmead during the study period were identified. This was the most common cause of spinal trauma, and represented approximately 30% of all spinal injuries for this age group at the two hospitals, with other leading causes being falls and sport. For the more serious spinal injuries, including spinal cord injuries, spinal fractures and major soft tissue injuries which involved dislocation or subluxation of the spine, traffic injuries accounted for nearly half of the sample. There were a total of 50 serious spinal injuries sustained in traffic related incidents.

The proportion of children suffering spinal injuries as a result of a traffic related event rather than some other cause varied slightly with age, with traffic related injuries accounting for slightly more of the younger children than the older children. This pattern was similar for the subset of children with serious injuries.

Children sustaining traffic-related spinal injuries were classified into occupants, pedestrians, pedal cyclists, motorcyclists (driver and passenger) and other. "Other" included two skateboarders injured while skating on the road. Overall, occupants accounted for approximately 60% of all spinal injuries, pedestrians 17%, and bicycle and motorcycle riders approximately 10% and 15% respectively. When the minor injuries, such as muscle strains, cuts and bruises, are excluded, traffic injuries account for approximately half of the spinal injury cases. Of those more serious spinal injuries, 50% were occupants, 24% pedestrians, 12% were bicyclists and 14% were using motorcycles ().

Table 3: Causes of traffic related spinal injuries

Category	All Spinal Injuries	Serious Spinal Injuries
Occupant	59	25
Pedestrian	17	12
Pedal Cycle	8	6
Motorcycle	14	7
Other	3	-
Total	101	50

There were, however, significant variations in the type of traffic incident leading to spinal trauma depending on age. As shown in Figure 1, fewer younger children (<8 years) received spinal injuries as an occupant than older children (9 -16 years), but more spinal trauma occurred in the youngest and oldest children injured as pedestrians (0-4 years, and 13-16 years) than children aged between 5 and 8 years of age. It is worthy of note that there were more spinal injuries among motorcyclists than pedal cyclists in this sample, including more serious injuries. The distribution of spinal injury causes among age groups was statistically significant (Fisher's exact test), p=0.04, with post-hoc analysis of the standard residuals indicating that children aged 0-4 were more likely to suffer injuries as pedestrians than children in other age groups.

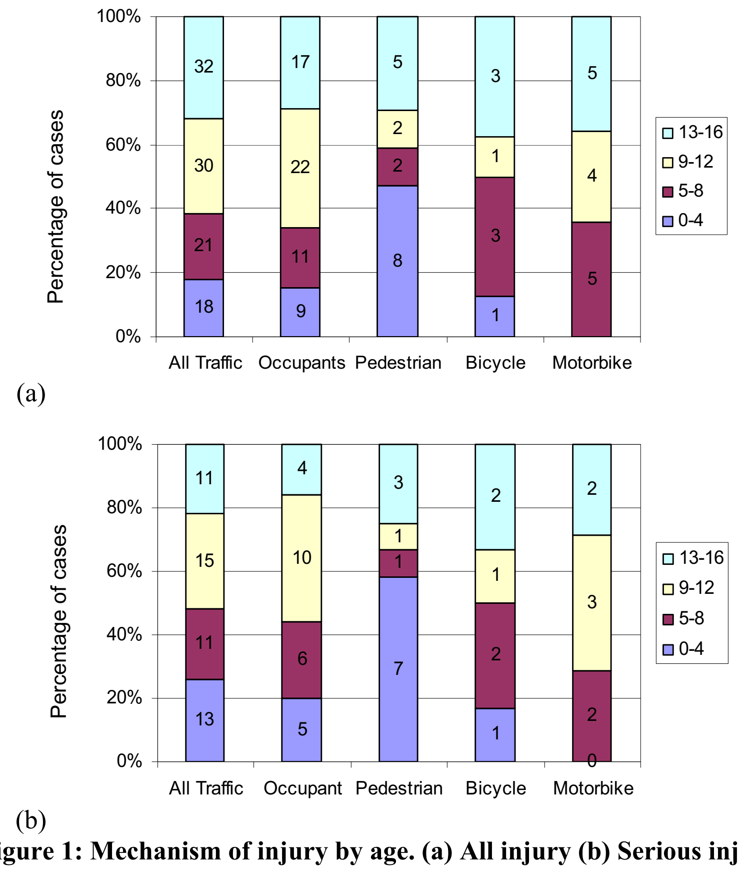

Figure 1: Mechanism of injury by age. (a) All injury (b) Serious injury

For children suffering spinal trauma from traffic incidents, the incidence of injury increased with age. Figure 2 shows the age distribution of all traffic injuries.

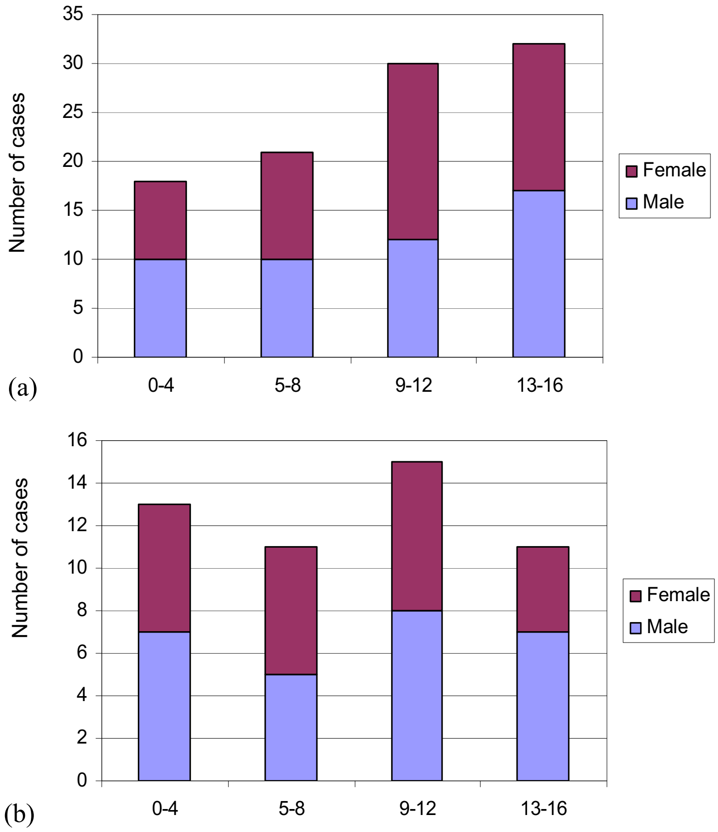

Figure 2: Age and gender distribution for all traffic injuries.(a) all traffic injury (b) Serious traffic injury only

Overall, traffic injuries were predominantly sustained at the cervical level (Cervical = 73%, Thoracic=12%, Lumbar=13%, Sacral=2%). This was also true for the subset of serious injuries, but the proportions were different (Cervical = 54%, Thoracic=21%, Lumbar=21%, Sacral=4%). See Figure 3.

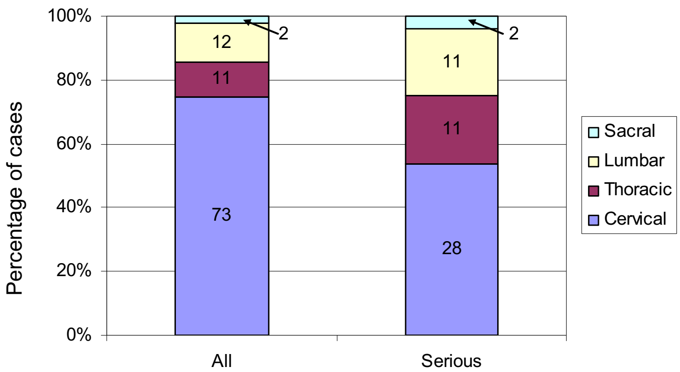

Figure 3: Distribution of spinal level for all traffic injuries and for the more serious subset of injuries.

Different patterns of injury can be seen according to age, as shown in Figure 4. Of particular interest is the increased proportion of soft tissue "whiplash" neck injuries in children over 5 years of age. That is, the proportion of cervical injuries that are minor is higher in children over 5 years (40/56 cervical injuries) than in children under 5 years (5/17 cervical injuries). Also of interest is that serious thoracic injuries were not seen in children under 9 years of age. The overall distribution of injury level with age was statistically significant (p=0.028, Fisher's exact test), and post-hoc analysis of the standard residuals indicated this was due to the increased proportion of 13-16 year olds sustaining thoracic injuries compared to other age groups. Among the serious injuries, the Fisher's exact test was also significant (p=0.001), and in this case in addition to the increased proportion of 13-16 year olds sustaining thoracic injuries, the 0-4 year old children sustained cervical injuries more frequently than other age groups.

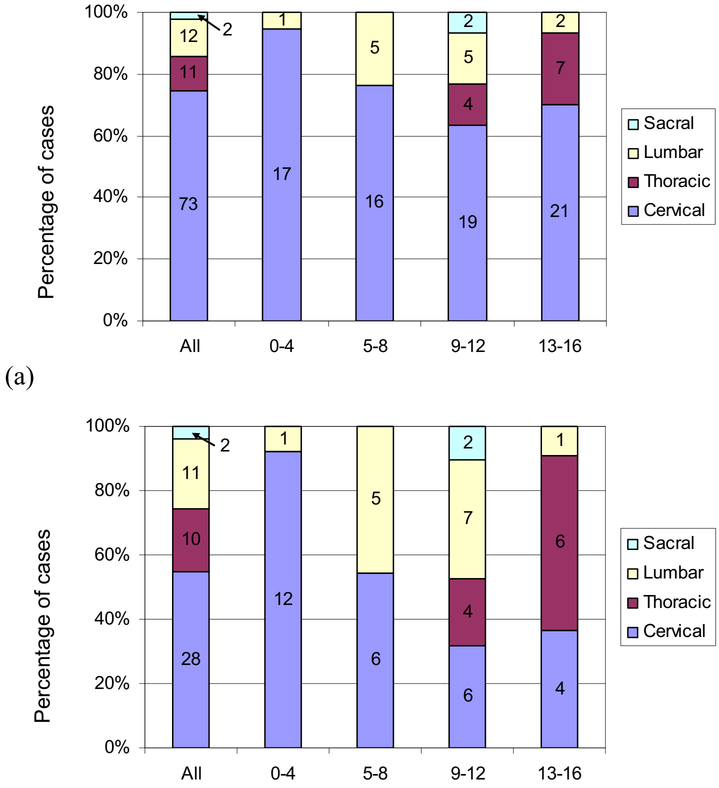

Figure 4: Injury by age and level. (a) All traffic injuries, (b) serious injuries only.

The serious cervical injuries were examined in more detail to identify any associated between age and injury level. Figure 5 shows that children up to 12 appear to sustain more high cervical injuries (C3 and above) while children older than 12 more commonly sustain lower cervical spine injuries, but the numbers are too small to draw firm conclusions. Note that 2 cases where the specific spinal level was not in the medical record are excluded from Figure 5.

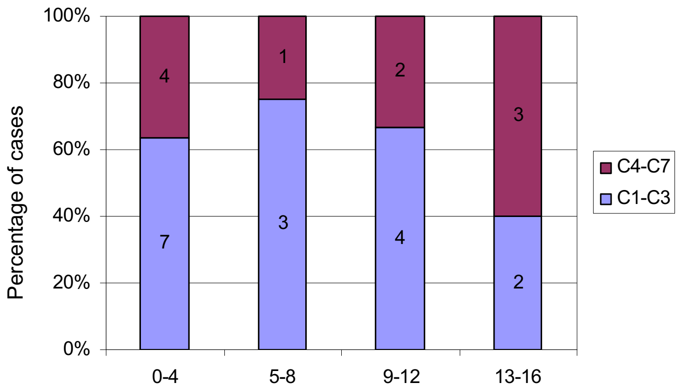

Figure 5: Serious cervical spine injuries by age and region of the cervical spine affected.

The type of injury is shown in Figure 6. Note that cases with spinal cord injury and a fracture are shown in the cord injury group rather than the fracture group. The minor injuries include neck strains, muscle spasms, transient tingling in fingers, cuts and bruises, and neck pain with no other findings.

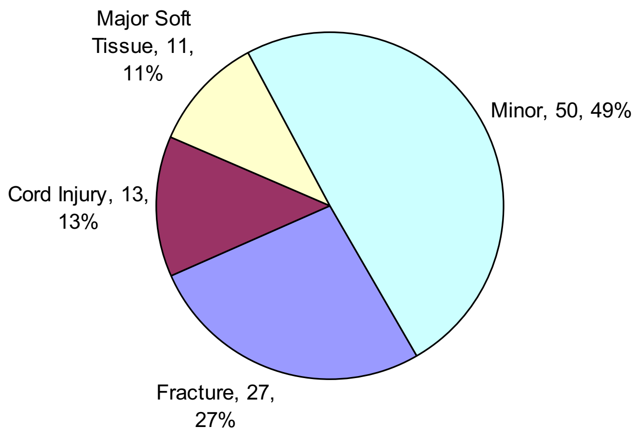

Figure 6: Injury type for all traffic injuries.

When the injury type is examined for different age groups, it appears that the youngest children are more prone to spinal cord injury, while children in the oldest age group are more likely to sustain a minor injury, as shown in Figure 7. However, the numbers for each group are small and the differences were not statistically significant.

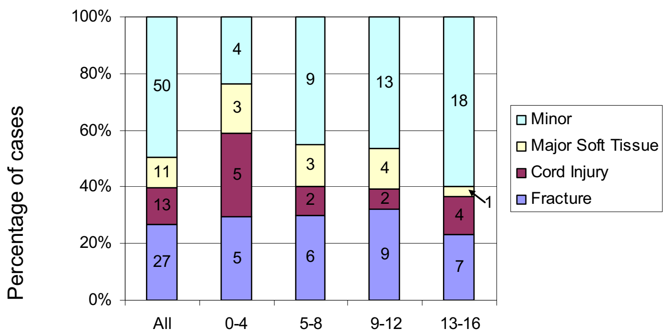

Figure 7: Injury type for different age groups.

Spinal injuries were often associated with other injuries. Seventy percent of cases involved at least one injury in addition to the spinal injury. Moreover, those with multiple injuries were more likely to sustain serious spinal injuries, as shown in Figure 8. Note that 5 cases where the presence or absence of other injuries was not clearly documented were excluded from Figure 8. Isolated injuries were statistically more likely to be minor (Fisher's exact test p=0.011, post-hoc residual analysis)

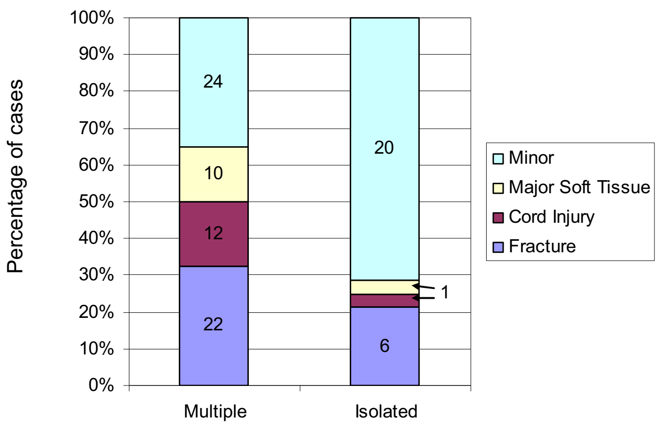

Figure 8: Relationship between type of spinal injury and other injuries.

Discussion

As with any hospital records based study, one must consider whether the sample was representative. The two hospitals from which cases were sourced are the two hospitals with paediatric spinal cord injury facilities. This means that the majority of serious spinal injuries in the state are transferred to one or other of these hospitals for final diagnosis and management. Therefore the sample will include many of the more serious spinal injuries from across the state, and thus the proportion of serious injuries may be exaggerated in this sample. However, children who sustain fatal injuries, whether the fatal injuries were to the spine or other body regions, and die at the scene are likely to have been missed in our sample. The accuracy of non-medical data in the medical records, such as injury mechanism, restraint use etc is open to question, as these are usually obtained from reports of a parent or other carer, or from the ambulance records. Note also that the sample of traffic-related cases is only 101 cases, and caution should be exercised in not over-interpreting the results.

The primary impetus for conducting this study was the recent finding by Brown et al. [15] that 6% of children aged between 2 and 8 years attending Westmead Children's Hospital following involvement as an occupant in a motor vehicle crash between July 2003 and January 2005 had sustained some form of spinal trauma. This was higher than expected with earlier similar Australian studies reporting 2% of child occupants with injuries to the spinal region and international studies reporting similarly low incidences in samples of restrained child occupants [16-18].

In this study, spinal trauma as a result of motor vehicle related incidents accounted for approximately 30% of all paediatric spinal trauma, and occupants accounted for almost two thirds of these cases. These figures are not dissimilar to international studies. Cirak et al. [6] reported 51% of their sample of children with all forms of spinal trauma collected at a North American Level 1 paediatric trauma centre were involved in motor vehicle related incidents, and 29% of these sample were occupants. Osenbach et al. [3], and Carreon et al. [1] studied children with more serious injuries and reported 56% and 66% of their samples respectively were attributable to motor vehicle related incidents, with occupants accounting for more than three quarters of the motor vehicle incidents in both studies. In our current study, occupants accounted for approximately half of the serious motor vehicle related cases, and traffic-related incidents accounted for approximately have of the serious spinal injuries, which is a sample more comparable to the above studies. The most meaningful comparison would be to compare population-based incidence, but this data is not available in Australia currently.

Our results agree with many of the epidemiologically based reviews of paediatric spinal trauma in other countries, in that motor vehicle related incidents were the leading cause of paediatric spinal trauma. Like other studies, we also saw an increase in the numbers of children suffering spinal trauma with age. The proportions of children suffering spinal trauma as a result of different types of motor vehicle events also varied with age with our sample containing more occupants aged over 8 years, and more children at the extremes of our range (i.e. the youngest and the oldest) being injured as pedestrians than other studies. Interestingly, this pattern was the same for the more serious injuries and the less serious injuries.

Unlike other studies, our sample contained approximately the same number of males and females overall, but there were more females than males in the occupant category. The reasons for this are unclear. However, males dominated the pedal cycle and motorcycle categories, and there were slightly more male than female pedestrians. Almost all studies reported in the literature have found adolescent boys are the children most often sustaining spinal trauma [6, 13]. According to Reddy et al. [7] there may be a physiological basis for the usual over-representation of males in paediatric spinal trauma samples. Our results do not support such a proposition but instead raise the possibility that there is a difference in exposure between males and females due to differences in involvement in different activities. That is, while there were more female than male occupants sustaining spinal injury in this sample, pedestrians were approximately evenly distributed between the genders, and the other road user classes were dominated by males. It is possible that both exposure and physiological differences play some role, and this area is worthy of further study.

Roche et al. [2] reported that above the age of 8, boys sustain spinal injuries more than twice as often as girls. In our current study, the gender balances were not greatly affected by age, however, the number of cases in each age group in each road user group (except for occupants) was small.

The cervical region was the most frequently injured spinal region in our sample of motor vehicle related spinal trauma. This corresponds with results published by Cirak et al. [6], and held true for all road user categories and across all age groups. There were, however, variations in the frequency of involvement of different spinal regions depending on the type of road user and the age of the child. Notably there were no serious injuries in the thoracic region in any child under 9, and lumbar injuries occurred most often in children aged between 5 and 12 years. Similar results have not been published widely and possibly represent a combination of effects from differences in the event leading to injury (i.e. occupant vs pedestrian) and biomechanical differences in the maturing spine.

There were also variations in types of injuries sustained by children of different ages. As others have reported [9], spinal cord injury occurred in the greatest frequency among the youngest children. Interestingly, there was an obvious increase in minor 'whiplash'-like injuries with increasing age. The reasons for this are not clear, but some factors may include the absence of adequate rear head restraints in rear seat occupants who are taller than the seat back (possibly increasing risk of whiplash in older children), low reporting of "whiplash" injuries in very young children due to language development, and increasing rigidity of the spine and surrounding tissues with age (which may affect injury mechanisms).

The greatest numbers of spinal injuries occurred to children as occupants and pedestrians. However, there were variations in the proportion of children of different ages in each of these groups. More of the occupants were aged over 8 years, while more of the pedestrians were aged under 8 years. However, for occupants, serious injury occurred in almost equal proportions to children under and over 8 years. Analysis of the data indicates that this appears to reflect an increase in reported soft tissue neck ("whiplash" type) injuries in older children. The reasons for this are not clear, but might reflect differences in susceptibility to these soft-tissue injuries as the spine matures and/or restraint effectiveness issues for older children, whose heads may not be well-supported by the rear seat. For pedestrians, the most serious injuries also occurred predominantly in the younger children. These figures are important in prioritising injury prevention strategies.

While the proportion of children sustaining spinal injuries as a bicyclist or motorcyclist in this sample was low, there were a number of interesting observations made in these road user groups. The proportion of serious injury in children suffering spinal trauma as bicyclists and motorcyclists was relatively high. This suggests that in terms of development of spinal injury countermeasures, these groups should not be overlooked.

The absolute number of young children injured as motorcyclists was quite high (14 % of the sample) and exceeded the number of children seen with spinal trauma on pedal cycles. As most of these incidents occurred off-road, these children might easily be missed in studies focused on road crashes. In fact, the high number seen in this sample suggests further investigation of this category is warranted. An interesting observation among these children is that most of the serious injury in the older children occurred while the children were attempting jumps on trail bikes, while in the younger children (under 10 years) it occurred following collision with wire fences on properties. This suggests that the younger children may not be able to adequately control the motorbikes and avoid collisions, and they should be discouraged from riding motorbikes.

A high incidence of children, particularly adolescents (12-15 years), in off-road vehicle related trauma has been noted by a few North American researchers [19, 20]. In one Canadian study, a high incidence of fractures to the extremities and the spine were noted [21]. A second study looking specifically at head injuries in children caused by off-road vehicles noted almost 20% of their head injured sample had an associated spinal injury [22]. Maynard et al. [23] looked specifically at a sample of patients (adults and children) suffering spinal cord injury in off-road vehicle crashes, including three wheel all terrain vehicles, two wheel dirt bikes and four wheel all terrain vehicles. They found injury occurring at all spinal levels, with the majority occurring at the thoraco-lumbar junction and concluded that widespread education about off-road injury prevention was necessary due the high risk of severe injury and the fact that, at their centre at least, the incidence of injury from off-road vehicles was comparable to that from diving incidents. Most studies reviewed suggest loss of vehicle control was the most common cause of the injury producing event [21, 22, 24]. Similar to the current study, Wiley et al. [24] noted that in their study, a significant number of injuries were caused by the patient being struck by their own bike and collisions with other objects.

On and off-road motorcycle injuries to children and adolescents in Victoria were studied by a group of researchers at Monash University in the early 1990's [25]. As part of this study, 174 riders and 11 passengers killed or injured were reviewed. About 60% of these were under licensing age and most of these were children injured in off-road crashes. The authors of that study believe that problems with vehicular control and familiarity played a significant role in many of these incidents. They noted that, similar to the current NSW sample of spinal-injured riders and passengers, the most common sites for off-road crashes were motocross tracks, farms or paddocks, and bush tracks. Interestingly, they also noted that the immediate causes of most off-road crashes were natural obstacles such as ditches and logs, and artificial obstacles such as fences, poles, gutters and jumps.

In child occupants with spinal trauma in our sample, there were variations in the level of the spine most seriously injured depending on the age of the child. In those 4 years and under, the cervical spine was the most frequently injured, but between 5 and 8 years, the lumbar region was more commonly involved, between 9 and 12 all regions of the spine were affected fairly equally and between 13 and 16 the thoracic region was most commonly affected. These results are interesting because they potentially demonstrate differences in biomechanical vulnerability of the maturing spine, however there are other factors that influence this, such as restraint type and injury mechanism. This finding cannot be easily compared with other published work because most authors have not looked in detail at the spectrum of spinal injury by road user category.

While spinal injuries in child occupants, particularly to the cervical region, occur frequently in unrestrained children, a number of authors have reported some cases of children suffering spinal injury while using some form of restraint [13, 16, 26-29]. In this study, 95% of the child occupants were restrained, of which 88% were using adult belts. Therefore, many of the injuries occurred in inappropriately restrained children. In children suffering spinal trauma while using a dedicated child-specific restraint, misuse was either confirmed or considered to be extremely likely, on the basis of the pattern of injury and statements in the medical record, in all cases but one. In this case involving a child using a booster seat, there was also a slight possibility the sash portion of the restraint may have been used incorrectly. Moreover, this 3-year-old child would have been more appropriately restrained in a forward facing child safety seat. The current study failed to uncover any child suffering a serious spinal injury in a correctly used forward facing child safety seat.

Of the child occupants in the current study sustaining serious spinal injuries, 92% sustained associated injuries to other body regions. The most serious of these associated injuries were to the abdomen and head. This is interesting because most of these children were using adult belts and this indicates that there was potentially poor restraint provided by the adult belt. This injury pattern was observed across the whole age range studied here. There was direct evidence of head contact in 9 out of 25 children who sustained a serious spinal injury. However, in many of these cases, where serious associated injuries were present, less serious injuries such as contusions and abrasions on the head may not have been noted in the medical record.

Pedestrians accounted for 17% of our current sample, and children 4 years and under accounted for almost half of these. Most of these children (70%) received serious injury involving the vertebral column and/or the spinal cord. This is comparable with figures reported elsewhere. In the Cirak et al. [6] study, 20% of their motor vehicle related sample involved pedestrians. However, the proportion of children under 4 years was much higher in our study, with pre-schoolers accounting for only 14% of pedestrians in the North American study. In our study, they made up 47 percent. The studies by Osenbach et al. [3], and Carreon et al. [1] grouped children into 8 years and under and 9 years and over. In these two studies, children 8 years and under accounted for approximately 55% and 40% respectively. In our study, children 8 years and under accounted for almost 70% of the serious injuries in pedestrians. It therefore appears possible that we have a greater problem in this area, and this issue is worthy of further investigation.

In terms of overall severity, other researchers have noted that pedestrian related injuries are often highly associated with multi-system trauma [6]. Multi-system trauma is more often associated with death, and a greater risk of death. Overall, we found 70% of cases in our sample to have at least one other injury. Almost all of the pedestrians in our sample suffered multi-system injury, particularly those involved in higher speed incidents. Serious head injury in particular occurred in association with almost 60% of the serious spinal injuries. This finding is similar to that seen in an earlier Australian investigation of head injury mechanisms in fatally injured children, with spinal injuries being present in addition to a head injury in half of the fatally injured child pedestrians seen in that study [30].

According to Roche et al. [2], between 25 and 50% of spinal trauma is associated with neurological damage in children, and this is similar to what has been reported for adults. In our sample of children suffering spinal trauma following involvement in a motor vehicle related incident, only 13% suffered injury to the spinal cord. It has been reported elsewhere [9] that spinal cord injury is more likely in children under 4 years of age, which is consistent with what was seen in the current sample.

This study revealed a high incidence of serious spinal injury among motorcycle riders. This includes two subgroups – the older children participating in trail-bike riding activities, and younger children in off-road motorbike activities, including motorcycle passengers. This suggests that specific injury-prevention strategies need to be developed for young motorcycle riders and passengers. Appropriate strategies for the two age groups may be different. This also requires further study of spinal and non-spinal injuries in children using motorcycles. This should include detailed study of crash circumstances and developmental factors that are involved.

Reducing serious spinal injury in child pedestrians may need different approaches to target the groups in which these injuries were seen to be more common. For example, approaches aimed at the 0-4 age group may not be suitable for the 13-16 age group. Behaviourally-based injury prevention strategies aimed at young pedestrians and their carers have been implemented in many states (e.g. "Kids need a hand in traffic" campaign in NSW). However, there are other strategies, such as vehicle design (e.g. pedestrian-friendly vehicle design) and warning systems (e.g. proximity alarms, cameras etc), which also have the potential to ameliorate injury and should be evaluated. In addition, the recent adoption of lower speed limits in residential and high pedestrian traffic areas has the potential to influence pedestrian injury, and these strategies need ongoing evaluation.

Conclusions

Serious spinal injuries to occupants occurred in similar proportions across the whole age range studied. While spinal injuries in younger occupants have received recent attention, children older than 8 years have not received the same level of attention, and there is a need to redress this imbalance. The injury mechanisms, restraint and vehicle factors involved in these injuries are not clear, and require further study. There may also be scope to include assessment of older child occupant safety in vehicle assessment programs such as ANCAP.

This review of paediatric spinal injuries has revealed that motor vehicle related spinal injuries account for approximately one third of all spinal trauma in the Sydney region. It has also identified specific problems in motorcycle users, older child occupants, and child pedestrians under 5 years. While the absolute numbers of these groups are small, and may be overlooked in studies of specific road user groups, the socioeconomic impact of these injuries is high.

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