

# **Injury Implications of Inappropriate Use of Adult Seatbelt Systems for Children Aged 2-8**

**Julie Brown<sup>1</sup> (Presenter); Lynne Bilston<sup>1</sup>; Mary McCaskill<sup>2</sup>**  
**<sup>1</sup>Prince of Wales Medical Research Institute, UNSW**  
**<sup>2</sup>Children's Hospital at Westmead**

## **Biography**

### **Abstract**

Current Australian child restraints offer excellent protection to child occupants under the age of four. While booster seats and adult seatbelts have also been shown to offer some level of protection to young children involved in crashes, the level of protection is somewhat lower than provided by dedicated child restraint systems. It is likely that the level of protection is even lower for children who graduate to such systems prematurely. Early graduation to seat belts is often called inappropriate restraint use. The focus of this study is to investigate the role of restraint misuse and inappropriate use on injury outcome for 2-8 year old motor vehicle occupants. The study is a prospective crash investigation study, involving children aged 2-8 who present to the emergency department following a motor vehicle crash. Detailed injury and crash data are collected. Preliminary results suggest that an overwhelming proportion of children in this age group are restrained by adult seatbelt systems rather than the more appropriate dedicated child restraints or booster seats. Common serious injury mechanisms have been observed in children inappropriately restrained. These injury mechanisms include abdominal injuries due to poor lap belt fit, neck injuries due to poor sash belt fit and head injuries due to poor control of head excursion. In addition, restraint misuse appears to be a factor in several of the more serious cases involving restrained children. Together, this data suggests that reducing the instances of inappropriate restraint use and restraint misuse are potential countermeasures for reducing the severity of injuries sustained by child motor vehicle occupants. Further examination of the potential for injury prevention by changes to restraint system design is underway using a complementary program of sled tests.

## **1. INTRODUCTION**

Australian legislation requires all children travelling in motor vehicles in Australia to use an approved child restraint. For children one year and under an "approved" restraint is one that has been specifically designed for this age range and complies with Australian Standard (AS) 1754. Children over one must also be restrained, however they may use a dedicated child restraint system or an adult seat belt. The use of adult belt systems by young children (over the age of one year) is therefore a legally acceptable practice.

How 'safe' the practice of restraining very young children in systems designed for adults, is a question that has long been debated by the international road safety community.

There are actually two forms of the above question and it is important to differentiate between the two. The first relates to whether or not the use of an adult seat belt system is in itself dangerous to a very young child and the second is how effective an adult seat belt system is at preventing injury in very young children. That is, how much below optimal are adult seat belts for young children.

Historically many studies concerning young children in adult seat belts have focussed on the "are adult seat belts dangerous" question. These types of studies have overwhelmingly

reported that adult seat belts are not dangerous since they provide a much higher level of protection than if no restraint is used and any injury suffered by children using an adult seat belt is much less severe than that which would be expected if no restraint were used. In fact many such studies have concluded that the use of adult seat belts by children significantly reduces the likelihood of death and serious injury. (Gotschall et al, 1998; Henderson et al 1994; Kraft 1990; Partyka 1988 & Morris 1983). However, it is now fairly well established that an adult seat belt does not provide a level of protection equal to that provided by dedicated child restraint systems. For example studies have estimated that rearward facing infant restraints reduce the risk of serious injury by about 80-90% (Tingvall 1987, Carlsson et al 1991; and Cuny et al, 1997), and forward facing child by approximately 70% (Weber, 2000; Cuny et al, 1997). While the effectiveness of adult belts used by children varied widely between 30 and 60%.

Based on results from studies like those cited above, it appears the effectiveness of an adult belt in protecting children appears to depend on the age of the child (Partyka, 1988; Cuny et al 1997 and Isaksson-Hellman et al, 1997), and the type of adult belt (ie lap belt compared to a lap/sash belt). (Mallieris & Digges, 1987; Lundell et al, 1991). In addition, premature graduation from one class of dedicated restraint to the next (e.g. from forward facing restraint to booster seat), has also been reported to influence the type of injuries suffered. (Khaewpong et al, 1995; Agran et al, 1997; Newgard and Jolly, 1998; and Isaksson-Hellman, 1997)

What has not been made clear in many studies conducted to date is how the age (or more importantly the size) of a child using a specific type of restraint influences the level of protection provided and more specifically the mechanism of injury. This is particularly of interest to the issue of young children using adult seat belts.

Our research group is currently conducting a number of related studies investigating mechanisms of injury in children restrained in different types of restraint. This work includes analysis of existing field and laboratory data; a prospective crash investigation study and related laboratory work.

This paper presents preliminary observations pertaining to the relationship between age, restraint type and injury outcome from a current study of children aged 2-8 year old involved in crashes. Particular emphasis has been placed on observations related to children within this study using adult seat belts. In addition, previously reported Australian data related to the crash experience of young children in adult restraints is reviewed.

## **2. OVERVIEW OF CURRENT WORK**

The primary objective of our current study is to examine existing crash investigation data, and prospectively collect crash and injury data on the injuries sustained by children aged 2-8 in motor vehicle accidents. This data will be used to identify the principal injuries sustained, and the relationship between the injury mechanism(s) and the use or misuse of restraints (child restraints, booster seats, harnesses and adult seatbelts). In particular, this work will delineate the injury mechanisms for Australian children in the 2-8 age range associated with the use or misuse of motor vehicle restraints. This will be achieved by determining the major types of injuries sustained by a sample of children aged 2-8 involved in crashes and correlating these injuries with restraint usage, crash type and crash severity. The role of restraint use or misuse in the aetiology of these injuries will be specifically targeted.

### **3. METHODOLOGY**

Prospective collection and analysis of cases involving children in our sample range involved in motor vehicle crashes cases presenting at the Children's Hospital at Westmead is underway. Data collection commenced late last year, and will continue for two years.

Informed consent is obtained from the parent/guardian to participate in the study. Following this, the child's medical data relevant to the crash is collected. A structured interview is conducted with the driver of the vehicle, and the vehicle is inspected. Medical data is coded according to the Abbreviated Injury Scale (AIS, 1990). The type and severity of the collision damage is assessed during vehicle inspection. An inspection of the vehicle interior provides information regarding seat belt and restraint use, and occupant contact points. Vehicle damage is used as input into a computer reconstruction package (Crash 3), which allows the impact severity ( $\Delta V$ ) to be estimated.

Retrospective review of existing data sources for child injury cases in motor vehicle accidents is also underway. The first of these data sets, that collected from the 1993 NSW CAPFA study is almost complete. The CAPFA study collected information about children involved in motor vehicle accidents from several major hospitals in the greater Sydney metropolitan area, Newcastle and Illawarra. This dataset contains approximately 97 cases of children in the 3-8 age group. Details available include injury data, crash severity data, restraint use and fitment quality, and vehicle make and model. In some cases, the source of a particular injury (eg seat belt webbing responsible for abdominal injury) is identified. Further details of the sampling methods can be found in the report describing the original study (Henderson et al, 1994).

A complementary laboratory test program is also being undertaken. This program includes the investigation of injury mechanisms and restraint design improvements for children involved in side impact crashes. A number of crash reconstructions based on data collected during the current prospective study are also planned.

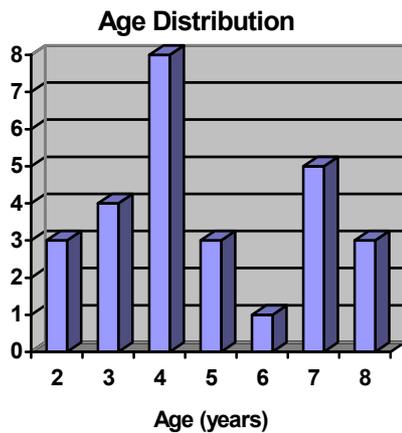
For the purposes of this discussion, existing crash investigation data and observations from our ongoing prospective data collection related to children in our sample age range using adult seat belts are presented.

### **4. PRELIMINARY OBSERVATIONS FROM PROSPECTIVE STUDY**

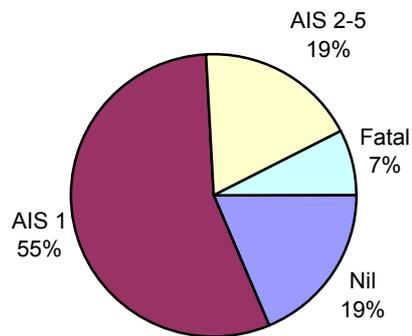
To date, we have a total of 27 complete cases in the study.. The age distribution is shown in Figure 1. There have been roughly equal numbers of male and female subjects. Injury severity in the sample is shown in Figure 2.

The majority of children in the study have been restrained in adult seat belts only. See Figure 3.

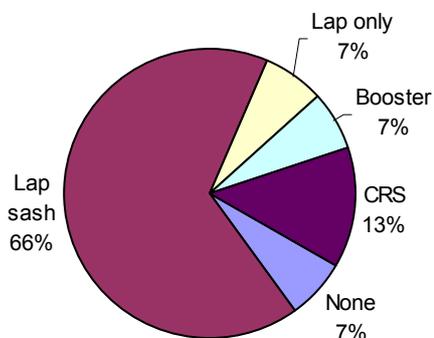
Only 20% of the children in the study were judged to be using the optimal restraint for their age and size. None of the 'optimally' restrained children suffered serious injury. Of the remaining 80%, half were 5 or under (one was 2 years old), and half were 6 or older.



**Figure 1. Age Distribution of Subjects**



**Figure 2. Injury Distribution**



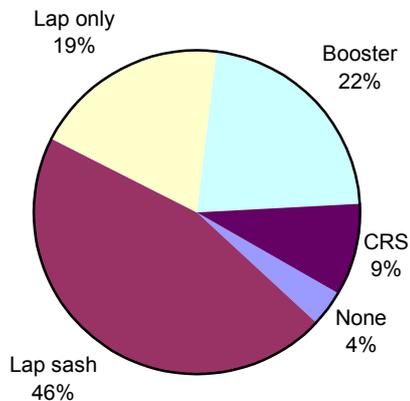
**Figure 3. Restraint used**

Among the younger children in the sample (2-4 years), two were fatalities (one unrestrained, one in an adult seatbelt). Two children, aged 3 and 4 in a severe side impact in dedicated child restraints suffered only minor bruises, cuts and abrasions. One four year old girl using an adult lap/sash belt seated in the front seat during a moderate frontal crash received serious abdominal injuries from the lap portion of the adult seatbelt. Injuries sustained by the other four children in this age range were limited to abrasions, small superficial lacerations and bruises.

For children in the 5-8 age group, one 8 year old boy sustained only minor injuries in a moderately severe frontal crash. Injury and vehicle data suggest that he had adequate belt fit. Two 7 year olds seated in the front seat of vehicles in side impacts were moderately injured, with indications that some injury was from the intruding structure and some was as a result of contact with the driver. Two other children, both aged 7, were seated in the rear seat when the car was involved in frontal impacts, however these crashes were more severe with impact speeds between 60 and 80-km/h. One of the 7 year olds suffered only seat belt bruising over the left iliac crest, indicating proper positioning of the lap belt. The other, a small 7 year old, suffered undisplaced bilateral fractures of the anterior pedicles at C2 with subluxation of the left C2/3 facet joint and evidence of soft tissue injury to the posterior ligaments at C1/C2, C2/C3 levels. An abdominal graze not over the iliac crest indicated poor lap belt fit, and bruising and abrasions on the neck indicate the sash was too high.

## 5. REVIEW OF EXISTING DATA

Review of data from the CAPFA study related to the types of restraint used by children aged between 2 and 8 years demonstrates that as in our current study, the majority of children were restrained in adult seat belts only. See Figure 4.



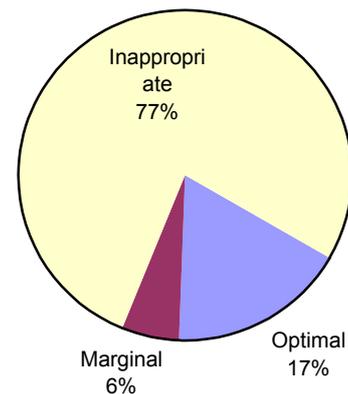
**Figure 4. Restraint used (CAPFA study)**

The appropriateness of restraint use or the level of optimal, marginal and inappropriate restraint usage at different ages is summarised in Figure 5. This classification is based on restraint recommendations outlined by Winston (2000). In addition, marginal restraint usage is defined as booster seat usage for children who are within the age-weight range for booster seat use, but who are still within the height/weight range for a forward facing CRS, which is the preferred restraint option. Marginal is also used to describe children between 135cm and 145cm who are restrained in adult seatbelts (US recommendation is 4'9" for seatbelts is > 145cm).

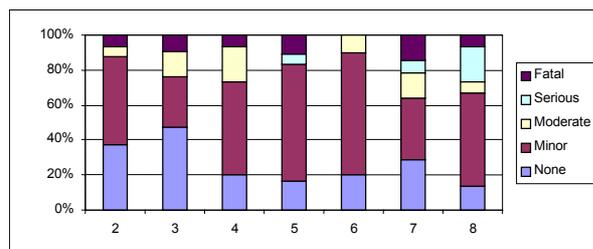
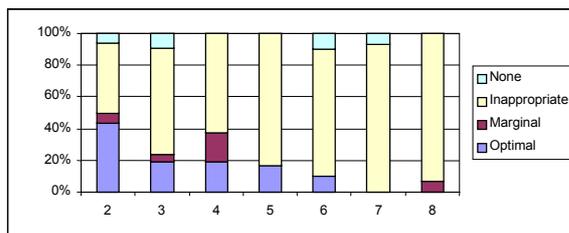
Note the high rate of inappropriate restraint usage at all ages. This is predominantly due to the early graduation to adult seatbelts.

It is also interesting to note the similarity in the small number of children judged to be appropriately restrained in our current study (20%) and the CAPFA study conducted 10 years ago (17%).

Figure 6 illustrates the appropriateness of restraint use for each age. While this figure again demonstrates the widespread problem of inappropriate use, there also appears to be a slight



**Figure 5. Appropriate use of restraints (CAPFA study)**



**Figure 7. Percentage distribution of injury severity at different ages.**

children in our prospective study sample have been using adult seat belts. Review of details

increase in inappropriate use with increasing age. This may be influencing a similar trend to an increased percentage of moderate to fatal injuries in older children in this group. See Figure 7 which shows the percentage distribution of injury severity at different ages.

## 6. DISCUSSION & CONCLUSIONS

While our work is ongoing, a number of interesting observations are emerging in respect to the types of restraints being used by children, in particular the use of adult seat belts by young children.

We have seen that the majority of the children in our prospective study sample have been using adult seat belts. Review of details

of all notifications for inclusion in this study from the New Children's Hospital, Westmead reveals that adult seat belts are the predominate type of restraint being used by all children in the 2 – 8 age range presenting at this hospital over the past 12 months. This situation is identical to that observed in NSW 10 years ago during the CAPFA study. Although the frequency of adult seat belt use appears to increase with age (between 2 and 8 years), significant use of seat belts is being seen in children as young as 2 and 3 years old.

If type of restraint being used is assessed in terms of biomechanically optimal, marginal or non acceptable terms (as opposed to legally acceptable versus legally unacceptable) it is clear that ten years ago the majority of children involved in crashes were sub optimally restrained. Our early observations from the current field study suggest little has changed in this regard.

It is unclear whether low usage of appropriate restraint type in our sample of injured children is a reflection of increased injury risk for children restrained in adult seatbelts alone, as is the case for unrestrained occupants, or whether this is representative of usage rates in the population as a whole. This type of inappropriate restraint usage has been shown to contribute to an increased risk of injury (Winston et al, 2000). However, we do not currently have accurate figures on restraint use patterns for children in New South Wales which would allow us to evaluate the impact of inappropriate restraint use. To address this, we intend to extend our current work to include a population-based survey of the type of child restraint being used by children in NSW.

Many researchers have reported differences in injury type depending on age and/or restraint type, particularly with respect to the part of the body injured. Preliminary observations from our prospective study related to children in adult belts agree with these findings. We have observed more abdominal injury in younger children (under 4) and more neck injury in older children (5-8). To date we have seen no serious injury in any child judged to be correctly using the most appropriate restraint for their height and weight age range.

Henderson (1994) reported a significant number of the children in the CAPFA study sustaining serious and fatal injuries were unrestrained. He also noted that in most cases restraint use by these children would have improved their injury outcome. To date we have seen only two unrestrained children from all those within our age range that have presented at the Children's Hospital at Westmead over the last 12 months. In both cases, the use of a restraint, even an adult belt would have in all probability reduced the level of injury received. One child was fatally injured in a moderate to high speed frontal crash in which all other (adult) occupants were restrained and survived the crash. The other child was ejected during a relatively low speed roll over involving a four wheel drive, receiving serious upper limb injuries due to the arm being trapped under the up turned vehicle.

The fact that adult belts can prevent injury (in even young children) that would have occurred had the child been unrestrained has meant that in the past road safety advocates have accepted adult belt use as 'better than nothing'. Gotschall et al (1998) note that in the United States the use of seat belts by children has greatly reduced injury and death in that country over the last 20 years. However, they also note that mortality rates for children aged between 5 and 15 years have not fallen as quickly as they have for other segments of the population. They believe this may be due to the sub optimal levels of protection provided by adult belts to children.

Australian children have very high restraint usage rates. Henderson (1994) reported that restraint usage rates about 10 years ago were as high as 98%. We believe it is time for Australian road safety advocates to shift our focus from simply aiming to have all children restrained to having all children optimally restrained. This has already occurred in the United States. In many States all children under the age of 4 are required by law to be restrained by

dedicated child restraints, and road safety advocates are now calling for these laws to be extended to children as old as 6. These “booster seat” laws have been enacted in several American states.

It is hoped that data collected during our current work will provide a thorough assessment of the magnitude and nature of inappropriate restraint use and its relationship to the type and severity of injuries being sustained by children in NSW. This information can then in turn be used to develop both behavioural and engineering strategies to address this problem.

### **Acknowledgements**

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