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Child occupant protection in Australia

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Abstract

Child occupants require special consideration in the motor vehicle, where the environment is largely engineered for adults. This paper reviews the issues that place child occupants in a special category and how these have been dealt with in Australia, as well as the history of legislation covering children in cars and its effectiveness in enhancing crash protection. Recent research highlighting current problem areas for Australian child occupants is also reviewed.

This review illustrates that the general principles of occupant protection can be applied to children but that this application also requires knowledge of the developmental stages of children. Legislation has been effective in getting children into restraints when travelling in cars, and recent changes to Australian law mandating the types of restraint used appears to have improved restraint choice in the short term. The history of legislation effectiveness suggests that it is likely that ongoing educational and enforcement activities will be required to sustain and maximise the effect of the new laws.

Ensuring that restraints are used correctly is as important as getting children into the right type of restraint. Increasing correct use among child occupants requires additional strategies. To date, the only strategies shown to be associated with increased levels of correct restraint use are hands-on demonstration and the use of services like the New South Wales Authorised Restraint Fitting Station network. There is a need for continued focus on reducing the complexity of child restraint systems to enable correct use. Other issues of current importance for child occupants include the need to ensure

interventions targeting optimal child restraint practices are made available to all members of the Australian community and that messages used in these interventions are consistent. Finally, there is currently a gap in protection for children too big for boosters but too small to be optimally protected by the adult seatbelt. This gap highlights the need for booster seats that can accommodate children beyond their 7th birthday and more focused attention to the safety performance of the rear seat of modern vehicles.

Introduction

Trauma is the leading cause of death and one of the main causes of hospitalisation in Australian children. Transport-related incidents are responsible for the greatest burden of this disease. [1] The rate of deaths among children due to transport-related causes in Australia compares poorly to other industrialised nations. In 2001, UNICEF ranked Australia 17th out of 26. [2]

Within New South Wales (NSW), an average of approximately 1130 child occupants are injured and a further 17 killed each year in motor vehicle accidents (MVAs), based on data from 2005-2009. [3] Nationally, the number of children killed each year approaches 70 (5 year average for 2005-2009 is 68 [4]) and the number seriously injured is in the vicinity of 3000 per year.

While these casualty figures are a vast improvement on the number of deaths and injuries seen in child occupants in the 1970s where approximately 3000 children were killed and injured on NSW roads alone (RTA 10 year average), there has been little improvement over the last two decades, with total casualty figures remaining static.

Motor vehicles have historically been seen as a product designed for the adult population, hence the design of safety systems have also tended to prioritise the protection of adult occupants. There have been a number of extremely successful vehicle safety interventions, such as better designed vehicle structure, with engineered 'crush zones', seatbelts and airbags, which have led to the reduced frequency and severity of injuries to adult occupants.

Child occupants are a unique class of road user. This paper reviews how Australia has dealt with providing crash protection to children in the motor vehicle, where the environment has been, and continues to be, largely engineered for adults. It also examines the current areas of greatest need for enhancing crash protection for child occupants.

Method

A non-systematic review of literature covering crash protection for child occupants and their special needs, and how this has been dealt with in Australia was conducted. This was achieved by targeted searches of published literature using Medline and the Australian Transportation Index, as well as the contents of published conference proceedings from relevant high profile international conferences, and following the citation trees of relevant publications. The catalogue of the then NSW RTA library was also used to identify relevant historical reports not widely available in the published literature but documenting important historical information. Recent research (in which the authors have been involved) that provides insight into the current problems for child occupants was also reviewed.

Results and Discussion

Principles of occupant protection

Occupant protection is based on a set of principles, largely founded on Newtonian physics, and the objective of controlling the force transferred to an occupant during a crash.

The primary principle involves maximising the distance over which an occupant decelerates during an impact so as to lower the forces felt by the occupant. This is often referred to as maximising the occupant's 'ride down'. In modern vehicles this is generally achieved by engineering 'crush zones' into the vehicle design. This allows the passenger compartment to come to a stop over the greatest possible distance, while energy is absorbed by the crushing vehicle. To gain the full benefits of the available 'ride down' distance the occupant must be coupled as tightly as possible to the vehicle. Secondly, it is important to control the forces generated when the occupant is coupled to the vehicle (restrained). It is important that any loads developed by the restraint system and applied to the occupant are applied to the parts of the occupant's body that can best withstand them.

Once the occupant is held within, and tightly coupled to, the passenger compartment, and loads are distributed in a controlled way, other principles of occupant protection become important. These include minimising the possibility of serious injury caused by the occupant contacting structures within the vehicle; the reasons behind this are similar to the key principle above, since contact with a rigid vehicle structure means the impacted body will decelerate over a very short distance and time. This is achieved by preventing the contact or, if this is not possible, ensuring any structures that are likely to be impacted control this deceleration as much as possible using energy absorption or compliant materials. Lastly, relative motion between adjacent body parts needs to be kept within physiologically tolerable ranges of motion.

These principles can easily be seen at work in the case of adult safety restraint systems. For seatbelts, the better the fit in terms of how tightly the occupant is tied to the vehicle, the closer the occupant's deceleration matches the rate of deceleration of the vehicle. Three point seatbelts are designed to make contact with the stronger bony parts of an adult occupant's body - the iliac crests of the pelvis, clavicle and sternum. Airbags also act to control the deceleration of an adult occupant's head, minimise contact between the occupant and the steering wheel or dashboard, and minimise relative motion between an occupant's head and neck. Head restraints, or headrests, also reduce relative motion between an occupant's head and neck in rear impacts.

Children are not scaled down adults

The same principles govern the protection of child occupants in crashes. However, there are significant differences in size, and the proportional size of different regions of the body in the child and in the adult, and these proportions change as a child grows from birth to adolescence. Body segment lengths and weight rapidly change in the first year of life, and growth slows incrementally until full adult size is attained. At 5 months the birth weight is doubled, at 5 years the birth weight has increased by a factor of 6 and by age 10 the body weight is 10 times that of the newborn. [5] At birth a child's head accounts for one quarter of the child's height and represents more than half of the total body weight. The size of the newborn brain is approximately 25% of the adult brain but the weight of an infant is only about 5% of an adult. In the infant, the torso and arms are proportionally longer than the legs. The relative difference in these proportions, compared to the adult, decreases as the child grows, resulting in distinct differences between children of different ages. At birth the mid-point of the body is slightly above the umbilicus, at 2 years it is slightly below the umbilicus and at 16 years it is near the pubic symphysis. [5]

These differences in body segment proportions have a marked effect on seated height. At birth, seated height represents about 70% of the total body length; at 3 years it is approximately 57% of overall height; at about 13 years it is about 50% and reaches the same proportion as an adult from about 15 or 16 years. [5]

Body segment differences also influence the centre of gravity, with the centre of gravity being much higher in children than in adults. The centre of gravity depends on size and weight distribution (as well as seated posture) and therefore also varies within age groups. Variations in seated height and the location of the body's centre of gravity, depending on age, underlie the need for variation in the approach to effective restraint to meet the principles of occupant protection.

There are also a number of other changes related to the structure and characteristics of bones, muscles and ligaments. These result in differences in structural and mechanical properties that are likely to result in differences in response to loading and are also likely to influence variations in injury patterns between children of different ages and between children and adults. For example the softer ligaments, weaker muscles, and less angled facet joints of the spine in young children predispose children to spinal cord injury in the absence of bony injury. This type of injury, known as SCIWORA (spinal cord injury without radiographic abnormality) is rare, but is a phenomenon seen most commonly among paediatric patients. [6] The reported incidence of SCIWORA in paediatric spinal injury patients ranges from 3% to 32% depending on the sample, definition used in the diagnosis, and method of diagnosis. [7] In adults, the upper range of reported incidence is about 12%. [8] Spinal injury and SCIWORA is rare, but the most common mechanism of spinal injury in children is motor vehicle accidents. [9] In a medical record review of child occupants aged 0-16 years with injury to the spinal region at two major childrens' hospitals in Sydney throughout 1999 to 2004, two of the 80 children identified were diagnosed with SCIWORA. [10]

One area of anatomical difference between children of different stages of development is of particular relevance to child occupant protection - the morphology of the pelvis. These differences have particular significance for differences in seated posture. In adults, the components of the hip bones are completely fused together to form a single bone; however, in infants and children they are not. The most anterior edges of the hip bones are known as the iliac wings and on these, in adults, are two pairs of bony prominences known as the anterior superior iliac spine (ASIS) and the anterior inferior iliac spine (AIIS). The ASIS is a well-known anatomical landmark used as an anchor point for the lap part of seatbelts. These bony prominences are absent in young children and the iliac wing is round and smooth until at least 8 to 10 years. [5, 11, 12] This probably limits the effectiveness of seatbelts in restraining the pelvis in younger children, and contributes to 'seatbelt syndrome' injuries observed in the field.

Another important difference is the proportional size of the abdomen, and the relative size and position of abdominal organs. There is less bony protection of abdominal organs in children. For example, at birth the liver occupies two fifths of the entire abdominal cavity and accounts for more than 5% of the total body weight. In an adult, the liver lies completely behind the ribcage and accounts for less than 3% of the total body weight. As the child's skeleton grows, more of the liver becomes covered by the ribs, but parts of the liver remain at least 1cm below the ribs up until about 6 years of age. Further to the skeletal size issues, the ribs of infants and children are more elastic than in adults. The thoracic wall is also thinner and, like the contents of the abdominal cavity, there are differences in the relative size and location of the heart and lungs in children and adults. [5, 11, 12]

Understanding the unique features of child occupants is critical to understanding how injury to children in crashes can be prevented. Specific attention to differences in anthropometry and physiology between children and adults like those described above has led to the evolution of restraint systems designed for children of different age and size ranges, as described below.

Child restraint types

Different types of restraint are available for children of different size ranges. In Australia, the design (and performance) of child restraints is regulated by Standards Australia. All child restraints sold in Australia must be approved to the current Australian Standard. This Standard designates five types of child restraints, which can roughly be grouped into restraints for infants (rearward facing restraints), restraints for toddlers/pre-schoolers (forward facing restraints) and restraints for young children (booster seats).

Type designations taken from Australian Standard (AS) 1754 are as follows:

- Type A1: Rearward-facing restraint with a harness or other means of retaining the occupant of supine length up to 70 cm, and approximately 6 months of age
- Type A2: Rearward-facing restraint with a harness or other means of retaining the occupant of supine length up to 80 cm, and approximately 12 months of age
- Type A3: Transversely installed restraint with a harness or other means of retaining the occupant of supine length of up to 70 cm and approximately 6 months of age
- Type B: Forward-facing chair with harness, suitable for children approximately 6 months to 4 years of age
- Type C: Forward-facing harness without chair, to be used in conjunction with a booster seat suitable for children approximately 4 to 7 years of age and without a booster seat for children approximately from 8 to 10 years of age
- Type D: Rearward-facing chair with harness, suitable for children approximately 6 months to 4 years of age
- Type E: A booster seat used in conjunction with a Type C child restraint and a seatbelt, or with a lap-sash seatbelt, suitable for children approximately 4 to 8 years of age whose height is less than 128 cm
- Type F: A restraint consisting of either

  (i) a booster seat used in conjunction with a Type C child restraint and a seatbelt, or with a lap-sash seatbelt suitable for children approximately 4 to 10 years of age whose height is less than 138 cm, or

  (ii) a converter used in conjunction with a seatbelt, suitable for children approximately 8 to 10 years of age.

The current standard, AS1754:2010, is currently under review and a new version is expected to be released in late 2012. There may be some changes to these type designations in that version.

Child Restraint anchorage systems

The current method of attaching rearward and forward facing restraint systems in Australia uses an adult seatbelt and a top tether strap. The adult belt is used as the means of tying the lower portion of a restraint system to the vehicle. Upper anchorage of the child restraint system is achieved through the use of the top tether strap. Top tethers provide much more secure attachment of child restraints compared to being attached by the seatbelt only. In particular, they provide secure attachment at the top part of the child restraint, so that it can 'ride down' the crash whilst the vehicle is crushing, and also considerably reduce excursion of the child's head relative to the vehicle interior in both frontal and side impacts. [13, 14]

Alternative forms of anchoring rearward facing and forward facing restraints are used in other countries. In Europe, the use of top tether straps is not universal, and some rearward facing restraints use a floor mounted tether as an alternative. Recently, in Europe and North America other forms of anchorage have begun to become commonplace. These fall under the category of dedicated child restraint anchorage systems. The intention of this concept was to develop a universal form of child restraint anchorage to overcome incompatibility problems between different designs of child restraint, vehicle seatbelt geometry and vehicle seat characteristics. An International Standard defining such a system was completed in 1999. [15] However, this international standard has not been universally adopted, and a number of different forms of this concept of anchorage are now being used in North America and Europe, including the European ISOFIX systems and North American LATCH systems. Numerous laboratory studies have demonstrated that a system incorporating two lower rigid anchorages and a top tether would enhance the protection currently being offered by Australian child restraint systems. [16- 19] However, implementation problems associated with harmonisation of Australian vehicle standards with international vehicle standards, and maintaining the same level of performance throughout a transition period where both the conventional and new forms of anchorage would be used, has slowed the adoption of such systems into Australia. [20]

The use of dedicated child restraint lower anchorages are being considered within the latest revision of AS1754 and it is likely that the next version of the Australian Standard will contain requirements for anchorage systems that will allow coupling of rearward and forward facing restraints with ISOFIX attachments provided in cars. The design and performance of the ISOFIX attachments within vehicles sold in Australia is covered by Australian Design Rules (ADRs). ADR 34/02 which includes requirements for ISOFIX anchorages in cars was recently published by the Federal government. The provision of ISOFIX anchorages by vehicle manufacturers is, however, optional.

Boosters are not generally tied to the vehicle, instead they are placed onto the vehicle seat and the adult seatbelt restrains both the child and the seat. Under AS/NZS 1754, combination forward-facing/booster restraints and booster seats over 2kg must use a top tether to limit the potential for the child to be excessively loaded between the restraint and the belt. In the past alternative (ISOFIX type) anchorage systems have not been used in combination with booster seats. More recently, a small number of booster seats designed for use with alternative forms of anchorage have come onto the North American market. However, there are potential problems with using booster seats with these anchorages, as they may overload the ISOFIX anchorages, which has resulted in some confusion in North American markets.

Child occupant legislation and restraint use

Children under 8 years of age were initially exempt from laws requiring the compulsory use of seatbelts introduced into Australia in the early 1970s. Mandatory use of restraints by Australian children began in Victoria in 1976 and was extended to NSW in March 1977, and it became compulsory for all children under 8 years to use an appropriate restraint where one was available. By 1982, this legislation had extended to all

Australian states and territories. [21] The law at that time required all children to be restrained by an appropriate restraint when travelling in a vehicle. However, the legislation defined 'an appropriate' restraint differently for children under and over 12 months of age. For children under 12 months, an appropriate restraint was defined as an Australian Standards approved child restraint. However, for children over 12 months, an appropriate restraint was defined as being either an approved child restraint or an adult seatbelt. [22]

Until recently, there have been few observational studies conducted in Australia examining the types of restraint being used by children of different ages. In NSW, a telephone survey exploring the restraint use by children aged 0-10 found that the majority of children aged 6 or older were using adult belts only. Among younger children, 40% of 5 year olds were using adult belts and 50% were using booster seats; more than half of 3 and 4 year olds were using either booster seats or adult belts and more than 20% of two year olds were using boosters. The predominant restraint used by children less than 2 years of age was a forward facing or rearward facing child restraint. [18] Similarly, in Victoria, self-reported appropriate use was low in children in this age range [23]. An observational survey conducted in South Australia found that booster seat use became common among children from age 2 onwards, and by 6 years adult seatbelts became the most common form of restraint being used. [24] Low child restraint use by children under age 4 was later confirmed in South Australia in an on-road observational study. [25]

In 2008, Brown et al. [26] conducted a cross-sectional population referenced observational survey of child restraint practices across NSW which confirmed the high rates of inappropriate restraint use in children from about 2 years.

Studies conducted in Australia [27] and internationally [28-30] demonstrated that the use of inappropriate restraints increased the risk of injury in crashes. Laboratory work demonstrated that the increased risk of injury among inappropriately restrained children was largely due to poor belt fit that occurs when young children are prematurely graduated to booster seats and/or adult belts. Poor belt fit allows loading of vulnerable parts of the body, particularly if the child is not in a 'good' posture at the time of impact. This work also found that appropriate restraint use better controls occupant motion, directs the restraint forces to regions of the body better able to withstand them, and thus reduces the risk of serious injury. [9] Du et al. [31] used the population-level observational data of Brown et al. [26] to estimate the population attributable risk fraction for different forms of sub-optimal restraint and estimated that casualties and fatalities among Australian children aged 1-7 could be reduced by up to 13% and 34% respectively by moving more children into appropriate restraints.

In 2007, the National Transport Commission (the body governing the Australian Road Rules) published a review of legislation pertaining to the restraint of children in cars. [32] This document recommended extending legislation requiring the use of child restraint and booster seats to children up to age 7 in the near future and up to age 9 at some later time. In 2009, new Australian Road Rules were released that specified use of age-appropriate restraints for children up to 7 years. These have now been implemented as new laws in all Australian states, except the Northern Territory.

The introduction of mandatory restraint laws for children in Australia in the 1970's had an immediate effect on the rates of restraint usage among child occupants. Prior to the introduction of the legislation, only about 30% of children travelling in cars used some form of restraint; this increased to almost 60% after the introduction of the legislation in NSW. [33] However, according to Freedman et al. [34], these immediate increases in usage were shortlived and usage rates dropped to around 40% eight months after the introduction of the legislation. Further increases were gained through targeted educational campaigns. Ongoing efforts in this area resulted in usage rates in NSW in 1994 being between 80% and 90% depending on where the child was seated, with slightly higher usage rates in front seat positions. Currently, children in NSW have restraint usage rates beyond 98%. [35] Similar current usage rates have been reported in other states. [36] However, as noted above, prior to implementation of mandatory appropriate use laws, many of these restrained children were using restraints designed for older children or adults.

Data from direct observations of child restraint practices in NSW in 2008, prior to introduction of the new legislation in 2010, were compared with direct observations of child restraint practices among children aged 2-5 years within low socioeconomic areas in 2010 (in the immediate post legislation period). Logistic regression was used to adjust for any variations in demographic distributions between the samples. Age-appropriate restraint use increased from 41% to 73%. After controlling for the child's age, parental education, income and language spoken at home, children in the post-legislation sample were more likely to be appropriately restrained (OR 2.2; 95%CI 1.4-3.6). [37]

Keay et al. [38] demonstrated that a multifaceted intervention that included education, hands-on instruction and restraint subsidies was able to significantly increase optimal child restraint practices beyond the effect of legislation.

Current problem areas for Australian child occupants

Incorrect use

The real world benefit of a passive occupant crash protection system is determined by both its inherent design and how it is used in the real world. Getting children into the right design of restraint for their age is only half of the solution. Optimal crash protection requires correct use of size-appropriate restraints. Errors in how a child restraint is used increases risk of injury in a crash because they loosen the link with the vehicle and allow greater motion of the child and/or alter the way crash forces are distributed over the body. A number of Australian studies have reported observed errors in child restraint use in convenience samples. [39-40] We recently estimated that half of all child passengers aged 0-12 years in NSW [26] had at least one error in how they were using restraints when travelling in cars, and have calculated that removing these errors in use among appropriately restrained children could prevent 42% of fatalities and 55% of non-fatal injury among children aged 1-6 years. [31] It is important to understand that prior to the new legislation, incorrect use was occurring as frequently as inappropriate restraint selection [26] and it potentially carries a higher risk of injury in crashes than simply using the wrong sort of restraint for the size of the child. [41, 31]

Brown et al. [26] examined the types of misuse and the frequency with which they occurred. Errors are more common in convertible restraints, and when errors occur they usually occur in combinations. From this work it appears that addressing harness misuse is the highest priority for rearward and forward facing restraints, followed by installation problems involving the seatbelt and the top tether. The highest priority areas for booster seats involve misuse of the seatbelt, and belt guide features. Similarly for seatbelt users, the priority is correcting errors associated with positioning of the belt. The most common harness and seatbelt errors, are excessive (>25mm) slack and non-use or partial use of the internal harness or belt.

In NSW, an Authorised Restraint Fitting Station (ARFS) network has been operating since the 1980s and is overseen by the State government road safety department. The fitting station network was established to assist parents and carers to correctly install and use child restraint systems. Restraint fitting stations also operate in other Australian states but do not all operate under the same governance system used in NSW, where operators must be accredited, and the services are audited regularly. Use of the NSW ARFS network is associated with less incorrect use, as shown in a recent analysis. [42] The results demonstrated that the odds of children of respondents who did not use restraint fitting stations being incorrectly restrained were 1.8 times higher (95% CI 1.1–2.8) than for children of users, based on parental report of the use of a fitting station. Regardless of whether or not a restraint fitting station had been used, there was a trend towards greater odds of incorrect restraint use as the length of restraint ownership increased (OR 1.3, 95% CI 1.0–1.7), suggesting that the improvements in restraint use arising from use of the fitting stations 'wear off' over time. [42]

While the above results relate to NSW fitting stations, it is likely that the hands-on instruction many parents receive at similar services are helpful regardless of how this is delivered, provided that they receive accurate and appropriate instruction. Hands-on demonstration of correct use outside of a formal fitting station network has also been shown to be effective in reducing errors in restraint use. [43]

Not all parents use services like the fitting station networks and/or free restraint checking days held by different organisations. In the NSW study, only about 30% of parents reported using these services and greater understanding of the barriers to use of these services is needed. [42]

Other strategies in place in Australia to counter errors in use are directed at the design of child restraints. Child restraint systems can be more complex to use than adult seatbelts because these restraints must be installed in the vehicle and there are usually more steps necessary to properly secure the child in these restraints than in an adult seatbelt. Few restraints incorporate automatic adjusters, while these are almost universal for seatbelts. In many cases, the inherent designs of the restraint systems do not assist the process. Correct installation can be difficult to achieve because of confusing belt paths in rearward and forward facing restraints and difficulties in being able to completely remove slack from the belt and tether. Securing the child correctly can also be difficult to achieve and it is not always intuitively easy to understand which features need to be used, and when and how these features are supposed to be used. Further, there are no restraints currently on the Australian market that provide any feedback to the user as to whether or not the restraint is being used correctly. The Australian Child Restraint Evaluation Program (CREP) assesses the ease of use of child restraint systems on the Australian market and communicates this to consumers using a rating program. As part of its aims, CREP tries to encourage manufacturers to provide restraint systems that are not only easy to use but are also difficult to use incorrectly. This issue has also been picked up by Standards Australia with greater attention beginning to be placed on requirements centred around assisting users to achieve correct use, including enhanced labelling and warnings, and a new method of determining whether a child is using the most appropriate restraint for their size, based on seated shoulder height markers. [44]

Children from culturally and linguistically diverse (CALD) communities

The dominant language in Australia is English, but approximately 20% of the population speaks a different language at home. [45] Children from such families are more likely to incorrectly and inappropriately use restraints. [46, 47] This study identified that the increased risk of sub-optimal restraint use is associated with inadequate knowledge [46, 47], the determinants of intent and types of knowledge deficit in CALD communities in Australia are similar to those reported in mainstream populations [48], and there is a specific need to ensure access to detailed information through appropriate delivery strategies and languages. In a recent randomised controlled trial of a program delivered through early childhood education centres, the authors found an education program (including language specific material and free restraint checks) was equally successful in improving restraint practices of children from CALD families as children from English speaking families. [38]

There is a clear need to ensure that any strategies implemented to enhance the effectiveness of legislation in promoting optimal restraint of children are implemented in appropriate languages and through appropriate delivery points to reach CALD community members, including the most recently arrived immigrants.

Gap in protection

For child passengers there is also a gap in availability of suitable restraints between the time they become too big for available 'child' restraints and the size required to achieve good protection from adult belts. Current Australian law mandates the use of size–appropriate restraints up to age 7, and 'add-on' restraints are available that would accommodate most children up to about 9 years. A new category of booster seats (Type F) introduced in the 2010 edition of the Australian Standard (AS/NZS 1754) aimed to close this gap to some extent, but these restraints are designed to accommodate children up to 8-10 years of age, so there will still be a 'gap' for some children. This also reflects the situation internationally. However, adult restraint systems in many cars are unlikely to provide optimal protection for many children even up to the age of 16. [49] This highlights the importance of the inherent safety of the rear seat for optimising protection of older child occupants.

Almost 30% of passengers aged 9 years and older who were admitted to hospital in NSW following a motor vehicle crash during the three years 2005-2007, were rear seat occupants. Compared to drivers and front seat passenger positions, the rear seat had a greater proportion of fatalities (11% compared to 3% of drivers and 7% of front passengers). Among this sample, child occupants occupied rear seat positions relatively more often than adults, and while the proportion of fatalities among the rear seated older child occupants was similar to that for adult rear seat occupants, injury severity, in terms of length of stay in hospital, was greatest among the older child rear seat occupants with 2% requiring a hospital stay of longer than one week compared to only 0.5% of adults aged 17-55 years and 1% of the oldest adults. [37]

In Australia, there is currently no regulatory or other routine assessment of the rear seat and its safety systems. Recently, performance requirements have been introduced for rear seat crash tests in some New Car Assessment Programs (NCAPs) in other countries e.g. Japan, China and Europe. However, as shown by Brown et al. [50] these assessments do not adequately assess the rear seat for older child occupants. Brown et al. [50] suggest data from crash studies indicate a need to assess abdominal and lumbar/thoracic spinal injury risk in addition to assessments of head and chest injury risk like that currently included in NCAP protocols. Moreover. a lack of sensitivity to pelvic rotation in current generation Hybrid dummies makes assessment of abdominal and spinal injury risk difficult. [50, 51]

Interventions beyond legislation

The success of the multifaceted intervention as demonstrated by Keay et al. [38] was based on a consistent message. Studies prior to the introduction of the new legislation illustrated the confusion felt by parents as to how best to protect their children in cars. The age-based nature of the new legislation, together with changes made in the 2010 version of the Australian Standard to support the age- based legislation, will address some of the confusion felt by parents. However, it is imperative that messages and answers to questions frequently asked by parents and the community give consistent advice in line with best protection principles. There are numerous agencies across Australia that provide guidance and advice to parents on how best to protect children in cars. However, there is currently no overriding co-ordination of these agencies or the advice given. Added to this is the growing number of informal parenting social internet networks where parents provide each other with advice, some of which might be correct advice but some which may not. There is a need for a single set of 'best practice' guidelines that can provide definitive and consistent advice for parents, carers and restraint professionals alike. The development of such a set of guidelines is currently underway. This co-ordination of messages is key to ensuring optimal restraint practices and the effect of the new legislation is maintained and improved on over time.

Conclusion

Child occupant protection has come a long way in Australia since the 1970s when restraint use for children first became mandatory. Australia now mandates age appropriate restraint use up to age 7. Dedicated child restraint systems are available that will provide good protection up to about 9 years. However, there are still a number of areas where focused attention is required to ensure optimal crash protection for all child occupants. In particular there is a need to (i) actively encourage correct use of restraints, (ii) ensure information and interventions targeting optimal child restraint reach all members of the Australian community, (iii) actively pursue ways to ensure children too big for booster seats are offered high levels of crash protection in the rear seat, and (iv) ensure the effectiveness of the age appropriate restraint use legislation is sustained, and improved upon, by ongoing education and enforcement campaigns.

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A cross sectional observational study of child restraint use in Queensland following changes in legislation

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Abstract

As part of an evaluation of the 2010 legislation for child vehicle occupants in Queensland, roadside observations of private passenger vehicles were used to estimate the proportions of children aged under 7 years travelling in each of the five different restraint types (eg. forward-facing child restraint). Data was collected in four major population centres: Brisbane, Sunshine Coast, Mackay and Townsville. Almost all children were restrained (95.1%, 95% CI 94.3-95.9%), with only 3.3% (95% CI 2.6-4.0%) clearly unrestrained and 44 (1.6%, 95% CI 1.1-2.1%) for whom restraint status could not be determined ('unknown'). However, around 24% (95 CI 21.8-26.2%) of the target-aged children were deemed inappropriately restrained, primarily comprised of 3-6 year olds in seatbelts (18.7% of the 0-6 year olds, 95% CI 16.3-21.1%) or unrestrained (3.7% of the 0-6 year olds, 95% CI 2.5-4.9%) instead of booster seats. In addition, compliance appeared significantly lower for some regional locations where the proportion of children observed as completely unrestrained was relatively high and of concern.

Introduction

Surveys of restraint use in Australia have shown consistently high levels of compliance over the past three decades, with recent figures indicating that compliance is in the order of 95-99% for all occupants. However, prior to 2010, legislation for children's restraints only specified the type of restraint that should be worn for infants under 12 months of age: these children were required to use an Australian Standards approved (AS/NZS1754) restraint [1]. For children of this age, approved restraints incorporate a 6-point internal harness and are secured to the vehicle by both an adult seatbelt passed through the frame of the restraint and a top tether attached to an anchor point, generally located in the rear of the vehicle (Australian Design Rules govern where these anchor points may be located). For newborn babies, restraints face rearwards until the child outgrows the specification for the restraint (approximately corresponding to 6-12 months old depending on the restraint). Once this occurs, and the baby can support his or her head reliably, a forward-facing restraint can be used.

Before amendments to the pre-2010 legislation, it was perfectly legal for a child of 12 months old or more to be restrained in an adult seatbelt. However, research has consistently demonstrated that restraints specifically designed for children are very effective in reducing injury and death [1-7] and that children are better protected when they wear these restraints rather than adult seatbelts [8-11]. Fortunately, even though not mandated at the time, it was common practice in Australia for children aged 3 years and under to be restrained in child restraints [12-14]. Once past this age, studies in NSW, South Australia, Victoria and Queensland suggested that a large proportion of children were restrained in adult belts rather than dedicated restraints [12-17].

In recognition of this gap between the legislation and optimal protection, the National Transport Commission (NTC) amended the Australian Road Rules in 2009 to specify that child restraints should be used until children are at least 7 years old. Moreover, the type of restraint required and the seating row was also specified according to age in these new rules. From late 2009 to the end of 2010 all states and territories in Australia, with the exception of the Northern Territory, enacted legislation that incorporated these new child restraint requirements. For Queensland all child passengers have been required to use a dedicated child restraint until at least age 7