



Task 1.2

Overview Report Of Research Into The Incorrect Use Of Child Restraints In Selected Countries

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**From contributions from Task 1.2 partners which are attached
as Annexes**

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Executive summary

In the developed world, motor vehicle collisions are a major cause of severe and fatal injuries to children. The purpose of child restraint systems is to reduce these injuries by preventing the child from contacting the vehicle interior during the collision and by absorbing and distributing the impact forces over the strongest parts of the child's body. There are several types of child restraint available, each appropriate for children of a certain size.

Most countries mandate the use of child restraints to some extent but there are often gaps and exceptions, particularly as children get older. Through a combination of legislation and publicity it has been possible to change the behaviour of parents to such an extent that the use of child restraints is now higher than ever before. However, research shows that the majority of children are not restrained correctly and even with the most appropriate restraint for a child's size, the way it is used can affect its performance. The result can be serious injury and death if the device is not properly secured to the vehicle or if the child is not well restrained within it.

The European Community project; CHild Injury Led Design (CHILD) aims to improve the knowledge of child biomechanics and injury tolerance and establish protection reference values for a new child dummy called the Q series. This will be achieved by reconstructing real accidents with the dummy. However, these reconstructions will usually be based on police reports, which may make it difficult to tell if the restraint was used correctly or not. To give an indication of the level of misuse, each partner in the CHILD project was tasked with producing a national literature review, forming a comprehensive review of the incorrect use of child restraints in the developed world.

Research in the USA shows that as many as 80% of child restraints are misused in some way. Child restraints may be misused in a variety of ways, including incorrect fitting, facing the wrong direction and the child not being properly secured in the restraint. There are also instances of inappropriate use; not ensuring the child restraint is of the correct type and size for the child.

Improved child seat design may reduce some forms of misuse; such as dedicated attachment systems to reduce the risk of the adult belt being incorrectly routed through the restraint.

Interviews with parents suggest that most do not have a good understanding of the installation and use of child restraints and of those that do, some still choose to misuse the restraint because they perceive there is some benefit in doing so. Parents generally behave in this way because they are not aware of the consequences of their actions. Research also shows that there is a link between certain demographic factors and misuse, such as academic achievement or socioeconomic status.

Two groups of children are most at risk when restrained inappropriately: infants using forward facing child restraints when they are less than one year old, and children using the seat belt when they should be using a forward facing seat or booster seat.

Improved child restraint designs are unlikely to address the issue of inappropriate restraint selection by parents. Instead, this must be addressed by awareness campaigns; there is a need to emphasise to parents that restraint laws provide a minimum level of protection and can differ from the best practice. For example, in some countries occupant protection laws allow children over 4 years of age to be restrained by an adult seatbelt without a booster cushion.

Child restraint misuse is associated with greater injury severity in real accidents. In particular, children in misused child restraints receive more head injuries than children who are correctly restrained. Inappropriately restrained children are also placed at a greater risk of injury than children using the correct restraint for their size and weight. However, it is important to note that the risk of sustaining injuries from misused or inappropriate child restraints is less than the risk of sustaining multiple serious injuries from travelling unrestrained.

Studies in the UK show that the percentage of correctly fitted child restraints is low, although their use is high. Information was obtained from small, local studies run by county councils, safety campaigns run by child product manufacturers and surveys from safety organisations. Studies show that parents are often not confident that their child is restrained correctly. Studies also show that instructions given with child restraints need to be clearer to increase the likelihood of correct fitting and parent confidence.

A proportion of child restraints used in the UK will have been purchased privately second hand and hence may not provide the best protection for the child. For example, Hampshire County Council Trading Standards Service conducted a study on the crash performance of second hand child restraints – all 15 child seats tested, failed to meet the R44.03 standard.

The major problem in Spain is lack of restraint use in general. Accident studies have shown that in a number of cases where the child was restrained using a child restraint; the restraint was either incorrectly fitted or not attached to the car at all. Early graduation to using an adult belt only as a restraint is also a problem, particularly for children in the 7-9 age group.

Swedish studies have found that 83% of children always use a seatbelt. However, the restraint use is not always correct or appropriate. In Sweden children under 3 should travel rear facing but one study found nearly 30% travelling forward facing. Another study showed that whilst the majority of parents believe their child to be correctly restrained, only 60% fully understood the correct restraint to use for their child and how to fit it.

In France, 307 cars with 478 children were observed at various locations. The study found that 73% of the child restraint systems were misused in some way. Several factors were identified as contributing to or being associated with the misuse of child restraints; parents find child restraints difficult to install, second hand child restraints are used, parents take less care installing child restraints for short trips and parents allow children to adopt a more comfortable position for long trips especially in the evening. The most common types of misuse observed in the French study were slack in the harness, slack in the seat belt and misrouting of the seat belt.

1 Introduction

In the developed world, motor vehicle collisions are a major cause of severe and fatal injuries to children. The purpose of child restraint systems is to reduce these injuries by preventing the child from contacting the vehicle interior during the collision and by absorbing and distributing the impact forces over the strongest parts of the child's body. There are several types of child restraint available, each appropriate for children of a certain size.

Most countries mandate the use of child restraints to some extent but there are often gaps and exceptions, particularly as children get older. Through a combination of legislation and publicity it has been possible to change the behaviour of parents to such an extent that the use of child restraints is now higher than ever before. However, research shows that the majority of children are not restrained correctly and even with the most appropriate restraint for a child's size, the way it is used can affect its performance. The result can be serious injury and death if the device is not properly secured to the vehicle or if the child is not well restrained within it.

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This document is intended to summarise the contributions received from each partner in the CHILD project; the individual contributions have been included as annexes to this summary. Most partners have contributed a review of research conducted in their own country. However, since two partners were based in the UK, VSRC have reviewed all relevant information available in the UK and TRL have reviewed research on the subject of child restraint misuse from other developed countries. English speaking countries were the focus for the review within the scope of this project as literature from these countries was accessible and there were no problems associated with translation.

The full texts of each review of literature or field study on the incorrect use of child restraints are contained in Annexes 1 to 6. [Annex 1](#) contains the review of literature from Non EC Countries by TRL; [Annex 2](#) contains information from the UK by VSRC; [Annex 3](#) contains a review of child restraint use in Spain by Idiada; [Annex 4](#) contains a review of incorrect restraint use in Sweden by Chalmers University; [Annex 5](#) contains a review of child restraint use in France by INRETS, Renault and PSA and [Annex 6](#) contains research from Germany by BAST. Annex 6 was provided in German with an English abstract. A full English translation of this document has not been provided, consequently this State of the Art report does not include the German research.

2 Misuse

Misuse of a child restraint system is defined as any incorrect fitting of the restraint in the vehicle (e.g. having the adult seatbelt routed incorrectly) or incorrect positioning or restraining of the child within it (e.g. having the harness too loose).

2.1 Introduction

Countries outside the EC:

There are a wide variety of techniques used to measure child restraint misuse, such as roadside observation studies, car park inspection events and parent interviews. Transport Canada reported that 25% of child restraints were misused, in a roadside study observing cars at traffic lights and stop signs (Transport Canada, 1998). The National SAFEKIDS campaign in the USA inspected more than 17500 children at an inspection event and found that 85% of restraints were misused in some way (Taft et al 1999). In a similar study, Decina and Knoebel (1997) found over 80% of restraints were misused.

UK:

In the UK it is evident that the percentage of correctly fitted child restraints is low, even taking into account the scientific limitations of the car park surveys from which this data is available. In the larger studies (GMTV/Britax, Pampers) only around 25 to 40% of child restraint systems are found to be fitted correctly. During a campaign carried out in Scotland in 2002 (Scottish In-Car Safety Initiative) 40% of child restraints were found to be fitted incorrectly.

The picture of incorrect use is very similar for the smaller checking campaigns that are carried out at a more local level throughout the UK.

In the larger campaigns the levels of incompatibility between car and child restraint were between 9 and 20% and the combined categories that are cause for major concern (in need of major adjustments, incompatible with the car or condemned), range from 37 to 42% over the 3 years of the GMTV/Britax campaign, higher than the percentage of minor adjustments in this campaign, 30 to 38%. In the checks carried out by the Scottish In-Car Safety Initiative, 23% of child restraints were put into the major adjustments, incompatible or condemned category.

Spain:

In Spain, non-use of child restraints seems to be the major cause of concern, since the majority of children still travel unrestrained on Spanish roads.

Sweden:

Child restraint use and misuse were studied in Ostergötland, Sweden. 274 children were observed at supermarkets and child care centres and of those, almost 40% were in misused restraints. In Sweden, children under 3 years of age should be restrained in rear facing restraints. Nearly 30% of children under 3 years of age were found travelling forward facing, but the main type of misuse was seatbelt misplacement (Anund, 1998).

France:

It is understood that there is no published research on child restraint misuse in France. However, a field study was performed as part of this project and 478

children were observed in 307 cars. The study found that 73 percent of children were travelling in a misused restraint system (including the adult seat belt). The children were observed inside their car and parents were interviewed after the inspection to gauge their understanding of misuse.

2.2 The effects of child restraint type or design on misuse

Countries outside the EC:

Almost all aspects of child restraint design are misused in some way. Researchers agree that some types of misuse are more serious than others but any misuse is likely to compromise the performance of the restraint. The design of child restraints has improved considerably in recent years but there is evidence that parents still find them difficult to use.

Misuse of the seat belt when it is used to attach the child restraint to the car is already being addressed by better design. In the latest development, ISOFix anchorages are found in most new cars around the world and child restraint regulations are being updated to encourage designs that use these anchorages. Another concern, however, is the way the child is held in the child restraint. In many cases identified in research studies, the harness was loose because it had not been adjusted correctly. As child restraints now have a single strap for adjustment, which should be easy to use, further improvements may therefore be necessary. Possibly self-adjusting harnesses or a 'tell-tale' device to alert parents to poor fittings (Lang et al, 2002) would reduce the likelihood of misuse.

UK:

In the UK, observations of child restraints being fitted as part of a study on instructions (Royal Society for the Prevention of Accidents, RoSPA) and comments from local checking days indicate that the most common cause of child restraints being fitted incorrectly is because they are too loose, with the restraint looking secure, but being easy to move.

In a survey reported by Campbell et al (1997) the highest rate of incorrect fitting was found in two way seats, followed by rear facing infant carriers and forward facing seats. The lowest rate of misuse was found for booster seats.

During the RoSPA trials, it is reported that many of the volunteers failed to put the handle of infant carriers into the lowest position, which is necessary (in the case of the models examined) to obtain a secure fitting. Some volunteers also found the correct routing of the seatbelt difficult, especially at the back of the restraint.

In a study of ISOFix attachment systems, TRL found that all 4 of the possible ISOFix systems examined resulted in lower rates of misuse than with the conventional child restraint (Lowne et al 1997). Of the ISOFix child restraints, the system with webbing attachments, opposed to rigid attachments, was fitted incorrectly more frequently, resulting in greater slack, especially when fitted for the second time.

Sweden:

Berg and Gregersen (1992) & Berg (1998) investigated the effectiveness of systems with child seat fastenings incorporated into the car seats or chassis with respect to correct mounting by parents. The results showed that these systems minimise incorrect mounting of child restraints; the ISOFix system being ranked highest for ease of use and security of fastening.

Spain:

An investigation of crashes where the child restraint was found unattached to the car after the crash assumed the restraint had been fitted incorrectly and found that in the majority of cases, an adult belt had been used to attach the restraint to the car. This could imply that parents had struggled with this method of attachment the most or that this was simply the most common attachment method. In 27 percent of cases, it

was believed that the restraint had not been attached to the car at all prior to the crash.

France:

The observation study carried out in France found that some types of child restraints were misused more often than other types. For instance, infant carriers (72 percent misused) and child safety seats (85 percent) were more likely to be misused than booster seats (64 percent) and booster cushions (67 percent). The main difference between these child restraints concerns the way the child is held within them. Infant carriers and child safety seats use an integral three or five point harness to restrain the child, while the booster systems use the adult seat belt to hold both the child and the child seat in place. It seems that there is a greater potential for misuse when a harness is used to hold the child, probably because parents are less familiar with these compared with seat belts. This assumption was supported by the frequency data for each type of misuse that was identified. In the case of infant carriers, problems with the harness were the most common type of misuse accounting for 59 percent of all the misuses observed with this type of child restraint. The corresponding figure for child safety seats was 72 percent. These data suggest that it would be desirable to improve this aspect of the design of these child restraints. In the case of booster systems, the most common types of misuse concerned the position of the seat belt. These included instances where the lap part of the belt was routed above the guides and hence across the child's abdomen (25 percent). Also, there were instances where the seat belt was twisted (20 percent) or the seat belt passed under the child's arm (16 percent). It is possible that these types of misuse could be reduced with better child restraint designs, however, it is difficult to imagine how and, therefore, education of parents may be a better approach.

2.3 The Effects of Parent Understanding on Misuse

Countries outside the EC:

Two approaches have been taken in the literature; researchers have tried to use the demographics of parents to see if particular groups are more likely to misuse child restraints and secondly, interviews have been carried out to gauge the knowledge and understanding of parents about child restraints. These results have then been used to recommend the provision of educational programmes where they are most needed.

Parent restraint use correlates with child restraint misuse such that parents who fail to use restraints themselves are more likely to misuse their children's restraints (Cynecki & Goryl, 1986 and Eby & Kostyniuk, 1999).

Parents generally find buying restraints difficult and staff uninformed according to Glanvill (2000). Once the restraint has been purchased most parents choose to fit it themselves and consider this well within their capabilities (Decina & Knoebel 1997 and Glanvill 2000).

Most parents use the instructions to fit the restraint the first time, however, studies have shown that child restraints are more likely to be misused if regularly removed from the vehicle, implying the instructions may not be used after the first fitting (Cynecki & Goryl 1986, Decina & Knoebel 1997 and Eby & Kostyniuk 1999). Some parents also fail to use the instructions to secure the child in the restraint; parents who took this approach were more likely to misuse the restraint (Decina & Knoebel 1997 and Eby & Kostyniuk 1999). However, parents who did use instructions to fit the

restraint were also found to misuse the restraint, implying that instructions may not be easy to understand.

Most parents interviewed in studies were unaware that they were misusing the restraint; however, some parents were shown to have been misusing the restraint intentionally. An example of this was parents knowingly using an infant carrier facing forwards because they wanted to be able to see their baby and could not place the infant carrier in the front seat (Weber 1989). Another example was parents leaving the restraint harness loose so as not to make their child uncomfortable (Eby & Kostyniuk 1999).

Low academic achievement has been linked to misuse (Eby & Kostyniuk 1999); better educated parents were more likely to use child restraints properly. A "hands on" approach to instruction has been shown to reduce mistakes in fitting and using restraints (Lane et al 2000). This approach may also benefit non English speaking populations within each country, although in general the focus is still on getting these groups to use child restraints.

In general, age, gender and employment status have not been found to influence misuse and the only two studies comparing parents with other adult carers in terms of the likelihood of their misusing restraints had different findings so no conclusions may be drawn about this. (Cynecki & Goryl 1986, Decina & Knoebel 1997 and Eby & Kostyniuk 1999).

UK:

In the UK, the work of RoSPA regarding child restraint fitting instructions found many general problems with instructions that could lead to the incorrect fitting of the child restraint. Many issues are cited in the work but the overall conclusion is that the quality of instruction booklets needs to be standardised to bring the poorest examples in line with the good examples. It is also suggested that videos are provided as part of the fitting instructions.

A major problem of parent understanding is highlighted regarding how secure the restraint should be. It is commented that clearer advice to check the security of the fitting should be provided, with guidance on what is regarded as 'secure' and 'insecure'. A Road Safety Officer suggested in a telephone conversation that some parents purchase seats believing that they are a universal fit and are suitable for all cars. From information from checking days it is obvious that this is not necessarily the case, especially if seat belts are not long enough to route correctly through the child restraint.

During a Scottish Police Force child safety campaign in 2001 a telephone line was set up to offer advice. Of the 165 callers who stated that they drove with children, 94% claimed to use a child or booster seat. Of those callers, only 54% stated that they were confident to fit the (child) seat. This obviously indicates that although most of these parents had the knowledge that they should be using a form of child restraint only around half felt that they then had the knowledge to fit it confidently.

France:

As part of their field study, French researchers interviewed the parent or guardian of each child. They were asked whether they found it easy or difficult to install the child restraint. Most parents replied that they found the child restraint easy to fit, but there were differences between the various types of restraint. For instance, parents of children using booster systems seemed to find these child restraints easier to fit than parents of children using infant carriers and safety seats. Ninety-six percent of parents said that their child's booster seat or cushion was easy to use, however, the

corresponding figure for infant carriers and rear facing safety seats was 75 percent and for forward facing safety seats it was 63 percent. These figures seem to reflect the rate of misuse for each type of restraint, suggesting that parents are more likely to misuse child restraints that they find difficult to use. This was examined more closely by looking at the relationship between the ease of use of child restraints and the occurrence of misuse. Only forward facing safety seats were examined because of the low levels of difficulty reported for the other types of child restraints. The analysis showed that almost all parents (96 percent) who found the safety seat difficult to use had installed it incorrectly. However, it was interesting to note that 80 percent of parents who said the safety seat was easy to fit, had misused it nevertheless.

Parents were also asked how they had learnt to install the child restraint for the first time. It was somewhat concerning that only 39 percent reported using the instructions supplied with the child restraint. Over half of parents questioned (54 percent) said that they had installed the child restraint by themselves, ignoring the user manual. However, analysis showed there was no significant difference in misuse levels, irrespective of how the child restraint was installed for the first time. This suggests that many parents find the instructions difficult to understand.

2.4 The Effects of Child Age and Weight on Misuse

Countries outside the EC:

The literature suggests that the age and weight of a child only affects child restraint misuse because children use different restraint systems as they grow and some are easier to misuse than others.

Several studies were conducted looking at children in the 0 to 4 age range but the results were inconsistent. Two studies found that the youngest children were more likely to be seated in a misused child restraint, whilst two others found there was no difference across the age range.

When age groups were compared, several studies found that children in the 5-9 age range were less likely to be seated in misused restraints than those in the 0-4 age range. However, this was probably due to older children being restrained with only an adult belt and therefore there being less chance of misuse.

Similar trends were reported for the effects of child weight on misuse. However, one study compared booster seat misuse with child weight and found that children under 40lbs (approximately 18kg) were twice as likely to be seated on a misused booster seat than those over 40lbs (Morris et al 2000).

2.5 The Effects of Journey Type and Time on Misuse

Countries outside the EC:

There were few publications which considered the effects of journey type and time on misuse. A few studies considered the distance and time from the last stop and determined that that these factors did not influence misuse; however, these studies were conducted in urban areas during daylight hours. One study found that restraints were used less during late night and early morning trips, possibly because parents allowed their children to lie down or sit in a different position at these times. These factors may also affect misuse but it is clear that further research is necessary in this area.

France:

The observation study in France found that child restraints were more likely to be misused during shorter trips (less than 15 minutes). In the case of child safety seats, the rate of misuse decreased as the duration of the trip increased. However, a different trend was observed for booster systems. With these child restraints, misuse did decrease for 16 – 45 minute trips, compared with trips less than 15 minutes, but misuse then increased for longer trips above 45 minutes. This was attributed to comfort and the behaviour of children on longer journeys.

Some observations were made in the evening in order to examine the effect of the time of day on misuse. To remove other influences, only journeys greater than 2 hours were included. The study found that 76 percent of children travelling by night were seated in a misused restraint system, compared with 59 percent during daytime. This was attributed to parents allowing their children to adopt a more comfortable position in order to sleep.

2.6 Injuries Associated with Frequent Misuse Modes

Countries outside the EC:

Different studies have considered the additional risk to children in an accident, based on the type of misuse of the restraint but findings vary. Glanvill (2000) found that 25% of misuse faults were so serious that they put children at greater risk of death or injury, whilst Weber (2000) found that most types of misuse were relatively minor.

It is difficult to identify incidences of misuse from real accident data; however, several accident reconstruction studies have effectively shown that misuse of child restraints was associated with greater risk of injury. Children in misused restraints receive more head injuries but misuse is also associated with a higher incidence of abdominal injury (Sweitzer et al 2002).

3 Inappropriate Use

This section summarises the research on the inappropriate use of restraint systems by children in cars. Inappropriate use is defined as the child being restrained in the wrong type of restraint for their size, age or weight. Children most at risk of being inappropriately restrained were the focus for the review, which also considers what factors might be associated with inappropriate restraint use and the consequences, in the event of a crash.

3.1 Introduction

Countries outside the EC:

Studies of restraint use often observe children in the wrong type of restraint for their weight and size. For instance, the National SAFE KIDS campaign observed over 9000 children. They found that 33 percent were inappropriately restrained and a further 14 percent were unrestrained (Cody *et al*, 2002).

Spain:

A high percentage of children (varying from 30% to 40%, depending on the city) travel unrestrained or inappropriately restrained every day. Early graduation to adult seat belts is a serious problem in Spain, since almost no children between 7 and 9 years of age use booster seats. When these children are restrained, they normally use the adult seat belt. Rollovers account for almost half of the fatalities. For appropriately restrained children, lateral crashes are the most dangerous event. The study has shown that unrestrained children suffer 2.5 times more serious injuries than appropriately restrained children, and 1.8 times more than inappropriately restrained children.

France:

Child restraint misuse seemed to be the main focus for the French observation study carried out within this project. Nevertheless, researchers also examined whether each child was using an appropriate restraint system for their weight, height and age. Overall, 15 percent of children were using an inappropriate restraint system (including adult seat belts), however the rate varied according to the child's age.

3.2 The effects of child restraint type and design on inappropriate use

Countries outside the EC:

Before considering the effects of design, it is important to establish the weight and size of children for whom each type of child restraint is appropriate.

For each of the restraints listed below, the child has outgrown the restraint when their head is above the top of the seat back.

Infant Carrier – Designed to be used by children aged 0-1 year, under 9kg in weight.

Convertible Seat – Designed to be used by children from birth until they are 18 months old and 13kg in weight. May be used rear or forward facing but children less than one year old must not travel forward facing.

Forward Facing Child Seat – Designed to be used by children over one year in age until they reach 18kg in weight (4 years of age).

Combination Seat – As above but has higher seat back and removable harness so it can be used as a booster seat when the child reaches 18kg in weight (4 years of age).

Booster Seat – Used to raise the child's height and make it safer for them to use an adult seatbelt. May be used by children from 18kg to 36kg or 45kg in weight depending on the design.

Children at risk are usually those using restraint systems too advanced for their development. The two groups most at risk are infants placed in forward facing seats and children restrained by an adult seatbelt when they should be using a booster seat.

Child restraints are provided with instructions and labels illustrating when it is appropriate to use them forward facing and it was shown in Section 2.3 that some parents deliberately restrain their child facing forward before it is appropriate to do so; it is therefore unlikely that seat design is to blame for this type of inappropriate use.

It is also unlikely that the failure of some parents to use a booster seat to restrain their children is due to booster seat design, as occupant protection laws in most states in the USA only require that children under 3 be appropriately restrained.

Sweden:

Occupant restraint laws are also more likely to influence inappropriate restraint use than design in Sweden, where currently it is only mandatory for children of 6 years of age and below to be restrained using a child restraint. No literature relating specific design issues to inappropriate use was available.

3.3 The effects of parent understanding on inappropriate use

Countries outside the EC:

Studies in the USA indicate that parents may be unaware of the consequences of inappropriate use of certain restraints. For example, one study (Vaca et al 2002) showed that the majority of parents (over 90%) are aware that children under one year of age and 9kg should travel rear facing, whilst another (Cody et al 2003) indicated that only 74% of infants were actually correctly restrained. Vaca et al (2002) also showed that only 46% of parents could identify booster seats as the appropriate restraint for children of 18kg to 27kg in weight. In this case, state laws are most likely to be the cause of parents' misconceptions

Sweden:

In Sweden, it is recommended that all children under three years of age travel facing rearwards (Anund, Sörensen & Yahya, 1999). A significant correlation was found between the percentage of forward facing children under three and both the educational level of parents and their household income. There was also a link between misuse and whether the parents were immigrants; it was believed that this was because these parents had not received or investigated the necessary information. Overall, most parents were convinced that their child was restrained correctly, even though survey results indicated that less than 60% actually understood correctly which restraints they should have been using.

3.4 The effects of child age and weight on inappropriate use

Countries outside the EC:

The research summarised in the previous sections has shown there is a relationship between age and inappropriate restraint use. The relationship is not uniform; instead, there is a sharp increase in inappropriate use when children reach 4 years old. This is explained by the occupant protection laws. When children reach four years of age, most countries no longer mandate the use of a child restraint. Many children are therefore inappropriately placed in restraint systems designed for adults or are even unrestrained.

Sweden:

Anund, Sörensen & Yahya (1999) found that there was a correlation between the age of the child and the use of a child restraint. Among one to two year olds, 7% travelled without a child restraint in at least one out of 20 trips, whilst 30% of 3-9 year olds travelled without a child restraint for at least one out of 20 trips.

Spain:

Research indicates that, in general, inappropriate use was highest for infants and children aged 4-6. The utilisation of restraint systems decreases as child age increases, especially above 3 years old. One Spanish study showed that for children of three years old, more than 50% travelled without being restrained in a child restraint. For children aged seven to nine years of age, 80% travelled without a child restraint. The study does not indicate what proportion of these children may have been restrained using an adult belt.

France:

The French observation study found that 40 percent of children less than a year old were restrained (inappropriately) in forward facing child restraints. Weight is the deciding factor when selecting a child restraint system, however, children less than a year old should travel rear facing to protect them from serious spinal injury in a front impact. It is possible that these children also weighed more than 9 kg (the minimum weight for forward facing), but even if this was the case, a rear facing system should have been used.

3.5 The effects of journey type and time on inappropriate use

Countries outside the EC:

It was not possible to find any significant literature on the effects of journey type and time on inappropriate use. Restraint use is less during late night and early morning hours (Agran *et al*, 1998), but generally, little is known about the circumstances in which parents might vary the way they restrain their children.

Spain:

One Spanish study compared restraint use on different types of road. In general, use rates were low as has already been indicated in previous sections. Inappropriate use was higher for more major roads but this is likely to be because restraint use was more frequent on these roads and not indicative of any relationship between journey type and inappropriate use of restraint.

3.6 Injuries associated with inappropriate use

Countries outside the EC:

Data from the Crash Injury Research & Engineering Network is reported to show that inappropriately restrained children are nearly three and a half times more likely to suffer a severe injury than appropriately restrained children (Cody et al, 2002).

As indicated in previous sections, the two groups most at risk are infants less than one year old restrained in forward facing child restraints and children restrained by an adult belt when they should also have a booster seat.

Infants under one year old are vulnerable to cervical spine injury when restrained forward facing, due to their proportionally large head and loose spinal ligaments (to allow for rapid growth). The spine can be stretched and the spinal cord damaged, resulting in quadriplegia or death.

Children aged between 2 and 5 restrained by an adult belt tend to rotate out of the belt due to their higher centre of gravity and thus sustain head injuries. Slightly older children have different kinematics but still do not engage the lap belt properly and are at risk of sustaining chest, abdominal and lower extremity injuries as a result. However, risk of injury from an adult belt is still less than the risk of sustaining severe injuries when unrestrained.

Spain:

Research suggests that the majority of children restrained inappropriately, who are killed on Spanish roads, suffer head injuries.

Sweden:

Child fatalities in Sweden between 1992 and 1997 were reported by Wenäll (2001). In cases where children were inappropriately restrained head injuries predominated (this was also the case for unrestrained children).

4 Second Hand Child Restraints

UK:

As a safety product, it is necessary for child restraints to comply with performance requirements laid down in regulations and standards. However, their sale falls within the market of nursery products. This market is considerable and consists of both new and second hand retail sales, with the associated consumer protection legislation and statutory obligations. There is also a considerable private activity of sale, exchange, loan and gift of nursery goods. This activity ranges from private sales and small advertisements, to loaning between friends and family and handing down from one to the next child.

Although products sold second hand in a business context can still be assessed under the terms of the General Product Safety Regulation, there is no requirement for assessment of a child restraint sold privately or passed on as an exchange or gift.

No information has been found about the size of this private trade, either in value or frequency. Unfortunately within the information available, it is not defined as to whether a second hand car seat is one bought second hand or passed on from friends or family.

As a consequence of this trade in child restraints, the life expectancy of each product sold new is considerably longer than the period of use that is possible for the type of restraint (for example a Group 0 infant carrier can be used for a child up to 9 months, but the product will still be fit for use after the infant has grown out of it).

During this life cycle, a number of events could happen, which may affect the condition and crash performance of the child restraint. Examples are given in the table below (Table 1), together with the possible consequences, but the list is not exhaustive.

Throughout the period of use of the child restraint the state of the art of child restraint design is changing. The relevant standards are updated, new designs are introduced, improved materials are used and the vehicles in which the child restraints are used are also changing.

First time parents are particularly likely to be using second hand child restraints; this is reflected in statistics from the Baby Products Association (BPA) that 60% of group 0 child restraints are second hand.

From information gathered there are problems with second hand child restraint systems. Regarding the provision of fitting instructions, one of the recommendations from the RoSPA study on child restraint fitting instructions was that instruction booklets and on-product stickers should be more durable. Knowledge about the history of the child restraints and previous involvement in an accident was found to be an issue in a study carried out by Hampshire County Council Trading Standards Service. This was a large study looking at the crash performance of second hand child restraints, with all 15 failing to satisfy the criteria of R44.03.

Table 1: Life-cycle events that may affect the performance of a child restraint

Event	Consequence	Influence on crash performance
The harness will be adjusted frequently	Wear and tear of the webbing and slack may be introduced to the system	Slack in the harness can cause or exacerbate injuries
The cover will be removed for washing	This may involve removing the harness, which may not be correctly replaced	Misrouting of the harness is known to contribute to injury
The harness will be removed for adjustment and/or cleaning	The harness may not be replaced correctly or adjusted correctly	Slack in the harness can cause or exacerbate injuries
The cover may be replaced	If the original cover is no longer made a newer version may be available, giving the impression that the CRS is newer than it really is	An old CRS may not perform as well in crash conditions
<ul style="list-style-type: none"> • Wear & tear • Moisture (accidents and cleaning) • Temperature extremes (heat in the sun and cold overnight in winter) 	Materials will degrade	Materials may not perform as expected in crash conditions, with a reduction in performance.
Damage may be caused due to repeated refitting and other use such as storage, dropping	Damage may occur that is not noticed	May reduce the performance of the CRS
Damage may be caused as the result of use in a crash	Damage may occur that is not noticed	May reduce the performance of the CRS

5 Conclusions

The level of restraint use and misuse varies from country to country but misuse and inappropriate use are world-wide problems. In every country where a literature search was carried out, the literature implied that a significant proportion of child restraints were being used incorrectly in some way.

Common problems included:

- Incorrect fitting of the restraint, often due to incorrect routing of the seatbelt or the seatbelt being tightened insufficiently to hold the restraint in place.
- Incorrect restraining of the child in the restraint – in particular, failure to tighten the harness sufficiently.
- Use of adult seatbelts only as a restraint for children between the ages of 4 and 10 years.
- Use of infant carriers facing forwards instead of rearwards.

It was also apparent that occupant protection laws were often a source of parents' misconceptions about the safest way to restrain their child and this is an area where change could make an impact on correct restraint use in many countries.

Where restraint fixture systems were trialled, the ISOFix system was found to be the best system currently available in most countries for ease of use for parents.

Little evidence has been found in any country to link either journey type or time, or child age or weight to incorrect use. Particular children have a higher risk of being inappropriately restrained because of the type of restraint (e.g. infant carrier) rather than their particular characteristics.

6 Recommendations

It is recommended that those responsible for accident reconstructions within the CHILD project should be aware of the most common restraint use problems identified by the review and listed above. It is important that the most common modes of incorrect restraint use are kept in mind when reviewing accident data so that a decision can be made as to whether to fit the restraint correctly in the reconstruction or not.

Recommendations for reducing the most common incorrect uses of child restraints are as follows:

- Improvements in child restraint design, particularly in producing a dedicated attachment system that does not require use of the adult seatbelt, would reduce the amount of incorrect fitting of child restraints by parents.
- Clearer instructions and labelling on restraints, as well as making instructions more durable would also be likely to reduce the amount of incorrect fitting and use of restraint systems.
- Better parental education is required, as parental understanding was shown to be a major cause of restraint misuse and inappropriate use, regardless of location. In many cases it was apparent that parents were not aware of the consequences of incorrect restraint use. Parents should be informed:
 - That they should use child restraints
 - Why it is important to use child restraints
 - The consequences of not using a child restraint for their child
 - Why it is important to use restraints correctly and the consequences of not doing so

Although it is impossible to inform all parents on the correct installation of all restraints, they should be made aware of general safety aspects applicable to all seats, as well as being encouraged to use specific manufacturers instructions for all aspects of child restraint use. Hands on instruction and training for parents in how to fit restraints correctly may be useful in overcoming educational barriers.

- Occupant protection laws should be easily available and understood by parents, as well as covering appropriate restraint systems for all occupant groups – i.e. appropriate restraints should be specified for all children under 12 years of age, additional to the adult seatbelt.

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