

INJURY CLASSIC

Observed child restraint use in automobiles

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This is the 16th paper in a series of Injury Classics. Our goal is to reprint one or two such papers in each issue to introduce newcomers to these old, often quoted, and important contributions. As many are difficult to find, it should help all of us to have a copy at hand. Your suggestions about future articles are welcome. Write to the editor with details of your favourite, most quoted paper.

Abstract

Visual observations were made on restraint use in occupants of 5050 automobiles containing at least one passenger less than 10 years of age, and short interviews were conducted with the drivers. Ninety three per cent of passengers less than 10 years old were not restrained. Eighty nine per cent of passengers 10 or older and 78% of the drivers were not restrained. Sixteen per cent of child motor vehicle restraint devices observed were not used, and 73% of those in use were not used correctly. Use of such devices declined sharply after age one. Although child passengers were more likely to be restrained if the driver was restrained, more than 75% of the children were not restrained when the driver was, even if the driver was the child's parent.

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When a motor vehicle crashes, unrestrained occupants are often flung about, striking interior vehicle surfaces, each other, or exterior surfaces, if ejected. One of several means of reducing the incidence or severity of injuries sustained by vehicle occupants is to restrain them by seat belts.¹ However, recent observational surveys of drivers, the only vehicle occupants on whom adequate data on restraint use exist, indicated that lap or lap and shoulder belts were used by less than one in four.²⁻³

Restraint of infants and children travelling in motor vehicles is of interest because of the large number of deaths and injuries sustained by young vehicle occupants, and because there are special problems involved in protecting children in crashes. In 1973, 1090 motor vehicle occupants less than 5 years old and 1650 occupants between the ages of 5 and 14 were killed,⁴ and passengers of these ages receive many of the nearly four million annual injuries resulting from motor vehicle crashes,⁵ frequently head injuries.⁶⁻⁸

Considerations of size, proportions, and physiology of bone growth of children have led to the view that specially designed restraint devices are preferable to seat belts for those less than about 4 years of age.⁷⁻⁹ Many of the devices that are used to transport children in vehicles provide no crash protection, eg, "car seats" that hook over regular automobile seats, prohibited by US law from manufacture since

1971,¹⁰ and other seats and carriers designed in ways that ensure that they do not protect children in crashes. These inadequate protective devices must be distinguished from restraint devices that are designed to protect children in crashes and that offer at least some protection if used correctly. Child motor vehicle restraint devices include car seats manufactured on or after April 1, 1971, covered by US Federal Motor Vehicle Safety Standard (FMVSS) 213,¹⁰ for use by children old enough to sit erect. Also included any types of devices not covered by FMVSS 213 that may be designed to protect children in crashes: child safety harnesses, covered by FMVSS 209, which applies to seat belt assemblies,¹¹ and car beds and infant carriers for infants transported in recumbent and semirecumbent positions, not covered by any FMVSS.

If child motor vehicle restraint devices are not used correctly, crash protection they otherwise provide may be reduced or eliminated. In order to limit the child's motion in a crash, the child must be restrained within the device and the device itself must be restrained.

Even if car seats satisfying the requirements of FMVSS 213 and other child motor vehicle restraint devices are installed and used according to the manufacturer's instructions, there is some uncertainty about the amount of crash protection they provide. Many car seats certified as complying with FMVSS 213 have been judged to offer limited crash protection when tested in simulated crashes using "child" dummies.¹²⁻¹⁵ However, there is little information bearing on the impact performance of the various child motor vehicle restraint devices in actual crashes, or on the recommendation that for younger infants such devices are preferable to vehicle seat belts.¹⁶⁻¹⁷ It is likely that vehicle seat belts or any properly designed and constructed child motor vehicle restraint devices used correctly (but not the inadequate protective devices) provide some, if not optimal, crash protection, whatever the age of the child. Clearly, children should never travel in a motor vehicle in such a way that they will be unrestrained if a crash occurs.¹⁷⁻¹⁸

Very limited information on child restraint use is available from previous studies, and most of this information is based on the parent's report of the child's use rather than actual observation.¹⁹⁻²¹ In the case of drivers, claimed seat belt use has been found to yield an overestimate of actual use. This article

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reports a study of actually observed child restraint use.

Subjects and methods

The data on restraint use were collected at 14 amusement areas and shopping centres in Maryland, Massachusetts, and Virginia during daylight hours, August 16, 1974, through September 15, 1974. Moving passenger cars and station wagons exiting from these sites were stopped by two person teams that consisted of an interviewer and an observer. A "spotter," stationed some distance away from the interviewer and observer and at a vantage point from which he could see into passing vehicles, signalled whenever an automobile possibly containing at least one passenger less than 10 years old (hereafter referred to as "children") passed by.

The interviewer, stationed on the driver's side of the vehicle, signalled the driver to stop and obtained from the driver the following information on all child passengers: age, sex, estimated weight, and relationship to the driver. The interviewer also obtained from the driver information on model year of the vehicle, miles to next stop, and last year of school completed by the driver; in addition, the interviewer observed and recorded information on the children's location in vehicle and restraint use. If the vehicle did not contain at least one child, it was not included in the series.

The observer was stationed on the side of the vehicle opposite the driver, several feet back toward the spotter in relation to the interviewer. As the vehicle slowed to a stop, the observer recorded information on the driver's restraint use and apparent race, and the location in the vehicle and restraint use for all passengers 10 years of age or more. (Information on correlates of restraint use of drivers and passengers 10 years of age or more, and correlates of child restraint use involving education, race, location in vehicle, miles to next stop, and model year of the vehicle will be presented in a separate article.)

Children in car beds, car seats, and infant carriers were considered restrained only if three criteria were met. It was necessary that the device be restrained by the vehicle seat belt. If the car seat had as part of its design a top tether strap that attaches to the top rear of some car seats and is designed to prevent forward tipping in a crash, it was necessary that this strap be anchored. It was also necessary that straps be used to restrain the child within the device, except in devices that have a barrier shield in front that serves to restrain the child, and no restraining straps as part of the design. If the three criteria were met, these child motor vehicle restraint devices are referred to as having been used correctly, although additional criteria for protection of the child that were not investigated in the present study, such as tautness of the top tether strap, are also important.²³ Children in safety harnesses were considered restrained if the harness was anchored permanently to the vehicle. Children were not considered restrained if they were

using inadequate protective devices or if they were lying or sitting unrestrained on someone's lap.

Results

Interview and observational data were obtained on 5050 automobiles containing at least one child. There, was a total of 8993 passengers. Only 140 drivers (3%) were reported not to have stopped in response to signals of the interviewer and observer, or, once stopped, refused to participate.

RESTRAINT OF CHILDREN BY TYPE OF RESTRAINT

Table 1 indicates that of the 8893 children on whom information on restraint use was obtained, 93% were not restrained. In comparison, 89% of 6345 passengers 10 years or older and 78% of the drivers were not restrained.

Of the 433 children restrained by the vehicle seat belt only, 396 (91%) were using the lap belt, 17 (4%) were using lap and shoulder belt, and 20 (5%) were on someone's lap with the seat belt around both, a practice likely to result, because of the forward movement of the much more massive adult, in serious abdominal injury to the child in a crash.

Of the 562 child restraint devices in use, however used, there were 490 (87%) car seats, 45 (8%) infant carriers 22 (4%) car beds, and five (1%) child safety harnesses. Only 153 (27%) of these 562 potentially protective devices were used correctly: 27% of the car seats, 40% of the infant carriers, almost none of the car beds (one of 22), and almost all of the few child safety harnesses (four of five).

Of the 53 inadequate protective devices used, there were 41 "car seats" that hook over regular automobile seats, 11 seats or carriers not designed for the purpose of protecting children in crashes, and one pouch.

RESTRAINT OF CHILDREN BY AGE AND TYPE OF RESTRAINT

Table 2 presents information on restraint of children by single age categories under 4, the ages at which use of child motor vehicle restraint devices is believed by some to be preferable to vehicle seat belts, and ages 4 to 9, at which most children are too large for child seating devices.

Table 2 indicates the following: (1) children less than 2 years old were more often restrained

Table 1 Restraint of children in automobiles*

	No (%)
Restrained vehicle seat belt only	433 (5)
Child motor vehicle restraint devices restrained and child restrained within device	153 (2)
Total children restrained	586 (7)
Not restrained sitting or standing alone	7280 (82)
On someone's lap	565 (6)
Child motor vehicle restraint devices not restrained and/or child not restrained within device	409 (5)
Inadequate protective devices	53 (1)
Total children not restrained	8307 (93)†
Total	8893 (100)

*Information on restraint use not obtained in the case of 100 child occupants of vehicles stopped.

†The difference in the column subtotal from the sum of its component percentages is due to rounding.

Table 2 Restraint of children in automobiles*

	Age (years)				
	<1 No (%)	1 No (%)	2 No (%)	3 No (%)	4-9 No (%)
Restrained vehicle seat belt only	9 (3)	12 (2)	31 (3)	44 (4)	337 (6)
Child motor vehicle restraint devices restrained and child restrained within device	34 (10)	50 (10)	40 (4)	16 (1)	13 (0)
Total children restrained	43 (12)†	62 (12)	71 (7)	60 (6)†	350 (6)
Not restrained sitting or standing alone	56 (16)	163 (31)	679 (69)	897 (83)	5485 (92)
On someone's lap	145 (42)	130 (25)	125 (13)	70 (6)	95 (2)
Child motor vehicle restraint devices not restrained and/or child not restrained within device	83 (24)	150 (29)	97 (10)	43 (4)	36 (1)
Inadequate protective devices	17 (5)	15 (3)	8 (1)	8 (1)	5 (0)
Total children not restrained	301 (88)†	458 (88)	909 (93)	1018 (94)	5621 (94)†
Total	344 (100)	520 (100)	980 (100)	1078 (100)	5971 (100)

*Information on restraint use not obtained in the case of 100 child occupants of vehicles stopped.

†The difference in the column subtotal from the sum of its component percentages is due to rounding.

(12%) than were children 2 to 9 years old (6%); (2) use of all child seating devices, both motor vehicle restraints and inadequate protective devices, declined with age, quite sharply after age 1; and (3) younger children were much more likely to be on someone's lap unrestrained and older children were more likely to be sitting or standing alone unrestrained.

UNUSED CHILD MOTOR VEHICLE RESTRAINT DEVICES

In addition to the 562 child motor vehicle restraint devices in use, there were 105 such devices not in use in vehicles containing at least one child on someone's lap or at least one child sitting or standing alone unrestrained who was of the recommended age for the unused device.²⁴ Thus, 16% of the child motor vehicle restraint devices that could have been used were not being used at the time of the observations.

HOW CHILD MOTOR VEHICLE RESTRAINT DEVICES WERE USED

The data in table 3 indicates that 54% (30% + 24%) of the car beds, car seats, and infant carriers were restrained by vehicle seat belts. A top tether strap was part of the design on 66 (13%) of the 490 car seats and was anchored on only 35 (53%) of these 66 seats. Forty three per cent (30% + 13%) of the children were restrained within car beds, car seats, and infant carriers. Twenty four of these car seats had a barrier shield in front to restrain the child and did not require straps for this purpose.

Table 3 shows that when the criteria for restraint were considered in combination, 185

(33%) of the car seats, car beds, and infant carriers were not restrained by the vehicle seat belt and the child was not restrained within the device. In 70 (13%) of the cases the child was restrained but the device was not. In 132 (24%) of the cases, the device was restrained by the vehicle seat belt, but straps required to restrain the child within the device were not used. This arrangement provides some restraint of the child in a crash if the seat belt is around the child as well as the device. However, for car seats, where this type of information was obtained, the seat belt was around the car seat but not the child in 67 (55%) of the 122 cases in which only the seat belt was used.

One hundred seventy (30%) of the car seats, car beds, and infant carriers were restrained by the seat belt and the child was restrained within the device. However, there were 21 such car seats that had a top tether strap that was not anchored, an arrangement that allows the car seat and child's head to swing forward in a crash, possibly striking interior vehicle surfaces.¹⁵ All 24 car seats having a barrier shield in front to restrain the child were restrained by the seat belt.

Information collected on type of straps used to restrain the child within the car seat and how the seat belt was used indicated that in 57 (44%) of the 130 cases in which car seats were used correctly, the seat belt was around the car seat and child, touching the child's body, and/or the child was restrained by a single lateral (cross) strap. Car seats with these characteristics that have been tested dynamically have been judged to offer only limited crash protection.^{12 13}

Table 3 Use of child motor vehicle restraint devices: restraint of the device and child

	No of devices				Total
	Device restrained with vehicle belt		Device not restrained with vehicle belt		
	Child restrained within device	Child not restrained within device	Child restrained within device	Child not restrained within device	
Car seats: top tether strap					
Anchored	21	6	4	4	35
Not anchored	21	4	4	2	31
Not required	109	112	57	146	424
Total	151 (31)*	122 (25)	65 (13)	152 (31)	490 (100)
Infant carriers	18 (40)	9 (20)	3 (7)	15 (33)	45 (100)
Car beds	1	1	2	18	22
All devices	170 (30)	132 (24)	70 (13)	185 (33)	557 (100)

*Numbers in parentheses are percentages.

USE OF VEHICLE SEAT BELTS AND STRAPS ON CAR SEATS BY AGE OF CHILDREN

There were no significant age differences in the percentage of those in car seats who were restrained in terms of the three criteria used. However, figure 1 shows that use of straps to restrain the child within the device decreased with age and that use of vehicle seat belts to restrain the car seat increased with age through age 3 and declined among the 47 car seats used by those between the ages of 4 and 8. Use of the top tether strap on car seats was not significantly associated with age of the child.

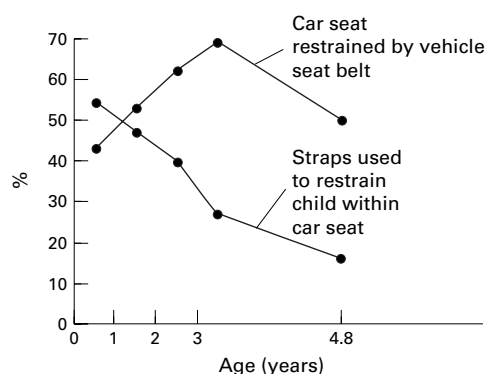


Figure 1 Per cent of car seats restrained by vehicle seat belt and per cent in which straps necessary to restrain child within car were used, by age of user.

RESTRAINT OF CHILDREN IN RELATION TO DRIVER RESTRAINT

Table 4 shows that if the driver was using the seat belt, 22% of the children in those vehicles were restrained, compared with 2% if the driver was not restrained.

Seventy eight per cent of the children were travelling in automobiles driven by one of their parents. Sons and daughters of the drivers were more likely to be restrained than were children not so related to the driver (7% v 4%). This relationship held both when the driver was restrained and when the driver was not restrained. However, even when parents who were driving were restrained, only 23% of their children travelling with them were also restrained.

Comment

Very few of the 8893 children (less than 10 years old) observed in this survey were in correctly used child motor vehicle restraint devices or were restrained by their vehicle's seat belts. Only 7% were restrained, fewer than passengers 10 years old or more (11%) and drivers (22%) travelling in the same vehicles.

Among children who were not restrained, younger children, especially those less than 2 years of age, were much more likely than older children to be on someone's lap rather than sitting or standing alone, although even among those less than 1 year old, 16% were on the

vehicle seat by themselves. Travelling on someone's lap does not provide crash protection, as the infant, even if held firmly, will very likely be torn away from the holder by the crash forces. Moreover, if the holder is also unrestrained, as was so in over 90% of such cases, the infant may be crushed between the holder and interior surfaces of the vehicle.^{7 25}

Child motor vehicle restraint devices were used infrequently at all ages, but their use declined sharply after the age of one. Seat belts, recommended at ages less than 4 if child motor vehicle restraint devices are not available, were used by very few (3%). Use of seat belts was not much higher among those aged 4 to 9 (6%), the ages at which most children are too large for child seating devices. Children's use of seat belts included a number of cases in which the child was on someone's lap with the seat belt around both. In a crash, a child thus restrained would be compressed between the holder and the seat belt and would very likely be injured as a result.

Seventy nine per cent of the observed devices placed in vehicles for child travellers were either inadequate protective devices, were not used by children of the recommended ages for their use, or were not used correctly. Of the child motor vehicle restraint devices in use, only about one in four were used so that the child was restrained within the device and the device itself was restrained. In most cases in which child motor vehicle restraint devices were not used correctly, neither straps to restrain the child within the device nor the seat belt required to hold the devices themselves in place were used, or they were used in such ways that neither would serve to properly limit the child's motion and properly moderate his deceleration in a crash. In effect, infant carriers and car seats used improperly in the ways routinely observed would function as launching platforms in a crash, flinging the child into upper parts of the vehicle interior, possibly resulting in even more severe injury than would result had the child been sitting unrestrained on the vehicle seat.

It is clear that factors associated with how child motor vehicle restraint devices are used need to be studied, and means devised for ensuring that such devices are used so as to provide optimal crash protection. In studies of drivers, discomfort and inconvenience of wearing seat belts have been found to be associated with their non-use.^{2 26} The time and inconvenience involved in fastening straps around a child, and restraining the device with the seat belt in cases in which the belt cannot be left fastened around the device, are likely to be greater than in fastening the seat belt around an adult. Moreover, children may well be uncomfortable in car seats or resist having their movement restricted or their lateral or forward vision restricted, as occurs with some devices.

It has been pointed out that comfort and convenience of use should be important criteria in the design of child motor vehicle restraint devices.^{23 27} It is notable that in this survey all 24 car seats in use that had a barrier shield in front and did not require straps to be

Table 4 Restraint of children in automobiles in relation to use of seat belts by drivers*

Children	Drivers†	
	Using seat belt No (%)	Not using seat belt No (%)
Restrained vehicle seat belt only	338 (18)	93 (1)
Child motor vehicle restraint devices restrained and child restrained within device	71 (4)	79 (1)
Total children restrained	409 (22)	172 (2)
Not restrained sitting or standing alone	1257 (67)	5957 (86)
On someone's lap	110 (6)	451 (7)
Child motor vehicle restraint devices not restrained and/or child not restrained within device	105 (6)	301 (4)
Inadequate protective devices	7 (0)	46 (1)
Total children not restrained	1479 (78)‡	6755 (98)
Total	1888 (100)	6927 (100)

*Data not included on 178 cases.

†Information on a driver's use of seat belts was included more than once if there was more than one child in the vehicle.

‡The difference in the column subtotal from the sum of its component percentages is due to rounding.

fastened were used correctly. The seat belt is fastened around the shield to restrain such car seats, and many children can get in and out of these seats without the seat belt being unfastened.

Expressed resistance of the child toward being strapped into a car seat may increase as he grows older, becoming more mobile and verbal. This may explain why the use of straps to restrain children in car seats declines with age, and why use of car seats drops sharply after age 1. These declines with age may also occur if parental motivation in using car seats is to provide support for infants and to prevent them from moving about in the vehicle rather than crash protection. Such parents may be less concerned about the movement of older children within the vehicle or more able to control such movement verbally. However, it is not clear why use of the seat belt to anchor child motor vehicle restraint devices increases up to age 3 and then declines.

Unfortunately, even in the relatively few instances in which child motor vehicle restraint devices were used correctly, there is likely to be wide variation in the protective capability of these devices. It is likely that most of the car seats observed in this study were certified as complying with FMVSS 213, although it was not possible to collect this information systematically. However, Consumers Union has labelled FMVSS 213 a "cruel hoax" (p112¹⁵) and stated in 1974 that "under present Federal safety standards, you cannot buy a car safety restraint for a small child with any assurance that it will protect him from serious injury or death in a crash" (p108¹⁵). More than half the car seats observed in this survey that were used correctly were similar to types that have been judged on the basis of simulated crashes to offer limited protection.

There is evidence based on simulated crashes that improvements are being made in the crashworthiness of car seats.²⁸ Moreover, a proposal that would substantially upgrade FMVSS 213 was issued March 1, 1974, by the National Highway Traffic Safety Administration (NHTSA).²⁹ The proposal would replace the present static pull test with dynamic crash sled tests and apply to car beds, child safety harnesses, and infant carriers, in addition to car seats. (No final action had been taken on this proposal as of July 1976.) The possibility must be recognized that more stringent standards may result in child motor vehicle restraint devices that cost more and are less comfortable and convenient to use than present models, factors that theoretically might have a negative effect on the purchase and correct use of such devices. In any case, even if all devices manufactured from now on met the performance standards of FMVSS 213 as revised, it would take a number of years for less adequate devices to disappear from use. For example, after April 1, 1971, when FMVSS 213 became effective, "car seats" that hook over regular automobile seats were prohibited from being manufactured, although such seats already manufactured could be sold after that date. Almost 3½ years later, these "hookover" seats

accounted for 8% of the "car seats" used in vehicles in this survey.

The assurance that when one purchases a car seat certified as complying with federal standards it will provide adequate protection in a crash is of obvious importance. However, of greater concern is that most car seats or other child motor vehicle restraint devices are not used correctly, if at all, and in general, very few children are restrained. Attempts to increase the number of restrained children, especially infants, are naturally directed at parents, who have responsibility for their children and some degree of influence over them. It is possible that face-to-face communication with parents by pediatricians can increase usage and correct usage of child motor vehicle restraint devices, although it is doubtful that many pediatricians provide such information routinely. In hospital programs for new mothers are also being tried as a means of increasing the use of these devices.³⁰ Although parents bear much of the responsibility for making sure their children travelling with them are restrained whether or not they themselves are, it was found in this study that when parents were driving unrestrained, virtually none of their children were restrained. When parents who were driving had taken the initiative to fasten their seat belts, more than 75% of their children were not restrained. Stated differently, parents transporting their own children on the average took far better care of themselves with crash restraints than of their children. This was also the case when drivers transported others' children. Why this is so is a question that needs investigation. Questions of legal liability of parents and other drivers for damages might arise in the case of injury to unrestrained children in a crash.

The criteria issued by NHTSA for incentive grants to encourage states to pass mandatory seat belt laws require such laws to apply only to motor vehicle occupants age 4 or older, weighing 18.1 kg or more, although NHTSA has urged that after satisfying these criteria, states amend the seat belt laws to require restraint use by all children.³¹ Even if this were to occur eventually, the issue of correct use of child motor vehicle restraint devices would remain. Given these considerations, plus the very low numbers of restrained children and the failure of parents even if restrained themselves to ensure that their children are protected as much as possible from serious injury or death in a crash, it is apparent that "passive" protection³²⁻³⁵ is needed for children.

Passive countermeasures, such as air cushions that inflate automatically in severe crashes, do not require the child or his parents to take any action for the child to be protected. It is important that passive restraint technology be directed at children as well as adults, taking into account their size, anatomical features, and likely locations in vehicles. For example, the possibility has been raised that child passengers standing in front of the dashboard or travelling in other front seat positions in which they would be contacted during early

stages of air cushion deployment would be injured by an air cushion in a crash.^{36 37}

However, recent developments in air cushion technology suggest that the problem of protecting with an air cushion system the very few children observed to travel in such positions³⁸ can be solved, and that passive protection can be provided for children at least as young as 3 years of age.³⁹ However, providing passive protection for very young children, in particular infants unable to sit up by themselves, will probably require modification of some present interior vehicle surfaces. For example, unrestrained infants can receive serious and fatal injuries through contact with unnecessarily hard interior vehicle surfaces in sudden braking situations. Adequate padding of likely child impact areas and floors to which they would fall after impact might largely solve this problem. As early as 1966, NHTSA (then the "National Traffic Safety Agency") proposed that manufacturers be required "to provide special means of protection for the unrestrained child."⁴⁰ Difficulties encountered at that time with the definition of "unrestrained child impact areas" led to the exclusion of vehicle areas likely to be impacted by unrestrained children from the US federal standard providing for occupant protection in interior impact.⁴¹ Such areas are still not covered by this federal standard, despite the stated intention in 1967 "to proceed with the development of requirements to further reduce the impact hazard to the unrestrained child".⁴⁰

In view of these delays, specially designed restraint devices are likely to continue for some time to be necessary to protect infants travelling in vehicles, and pediatricians and others have an obligation to so inform parents and to encourage the use of these devices.

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