SURVEYS OF CHILD RESTRAINT USE IN NEW SOUTH WALES

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ABSTRACT

Child restraints are very effective at protecting young occupants in severe motor vehicle crashes. The protection provided by these devices can be reduced, however, if they are not correctly installed in the vehicle or if the child is not correctly strapped into the restraint. In order to determine the quality of installation of child restraints the Roads and Traffic Authority of New South Wales commissioned surveys of (a) child restraints fitted to unoccupied vehicles in shopping centre car parks and (b) people attending family restaurants or child care centres with children.

Car park surveys were carried out at 18 locations throughout New South Wales. Of the 1,177 cases where installation quality could be determined 20% of infant capsules and 19% of child seats were found to have safety-related installation problems.

The interview/observation survey was a pilot study. A total of 149 interviews were conducted at 12 sites in 10 towns. Overall 88% of those approached agreed to both the interview and the in-vehicle inspection of child restraints. About one quarter of the restraints were found to have safety-related installation problems. Technically the interview surveys were considered to be successful but they were found to be resource intensive.

Other sources of information about the performance of child restraints in Australia are briefly reviewed. These are: dynamic (sled) tests of child restraints under the Child Restraint Evaluation Program (CREP); consumer crash tests conducted under the Australian New Car Assessment Program and two in-depth crash studies that provided information about child occupants in crashes during the 1990s.

INTRODUCTION

The protection provided by child restraints can be reduced if they are not correctly installed in the vehicle or adjusted for the child. Between 1979 and 1989 the Roads and Traffic Authority of New South Wales (RTA) conducted surveys of child restraints fitted to cars in shopping centre car parks. The people conducting the survey observed the restraints through the windows of parked vehicles to establish whether the child restraints had been fitted in accordance with manufacturer's instructions. Approximately one third of child restraints were found to be incorrectly installed in the 1984 and 1989 surveys. In Australia child restraints (other than integrated child seats) are required to comply with Australian Standard 1754. The use of unapproved restraints was noted in the carpark surveys but in latter years was not found to be a problem.

Seat belt usage surveys, involving the observation of vehicles waiting at traffic lights, have been regularly conducted by the RTA since 1970. These surveys have included the observation of child occupants and the use of child restraints. However, the survey techniques do not facilitate the checking of the correct installation of child restraints in the same manner as the car park surveys.

Since 1986 New South Wales has operated a network of authorised Restraint Fitting Stations (RFS). These are small businesses, usually associated with mechanical repair shops, which provide a service fitting child restraint anchorages, installing child restraints in vehicles and advising carers how the child restraints should be used.

During 1998 the RTA commissioned further surveys of child restraint usage. The purpose of the project was to provide good quality information about the fitting of child restraints that was representative of urban and rural NSW. The objectives were:

- To clarify the situation regarding the quality of fitment of child restraints in vehicles

- To determine correct fitting rates by type of restraint and type of vehicle
- To isolate and report fitting problems found during the surveys
- To determine any geographical differences
- To ascertain the public knowledge and perception of the Restraint Fitting Station network in NSW

The study was done through two types of survey:

a) by repeating the car park surveys described above and

b) by introducing a new type of survey, involving the interview of adults in association with detailed inspections and measurements of child restraint installations in vehicles.

METHODOLOGY

Car Park Surveys

The car parks surveys were conducted using the same methodology as used previously (described in TARU Research Note RN 5/85). In brief, one person with good experience in the installation of child restraints arranged to visit shopping centre car parks. The person walked around the unattended vehicles and looked through the windows in order to try and determine the make and model of child restraint and the quality of installation of the restraint. Difficulties included:

• authorisation - alternative sites were needed in three cases: one shopping centre requested payment of an unreasonable fee and two others refused outright. It is understood that these difficulties had not been encountered in previous surveys.

• security concerns - despite prominent displays of the words "Child Restraint Survey in Progress" on sandwich boards and clothing many people were concerned about someone looking in the windows of parked cars

• visibility - some shopping centres had poor lighting. A further problem, which appears to have arisen since the 1989 survey, is that many vehicles now have tinted film applied to rear windows and this can make observation of child restraint installations very difficult.

Surveys lasted for at least two hours at each site and were conducted either late morning or early afternoon. Generally this allowed observation of between 300 and 500 vehicles per site, of which about 20% had child restraints. A total of 13 Sydney locations and 5 regional locations were surveyed.

Observation/Interview Surveys

The observation/interview surveys were conducted at 5 Sydney locations and 5 regional locations. The intention was to identify locations where child passengers are commonly encountered. Several potential types of sites were considered: day care centres, pre-school kindergartens, paediatric clinics, shopping centres, family restaurants, highway service centres, suburban service (petrol) stations, theme parks and sports venues. After considering the likely number of child restraints that would be encountered, sampling issues, safety issues and logistics it was decided to confine the surveys to family restaurants and day car centres.

The sequence at each site was:

- The vehicle was observed entering the car park and, where possible, notes made about child restraint usage before the vehicle stopped (generally this was not successful).
- When the vehicle stopped in a parking spot the driver was approached to seek participation in the survey.
- If the driver agreed, one researcher assessed the quality of restraint fitment, including measuring the freeplay in specified directions (Figure 2).
- The second researcher conducted an interview, generally next to the car. It was intended the interview would last no more than 5 minutes - this could take longer if there was a problem with a child restraint or the participant wanted to find out more about the issue.
- If there was a problem with the fitment or use of restraints the first researcher offered to show the problem to the carer.

Forms were completed during and after the interview (see Appendix)

Child safety can be a very emotive issue and it was important that the interviews were conducted in a diplomatic and sensitive manner. This was essential to minimise the risk of parents/carers becoming defensive and uncooperative. It was also important to reduce the restaurant owner's perception that it was affecting business.

A pilot survey was held at a family restaurant to refine the methodology and assess the arrival rates of vehicles with children. Arrival rates were not promising and discussions with the restaurant staff

revealed that number of children attending tended to be unpredictable. Experience with the pilot was one of the reasons for adding day care centres to the survey. Despite the low numbers, the methodology was found to be suitable and people were found to be very cooperative.

RESULTS

Car Park Surveys

Car park surveys were carried out at 18 locations throughout New South Wales. Of the 1,177 cases where installation quality could be determined 20% of infant capsules were found to have safety-related installation problems (but see comments below about top tethers). 19% of forward facing child seats had safety-related installation problems. Figure 1 summarises the problems.

Lack of a top tether was a problem in 11% of infant capsule installations and 3% of child seat installations. Note that it is more difficult to establish that a top tether is not being used in the case of infant capsules, compared with child seats, because the forward part of the tether is usually disconnected in order to take the child out of the capsule. However, most capsule designs have a quick release buckle within easy reach and it is most unusual for the carer to unclip the top tether from the anchorage point. In most of the cases recorded as top tether problems for capsules there was no tether attached to the anchorage.

Incorrect threading of the adult seat belt was a problem with 4% of infant capsules and 11% of child seat installations.

Child harnesses and booster seats had relatively few installation problems, except for 5 cases where a booster seat was used in conjunction with a lap-only seat belt. This is a dangerous combination.

It was found that there were significant variations between towns for the proportion of incorrectly fitted restraints.

Observation/Interview Surveys

The interview/observation survey was a pilot study. A total of 149 interviews were conducted at 12 sites in 10 towns, including 5 towns outside the Sydney metropolitan area. Ten sites were at McDonalds Family Restaurants and two sites were at day care centres. Overall 88% of those approached agreed to both the interview and the in-vehicle inspection of child restraints. Installation quality was determined for a total of 162 child restraints and involved the technician entering the vehicle and making physical measurements of the unoccupied child restraint (Figure 2). Safety-related installation problems were found in about one quarter of the restraints.

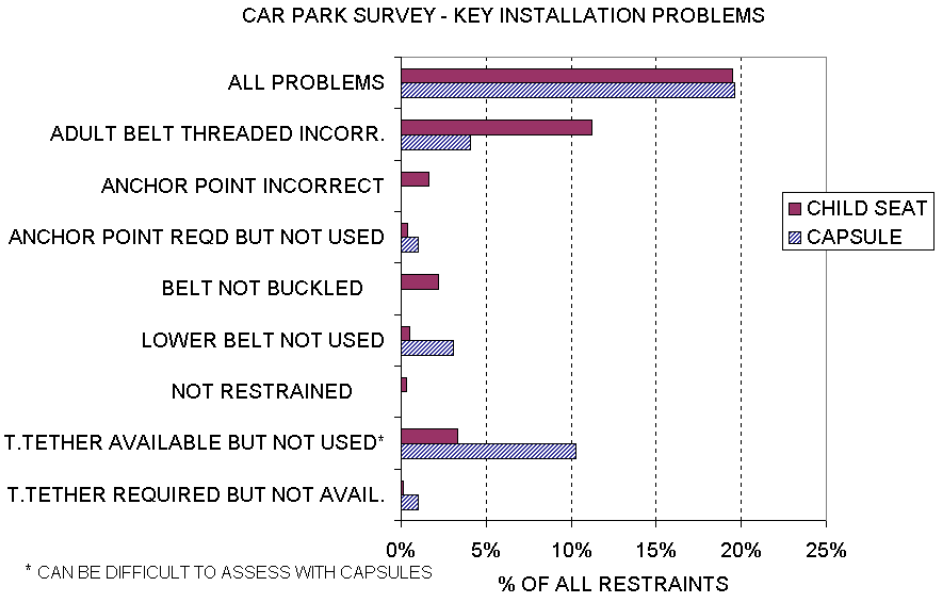

Figure 1. Installation problems with child seats and infant capsules observed during car park surveys.

Subject to caution about the small sample sizes, installation quality was more likely to be poor if the carer was aged 45 or more. This *might* indicate a problem with grandparents looking after children on weekdays and, possibly, swapping child restraints between vehicles.

Technically the interview surveys were considered to be successful but they were found to be relatively resource intensive, due mainly to the low numbers of eligible vehicles arriving at the sites. It was concluded that future surveys should place greater emphasis on observing the manner in which the child is placed into the restraint.

The research report on this project has not yet been released by the RTA.

Figure 2. Measuring yaw rotation of a baby capsule

OTHER MEASURES OF CHILD RESTRAINT PERFORMANCE

This section describes methods of assessing the performance of child restraints in Australia.

Since the 1970s dynamic testing of child restraints has been required under the Australian Standard for child restraints.

In 1994 New South Wales introduced the Child Restraint Evaluation Program (CREP) to provide a guide to consumers. This program includes sled tests of child restraints.

In 1999 Australian New Car Assessment Program (ANCAP) aligned its testing procedures with those of the European New Car Assessment Program (EuroNCAP). Offset frontal and side impact crash tests of vehicles now include child restraints, with P1.5 and P3 dummies in the rear seat.

In-depth investigations of real world crashes have been conducted in NSW from time to time. In 1993 a major study of 131 crashes involving 247 children was conducted for the Child Accident Prevention Foundation of Australia (CAPFA - now Kidsafe).

In the late 1990s the NSW RTA undertook a "Crashed Vehicles Study" that collected a wide range of data about crash involved vehicles. That study included inspections of 4426 vehicles involved in 2705 crashes. Data from that study are still being analysed but it is expected that it could provide information on several hundred crashes involving child occupants.

NEW CAR ASSESSMENT PROGRAM (NCAP)

NCAP assesses the crashworthiness of new vehicles and provide a star rating for the protection provided to front seat occupants. Under the EuroNCAP protocol two types of crash test are used in the assessment - an offset frontal crash test and a side impact crash test.

The offset frontal crash is conducted at 64km/h (Figure 3). The vehicle hits a crushable aluminium honeycomb barrier and the crash forces are concentrated on the driver's half of the vehicle. The side impact involves a moving barrier, fitted with a crushable aluminium front, hitting the driver's side of the car at 50km/h.

ANCAP crash test procedures are based on those used by EuroNCAP. Under these procedures two child restraints are installed in the rear seat of the vehicle. The child dummies used are TNO P1.5 and P3, simulating 18 month and 3 year old children respectively. In the offset frontal crash the P3 sits behind the driver and the P1.5 sits behind the front passenger. The positions are swapped for the side impact crash test (which does not have a front passenger dummy).

The child dummies are instrumented with head and chest accelerometers. Dummy movement is recorded on high speed film and is analysed to estimate the movement of each dummy and possible head contacts.

The child restraint assessment is not included in the vehicle overall star rating but is reported separately by EuroNCAP. Due to the fundamentally different design of child restraints in Australia ANCAP does not currently report the results of child restraint performance (discussed in more detail below).

Figure 3. Offset Frontal Crash at 64km/h showing P3 dummy behind driver (ANCAP).

Under the EuroNCAP protocol "No part of the head shall pass outside the forward projected exterior surface of the child restraint". It is sometimes difficult to fully assess this requirement given the awkward video angles that are available. ANCAP uses two onboard cameras (Figure 4) that give a much better view of the child dummies than the EuroNCAP videos but analysis is still difficult.

ANCAP test data and videos can be made available to researchers. Note that all tested child restraints had top tethers.

Figure 4. Peak of side impact crash at 50km/h showing extreme dummy movement (ANCAP).

AUSTRALIAN STANDARDS

Child restraints used in Australia must comply with AS1754. The dynamic testing for CRs is set out in AS3629.1. This specifies the following sled tests for child seats (type B restraints):

- a frontal impact at about 49km/h with a peak deceleration of 24g and
- a 90 degree side impact test with a peak deceleration of 14g and an impact speed of 32km/h.
- a rear impact test with a peak deceleration of 14g and an impact speed of 32km/h.

Infant capsules are also subjected to an inverted test at 16km/h to simulate a rollover crash.

Systems are assessed for:

- retention of the child restraint
- retention of the dummy
- separation of load bearing components
- fragmentation of rigid components
- adjuster slip

Restraint manufacturers arrange for these tests to be conducted and the results usually remain confidential.

CHILD RESTRAINT EVALUATION PROGRAM

The Child Restraint Evaluation Program (CREP) is operated by the NSW RTA, NRMA and RACV in association with the Australian Consumers Association. The outcome is a buyers guide to child restraints. The assessments are based on the Australian Standard but involve higher crash forces and additional test procedures. In addition to the AS1754 tests described above a frontal test at 56km/h and 34g is conducted.

The side and rear impact tests are conducted at the same speed as the Standard but, in the side impact test, a structure that is intended to replicate the interior of a side door is added to the test configuration.

Figure 5. CREP 45^{o} side impact with door structure (Crashlab).

A side impact test is also conducted at an impact angle of 45 degrees (Figure 5).

With child seats a P6 dummy is used for the frontal test and a P3/4 for the other tests.

Kelly and others (1996) describe the CREP assessment protocol. CREP test data and videos can be made available to researchers.

REAL WORLD CRASH DATA IN NSW

The CAPFA Study

In 1993 an in-depth study of children involved in car crashes in NSW was initiated by the RTA. It was known as the CAPFA Study (Henderson 1994). It covered 131 crashes involving 247 children.

There were 38 children in forward-facing child seats. There was one fatality and it involved gross misuse (use of an adult seat instead of the built-in harness). There were minor injuries in 17 cases and five cases where an individual injury was AIS 2 or more. All but one of the serious injuries involved serious misuse of the child seat that included failure to fasten the top tether. Note that "misuse", particularly minor problems, can be difficult to determine with this type of post-crash investigation.

Due to the method of selection and the small sample size, the CAPFA accident cases might not be representative of the general population, but they indicate the importance of correctly fitting and adjusting the restraint.

In a 1996 AAAM paper concerning the CAPFA study Henderson described the severe crashes in which restrained children survived with no serious injuries. The paper concluded: "There are few safety devices that are as effective as child restraints. We found in our study that the only injuries caused by deceleration alone were bruising and abrasion from loads imparted from harness and seat belt webbing. The head remains the most important part of the body to be protected. The principal threat to the restrained child is from invasion of the child's space through impact intrusion, collapsing seat backs, flying glass and loose objects. The child is also at risk if allowed to move out of its space and restraint design should place a high priority on the minimisation of excursion of the upper body in order to prevent head contact."

Crashed Vehicles Study

Between May 1995 and June 1998 teams of RTA inspectors conducted inspections of some 4426 vehicles that had been involved in a total of 2705 crashes. Details of the crashes and resulting inspections are still being analysed by the RTA. A total of 2927 cars were inspected. Based on RTA roadside surveys it can be expected that roughly 10% of these would have had a child occupant in a child seat - that is an estimated 270 cases. At this stage the data for these crashes has not been analysed. Furthermore comprehensive injury data, other than that recorded by the Police, has not been collected, although this was intended at the start of the study.

DISCUSSION

Top tethers, as used on all Australian child restraints, are extremely effective at limiting forward head excursion - considered to be the most hazardous feature of child kinematics in a frontal crash. Australian crash experience shows that children correctly restrained in child seats can withstand severe crash forces without serious head, neck or chest injuries. Unless there is rearward movement of the front seats, or other intrusion into the child occupant survival space, it is unlikely that a head contact would occur, other than with a restraint component.

This suggests that the EuroNCAP injury criteria for the frontal crash are inappropriate for the assessment of child restraints with top tethers. In particular the limits on head and chest decelerations are considered to be too low and might encourage excessively flexible installations that could result in greater risk of injury from head contacts. For the time being ANCAP is not publishing the results of child dummy injury measurements in cases where a top tether is used.

There are a few cases where near-identical vehicles have been tested by both EuroNCAP and ANCAP (possibly the Daihatsu Sirion, Hyundai Accent and Toyota Camry). Although there were differences for front occupant protection in these cases (mostly airbag differences) it might be useful to compare the performance of the child restraints since the ANCAP tests used child restraints with top tethers and the EuroNCAP cases did not have top tethers.

It is considered that the design of booster seats has received too little attention. Designs with wings that provide some extra head protection in side impacts and also help to prevent a sleeping child from falling sideways are desirable.

VEHICLE DESIGN ISSUES

Key features of vehicle design that affect the performance of a child restraint are:

Location of anchorages for top tethers. Given the demanding test loads required under the regulations

this is mainly an ease of access and adjustment issue. Locations which require the use of a top tether extension strap should be discouraged. Also top tether straps that could be affected by movement of luggage are undesirable.

Retention of the CR by the adult seat belt. This is also an ease of use issue. Lockable retractors for rear seat belts are sometimes used in Europe and the USA to improve the task of installing a child restraint. With top tethers these are not necessary and retractors do not appear to cause problems in Australia.

Rear seat design. A compliant seat back and seat cushion will (in Australia) allow extra movement of the lower part of the child restraint. This is mainly a concern in side impacts where the compliant seat may allow excessive yaw motion of the restraint and expose the occupant to direct contact with the (intruding) interior of the vehicle. Compliant seat cushions can also contribute to undesirable rebound motion in frontal crashes. A test methodology for assessing the installation of child restraints was developed for the 1998 RTA survey. In particular, the following should be considered for ANCAP assessments: transverse movement of top of child seat and yaw rotation of child seat (about a vertical axis - see Figure 2).

Intrusion of vehicle components into the child's survival space. In particular, front seats which rock excessively backwards are a concern. This may occur during rebound. Another possible source is dynamic buckling of the floor pan under the front seat, causing the seat to rock backwards, even though the occupants are thrown forwards at this time. This was observed in a recent ANCAP crash test.

Provision of placards, stickers and owner's manual instructions that go beyond the minimum required under the regulations for informing vehicle owners about the use of child restraints. For example, the vehicle manufacturer could provide a list of models of child restraint that have been adequately installed in the vehicle. A video showing correct installation procedures would be very helpful.

CONCLUSIONS

The child restraint designs used in Australia have been shown to provide exceptional protection to child occupants in severe crashes. Cases of serious injury are likely to involve misuse of the child restraint.

Observational surveys of unoccupied child seats indicate that, in NSW, about one fifth of child restraints are incorrectly fitted to vehicles. The most prevalent problem with child seats is incorrect threading of the adult seat belt but in most cases the restraint would still provide reasonable protection. These surveys do not assess the manner in which the child is strapped into the restraint and this may represent half of the misuse problem. One concern is that most carers interviewed thought that the method of strapping the child into the restraint was "obvious" and they did not check labels or instructions. Further research is evidently needed into this area of misuse.

Dynamic testing of child restraints using sleds is conducted for Australian Standard compliance and the Child Restraint Evaluation Program. CREP data is available for research purposes.

Child restraints are now included in new vehicle crash tests conducted under the Australian New Car Assessment Program. ANCAP data is available for research purposes.

Our recommendations for ensuring further improvements to Australian child restraints are:

1. Continue with CREP and increase public awareness of the Buyer's Guide. Review the CREP assessment protocol.
2. Continue to include child dummies in ANCAP crash tests. Compare with EuroNCAP tests of similar vehicles to determine the effects of the top tether in Australia.
3. During ANCAP testing, assess the ease of installation of child restraints in each vehicle and measure the amount of movement present when restraint is correctly installed and adjusted. Encourage vehicle manufacturers to give greater attention to child restraints in vehicle design.
4. Conduct observational surveys and carer interviews that include observing the way in which the child is strapped into the child restraint.
5. Identify design improvements for child restraints and vehicles and discuss with manufacturers. Issues include rear seat design (shape, softness, seat belt geometry), performance of split seats and resistance to luggage impacts. Rearward collapse of front seats is also an issue.
6. Investigate ways to improve the protection provided to children in booster seats.

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The views expressed are those of the authors and do not represent the views or policy of any organisation.

APPENDIX - INTERVIEW FORM USED IN 1998 SURVEY

Child Restraint Study for RTA - Interview Survey Form

VDR Vehicle Design & Research

SELECTION DETAILS ☐☐☐

Location: _ _ _ _ _ _ _ _ _ _ _ _ _ Date: _ _ /_ _ / _ _
Time: _ _ : _ _ Main form No. _ __ (if more than 3 CR)
Male / **F**emale
Approx generation: a-teen b-parent c-grandparent
In car: Adults _ Children 5-16: _
Children 1-4: _ Infants _

INTRODUCTION

1. Could you spare five minutes to answer some questions? **YES/NO**
(if NO: Reason _)

2. If YES: While we talk would you mind if my colleague takes a look at the child restraint(s)? **NO / YES**
(If refuses: Reason:_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _)

3. What is your age range (optional)?
Under 25 / 25-34 / 35-44 / 45-54/ 55 or more

4. Is English the main language spoken at your home? (optional) **YES/NO**

GENERAL QUESTIONS

13. (Unless answered above) Have you heard of Restraint Fitting Stations? **YES / NO**
(If NO: briefly explain and offer list of RFS)

13a. If YES: Where from? **a.HOSPITAL/b.STREET SIGNS/ c.WORD OF MOUTH/ d.MAGAZINE/ e.PHONE BOOK / i.OTHER _ _ _ _ _ _ _ _ _ _ _ _ _**

14. How can Restraint Fitting Stations be better publicised?
_ _

15. What are the main reasons that children might travel unrestrained from time to time when you are driving ?
a.NEVER HAPPENS
b.CHILD WRIGGLES OUT
c.CHILD COMPLAINING
d.SHORT TRIP
e.NOT ENOUGH SEAT BELTS
f.DON'T REGARD IT AS UNSAFE
i.OTHER _

FOR EACH RESTRAINT:

Question	**Answer for 1st Restraint**	**2nd Restr.**	**3rd Restr.**
Cross reference & seating pos.	**OBS.FORM No. _ _ _ _ _ _ / SEAT POS.: _**	_ _ _ / _	_ _ _ / _
.Age & weight of usual child	Years _ Months _ _ / _ _ kg	Y_ M_ _ / _ _	Y_ M_ _ / _ _
5. Who installed the child restraint in this vehicle?	a.SELF / b.HUSBAND /c. WIFE / d.RELATIVE / e. FRIEND / f. MECHANIC / g.RFS / h.RETAILER i.OTHER_ _	a. b. c. d. e. f. g. h. i _ _ _ _ _ _ _	a. b. c. d. e. f. g. h. i _ _ _ _ _ _ _
6. If SELF: Where did you find out about the correct way to install the child restraint?	a.INSTRUCTION MANUAL / b.INSTR. LABEL c.SPOUSE/d.FRIEND/e.OBVIOUS/g.RFS h.RETAILER/ i.OTHER _ _ _ _ _ _ _ _ _ _ _ _ _ _	a. b. c. d. e. g. h. i. _ _ _ _ _ _ _	a. b. c. d. e. g. h. i. _ _ _ _ _ _ _
7. How long ago was the child restraint fitted to the vehicle?	a.TODAY/b.WEEK/c.MONTH/d.MORE	a. b. c. d.	a. b. c. d
8. How often is this child restraint moved from this seating position?	a.DAILY/b.WEEKLY/c.MONTHLY/d.MORE e.NEVER	a. b. c. d. e.	a. b. c. d. e.
9. Are you aware of any difficulties experienced when installing the child restraint ?	NO YES _	NO YES _ _ _ _ _ _ _	NO YES _ _ _ _ _ _ _
9a If by RFS: was the work satisfactory?	NO _ YES	NO _ _ _ _ _ YES	NO _ _ _ _ _ YES
10. Where did you find out how to strap the child into the restraint?	a.INSTRUCTION MANUAL / b.INSTR. LABEL c.SPOUSE/d.FRIEND/e.OBVIOUS/g.RFS h.RETAILER/ i.OTHER _ _ _ _ _ _ _ _ _ _ _ _ _	a. b. c. d. e. g. h. i _ _ _ _ _ _ _	a. b. c. d. e. g. h. i _ _ _ _ _ _ _
11. Have you experienced difficulties in adjusting the child restraint for a particular child?	NO YES _	NO YES _ _ _ _ _ _ _	NO YES _ _ _ _ _ _ _
12. Do you have any suggestions for making the child restraint	NO YES _	NO YES	NO YES

INSTALLATION FOLLOW-UP

*Only applicable where the in-car observation reveals a problem with a child restraint installation*We have found a problem with the child restraint installation and would like to show you how to install/adjust the child restraint correctly.

Reaction: _

ANY OTHER COMMENTS?
PTO? **YES / NO**