Title

Population-level estimates of child restraint practices among children aged 0-12 years in
NSW, Australia

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Abstract

This cross-sectional study provides population-referenced data on the restraints used and the extent of incorrect restraint use, among child vehicle passengers aged 0-12 years in NSW, Australia. A multistage stratified cluster sampling plan was used to randomly select vehicles from baby/child health clinics, pre-schools/day care centres, and primary schools across NSW to undergo detailed inspection of restraints used by child occupants within those vehicles. Overall, there were very high restraint usage rates (>99% of sampled children) but fewer than one quarter of children were using the correct size-appropriate restraints. Incorrect use (51.4%) was as common as inappropriate use (51.2%). Incorrect use was highest among users of dedicated child restraint systems (OR 16.0, 95% CI 6.9-36.0), and was more likely among those using size-appropriate restraints than those using inappropriate restraints (OR 1.8 95% CI 1.1-3.2); and among convertible restraints than those designed for a single mode of use (OR 1.5 95% CI 1.2-1.7). As incorrect use substantially reduces the protection from injury that is offered by child restraints, it is important that future strategies to reduce casualties among child occupants target both inappropriate and incorrect use.

1 Introduction

Traffic crashes are the most common cause of death and injury among children in all developed countries (UNICEF, 2001) and casualties among children travelling in cars account for a substantial component of this burden (WHO, 2008). While a lack of restraint use is a primary contributor to child road trauma in developing countries, in developed countries, problems with the *quality* of restraint use (i.e. how well the restraint suits the child's size and how the restraint is being used) are now widely recognised as important contributors to these casualties (Arbogast et al., 2004; Brown et al., 2006, Brown & Bilston, 2007; Du et al., 2008; Elliot et al., 2006; Durbin et al., 2003; Valent et al., 2002; Winston et al., 2000). Understanding the extent and quality of restraint among child occupants is necessary for establishing where limited health promotion and injury prevention dollars are best targeted.

In addition to non-use of restraints, there are two forms of suboptimal restraint use known to increase injury risk in crashes (Du et al., 2008). The first is inappropriate restraint use, which occurs when the child uses a restraint type that is not the most size-appropriate. This commonly arises when small children prematurely graduate into restraints designed for older children and adults. A second form of sub-optimal restraint use is incorrect use, which occurs when the user does not use the restraint as it was designed to be used, either in installing the restraint in the vehicle or securing the child in the restraint.

Both inappropriate and incorrect restraint use have been reported to be widespread in North America, Europe, and Australia. However, most of the relevant studies relied on parent reports of restraint use (Koppel et al., 2008; Bilston et al., 2008) and/or self-selected

(Koppel and Charlton, 2009 crash-involved Winston et al., 2000; Brown et al., 2006), or convenience samples (Campbell et al., 1997; Decina and Knoebel, 1997; Paine et al., 2001; Simpson et al., 2003; Simpson et al., 2006; Vesentini and Williams, 2007; Blair et al., 2008;). Moreover, few studies have reported the prevalence of both inappropriate and incorrect restraint use and none have examined the prevalence across all child restraint types. Most studies do, however, suggest that rates of inappropriate and incorrect use are likely to vary for children of different ages and across different restraint types, but this is yet to be confirmed in a study examining child restraint practices across all restraint types.

This study aims to provide population-level estimates of both appropriateness and correctness of restraint use among child occupants, and to determine whether restraint appropriateness, and the severity of incorrect use, vary with age of the child and restraint type.

2 Methods

2.1 Sample design

A multistage stratified, clustered random sample plan was used to collect data representing the population of children aged 0-12 years in NSW, Australia. Four strata (Metropolitan, Metropolitan Fringe, Regional, and Rural) were constructed from local government areas (LGAs) using the Australian Classification of Local Governments (ACLG) which is based on geographical location, socioeconomic characteristics, and accessibility to services (Carter et al., 2009). For efficiency reasons, LGAs with less than 0.5% of the State's total population were omitted. Probability proportional to size sampling was used to distribute

sampling units (LGAs) across the strata, and simple random sampling was then used to select individual LGAs from each stratum using Australian Bureau of Statistics (ABS) 2001 census-based end of year population estimates for each LGA in NSW (from www.abs.gov.au).

Within each randomly selected LGA, baby/child health clinics, preschools, day care centres, and primary schools were identified as sites where the probability of child attendance was relatively equal for any child. Sites were chosen using simple random selection and then inspected for suitability as data collection sites. Sites were deemed suitable if they allowed for adequate, safe observation of the restraints worn by child occupants (both in-situ, i.e. within the vehicle and with the child out of the car), with minimal impact on normal traffic flow.

Children were randomly chosen as the vehicle arrived at the selected sample site. In vehicles where there was more than one child, the child who had had the most recent birthday was selected irrespective of their age.

2.2 Data collection

Trained researchers attended data collection sites throughout 2008 over a one to two hour time period corresponding with drop off times at preschools and primary schools, and morning and afternoon sessions at early childhood health clinics. Eligible vehicles were approached as they arrived at the institution, and the driver of the vehicle was invited to participate. All refusals were recorded, and reasons for non-participation noted.

If the driver agreed to participate, initial observations were made with the selected child in situ (i.e. in the restraint within the vehicle). Once the child left the vehicle, a structured interview was conducted with the driver while a detailed examination of the restraint installation was conducted. The height and weight of the child was measured using a portable potentiometer and scales. For children <1 years recruited through baby health clinics, height and weight measurements were made by early childhood nurses during the clinic visit and were reported by the parent.

2.3 Variable descriptions and definitions

Use of restraints by children with weights within the defined limits of the restraint (as defined by Australian Standards/New Zealand Standard 1754 (AS/NZS, 2004)) was coded as ‘appropriate’, and use by children with weights outside the weight limits of their restraint was coded as ‘inappropriate’.

Incorrect use refers to incorrect installation of and/or securing of a child in a restraint system. For example, incorrect installation involves the restraint not being correctly secured to the vehicle by the vehicle seat belt system, and incorrect securing involves the child not being correctly secured by the internal harness system. Each form of incorrect use was coded as an ‘installation’ error, or a ‘securing’ error and was rated as minor, moderate, or serious based on the likely threat of injury and/or the likely degradation in protection.

Rating assessments were based on evidence published in laboratory studies investigating the influence of incorrect use (Hummel et al., 1997, Lalande et al., 2003; Lesire et al., 2007; Bilston et al., 2007), and crash studies demonstrating the real world effect of

incorrect use (Gotschall et al., 1997; Brown et al., 2006; Bulger et al., 2008). An attempt was also made to ensure consistency with other observational studies that have included incorrect use severity ratings (Eby and Kostyniuk, 1999; Decina and Lococa, 2005). Minor errors were taken to be those known to have no deleterious effect on the protection provided e.g. less than 25mm of slack in the restraint and/or anchorage system (N.B Australian child restraints must pass the mandatory Australian product standard dynamic tests with 25mm of slack in the system), and moderate to serious errors were those known to substantially increase injury risk. A full description of all errors is provided in Brown et al. (*in press*).

A ‘quality of restraint use’ variable was constructed to describe restraint status. Based on observations described above, children were coded as being unrestrained, using their restraint incorrectly only, using their restraint inappropriately only, using their restraint incorrectly and inappropriately, or using their restraint optimally.

Restraint types were described as rearward facing restraints, forward facing restraints, child safety harnesses, or booster seats, according to restraint type definitions described in AS/NZS 1754 (AS/NZS, 2004); and seat belts (including both lap only and lap/sash belts). Booster seats are used with either an adult lap/sash or a child safety harness. Booster seats used with a child safety harness were coded as booster seats only. Therefore those restraints coded as child safety harness refer to the use of a child safety harness alone. In some analyses restraints were grouped into dedicated child restraints (rearward facing restraints, forward facing restraints, child safety harnesses, or booster seats) and seat belts.

Restraints were also categorized as ‘convertible’ or ‘single mode’. Convertible restraints are designed for use in more than one mode, i.e. restraints that can be used both rearward and forward facing, and forward facing restraints that convert to booster seats.

For descriptive purposes, child weights were collapsed into the following weight categories: 0-9kg, 9.1-13.9kg, 14 -17.9kg, 18-26kg, 27-32kg, >32kg, and ‘not measured’.

Child age at the time of observation was coded in years rounded to last birthday and in some analyses was collapsed into three categories: 0-3 years, 4-8 years, and 9 + years, as commonly reported in the child restraint literature.

2.4 Data analysis

All data analysis was performed using SAS version 9.2 (SAS Institute, 2008). Sample weights were constructed using standard weighting procedures as outlined by Lohr (1999) and Korn & Graubard (1999). Post-stratification weighting for age distribution variations and both, over and under sampling at different sites was used to generate population-level figures for the state of NSW. Population weighted estimates of the proportion of children in each ‘quality of restraint use’ category were generated using the SURVEYFREQ procedure, to estimate variance and corresponding 95% confidence intervals (CI). The significance of associations between incorrect use, the severity of incorrect use, restraint type, and appropriateness of restraint was evaluated using univariate logistic regression via

the SAS SURVEYLOGISTIC procedure. Odds ratios (OR) and 95% CI were calculated, relative to a baseline or reference category for each independent variable.

2.5 Approvals

Approval for the conduct of this study was granted by the UNSW Human Research Ethics Committee, NSW Health Ethics Committees, the NSW Department of Education and Training, and the principal of each sampled school.

3 Results

Overall, 503 children aged 0-12 years across NSW participated in this study. The refusal rate was 37%, with lack of time the most common reason given for non-participation.

Height and weight were not recorded in two cases due to parents and/or children being unhappy for these measurements to be taken. These cases were omitted from this analysis leaving a total sample of 501.

Few children were unrestrained (0.8%), but the prevalence of incorrect and inappropriate restraint use was high (51.4%, 51.2% respectively). Almost one in five children were *both* incorrectly and inappropriately restrained. When minor forms of incorrect restraint use were ignored, both incorrect and inappropriate restraint use remained common (38.3% and 48.1% respectively) (Table 1).

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Incorrect use was most common for children aged 0-3 years (66%). Conversely, inappropriate use was most common among children aged 4+ years (73% of 4-8 year olds and 47% of 9+ year olds).

The quality of restraint use varied with restraint type (Figure 1). Incorrect use was twice as common in dedicated child restraints than in seat belts (OR - any incorrect use 2.3, 95% CI 1.5-3.6; OR - serious and moderate severity incorrect use 1.3, 95% CI 1.1-1.6). Incorrect use was also significantly more likely in convertible restraints than in single mode restraints (OR - any incorrect use 1.5, 95% CI 1.2-1.7; OR - serious and moderate severity incorrect use 1.2, 95% CI 1.1-1.6).

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Children using a size-appropriate restraint (i.e. appropriately restrained) were nearly twice as likely to be incorrectly using restraints in a serious or moderately severe manner (OR 1.8, 95% CI 1.1-3.2) than those using inappropriate restraints.

There was an elevated, but not significant, risk of seat belt errors among booster users who had prematurely graduated from forward facing child restraints (i.e. who were inappropriately using booster seats), than among those appropriately using booster seats, (OR 2.6, 95% CI 0.9-8.3).

Incorrect use included 'installation' errors (in 3.7% of children, 95% CI 0-7.7%), 'securing' errors (in 33.3% of children, 95% CI 22.0-44.6%), and a combination of both (in 14.2% of

children, 95% CI 7.5-21.0%). Incorrect use was more likely to be of a serious or moderate severity when there was a combination of installation and securing errors (OR 6.8, 95% CI 3.9-11.7).

4 Discussion

This is the first Australian study and one of few internationally, to provide population representative estimates of the quality of restraint use among children travelling in cars, and to consider appropriateness and correctness of restraint use concurrently. The results confirm high restraint usage rates among children aged 0-12 years but indicate that both inappropriate and incorrect restraint use are common.

The results of this work support the need for better strategies to ensure children use size-appropriate restraints and supports legislative changes underway in Australia and elsewhere to achieve this. However, such legislative changes alone are unlikely to address the widespread problem of incorrect use.

4.1 Quality of restraint use

Extrapolating from our results, it appears that almost one half of children aged 0-12 years travelling in vehicles in NSW are using an inappropriate type of restraint for their size. This is a similar proportion to that reported in other Australian and international observational studies (Edwards et al., 2006, Vesentini & Willems, 2007), and also similar to parental report in an earlier survey (Bilston et al., 2008). Although one previous Australian study (Koppel et al., 2007) reported a lower prevalence of inappropriate use among 4-8 year olds,

this may have been due to self-selection bias in the sample rather than bias introduced by parental report.

Many previous investigations into inappropriate restraint among child occupants have focussed on premature graduation into adult seat belts, and concomitantly low booster seat usage rates among 4-8 year olds (Ramsey and Simpson, 2000; Simpson et al., 2002; Simpson et al., 2003; Bingham et al., 2006; Koppel et al., 2008). Importantly, we found that premature graduation into booster seats is also common; almost one third of booster seat users could still have been using forward facing seats (i.e. they weighed less 18kg). Most of these children were aged less than 4 years. In Australia, it is possible that this form of premature graduation is inadvertently encouraged by overlapping weight ranges (14-18kgs) in the designations of forward facing child restraints and booster seats in the current mandatory child restraint standard (AS/NZS, 2004). Removing these overlaps may assist in reducing this form of premature graduation.

Incorrect restraint use is also widespread. Some form of incorrect use was reported for more than half of all sampled children. No previous studies have investigated incorrect use across such a broad age range and included children using dedicated child restraints and adult seat belts. Therefore comparing the overall incidence of incorrect use with other studies is difficult. Nonetheless, our finding that incorrect use was highest among dedicated child restraint systems (almost 81% overall, and 62% after excluding minor forms of incorrect use) is consistent with the findings of several convenience-sample based studies (Koppel et al., 2009; Blair et al., 2009; Decina et al., 2005; Decina et al., 1997).

Because incorrect use carries an increased risk of injury (Brown and Bilston, 2007), the finding that it is most common among users of dedicated child restraint systems has important implications for strategies that aim to reduce casualty numbers by increasing appropriate restraint use. For most children ≤ 12 years, the use of a size-appropriate restraint involves the use of a dedicated child restraint so unless incorrect use is also targeted, the prevalence of incorrect use might increase as more children are moved into appropriate restraint systems.

Dedicated child restraint systems are more complex to use correctly than adult seat belts because there are more opportunities for errors in using these restraints and this most likely underlies the greater incidence of incorrect use. Among dedicated child restraints, convertible child restraints are arguably even more complex as they can be used in two different modes by children over a greater size range. Correspondingly, we found that convertible child restraints were the restraint types most likely to be used incorrectly. This is concerning given the large numbers of convertible restraints being used (47% in this study sample). Further exploration of these issues was outside the scope of this study, but is an important direction for future work. However, these data strongly suggest that it is imperative that interventions to improve child restraint practices should target both the use of size-appropriate restraints and correct use of those restraints.

Among those restraint types that require installation, installation problems accounted for 13% of all errors. This figure is lower than that reported in some North American studies

(Decina et al., 2005; Blair et al., 2008), and another Australian study (Koppel et al., 2009), probably because the current study included observation of children in situ, which allows identification of securing errors that would be missed when in situ observations are not included. With the identification of more securing errors the proportion of installation errors will be lower. Eby et al. (1999) also observed children in situ, and found a high proportion of ‘securing’ errors.

4.2 Incorrect use in crash studies

The results of this study demonstrate that some form of incorrect use occurs in one out of every two restrained children, and moderate/serious forms of incorrect use occurs in at least one out of three restrained children. A much lower prevalence has been reported in crash studies (Arbogast et al. 2004, Winston et al. 2000, Brown et al., 2006), which is likely to be due to the difficulty of identifying incorrect use retrospectively. Usually, only the most serious forms of incorrect use are identified, and multiple errors are rarely mentioned. Consequently, the role of incorrect restraint in injury causation and risk may hitherto have been substantially overlooked or underestimated.

4.3 Limitations

The major limitation of this study is the possibility of bias introduced through the 37% non-participation rate. During data collection an attempt was made to record non-participant characteristics, such as type of car, gender of driver, number of children in vehicle and restraint status of children. However, due to the time constraints during the data collection time period (i.e. during drop off times at pre-school and schools) this information was only

collected on just over half of the non-participants. Comparing this group to participants, there was some difference in the cars being driven (proportionally less four wheel drives and more sedans among the non-participants), but no difference in the proportions of male and female drivers, the median number of children in the car and the percentage of children not using restraints. There was also no difference in the proportions of children using appropriate and inappropriate restraints (noting that in the non-participant group this assessment was based on a visual estimate of age). There was significantly more incorrect use among the participating children but this reflects the inability to make accurate assessments of correctness of restraint use via quick 'through the window' observations. Based on the above, we believe any potential bias from the non-participants was likely to be minimal.

Another potential limitation of this study is that the sample plan assumed an equal probability of all children within NSW being at the sites used as data collection points. For school-aged children this would be true, but for the younger children, for whom attendance at pre-schools/long day centres and early childhood health clinics is not mandatory, this assumption might not hold. To account for possible population under-coverage, post-stratification was used to adjust the sample weights (Lohr, 1999; Korn, 1999). This also assists in addressing distribution variations due to non-participation. Nonetheless, the types of data collection sites used in this study are the best available in terms of having a high concentration of target aged children as noted by Eby et al. (1999), thereby adding strength to our sampling strategy.

The vehicles carrying the children captured in this study were predominantly driven by mothers. There may be differences in how children are restrained when they travel with fathers and other family members, and this potential effect could not be estimated with our study design but should be considered in future studies.

Finally, data were collected as children arrived at early childhood centres, long day care centres, pre-schools, and schools, and therefore on weekdays only. Restraint status might vary with trip type, weekday/weekend travel and also time of day (Chen, 2005). Variables such as the type of vehicle, and the number of occupants within each vehicle were not included in this analysis, and it is possible that restraint status might also vary by vehicle type and the number of occupants in the vehicle at the time of the observation. Similarly, there could be other parental and family characteristics that influence quality of restraint use among child occupants.

5 Conclusions

This study confirms that, restraint use among children travelling in cars in NSW is very high, but that the quality of restraint use is often poor. For the first time, population-based estimates of the degree of both incorrect and inappropriate restraint use occurring among children aged 0-12 years in NSW are provided, indicating that both forms of suboptimal restraint are prevalent. Whilst NSW-based agencies have been very successful in getting children to use restraints at a population-level, they should now shift their focus away from simply getting parents to ensure their children use a restraint towards parents ensuring their children correctly use the most appropriate restraint. The novel analysis of children across all age ranges demonstrates that the quality of restraint use varied between children of

different ages and children using different restraint types. Most children under 4 years were appropriately using rearward facing and forward facing restraints, and interventions targeting these children should place a high priority on increasing correct use.

Inappropriate restraint use is currently the greatest problem among child occupants aged 4+ years, however the results of this study indicate that incorrect use occurs more commonly in dedicated child restraints than in seat belts so it is imperative that interventions target both appropriate and correct restraint use.

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