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Restraint Use Patterns for Injured Children in Japan

Abstract

Since the compulsory use of child restraints for children up to 5 years of age was introduced in 2000, restraint use among younger children has increased significantly. However, the observed rate of child restraint use plateaus at around 50%, and apparently little spillover effect has been found for older children who are not covered by the law. This report examines the restraint use patterns for children who were injured in cars in relation to driver and child passenger characteristics. Univariate and multivariate analyses were conducted to describe the association between the outcome measure (the proper use of restraints for children) and relevant variables. Better ways for parents and caregivers to improve the use of restraints for children are also discussed.

Introduction

Since the compulsory use of child restraints was mandated in 2000, the use of child restraints among Japanese child passengers has increased markedly. However, there is also evidence showing that many children are still unrestrained in cars and more could be done to improve this situation. Results of the latest survey conducted in 2005 show that the observed rate of restraint use among infants up to 1 year old was 74%, but this figure falls as the age of the children increases – 49% for children 1 to 4 years old and 30% for 5 year olds. Overall, just half of the children younger than 6 years of age (the age group targeted by the law) were appropriately restrained [1]. Of greater concern is that the proportion of child occupants observed to be appropriately restrained had begun to slightly decline in 2003 and has since leveled off. This occurred only three years after the law was enacted. Furthermore, the use of child restraints has apparently not expanded among older children who are not covered by the law, but still too small to be restrained by adult safety belts.

The problems are twofold: (a) the use of child restraints among children covered by the law is not sufficiently high, and (b) restraint use also remains low for other passenger age groups – older children and adults. The latter point has been raised for two reasons. First, if younger children or their parents became accustomed to using child restraint systems (CRS), they would continue to use CRS even when the children become older than 5 years old, until they typically outgrow booster seats. Secondly, it is not realistic to expect a miraculous rise in CRS use to occur only among young children, while the majority of older children and adult passengers in rear passenger seats are not restrained. In Japan, the rate of safety belt use among rear seat passengers is generally very low at 8% [1]. This apparently reflects the current law (or lack of regulation) in Japan where there are no punitive measures for not wearing safety belts while riding in the rear seats. This contrasts sharply with the high rate of using safety belts among drivers and front-seat passengers (92% and 80%, respectively [1]).

The present study attempts to identify the factors associated with proper use of restraints for children, and suggests recommendations for promoting the use of child restraints with a focus on the role of parents and caregivers.

Methodology

Database

The national traffic accident database of the National Police Agency (NPA) was used for this study. The NPA database consists of all police-reported accidents resulting in the injury or death of at least one person. For each accident, a minimum of 67 items of data is recorded, such as driver characteristics, collision details, environmental information. Passenger information is only compiled in cases of reported injury. At least 21 items of data items are typically recorded for each passenger involved in an accident. However, the NPA database does not provide information on passengers who do not sustain injury. Therefore, uninjured child passengers are not included within the scope of the present study.

Data coding of child restraint use patterns

The outcome measure of the present study is the proper use of restraints by child passengers. Information on the use of child restraints in the NPA database is recorded as follows: (1) appropriate CRS use, (2) CRS misuse, (3) restrained by safety belts, (4) unrestrained, (5) exempted due to illness and other reasons, and (6) unknown. Of these, (5) and (6) were excluded from the analysis. Appropriate CRS use refers to use of the appropriate safety device based on the weight and height of a child, and seating in an appropriate position within the vehicle [2]. CRS misuse is interpreted as gross misuse resulting in a child being ejected from the CRS due to an accident, and is typified by the loose attachment of safety belts to the CRS and loose harness straps.

Parameters (1) to (4) were re-coded separately for younger children (up to 5 years old) and older children (6 to 12 years old) as shown in Table 1. For younger children, cases where they were appropriately restrained by CRS were re-coded as 'properly restrained', and others (parameters (2), (3) and (4)) were re-coded as 'not properly restrained'. For older children, cases where they were appropriately restrained by CRS or restrained by safety belts (parameters (1) and (3)) were re-coded as properly restrained. The use of safety belts by children younger than 13 years of age may be considered a premature graduation from CRS and therefore inappropriate. However, since the purpose of this study is to investigate the use of child restraints at the time of an accident in conjunction with the current law, parameter (3) was re-coded as properly restrained for this age group.

	Outcome measure	
	Properly restrained	Not properly restrained
0-5 years olds	Appropriate CRS use	CRS misuse Unrestrained Restrained by safety belt
6-12 years olds	Appropriate CRS use Restrained by safety belt	CRS misuse Unrestrained

Table 1: Re-coding of child restraint use

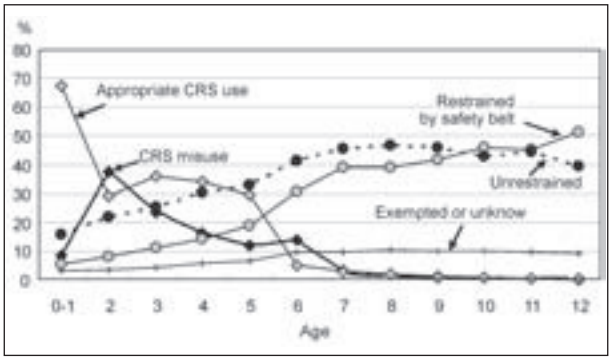

Figure 1: Restraint use patterns in percentage by age of children injured or killed

Data sets

Original data set

The following cases were extracted from the NPA database to form a separate data set: accidents in which child passengers up to 12 years old were injured or killed during the years 2004 and 2005 in privately owned passenger cars. This data subset is called the original data set. Large vehicles, school buses, taxis, and rented cars were excluded. This original data set includes information on 47,283 children who were injured or killed in car accidents.

Children up to 5 years old are the target group of compulsory CRS use under the current law. Older children 6 to 12 years old, covering all primary school-age pupils, were also included for analysis. Figure 1 shows the restraint use pattern for children who were injured or killed as obtained from the original data set. The percentage of appropriate CRS use is relatively high only for infants up to 1 year old, but drops below 40% for children 2 to 5 years old. Fewer than 5% of the children injured or killed who were at least 6 years old used CRS appropriately. Conversely, the percentage of children who were restrained by safety belts or not restrained at all increases with the children's age.

Not-at-fault rear-end collision data set

Since the NPA data provides information only on injured passengers, it is quite possible that certain types of accidents are overrepresented while others are underrepresented in the original data set. For example, a previous data analysis of Japanese child occupants showed that a higher proportion of injured child passengers were found to be unrestrained in head-on collisions and single-vehicle accidents than in rear-end collisions [3]. It is assumed that head-on collisions and single-vehicle accidents are overrepresented in the data due to the high speed at impact, thus reflecting a higher incidence of injury to child passengers, which results in higher percentage of the injured child passengers found to be unrestrained. This is not

necessarily due to a lower rate of CRS use among those involved in head-on collisions. The main focus of the present study is to identify the demographic and behavioral characteristics of occupants associated with the proper use of restraints under existing regulations. To this end, it would be best to eliminate the effects of certain factors if they excessively influence data representation.

Drivers who were involved in rear-end collisions as the party least responsible can be considered a pseudo-sample of drivers who happened to be involved in an accident "by chance". Admitting that this is only a rough estimate, much of the bias influencing the use of child restraints could be eliminated by focusing on those involved in a rear-end collision, thus making it possible to identify the factors associated with the use of restraints by children. It is indeed true that this estimate still suffers from selection bias, for example, inflated restraint use rate, and this is discussed later in this paper. This "quasi-not-at-fault driver subgroup" data set was created by extracting the drivers whose vehicles were struck by another vehicle in a rear-end collision as the party least responsible, together with information on child passengers. This data subset is called the not-at-fault rear-end collision data set. This data set consists of 21,352 pairs of drivers and child passengers, accounting for 45.2% of the cases in the original data set. Almost all (99.3%) drivers were judged to assume no legal responsibility for an accident, and 90.2% of the drivers involved were actually braking to stop their cars uponrealizing the imminent danger. Nine children were killed within 24 hours of an accident (0.04%), and 63 were seriously injured (0.3%), meaning that virtually all the children suffered minor injuries (99.7%) – typically neck sprain or whiplash injury.

Data analysis

Based on the not-at-fault rear-end collision data set, Pearson's chi-square and t-statistics were used to compare the demographics of occupants (age, gender, and license status), characteristics of travel (purpose, time of day, and day of the week), and other relevant variables (use of a safety belt by the driver, seating position, and total number of occupants) to the outcome measure (the proper use of restraints for children). After univariate associations with outcome were calculated, correlation coefficients (r) were computed to check the relationship between independent covariates of interest. Logistic regression was then applied to compute the odds ratio, adjusted for possible confounding variables.

Results

Univariate analysis

Table 2 summarizes univariate association with the outcome measure for younger children (up to 5 years old). A significant association was found between the outcome and time of day, day of the week, driver gender, driver age group, license status, purpose of travel, use of a safety belt by the driver, number of occupants, and the age of children. No significant association was found regarding the type of car and seating position of the children. Moreover, no association was found regarding the gender of children, results of alcohol tests, and the use of mobile phones while driving (not shown in the tables). Further detailed information on the occupants is not available, such as how many adults and children were seated together in a car.

Table 3 summarizes univariate association for older children (6 to 12 years old). A significant association was found between the outcome and day of the week, driver gender, driver age group, type of car, purpose of travel, use of a safety belt by the driver, number of occupants, and the seating position and age of the children. No significant association was found regarding the time of day and driving license status.

Multivariate analysis

In order to simultaneously adjust for possible confounders, multivariate analysis was conducted. Based on univariate analysis, any variable whose univariate test yielded a p-value <0.05 was included in the multivariate model. Table 4 and Table 5 show adjusted odds ratio (OR) and a 95% confidence interval (CI) for younger and older children, respectively.

As shown in Table 4, six variables were significant predictors of the proper use of restraints by younger children, when adjusted for the effects of other variables. The OR of proper restraint use was 14% lower at night compared with daytime (OR=0.86). Drivers aged 50 and older were less likely to restrain children properly, while drivers in their 30s

Variables			Properly restrained	Not properly restrained	x 2 or *t*
Time of day (%)	Day		81.0	77.7	X 2=16.803
	Night		19.0	22.3	
		N	4945	4922	
Day of week (%)	Weekdays		57.8	52.9	
	Weekends/ bank holidays		42.2	47.1	
		N	4945	4922	
Driver gender (%)	Man		37.1	42.3	X 2=28.213
	Woman		62.9	57.7	
		N	4945	4922	
Driver age group (%)	29 and under		29.0	31.7	X 2=56.553
	30-39		55.0	57.0	
	40-49		9.1	7.2	
	50-59		4.1	2.5	
	60 and older		2.8	1.5	
		N	4945	4922	
Driving license status (%)	Valid		99.9	99.8	X 2=5.451
	Notvalid		0.1	0.2	
		N	4945	4920	
Type of car (%)	Passenger car		69.9	68.2	X 2=3.36
	Mini car <660cc		30.1	31.8	
		N	4945	4922	
Purpose of travel (%)	Commuting		1.8	1.6	X 2=24.753
	Business		0.6	0.7	
	Leisure		14.3	17.7	
	Shopping		33.2	32.3	
	Visit		17.8	17.8	
	Escort		8.3	8.0	
	Other private		24.0	22.0	
		N	4945	4920	
Driver belt (%)	Belted		99.2	97.9	X 2=30.273
	Unbelted		0.8	2.1	
		N	4919	4898	
Seating position of child (%)	Front seat		25.3	26.3	X 21.22
	Rear seat		74.7	73.7	
		N	4926	4876	
Number of occupants	Average (SD)		3.04 (0.96)	3.41 (1.15)	*t*=17.33
	Mode		3	3	
		N	4945	4922	
Child age	Average (SD)		2.28 (1.46)	3.06 (1.39)	*t* =-27.093
	Mode		1	2	
		N	4945	4911	

1 p<.0.5, 2 p< 0.1, 3 p<.00.1

Table 2: Univariate analysis of proper restraint use for younger children (up to 5 years old)

Variables			Properly restrained	Not properly restrained	x 2 or *t*
Time of day (%)	Day		73.2	73.1	X 2=0.02
	Night		26.8	26.9	
		N	5044	4959	
Day of week (%)	Weekdays		45.8	41.5	X 2=19.223
	Weekends/ bank holidays		54.2	58.5	
		N	5044	4959	
Driver gender (%)	Man		34.5	41.7	X 2=57.883
	Woman		65.7	58.3	
		N	5044	4959	
Driver age group (%)	29 and under		6.0	5.3	X 2=28.343
	30-39		56.8	53.2	
	40-49		29.7	34.2	
	50-59		3.5	4.0	
	60 and older		3.9	3.3	
		N	5044	4959	
Driving license status (%)	Valid		100.0	99.9	X 2=2.70
	Notvalid		0.0	0.1	
		N	5044	4959	
Type of car (%)	Passenger car		66.6	69.5	X 2=10.052
	Mini car <660cc		33.4	30.5	
		N	5044	4959	
Purpose of travel (%)	Commuting		1.1	0.9	X 2=81.773
	Business		0.7	0.5	
	Leisure		16.0	22.4	
	Shopping		31.5	30.0	
	Visit		16.5	16.8	
	Escort		11.5	11.0	
	Other private		22.8	18.4	
		N	5044	4959	
Driver belt (%)	Belted		99.9	98.1	X 2=79.323
	Unbelted		0.1	1.9	
		N	5035	4946	
Seating position of child (%)	Front seat		59.0	8.5	X 2=2842.103
	Rear seat		41.0	91.5	
		N	5036	4952	
Number of occupants	Average (SD)		3.01 (1.10)	3.66 (1.29)	*t*=27.223
	Mode		2	3	
		N	5044	4959	
Child age	Average (SD)		9.04 (2.00)	8.66 (1.98)	*t* =-9.593
	Mode		11	6	
		N	5044	4959	

1 p<.0.5, 2 p<.0.1, 3 p<.00.1

Table 3: Univariate analysis of proper restraint use for older children (6 to 12 years old)

were most likely to use CRS properly. Drivers with an invalid license (suspended due to driving violations or accidents) were less likely to restrain children properly than drivers with a valid license (OR=0.24). Unbelted drivers were less likely to restrain children properly than belted drivers (OR=0.35). Children were less likely to be restrained properly when the total number of occupants increased (OR=0.73), and with increasing age of the children (OR=0.69).

Variables		Adjusted OR	95% CI
Time of day	Day	1.00	
	Night	0.86	0.77-0.95[2]
Day of week	Weekdays	1.00	
	Weekends/bank/ holidays	1.01	0.92-1.10
Driver gender	Woman	1.00	
	Man	0.96	0.87-1.06
Driver age group	29 & under	1.00	
	30-39	1.19	1.08-1.31[3]
	40-49	1.09	0.92-1.29
	50-59	0.67	0.53-0.86[2]
	60 & older	0.70	0.52-0.96[1]
Driver licence	Valid	1.00	
	Not valid	0.24	0.06-0.91[1]
Purpose of travel	Commuting	1.00	
	Business	1.09	0.60-1.98
	Leisure	1.12	0.80-1.57
	Shopping	1.08	0.78-1.49
	Visit	1.10	0.79-1.54
	Escort	1.21	0.85-1.72
	Other private	1.22	0.87-1.69
Driver belt	Belted	1.00	
	Unbelted	0.35	0.24-0.52[3]
Number of occupants		0.73	0.70-0.76[3]
Child age		0.69	0.67-0.71[3]
[1] p<.0.5, [2] p<.0.01, [3] p<.001 Wald test			

Table 4: Adjusted odds ratios of proper restraint use for younger children (up to 5 years old)

Variables		Adjusted OR	95% CI
Day of week	Weekdays	1.00	
	Weekends/bank/ holidays	1.00	0.92-1.09
Driver gender	Woman	1.00	
	Man	1.02	0.93-1.13
Driver age group	29 & under	1.00	
	30-39	0.94	0.78-1.13
	40-49	0.97	0.80-1.78
	50-59	1.07	0.81-1.42
	60 & older	0.88	0.67-1.17
Type of car	Passenger car	1.00	
	Mini car < 660cc	0.93	0.85-1.02
Purpose of travel	Commuting	1.00	
	Business	1.48	0.75-2.91
	Leisure	1.04	0.68-1.58
	Shopping	1.09	0.72-1.63
	Visit	1.05	0.69-1.59
	Escort	0.96	0.63-1.47
	Other private	1.44	0.95-2.18
Driver belt	Belted	1.00	
	Unbelted	0.06	0.03-0.13[3]
Number of occupants		0.62	0.59-0.64[3]
Child age		1.09	1.07-1.1[3]
[1] p<.0.5, [2] p<.0.01, [3] p<.001 Wald test			

Table 5: Adjusted odds ratios of proper restraint use for older children (6 to 12 years old)

Table 5 shows the predictors of the proper use of restraints by older children when adjusted for independent variables. After conducting regression analysis using all nine independent variables as possible confounders (obtained from the results shown in Table 3), it was noted that the variable of child's seating position could well act as a synonymous variable with the outcome (r=-0.53). In other words, when children were seated in the rear seat, most were unrestrained. When children sat in the front passenger seat, they were mostly restrained. Therefore, the seating position variable was excluded from the regression model. Three variables were significant independent predictors. When drivers were unbelted, children were also likely to be unrestrained (OR=0.06). As the total number of occupants increased, children were less likely to be properly restrained (OR=0.62). With increasing age, children were more likely to be restrained (OR=1.09).

Conclusion

Summary of the results

- The present study investigated the behavioral and demographic characteristics of drivers and child passengers who were involved in not-at-fault rear-end collisions. It was apparent that restraint use patterns differed completely between children up to 5 years old (the target of the current law) and children 6 to 12 years old.
- Univariate analysis of younger children (up to 5 years old) showed that such children were less likely to be properly restrained when accidents occurred at night, on weekends, or on holidays, during leisure trips, when men or older people drove the car, drivers had an invalid license, drivers were unbelted, there were more occupants in the car, and when the children were older.
- Univariate analysis of older children (6 to 12 years old) showed that such children were less likely to be belted when accidents occurred on weekends or on holidays during leisure trips, when men and older people drove the car, children rode in passenger cars, drivers were unbelted, children were seated in the rear seat, there were more occupants in the car, and when the children were younger.

- When adjusted for confounders, six predictors of the proper use of restraints for younger children were identified. The following variables significantly decreased the odds ratio of proper restraint use: nighttime accidents, older (>50) drivers, drivers with an invalid license, unbelted drivers, more occupants in the car, and older children.
- When adjusted for confounders, three predictors of the proper use of restraints for older children were identified. The following variables significantly decreased the odds ratio of proper restraint use: unbelted drivers, more occupants in the car, and younger children.

Interpretation of the results

- For both younger and older children, the use of a safety belt by the driver, age of injured children, and total number of occupants are apparently the most powerful predictors of the proper use of restraints for children. The relationship between the use of a safety belt by the driver and use of restraints for children has already been established in previous studies (for example [4]). Although there are very few reportedly unbelted drivers who were involved in not-at-fault rear-end collisions, the use of child restraints did mirror the use of a safety belt by the driver. It was also indicated that drivers are only keen to properly restrain very young children. It is quite likely that instead of continuing to use a child seat or booster seat, many parents simply discard the seats before children outgrow the CRS. Therefore, older children – unless seated in the front, as is often the case when there are only two occupants in the car (the driver and a child) – are not restrained at all. When there are more than two occupants in the car, chances are that the children sit in the rear seat and are simply left unrestrained.
- It may well be that existing regulations, although unintentional, serve to accelerate a premature graduation from the CRS for children who are too small to be restrained by safety belts and instead are left completely unrestrained, which is facilitated by situations where most adult passengers in the rear seat do not wear safety belts. Therefore, the compulsory use of restraints by both adults and children should be introduced and promoted hand in hand.
- There seems to be certain tendencies observed among drivers who do not restrain younger children properly: older drivers, possibly grandparents, are clearly less likely to use CRS properly, indicating that this particular generation would need to be informed of existing regulations and why it is necessary to use the CRS. Secondly, drivers with an invalid license, usually due to multiple driving violations or at-fault accidents, were unlikely to restrain children properly. In contrast, such specific driver characteristics were not found among those who had older child passengers in the car.
- Given the generally low number of fatalities involving child passengers in car accidents (the percentage being 0.2% according to the original data set), it is extremely difficult to increase the perception among caregivers regarding the inherent risk of misusing CRS. Furthermore, many characteristics of child restraint use and motor vehicle travel tend to reduce the perception of such risk, such as motor vehicle travel and having child passengers being perceived as a controllable, common, non-catastrophic, and familiar risk. It may therefore be necessary to arouse a sense of outrage by appealing to people's fears in order to promote the perception of CRS misuse as a serious risk [5].
- Some limitations should be considered when interpreting the results. Child passengers who were not injured in car accidents are omitted from the NPA database, and the results may not be applicable to driver-child passenger groups involved in accidents other than not-at-fault rear-end collisions. Finally, the police-reported use of restraints is known to be inflated due to the false reporting by occupants seeking to avoid being ticketed for such violation, and this is more of a factor in accidents involving minor injury where the occupants typically exit their vehicles before the police arrive [5].

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