

A comparative analysis of child passenger restraint use in China and the United States

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Background: Few published studies have examined child passenger safety practices across countries. This study compared the prevalence and associated factors of child passenger restraint use among children, aged 0 to 17 in the state of Iowa in the United States, and the city of Shantou in China.

Methods: Child restraint use observations were conducted in Iowa and in Shantou in 2012, respectively, among child passengers. Observations in Iowa were conducted at randomly selected gas stations, while in Shantou observations were completed at randomly selected schools or medical clinics. Research observers approached the driver, observed restraint use, and collected brief survey data.

Results: A total of 3049 children from Iowa and 3333 children aged 0 to 17 years from Shantou were observed. For children aged 0 to 3 years, only 0.1% were compliantly restrained in Shantou as compared to 95.9% in Iowa. The proportion of children who were compliantly restrained in Shantou increased with age, but generally decreased with age in Iowa. In Shantou, 36.0% of children aged 0 to 3 were sitting in the front seat as compared to only 1.7% of children of the same age in Iowa. Driver seat belt use was significantly associated with child restraint in both Iowa and Shantou; the association was stronger in Iowa than Shantou for all age groups.

Conclusions: A significantly higher prevalence of children who were not appropriately restrained was observed in Shantou than in Iowa. Our findings support the need of mandatory child safety restraint use legislation in China.

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Key words: child passenger safety restraint; cross country; motor vehicle occupant

Introduction

The "car culture" of the United States began in the 1930s, when individual car ownership grew to become the primary mode of transportation. The number of registered motor vehicles in the United States has grown by approximately three million vehicles per year from 74 million in 1960 to more than 254 million in 2009.^[1] Currently, China is experiencing a similar increase in motorization, with a dramatic increase from approximately 5 million in 1990 to over 23 million in 2004.^[2] In 2010 alone, China sold 18.1 million new vehicles, of which 13.8 million were passenger cars.^[3]

During the period of increasing motorization in the United States, increased attention to traffic safety led to improvements in roadway infrastructure, vehicle design, policy, and individual behavior. The motor vehicle fatality rate per 100 million vehicle miles travelled has decreased by 85.5% from a peak of 7.59 in 1950 to a low of 1.10 in 2010.^[4] However, developing a traffic safety culture in China is falling far behind the pace of rapid increases in motorization. Between 1985 and 2005, the traffic fatality rate in China has increased by 95% from 3.9 to 7.6 deaths per 100 000 population.^[5]

Children are among the most vulnerable motor vehicle occupants. Good child safety restraint practices, including rear seating, child safety seats, and booster seats can reduce the risk of death and serious injury in a crash by more than 50%.^[6-9] Many factors have influenced the use of child safety restraint in the United States, including legislation, distribution programs, educational efforts, enhanced enforcement, incentives and car seat check programs.^[10,11] Although the traffic-related mortality rate among children in

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China is much higher than in other developed countries,^[12] currently, China has not had a similar comprehensive effort to increase child safety seat use.

Few studies have examined traffic safety culture and child safety seat use across countries. This study compared child passenger restraint by age group in the state of Iowa in the United States, and the city of Shantou in China, both of which are smaller yet influential regions in their respective countries, and examined child restraint use. In particular, we compare child restraint use according to age categories, front and rear seat placement, type of vehicle, and use of restraint by the driver. We hypothesize that driver restraint use, which can serve as a proxy measure of safety culture, is more strongly associated with child restraint use in the United States than in China, in part because the traffic safety culture in the United States is currently more mature than Chinese traffic safety culture.

Methods

Study design

This comparative study was made possible through a collaborative relationship between the University of Iowa and Shantou University. The University of Iowa Injury Prevention Research Center conducts Iowa's Annual Child Occupant Restraint Survey, and these methods were replicated in the city of Shantou.

In Iowa, observations were done at gas stations, while the vehicle was stationary. A stratified sample was drawn by postal (zip) code to represent the state according to population density. A total of 36 communities were randomly selected and stratified into 4 strata (1000-2499 persons, 2500-9999 persons, 10 000-49 999 persons and 50 000+ persons). Relative to size, 50, 75, 100 or 125 observations were then conducted for the communities in the four strata, respectively. Research observers approached the driver, explained the study, and asked the driver if he or she would be willing to participate in a child and youth passenger safety survey. Observers collected information on children's age and seating position, restraint status [both child passenger(s) and driver] and vehicle type. For the purpose of this study, year 2012 observation data were used.

In Shantou, observations were conducted between April and May 2012 at four types of locations and 82 field sites including the following: 4 immunization clinics of hospitals, where infants and toddlers aged 3 or younger were the primary population; 24 kindergartens, attended by children aged 4-6; 31 primary schools, attended by children aged 7-13; and 22 middle schools, attended by children aged 14-17. Approximately 3000 children were observed in both the state of Iowa and the city of Shantou.^[13,14]

Study variables

The main variables to describe child restraint use included the age of the child passenger(s), restraint type (child safety seat, booster, seat belt or nothing), and seating position (front or rear). Age was collected as a continuous variable in Iowa and was broken down into the following categories to be consistent with age group collected in Shantou: 0-3 years, 4-6 years, 7-13 years, and 14-17 years. In addition, data on driver seat belt use, vehicle type (sedan, sport utility vehicle, van, standard pickup, and pickup with a back seat-club cab), and whether the child sat on the lap of an adult were also collected.

Since China does not currently have specific child passenger protection laws, a new variable named compliant restraint was created using Iowa child passenger restraint laws as the standard, based on the latest seat belt laws which were implemented in 2010. Compliant restraint was defined as the following: 1) children aged 0-6 years to be belted in a safety or booster seat in the rear seat; 2) children aged 7-13 years belted in a booster seat or wearing a seat belt in the rear seats; 3) children aged 14-17 years wearing a seat belt. It should be noted that booster seats are recommended for children through the age of 12 or 145 centimeters in height ("four-foot nine is the line"), and thus, compliant restraint is not optimal restraint. Since compliance was so low in Shantou, we could not use this as an outcome variable in a multivariable model. Our primary outcome variable for modeling was any restraint use, which was defined as safety seat, booster seat or seat belt use regardless of the age or seating position.

Analysis

Child passenger restraint use, seating position, placement on an adult's lap and compliant restraint use were examined by age group. Bivariate concordance between the driver's seatbelt use and the child's restraint use was also examined and compared between Iowa and Shantou for each age group using Chi-square tests. Multivariable logistic regressions were conducted to identify characteristics related to the child's restraint use for both Iowa and Shantou. Four variables from the observational survey were included in each model: child age, seating position, vehicle type and driver seatbelt use. The analyses were conducted in SAS 9.30.

Results

In total, 3333 children from Shantou and 3049 children from Iowa were observed. More children aged 4-6 years were observed in Shantou ($n=1139$, 34.2%) than Iowa ($n=591$, 19.7%), while more children aged 7-17 were observed in Iowa than Shantou. In Iowa, only 1.7%

of children aged 0-3 were sitting in the front seat, as compared with 36.0% of children in Shantou (Table 1). In Iowa, the proportion of children sitting in the front seat increased with age, and among those 14-17 years old, 70.2% were sitting in the front seat. In Shantou, age was not strongly related with seat placement. Over half (56.1%) of children aged 0-3 were sitting on an adult's lap in Shantou, compared to less than 5% in other age groups. Lap seating was not found in Iowa.

In Shantou, only one young child in the 0-3 age group (0.1%) was compliantly restrained (Table 1). The proportion increased with age, reaching 25.2% for children aged 14-17 who were compliantly restrained.

The proportion of children aged 0-3 in Iowa who were compliantly restrained was much higher at 95.9%. Also in contrast, compliant restraint in Iowa generally decreased with age. In Shantou, the odds of any child restraint use increased with age, with those aged 14-17 having nearly 20 times the odds of being restrained when compared to children 0-3 years of age (Table 2). In Iowa, the odds of any child restraint use decreased significantly with age.

Front seat placement was associated with increased odds of any restraint use in both Shantou and Iowa (Table 2). In Shantou, children were equally likely to be in the front seat regardless of age, but in Iowa front seat placement increased with age of the child. Sedans

Table 1. Distributions of restraint type and seating position in different age groups from Shantou and Iowa

Variables	Shantou (n=3333)				Iowa (n=3049)			
	0-3 y (n=906)	4-6 y (n=1139)	7-13 y (n=817)	14-17 y (n=471)	0-3 y (n=702)	4-6 y (n=591)	7-13 y (n=1004)	14-17 y (n=701)
Restraint type								
Total observed	906	1132	802	458	700	591	1004	699
Safety seat, n (%)	4 (0.4)	10 (0.9)	5 (0.6)	0 (0.0)	520 (74.3)	24 (4.1)	2 (0.2)	0 (0.0)
Booster, n (%)	0 (0.0)	3 (0.3)	0 (0.0)	0 (0.0)	162 (23.1)	396 (67.0)	69 (6.9)	2 (0.3)
Seat belt, n (%)	19 (2.1)	50 (4.4)	94 (11.7)	114 (24.9)	9 (1.3)	148 (25.0)	869 (86.6)	575 (82.3)
None, n (%)	883 (97.5)	1069 (94.4)	703 (87.7)	344 (75.1)	9 (1.3)	23 (3.9)	64 (6.4)	122 (17.5)
Seating position								
Total observed*	822	1104	789	463	700	589	1004	698
Front, n (%)	296 (36.0)	282 (25.5)	267 (33.8)	166 (35.9)	12 (1.7)	41 (7.0)	371 (37.0)	490 (70.2)
Rear, n (%)	526 (64.0)	822 (74.5)	522 (66.2)	297 (64.2)	638 (98.3)	548 (93.0)	633 (63.0)	208 (29.8)
Sitting on adult's lap								
Total observed	906	1139	798	466	700	591	1004	701
Yes, n (%)	508 (56.1)	35 (3.0)	9 (1.1)	3 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
No, n (%)	398 (43.9)	1104 (97.0)	789 (98.9)	463 (99.4)	700 (100)	591 (100)	1004 (100)	701 (100)
Compliant restraint†								
Total observed*	822	1098	774	452	700	589	1001	698
Yes, n (%)	1 (0.1)	9 (0.8)	33 (4.3)	114 (25.2)	671 (95.9)	409 (69.4)	597 (59.6)	577 (82.7)
No, n (%)	821 (99.9)	1089 (99.2)	741 (95.7)	338 (74.8)	29 (4.1)	180 (30.6)	404 (40.4)	121 (17.3)

*: Numbers that do not add up to the total are due to missing values; †: Compliant restraint was defined as the following: 1) children aged 0-6 years to sit in a safety or booster seat in the rear seats; 2) children aged 7-13 years to sit in a booster seat or wear a seat belt in the rear seats; or 3) children aged 14-17 years to wear a seat belt.

Table 2. Odds ratios of any child passenger safety restraint use*

Variables	Shantou			Iowa		
	n (%)	OR†	95% CI	n (%)	OR†	95% CI
Age (y)						
0-3	906 (27.2)	Reference	Reference	701 (23.4)	Reference	Reference
4-6	1139 (34.2)	3.40	1.96-5.55	591 (19.7)	0.23	0.10-0.55
7-13	817 (24.5)	7.90	4.79-13.03	1006 (33.5)	0.07	0.03-0.15
14-17	471 (14.1)	19.32	11.61-32.15	701 (23.4)	0.01	0.01-0.03
Seating position						
Front	1011 (31.8)	4.89	3.72-6.43	965 (31.7)	3.42	2.21-5.28
Rear	2167 (68.2)	Reference	Reference	2079 (68.3)	Reference	Reference
Vehicle type						
Sedan	2942 (88.3)	Reference	Reference	1142 (37.5)	Reference	Reference
SUV	191 (5.7)	2.47	1.53-3.98	786 (25.8)	1.99	1.21-3.30
Van	200 (6.0)	0.94	0.51-1.70	740 (24.3)	1.61	0.95-2.73
Pickup	N/A	N/A	N/A	119 (3.9)	0.31	0.16-0.61
Pickup with back seat	N/A	N/A	N/A	262 (8.6)	1.61	0.85-3.07
Driver seat belt use						
Yes	1961 (59.1)	6.71	4.68-9.62	2815 (92.6)	83.30	51.45-134.85
No	1357 (40.9)	Reference	Reference	226 (7.4)	Reference	Reference

*: Any restraint refers to: safety seat, booster seat, or seat belt use for any age, regardless of seating position; †: OR is adjusted for the other variables. OR: odds ratio; CI: confidence interval; N/A: not available.

comprised 88.3% of the vehicles observed in Shantou with SUVs and vans each comprising approximately 5.7% and 6% of observed vehicles, respectively. Compared with sedans, children in SUVs in Shantou were 2.47 times [95% confidence interval (CI)=1.53-3.98] more likely to be restrained. In Iowa, sedans comprised 37.5% of vehicles while SUVs and vans each comprised approximately a quarter. Children in SUVs were nearly two times (odds ratio=1.99, 95% CI=1.21-3.30) more likely to be restrained than those in sedans. Although standard pick-up trucks comprised only 3.9% of vehicles, children were the least likely to be restrained in a pick-up. Pick-ups with back seats, however, did not have a reduced rate of restraint. We examined the association of driver and child restraint use in Shantou and Iowa and the effects of modification by age (Table 3). Driver seat belt use was significantly associated with child restraint use in both Shantou and Iowa, and the association was stronger in Iowa than Shantou for all age groups. In Shantou, 41% of drivers were not belted, compared with 7.4% in Iowa. In Shantou, no children were restrained when the driver was not wearing a seat belt. When the driver was wearing a seat belt, 3.7% of children aged 0-3, were restrained. The association of child restraint use and driver restraint use increased with child age in Shantou. In Iowa, few drivers were not belted, and in contrast with

Shantou, driver belt use was most strongly associated with younger child restraint use.

Discussion

This study compares child passenger restraint use among children in Iowa and Shantou, located in the United States and China, respectively. The results showed that a significantly lower proportion of children in Shantou were compliantly restrained than that in Iowa. The proportion of children who were compliantly restrained increased with age in Shantou, with those aged 14-17 having nearly 20 times greater odds of being restrained than children aged 0-3. In contrast, the odds of child restraint use decrease significantly with age in Iowa. Furthermore, many young children were placed in the front seat and/or sitting on an adult's lap in Shantou. A significantly higher prevalence of children not appropriately restrained observed in Shantou in this study is supported by our previous study findings in Shantou; and the reason may be due to the lack of several factors including knowledge about safety seats, safety seat availability, programs to promote safety seat use, and compulsory legislation on child passenger safety restraint use.^[13,14] With increased global priority

Table 3. Concordance of child compliant restraint use and driver seat belt use from Shantou and Iowa

Variables	Shantou (driver seat belt use [*])			Iowa (driver seat belt use [*])		
	Yes	No	<i>P</i>	Yes	No	<i>P</i>
Age 0-3 y, <i>n</i> (%)						
Any restraint use						
Yes	22 (3.7)	0 (0.0)	0.0006	648 (99.7)	42 (85.7)	<0.0001
No	571 (96.3)	313 (100)		2 (0.3)	7 (14.3)	
Compliant restraint use [†]						
Yes	1 (0.2)	0 (0.0)	0.4728	628 (96.8)	41 (83.7)	<0.0001
No	541 (99.8)	279 (100)		21 (3.2)	8 (16.3)	
Age 4-6 y, <i>n</i> (%)						
Any restraint use						
Yes	55 (8.2)	7 (1.5)	<0.0001	539 (99.1)	28 (60.9)	<0.0001
No	614 (91.8)	453 (98.5)		5 (0.9)	18 (39.1)	
Compliant restraint use [†]						
Yes	6 (0.9)	3 (0.7)	0.6502	388 (71.6)	21 (45.7)	0.0002
No	643 (99.1)	443 (99.3)		154 (28.4)	25 (54.3)	
Age 7-13 y, <i>n</i> (%)						
Any restraint use						
Yes	90 (21.4)	9 (2.4)	<0.0001	908 (73.2)	26 (40.0)	<0.0001
No	331 (78.6)	369 (97.6)		25 (26.8)	39 (60.0)	
Compliant restraint use [†]						
Yes	28 (6.9)	5 (1.4)	0.0001	580 (62.2)	15 (23.1)	<0.0001
No	375 (93.1)	363 (98.6)		352 (37.8)	50 (76.9)	
Age 14-17 y, <i>n</i> (%)						
Any restraint use						
Yes	87 (33.3)	25 (13.0)	<0.0001	571 (89.8)	5 (8.3)	<0.0001
No	174 (66.7)	167 (67.0)		65 (10.2)	55 (91.7)	
Compliant restraint use [†]						
Yes	87 (33.6)	25 (13.3)	<0.0001	571 (89.8)	5 (8.3)	<0.0001
No	172 (66.4)	163 (86.7)		65 (10.2)	55 (91.7)	

*: Each percent in this table is column percent. The *P* value is achieved through the Chi-square test; †: Compliant restraint was defined as the following: 1) children aged 0-6 years to sit in a safety or booster seat in the rear seats; 2) children aged 7-13 years to sit in a booster seat or wear a seat belt in the rear seats; or 3) children aged 14-17 years to wear a seat belt.

to child passenger safety in recent years, China is taking the first steps toward making the use of booster seats mandatory. In December 2013, the China Center for Disease Control and Prevention initiated the country's first national campaign to encourage the use of child seats in Beijing, Shanghai, and Shenzhen.^[15] On March 1st, 2014, Shanghai enacted the first child passenger safety law that prohibits children younger than 12 to be in the front seat and requires children younger than 4 to sit in a safety or booster seat.^[16] Our findings support the urgent call to protect child vehicle passengers by implementing effective parental education programs and mandatory child safety restraint use legislation in China.^[17-19]

Nearly all children aged 0-3 in Shantou (99.9%) were not compliantly restrained. The younger the children were, the less likely they were to be appropriately restrained in Shantou. Studies in larger Chinese cities have found slightly higher restraint use and similar age trends.^[17,18,20] Furthermore, many Chinese parents hold their younger children on their laps, wrongly believing it is a way to protect infants or toddlers in the vehicle.^[13,14,19] In contrast, in the United States, the majority of children of all ages were appropriately restrained. The trend of young children riding on parent's laps was also commonplace in the United States prior to the introduction of policies and education aimed at appropriate child restraint use.^[21] Child passenger safety legislation has made a significant impact on child safety practices in the United States.^[6] Many hospitals provide educational programs and/or free safety seat education to birthing families before discharge.^[22,23] Laws and guidelines also help create common sense for caregivers, pediatricians and other groups interacting with the families to promote child passenger safety.^[22]

Many children, especially young children, were placed in the front seat in Shantou. We found that 36% of children aged 0-3 in Shantou were placed in the front seat, compared to just 1.7% of children of the same age in Iowa. Approximately one-fourth to one-third of children aged 4 and older in Shantou were sitting in the front seat. Children traveling in the front seat have 40% to 70% greater risk of injury compared with children in the rear seat.^[6,8,24,25] In 2011, the American Academy of Pediatrics released its revised Child Passenger Safety Recommendations, which indicate that children should be restrained in the rear seat from birth through the age of 12 or 13 for optimal protection.^[10,26]

The observed higher prevalence of children placed in the front seat in Shantou may be due in part to the fact that China's seat belt laws do not specify the age of passengers prohibited to be in the front seat.^[15,16] Parents decide where their children are seated, and rear seating is one simple, low cost approach to protecting children from serious injury when a child safety seat is not available.^[24] Just as

it is currently the case in China, children in the United States frequently rode in the front seat prior to increased campaigns and policies.^[21] The current high prevalence of rear seating position for Iowa children was an indicator of the successful dissemination of information about the safety of rear-seat placement, and could also serve as a safety culture indicator.

Our results showed that the association between driver and child restraint use was stronger in Iowa than Shantou for all age groups. The association of child restraint use and driver restraint use increased with child age. In Iowa, few drivers were not belted, and, in contrast with Shantou, driver belt use was most strongly associated with child restraint use amongst younger children. These findings suggest there might be a stronger "family" traffic safety culture in Iowa compared to Shantou.^[27-29] Driving without a seat belt is not a prevalent practice in Iowa and is commonly recognized as an unsafe behavior.^[27] In China, mandatory driver seat belt restraint laws have been implemented nationally, however, these laws are not yet widely enforced.^[20,28-30] Currently, China is actively engaging in campaigns and policies focused on occupant protection, and as these efforts change the safety culture and improve knowledge of and attitudes towards occupant protection, we would expect increased correlation of seat belt and safety seat use between driver and child occupant protection.^[15,16,31]

This study has several limitations. First, although the study protocol for Iowa and Shantou was similar, the observation sites were different. Observations in Iowa were conducted at gas stations, while in Shantou observations were completed at schools or clinics. Thus, the results from these two samples may not be comparable. Second, many differences observed on child safety restraint use between Iowa and Shantou may reflect differences in traffic safety culture. However, these data were not available due to the nature of an observational study, which limited our ability to interpret the findings. Finally, the prevalence of the child safety restraint use in Iowa and Shantou reported in this study may not be generalizable to the United States and China.

In conclusion, a significantly higher observed prevalence of children not appropriately restrained in Shantou was found than that in Iowa. A combination of lack of knowledge and promotion about safety seat use, and an absence of compulsory legislation may contribute to the low rate of child safety restraint use in Shantou. Our findings support the need of mandatory child safety restraint use legislation in China.

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Contributors: Yang JZ assisted with the development of the study, supervised data analysis, helped prepare drafts of the introduction and discussion, and edited and revised the manuscript. Li LP assisted with the development of the study design, implemented and oversaw the study, and participated in reviewing and revising drafts of the manuscript. Wu HQ performed data analysis, and drafted method and results sections and tables. McGehee D assisted in reviewing drafts of the manuscript and was part of the collaborative team. Peek-Asa C assisted in the development of the study design, provided input into study implementation, participated in data analysis, drafted the introduction and discussion sections, and reviewed and revised the manuscript. All authors approved the final version of the manuscript.

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