The relationship between the injury severity based on injury severity score and child seating position in the vehicle

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Abstract

The aim was to determine the relationship between the severity of the score and the child sitting position in the vehicle. In this retrospective cohort study, the severity score was obtained from HIS. After entering the data into STATA/SE version 14, univariate regression models were used to identify the potential confounding variables. Poisson regression estimators were applied to depict the relationship between safety devices, seating position of the child, and the severity indices. Out of 257 child occupants under 6 years, only 4.1% of the children used child seats and 7.7% used seat belts. There was a statistically significant positive relationship between ISS and middle rear seat (P = 0.026) and left rear seat (P = 0.000). A positive relationship existed between ISS and the right rear seat. Hospitalization of children sitting on the middle rear seat was longer than the others. The right rear seat was found to be the safest seat for children. The pattern of child accidents is different in the study region compared to other places. Local interventions should be implemented using evidences obtained from road traffic accidents. Thus, the governments should explore new strategies to increase the use of child seats by parents.

Introduction

Car accidents are one of the leading causes of death in infants and children, accounting for 22.3% of all related deaths. According to the World Health Organization, motor vehicle accidents were considered the leading cause of death in children under 7 years of age in most countries{Goodwin, 2015 #2390} in 2015.[1]

In the United States, one in five child deaths is caused by traffic accidents.[2] In Iran, traffic accidents are one of the principal causes of death of children under 5.[3] Children in motor vehicles are more vulnerable to injuries than adults due to their small body size.[4,5] Their head is relatively large and the ratio of their facial dimensions to the brain dimensions in children is different, which causes a higher center of gravity in children. Children's neck has a thin structure and their vertebrae have a lot of cartilages in contrary to adults.[6] Moreover, children's body structure is such that less part of the abdomen is protected by the pelvis and ribs. Children's ribs are less likely to break and bend than those of adults, which may cause extremely damage to the heart and lungs during a car accident.[7] Based on the position of sitting in the car, an unprotected child can be pushed forward with a force of 30 to 60 times more than his/her weight and hit the driver or the passenger next to the driver at a speed of 50 km/h.[8] The seating position in the car can increase the risk of injury during an accident[9]. The risk of accidents

in different seating positions of the car is highly dependent on the direction of the accident, the characteristics of the vehicles under study.[10,11] the condition of the roads, and safe driving culture, which vary in different countries.[12] The child's sitting position is associated with the risk of injury.[13] Therefore, the risk of injury and death are similar for the rear and front passengers of the car in side collisions.[11]

Research has shown that the place of safety seat directly affects the Injury Severity Score (ISS) and the Glasgow Coma Scale (GCS) according to the direction of impact to the car and its change in speed.[10] More fatalities were reported for the rear seat than for the front-seat occupants. In head-on collisions, there is evidence that the relative risk of death is higher in the rear passengers than in the front passengers. Rear seat occupants often suffer serious injuries to the thoracic, abdominal, and head areas, usually associated with the use of seat belts.[11] Rear seats have high risks of injury due to falls. Children sitting in the back row are injured by impact of the front and rear passengers.[14] Studies have shown that car occupants have a lower risk of death and injury in the back seat than in the front seat, especially in cars that have no airbags or the occupant has no restraint.[15]

The risk of car accidents affect the vulneribity the occupants sitting in different parts of the vehicle, vary in different countries. Thus, due to the importance of the issue and the insufficient information on evidence-based decision-making, this study sought to determine the relationship between ISS and LOS with the child sitting position in the private car.

Materials and Methods

Study design

This retrospective cross-sectional study was conducted after receiving the code of ethics from the Clinical Research Ethics Committee of Guilan University of Medical Sciences IR.GUMS.REC.1399.052 in Rasht Pursina Hospital, which is a referral hospital in Guilan Province, which is located in the north of Iran. All car accidents that occurred in a three-year period and met the entry criteria were included in the study.

Eligibility criteria

Data all of private car accidents which one child injured was referred to hospital were collected from 2019 to 2022 (a three-year period). The rest of the entry criteria were: the private car accidents has one or more than one occupant <years of age, with any outcome (injury or death), and the family's phone number is register in the record. Subjects where contact was missed for any reason or parents were not satisfied with providing additional data were excluded from the study.

Data collection tools

A checklist was designed and the questions were confirmed and edited by 4 health professionals. Data for the study were drawn from two sources based on the Declaration of Helsinki.

Hospital-related information related to the children [age, sex, location of accident (city, rural and out of city), type of transfer to hospital (EMS, clinic ambulance, private vehicle and others), length of hospital stay (LOS) and telephone number] from the HIS was obtained. The Injury Severity Score (ISS) is an anatomic scoring system which assigns a general score to patients with multiple injuries. The square of the score of the three severely damaged regions is added together to determine the ISS score, which ranges from 0 to 75 points.[16] According to Bolorunduro *et al.*, ISS is classified as follows: <9 = Mild, 9 – 15 = Moderate, 16-24 = Severe and >/=25 = Profound.[17] If ISS > 15, major trauma is defined.[18] In the present study, ISS score was calculated by a general medicine. In this way, the three regions with the most damage from the child's record in the HIS were determined, then based on the ISS book, a score was considered for each regions, and finally, the square of the scores of the three members were added together, and the final ISS score was given to each child.

Second, using the database data, the phone numbers were extracted and called with trained interviewers. The information that was not registered in the HIS and education of the parents(high school diploma, undergraduate and university education), type of child safety equipment at the time of the accident (seat belt, airbag, child seat and none) child seating position(front seat, left rear seat, right rear seat and middle rear seat) was obtained through a telephone interview. In the telephone interview, parents or guardians were interviewed using predetermined questions. Oral consent was obtained before asking the questions.

Sample size

The total number of injured children in this period was 306. However, from the 306 calls, 17 refused to answer the questions, 32 phones were off, and others did not answer the calls after three times of calling. At the end 257 cases answered to the questions.

Analysis

For analyzing the data for avoiding collinearity and having better degrees of freedom, first univariate regression models were estimated to identify the potential confounding variables. According to the results, none of the demographic variables (except for age and sex) were associated with ISS and LOS. Second, Poisson regression estimators were used to depict the relationship between safety equipment's, seating position of the child, and the severity indices (ISS and LOS). All of the analyses were performed using STATA/SE version 14.1.

Results

The present study included 257 occupants under 6 years of age who were referred to Pursina Hospital of Rasht due to private car accident during the last three years. The mean age of children was 2.9±0.13 years. Considering frequency in terms of sex, 54.1% (n=139) of the injured children were boys. Most children (64.8%, 151) were transferred to the hospital by 115 emergency services and the rest by private vehicle (15.9%, n=37). The highest number of private car accident occurred on roads out of the city (59.2%, n=122) followed by the private car accident inside the city (27.2%, n=56) and rural areas (13.6%, n=28). Only 4.1% (n=8) of the children used child seats and 7.7% (n=15) used seat belts. Maternal education in 73.1% (n=144) was high school diploma and undergraduate and 26.9% (n=53) had university education. The majority of their fathers (69.4%, n=134) had high school diploma and undergraduate education and 30.6% (=59) had university education. Most of the children's seating position was the front seat (37.2%, n=74) followed by the right rear seat (25.6%, n=51), left rear seat (24.6%, n=49) and middle rear seat (12.6%, n=25) (Table1).

The findings of the study revealed a relationship between the severity of injury based on ISS and the seat position of the child in the private car after controlling the confounding variables of age,

type of safety equipment, and child's sex using Poisson regression estimator. The results indicated that there was a statistically significant positive relationship between ISS and middle rear seat (P = 0.026) and left rear seat (P = 0.000). According to these results, the severity of accidents (according to the ISS) was higher in the middle rear seat and then in the left rear seat. A positive and statistically significant relationship was noticed between ISS and female sex (P=0.000) so that the severity of accidents was higher in girls (Table 2).

Figure 1 displays the predicted value of the ISS in a regression model with independent variables of age, sex, and safety equipment, based on seating position in the vehicle. The predicted ISS value in the right rear seat is the lowest possible, indicating that the seat is safer for children. The most unsafe seat was the middle rear seat. However, the level of the confidence interval in this chair was high (Figure 1).

There was not statistical relationship between LOS and type of safety equipment in children, But there was statistical relationship between LOS and Middle rear seat position children (p-value= 0.001). The LOS was significantly longer in injured girls than in boys. (P=0.000) (Table 3).

Figure 2 shows the adjusted value of the LOS and the child's seating position in the vehicle. The same results were analyzed based on the LOS and it was found that hospitalization of children sitting on the middle rear seat was longer than the others. The right rear seat was found the safest seat for children (Figure 2).

Table 1. Demographic characteristics of children under 6 years of age in private car accidents (N=257).

Description	N (%)
Sex	
Female	118(45.9)
Male	
Transfer to hospital	
EMS	139(54.1)
Clinic Ambulance	151(64.8)
Private vehicle	44(18.9)
Others	37(15.9)
Location of accident	
City	1(0.4)
Rural	56(27.2)
Out of city	28(13.6)
Safety equipment	
Seat belt	122(59.2)
Airbag	15(7.7)
Child safety seat	2(1)
None	8(4.1)
Seating position	
Front seat	170(87.2)
Left rear seat	74(37.2)
Right rear seat	49(24.6)
Middle rear seat	51(25.6)
Middle rear seat	25(12.6)

Table 2. Relationship between ISS with safety equipment, seating position, age and sex of children.

ISS Description		IRR	Standard deviation	p
Safety equipment	Seat belt		Base	
	Airbag	2.191	1.183	0.146
	Child seat	0.533	0.179	0.061
	None	1.237	0.217	0.224
Seating position	Front seat		Base	
	Left rear seat	1.265	0.134	0.026
	Right rear seat	1.037	0.115	0.747
	Middle rear seat	1.604	0.201	0.000
Child age		0.996	0.022	0.865
Sex-Female		1.481	0.119	0.000
Constant coefficient		2.54	1.039	0.023

Table 3. Relationship between LOS with type of safety equipment, seating position, age and sex of children.

LOS Variable		IRR	Standard deviation	p
Safety equipment	Seat belt		Base	
	Airbag	0.000	0.000	0.998
	Child seat	0.430	0.275	0.187
	None	1.041	0.254	0.870
Seating position	Front seat		Base	
	Left rear seat	0.888	0.151	0.485
	Right rear seat	0.773	0.139	0.153
	Middle rear seat	1.849	0.345	0.001
Child age		0.941	0.033	0.085
Sex-Female		1.481	0.233	0.000
Constant coefficient		1.801	3.353	0.000

Discussion

In present study, only 4.1% of children had safety seats. In an Iranian study by Moradi *et al.* (2019), the use of child seats was 18.7% in the capital and it was significantly higher in parents living in North Tehran who had higher monthly income, trained about child safety seats, and fathers who had more driving experience. Children's age, weight and height were also factors that influenced the use of child safety seats. The main reason for parents to use a child safety seat was knowing the benefits of this device.[3] In another study in a similar cultural setting, 80% of parents stated that they had never used a child safety seat, and only 13% had always used it. Meanwhile, more than 93% believed that the use of child safety seats is necessary and prevents children from being injured in accidents. 38% of parents were not aware of child safety devices in cars, almost 91% of parents reported that their use would increase if child safety seats were made mandatory. The child safety seat law, if implemented, will increase the chance of using a child safety seat by 6.5 times.[19] In the U.S.A., children who were not properly restrained in a car had a higher death rate than children who were properly restrained. In states where the use of child seats was mandatory for children ≤6 years, deaths were higher than in states where the law was mandatory for children ≤8 years.[20]

In the present study, 7.7% of children under six years of age had used a safety belt. Similarly, in one study, seat belt use was only 5.7% in children who had an accident and were transported to a Level I pediatric trauma center.[21] Previously, in a study in northern Iran, the use of restraint systems in school bus was low for students, and it was significantly higher in Sport Utility Vehicles (SUVs) and high income families.[22] In a study that examined the risk of injury to children in accidents, children who were not restrained at all were 4 to 5 times more likely to be injured than children who were properly restrained, and children who were not properly restrained were about 1.1 to 1.9 times more likely to be injured. Therefore, the effects of restraint type decrease with age.[23]

Based on the results of our study, the severity of accidents based on ISS was higher in the middle rear seat and then in the left rear seat mostly in girls. In one study, on the contrary the mean ISS for children restrained in the front seat in vehicles older than 2000 was 0.494. The average ISS for the second left and second right row seats was 0.374 and 0.322, respectively. The seats in the middle of the second row had a lower ISS than all the above seats. In general, the safest seat for a child was the middle seat in the second row, whether restrained or not.[24] In another study by Kallan *et al.*, there was an inverse relationship between the middle seat and older ages (39% for occupant's < 1-year-old vs. 18% for 3-year-old occupants). regardless of the number of extra row occupants, the child occupants in the middle seat were 43% less likely to be injured than the children sitting in each of the left and right rear seating positions.[25] In Mitchell et al.'s study, the distribution of injury severity and type of injury for rear and front-seat occupants was quite similar except for the abdomen, back, spine, back, and pelvic injuries which were more for the rear seat occupants. Most of the damages were to the head and chest. Front passengers (51.3%) had the most injuries. Rear seat occupants had a higher severity of injury than the front seat occupants.[26]

In present study, in addition to the ISS, we performed our analyses based on the LOS. It was previously reported that all three types of trauma scores have one positive effect on hospital LOS (GCS, ISS, and RTS)and Performance of ISS and NISS anatomical scoring systems is good in predicting hospital LOS and need for surgery.[27,28] Also the research performed by Navabi *et al.* suggested that the injury severity was associated with increased hospital stay.[29] The study proved that the LOS was longer for children sitting in middle rear seat than other seats. Almost similar to the results we saw about ISS. In a similar study, the relative risk of death depended on more factors. The relative risk of death was lower for restrained children younger than 8 years in the rear seat compared to right-front seat occupants, but higher for restrained children 9-12 years of age. There was no evidence of a difference in the risk of rear- and front-seat death for occupants aged 13 to 54 years, but there was evidence of an increased relative risk of death in adults aged 55 and older in rear-facing compared to right-front-facing occupants.[30]

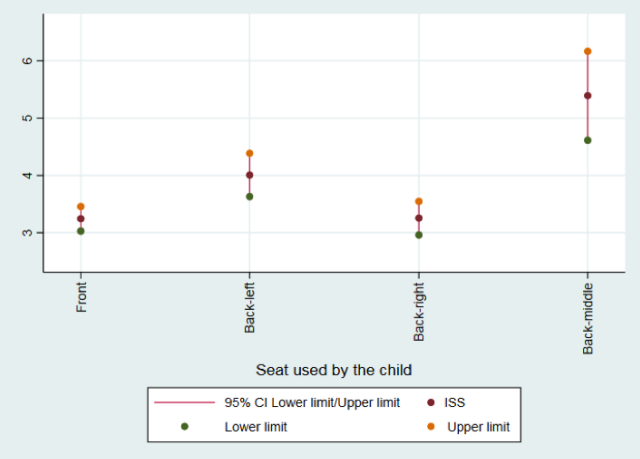

Figure 1. Adjusted value of ISS in different seating position of children. The predicted ISS value in the right rear seat is the lowest possible, indicating that the seat is safer for children. The most unsafe seat was the middle rear seat. However, the level of the confidence interval in this chair was high.

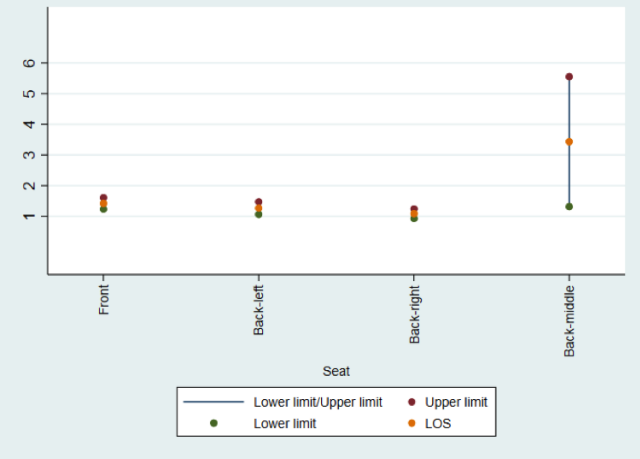

Figure 2. Adjusted value of LOS in different seats of children. The LOS children sitting on the middle rear seat was longer than the others. The right rear seat was found the safest seat for children.

There was also a statistically significant positive relationship between LOS and the female sex, which demonstrated that placing the child in the back seat causes injuries that may lead to longer hospitalization mostly for girls. Although the LOS does not demonstrate the severity of the injury, studies have exhibited a strong association between the two variables, especially in injuries due to traffic accidents. Morrison et al. worked on the TBI children who reported that girls had worse outcomes than boys and girls had more accidents.[31] In another study, after controlling for occupant age and gender, the relative risk of death was significantly greater for restrained rear-seat occupants than front-seat occupants in 2007 and newer vehicles, and was significantly greater in rear-end and right-side crashes.[30] The reason for the difference in the results is related to the type of private cars in Iran. To protect the passengers in the middle of the back, there is no safety device installed, not even a seat belt. Therefore, the child is practically unprotected and exposed to severe injuries. Therefore, both ISS and LOS have determined that the rear right seat is a safe seat for children under six years of age.

In the present study, ISS and LOS did not determine the risk of injury depending on the type of protective device used for the child. Of course, the amount of use of protective equipment was also very small. Therefore, we cannot recommend which type of protective device for our children would have resulted in less ISS and LOS and would have been safer.The current best recommendations for use by children of all ages are rear-facing, forward-facing child seats, booster seats, lap and shoulder belts, respectively.[23]

In present study, we did not check whether the accident was a rollover, ejection or other types and from which direction the car was hit as we did not have a plan to investigate this issue from the beginning. We wanted to determine the best seat position for the child to sit in the car according to the characteristics of accidents in our country, so there was no need to investigate and control the variable of the location of the accident. Moreover we did not have the information of those children who had an accident but were not injured, but only the information of the children who had even injuries need hospitalization due to the accident. The study was conducted in Guilan, a province with a high population density and vehicle traffic accident, which makes the findings less generalizable to other provinces of the country. The possibility of recall bias should not be ignored.

Conclusions

In Iran, no law has yet been approved for the use of child seats. Most families use cars without child seats to seat their children, because of the frequency of its use was very low, so it had no significant relationship with ISS and LOS. It is recommended that legislators and policy makers should pass this law considering the importance of the issue. The government should explore new strategies to increase the use of child seats by parents. The safe seat of private cars for children in our country is different from developed countries. Car engineers should pay attention to the design of cars that have good protection facilities for children<6 age in middle and left rear seats. On the other hand, families should be informed that the right seat is safer for children.

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