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Pediatric Seat Belt Use in Motor Vehicle Collisions: The Need for Driver Education Programs

Adel Elkbuli, MD, MPH ■ Brianna Dowd ■ Paul J. Spano II, MS ■ Mark McKenney, MD, MBA, FACS

ABSTRACT

Background: By statute, pediatric passengers transported in motor vehicles need to be appropriately restrained. The National Highway Traffic Safety Administration (NHTSA) estimates that currently only 2% of children do not wear safety restraints. This study aimed primarily to evaluate the use of pediatric restraints (seat belts) in motor vehicle collisions (MVCs) transported to our Level I pediatric trauma center (PTC) compared with historical NHTSA controls.

Methods: A 4-year review utilized our Level I PTC registry for patients younger than 16 years, involved in an MVC. Appropriate booster seat/child restraints were verified by EMS, fire rescue, and patient/ family. Odds ratios were used to compare occurrences and χ^2 for categorical values with significance defined as $p < .05$.

Results: A total of 685 pediatric patients in MVCs were admitted to our PTC during the study period. Only 39 of 685 (5.7%) pediatric patients were in restraints. Based on the NHTSA historical controls, 671 of 685 (98%) children would have been expected to be using restraints (5.7% vs. 98%, $p < .01$). The odds ratio of lack of use of child restraints or seat belts in pediatric trauma population was markedly higher compared with NHTSA historical controls (odds ratio 793.9, 95% confidence interval: 427.02–1475.98, $p < .0001$).

Conclusion: Astonishingly low rates of child restraints and seat belt use in pediatric patients in MVCs, requiring admission to a PTC, indicate the need for better injury prevention programs, and parental or driver education on risks associated with lack of restraints.

Key Words

Child restraints, Driver education, Injury prevention programs, Motor vehicle collisions, Pediatric trauma, Seatbelt use

Injuries and death due to motor vehicle crashes (MVCs) are one of the most prevalent causes of avoidable morbidity and mortality in the United States. Seat belts have been proven to be one of the most effective risk-reducing safety measures in MVCs, reducing the incidence of crash-related morbidity and mortality by more than 50% (National Highway Traffic Safety Administration [NHTSA], 1999). The increased use of seat belts over the last two decades has resulted in a significant decrease in both adult and pediatric MVC-associated mortality. A 10-year study conducted by the Centers for Disease Control and Prevention (CDC) shows a total fatality of 9,182 children aged 0–12 years and a resulting decrease in mortality of 43% during the 10-year study and an almost two-fold reduction in mortality for restrained compared with unrestrained children (CDC, 2017). Proper restraint use prevents vehicle passengers from being ejected from the car during a crash. Geographic epidemiological studies in the United States have found that the prevalence of adult restraint use in the West is 89.6%, followed by the South (86.1%), the Northeast (82.7%), and the Midwest (80.4%) (Strine et al., 2010). In addition, studies have determined that increased body mass index (BMI) is associated with decreased seat belt restraint use (Lichtenstein, Bolton, & Wade, 1989).

The kinematics of trauma and physical principles of conversion of energy dictates that those passengers who do not wear a seat belt are more likely to be subjected to forward momentum and subsequently impact the interior of the car or be actually ejected from the vehicle. Although different types of vehicles and styles of seat belts have reduced the amount of MVC-related mortalities, they have not entirely eliminated this issue. Although the total number of fatalities and vehicles associated with MVCs showed a downward trend within the last decade, this trend reversed in 2012 when fatalities and vehicles involved in fatal crashes began increasing, reaching a peak in 2016 (Florida Department of Health, 2018; Insurance Institute for Highway Safety, 2016). According to the NHTSA data, approximately 2% of children are estimated to be without child restraints during observational studies (Greenwell, 2015). Alternatively, another study determined that 39% of teenagers specifically are without seat belt restraints during observational studies (Kim, Depue,

Author Affiliations: Department of Surgery, Kendall Regional Medical Center, Miami, Florida (Drs Elkbuli and McKenney, Ms Dowd, and Mr Spano); and University of South Florida, Tampa (Dr McKenney).

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Correspondence: Adel Elkbuli, MD, MPH, Kendall Regional Medical Center, 11750 Bird Road, Miami, FL 33175 (Adel.Elkbuli@hcahealthcare.com).

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Spence, & Reine, 2009). This study aimed primarily to evaluate the use of pediatric restraints (seat belts) in MVCs transported to our Level I pediatric trauma center (PTC) compared with historical NHTSA controls and secondarily evaluate the impact of BMI on restraint use and injuries.

MATERIALS AND METHODS

This study is a 4-year review of prospectively collected data utilizing our Level I PTC's registry for pediatric trauma patients admitted from January 2014 through December 2017 presenting due to MVC. Pediatric patients were defined per Florida Department of Health guidelines and World Health Organization classification for pediatric age groups as: neonate and infant, 0 day to 2 years; young child, 2–6 years; child, 6–12 years; and adolescents, 12–16 years. Injury mechanism was defined as MVC. Restraints included booster seat, child restraint, or seat belt and use was evaluated on arrival through emergency medical services (EMS), Fire rescue, patient, or family interview. In cases of conflicting information, the admitting surgeon made the final determination. Rates of car restraint or booster seat use in the pediatric group were then compared with NHTSA historical controls, using 2% as the expected percentage of unrestrained children (Greenwell, 2015).

Pediatric patients were also divided based on BMI and characterized as either underweight, with a BMI less than the 5th percentile; normal weight, with a BMI the 5th to less than 85th percentiles; overweight, with a BMI the 85th to less than 95th percentiles; or obese, with a BMI more than the 95th percentile. BMI was determined by use of pediatric BMI charts endorsed by the CDC (CDC, 2016). Groupings were then subdivided based on seat belt use into patients wearing a seat belt at the time of injury (seat belt POS) and those not utilizing a seat belt (seat belt NEG). Odds ratios were calculated for risk comparison, statistics were performed using SPSS statistics software version 25 (IBM SPSS, Armonk, NY), and categorical data were analyzed using χ^2, with significance defined as $p < .05$. This study was reported according to the STROBE guidelines and conducted according to ethical practices. All identifying information has been concealed to ensure confidentiality while including demographics, injury information, and outcomes. This study received an exempt determination from our institutional review board.

RESULTS

During the 4-year study, 685 pediatric patients involved in MVCs were admitted to our PTC. Of these 685 pediatric trauma patients, mean age (years) was 6.7, gender was predominately male (60.7%), race was predominately White (71.5%), and ethnicity was 44% Hispanic or Latino. Average BMI (kg/m^2) was 23.3 and average Injury Severity Score (ISS) was 3.89 with a median ISS of 2. Of these 685 patients, 39 (5.7%) were confirmed to be using child restraints or child booster seat at the time of the crash, whereas 646 (94.3%) pediatric patients were assessed as not restrained, as seen in Table 1. Based on NHTSA historical controls, 671 of 685 (98%) children would have been expected to be using restraints (5.7% vs. 98%, $p < .01$). The odds ratio of lack of use of child restraints or seat belts in pediatric trauma population was an astounding 793.9 times higher compared with NHTSA historical controls (odds ratio 793.9, 95% confidence interval: 427.02–1475.98, $p < .0001$).

As our secondary aim was to evaluate seat belt use with BMI, we found, the prevalence of seat belt use was low in all BMI groups, as seen in Table 2. Additionally, the prevalence of injuries was significantly lower among all seat belt POS pediatric trauma patients regardless of BMI across all groups, as seen in Table 3. When categorized by age group, neonates and infants had a 1.3% seat belt use rate (3/225), young children had a 5.1% seat belt use rate (7/136), children had a 9.9% seat belt use rate (17/172), and adolescents had a 7.9% seat belt use rate (12/152). The difference in restraint use was significant for all age groups, as seen in Table 4.

DISCUSSION

All 50 states require pediatric passengers in motor vehicles to travel in booster seats or approved child restraint belts. The NHTSA estimates from observational studies that only 2% of children are not wearing safety restraints in motor vehicles (Greenwell, 2015). There are an average 3.5 deaths from MVCs among children aged 0–20 years, per year, per 100,000 people in Florida. This is 0.5 lower than the 4.0/100,000 national average of pediatric deaths from MVCs (CDC, 2012a). These findings would lead one to

TABLE 1 Prevalence of Restraint or Seat Belt Use for Pediatric Population

	Actual Restraint Use on Pediatric TC Admissions	Restraint Use Expected From NHTSA Historical Control	*p*	Odds Ratio
Seat belt NEG	646	14	<.0001	793.9
Seat belt POS	39	671	<.0001	
Total	685	685		

Note. NEG = negative; NHTSA = National Highway Traffic Safety Administration; POS = positive; TC = trauma center. The actual use versus the expected use of seat belts in the form of seat belt NEG, meaning no seat belt, and seat belt POS, meaning use of a seat belt. The table also provides the p values and odds ratio for the actual versus expected values.

TABLE 2 Pediatric Seat Belt Use among BMI Groups

Pediatric Seat Belt Status	Underweight (<5th Percentile)	Normal Weight (5th to 85th Percentiles)	Overweight (85th to 95th Percentiles)	Obese (>95th Percentile)
Seat belt POS	4 (6.9%)	25 (10.3%)	8 (8.2%)	21 (12.4%)
Seat belt NEG	54 (93.1%)	217 (89.7%)	89 (91.8%)	149 (87.6%)
p	.29	.63	.35	.75

Note. BMI = body mass index; NEG = negative; POS = positive. The use (seat belt POS) and lack of use (seat belt NEG) of seat belts categorized by BMI groups. The p value is provided between use and no use of seat belts for each BMI group.

believe that not only are Florida traffic laws more abided by or enforced more strictly, but also aid to prevent pediatric motor vehicle injuries. Furthermore, this shows that it leads to fewer pediatric deaths than the national average caused by motor vehicles. However, the results of our study indicate a much higher rate of unrestrained or improper restrained minors presenting to our PTC than would be expected compared with historical controls, with 94.3% of patients found to be unrestrained or improper restrained at the time of their MVC. This data show a significant lack of compliance with Florida pediatric restraint traffic laws or a significant increase in injury in unrestrained or improper restrained children. This lack of restraint use in motor vehicles predisposes pediatric patients to and is strongly associated with pediatric injury. The creation and implementation of child seat belt and child restraint laws were an effort to protect children from unintentional injury. In the state of Florida, according to Florida Statute §§316.613–14, "it is unlawful for any person to operate a motor vehicle in this state unless each passenger and the operator of the vehicle under the age of 18 years are restrained by a safety belt or by a child restraint device" and "every operator of a motor vehicle, while transporting a child in a motor vehicle on the roadways, streets, or highways of this state, shall, if the child is 5 years of age or younger, provide for protection of the child by properly using a crash-tested, federally approved child restraint device" (The Florida Senate, 2014). These are considered primary laws in the state of Florida and are enforceable, establishing that wearing a seat belt in Florida is mandatorily required for children.

Unlike Florida, not every state in the United States has primary seat belt and child restraint laws. For instance, in North Dakota, the law requires all front seat occupants to wear a properly adjusted and fastened seat belt. This is a secondary offense, meaning police cannot stop the vehicle based on this offense alone (North Dakota Highway Patrol, 2017). The North Dakota law also requires all occupants younger than 18 years to be properly restrained regardless of their location in a vehicle, which is primarily enforced (North Dakota Highway Patrol, 2017). These laws are not as specific nor as influential as Florida laws. In North Dakota, 81% of the population self-reported to wearing seat belts, which is under the national average of 86% of people wearing seat belts (CDC, 2012b). Additionally, there are approximately 11.0 pediatric deaths from MVCs among children aged 0–20 years per year per 100,000 people in North Dakota (CDC, 2012b). These findings demonstrate that pediatric deaths in North Dakota caused by MVCs are more than double the national average. This high number of pediatric deaths may be due to the lack of primary laws

TABLE 3 Prevalence of Traumatic Injuries and Seat Belt Use Among Pediatric Population

	Head and Neck Injuries Median ISS = 2 Mean ISS = 4.3			Thoracic Injuries Median ISS = 2 Mean ISS = 3.9			Abdominal Injuries Median ISS = 2 Mean ISS = 3.9		
	Seat Belt POS	Seat Belt NEG	*p*	Seat Belt POS	Seat Belt NEG	*p*	Seat Belt POS	Seat Belt NEG	*p*
Underweight (<5th percentile)	2	32	<.0001	0	7	.02	1	5	.20
Normal/healthy weight (5th to <85th percentiles)	15	130	<.006	6	20	.02	1	10	.02
Overweight (85th to <95th percentiles)	5	44	<.002	2	8	.11	2	6	.02
Obese (≥95th percentile)	14	81	<.007	4	15	.04	3	15	.02
Totals	36	287	<.004	12	50	<.005	7	36	.0002

Note. ISS = Injury Severity Score; NEG = negative; POS = positive. Seat belt use for traumatic injuries after motor vehicle collision categorized by BMI group. The p value is provided between use and no use of seat belts for each BMI group and for each traumatic injury.

TABLE 4 Pediatric Seat Belt Use Among Age Groups

Pediatric Seat Belt Status	Neonate/Infant: 0 Day to 2 Years *n* = 225	Young Child: 2–6 Years *n* = 136	Child 6–12 Years *n* = 172	Adolescent: 12–16 Years *n* = 152
Seat belt POS	3 (1.3%)	7 (5.1%)	17 (9.9%)	12 (7.9%)
Average ISS	1.33	7.85	6.56	7.41
Median ISS	1	2	4	4
Seat belt NEG	222 (98.7%)	129 (94.9%)	155 (90.1%)	140 (92.1%)
Average ISS	2.75	3.21	3.62	5.85
Median ISS	1	2	4	4
p value	<.0001	<.0001	<.0001	<.0001

Note. ISS = Injury Severity Score; NEG = negative; POS = positive. The use (seat belt POS) and lack of use (seat belt NEG) of seat belts categorized by age groups. The p value, average ISS, and median ISS are provided between use and no use of seat belts for each age group.

in North Dakota compared with other states. Ultimately, the comparison of state laws and the prevalence of seat belt use with the prevalence of pediatric motor vehicle deaths establishes that a lack of primary seat belt laws is associated with a lower seat belt use and increased cases of pediatric death caused by MVCs. Furthermore, the comparison between Florida and North Dakota shows that although having primary laws in place increases the use of seat belts or restraints and reduces the incidence of pediatric death, the implementation of these laws does not guarantee compliance to them. Nevertheless, there are differences between North Dakota and Florida in the rural–urban densities and access to care, which may influence motor vehicle deaths. More stringent adherence and enforcement of pediatric restraint laws need to be implemented to reduce pediatric injuries and mortalities resulting from MVCs. To increase seat belt use and safety in our pediatric community population, we have taken serious measures to promote seat belt safety. Our hospital recently initiated a preventive program called the car seat safety inspection program. This program involves voluntary monthly inspections of patients' cars with booster seat or restraints by certified personnel and parental education on proper safety application of seat belts for pediatric patients in an effort to increase seat belt and child restraints use and reduce associated injuries.

Moreover, previous studies have examined the prevalence of seat belt use. According to one study, adult seat belt use was approximately 84.1% in primary law states compared with 72.8% in secondary law states and declined with decreasing population density (Strine et al., 2010). This suggests that in states with a primary law, seat belt use is higher, and in areas of high population density, seat belt use is higher. This is nearly opposite to our study's findings, where in a primary law state and a high population density area, only 5.7% of pediatric patients were determined to be restrained at the time of the MVC. Another prevalence study on the association of BMI on seat belt use found that low BMI ($\leq$21.8 kg/m^2) was associated with 63% seat belt use compared with 50% associated with high BMI ($\geq$29.0 kg/m^2) (Lichtenstein et al., 1989), whereas our study, with an average BMI of 23.3 kg/m^2, was associated with 5.7% seat belt use. When categorized by age group, adolescents had the highest seat belt use whereas neonates and infants had the lowest seat belt use. This may suggest that increased parental education is necessary to increase seat belt use among children, as adolescents are more autonomous and may decide to wear seat belts themselves.

Likewise, a similar study examined the prevalence of teenage seat belt use and determined that only 60.71% of the teenagers were restrained by seat belts. This, while more comparable to our findings, is still much higher than the 5.7% of pediatric patients restrained in our study. Aside from poorer health and increased risk of diseases, it has been previously unknown whether obesity is a major risk factor for mortality resulting from motor vehicle accidents. Our study is one of the first to examine the association between pediatric BMI and use of car restraints.

In our study, the seat belt NEG groups of all BMIs were all associated with increased injury prevalence as compared with the seat belt POS groups of all BMIs. This demonstrates that lack of seat belt use is correlated to increased injury. These injuries include head and neck, abdominal, and thoracic injuries. Similarly, Caskey, Hammond, Peck, Sardelli, and Atkinson (2018) examined differences in injuries due to the type of restraints used for pediatric patients and determined that unrestrained children were more likely to experience moderate and severe injuries than restrained children. Furthermore, Loftis, Sawyer, Eubanks, and Kelly (2017) evaluated correlations between childhood MVC injuries, age, and restraint status and established that thoracic injuries, open head wounds, and open upper extremity wounds were significantly more common in unrestrained pediatric patients. These findings support our results that unrestrained pediatric patients experience increased injury prevalence; however, beyond this, we found BMI to have no effect on this trend.

Of note, the population in this study involves pediatric patients in MVCs who sustained or were suspected to sustain injuries severe enough to warrant PTC admittance. It is likely that seat belt use decreases the likelihood that a pediatric patient involved in MVC would be injured severely enough to require hospitalization. This may explain why the vast majority of pediatric patients in this study were without restraints at the time of injury, in contrast to the majority of the overall pediatric population reporting restraint use. This subset of patients involved in MVCs indicates that our results are representative of pediatric patients with injuries severe enough to require hospitalization, which may be different from the general pediatric population.

Although this study's population is different from the entire pediatric population involved in MVCs, the results of this study are nonetheless significant and demonstrate actionable information. The outcomes of this study indicate that seat belts reduce the risk of injury requiring trauma center admission, which is the general consensus and is supported by the extensive majority of literature. Furthermore, BMI did not appear to play a role in pediatric patients admitted to our trauma center after an MVC.

Our study has limitations; it is a single-center study to explicate our experience with restraint use in our pediatric trauma patients. In some cases of patients transferred to our hospital who did not have restrain use documented by EMS, we had to rely on the trauma or pediatric surgeon's best judgment to determine whether seat belt or booster seat was utilized. Furthermore, information regarding restraint use was provided by EMS. Prior training or knowledge of restraint use, and type were not provided by our trauma center to EMS for this study. Moreover, information regarding restraint use provided by the patient family members may present as a major point of bias. In addition, there are cases in which the seat belts are properly worn but they may have malfunctioned and not tensed up at the moment of impact and still allowed the child to get injured. Further, we were unable to include any child who was involved in MVCs that did not sustain injuries, which require hospitalization.

Seat belts or restraints should be used by all pediatric patients as a mechanism to significantly reduce injuries and mortality. Increased injury prevalence and severe risks associated with lack of restraint use may warrant reevaluating and enforcing existing laws and policies. Stakeholders and policy makers need to work collaboratively to raise public awareness and legislate solutions to reduce pediatric injuries and mortalities resulting from lack of child restraints and seat belt use.

CONCLUSION

Lack of child restraints in motor vehicles is associated with an almost 800-fold increase in pediatric injury requiring admission to a PTC. BMI did not play a role in this dramatic increase in injury requiring admission to a trauma center. Astonishingly low rates of child restraints and seat belt use in pediatric patients in MVCs requiring admission to a PTC indicate the need for better parental and driver education on risks associated with lack of restraints.

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