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## Trends in Pediatric Passenger Restraint Use by Rurality and Age in Iowa, 2006-2019

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### Abstract

**Objective:** Pediatric restraint use has increased over time in the United States, but motor vehicle crashes remain a leading cause of death for children under age 18. Age-appropriate use of safety restraints (safety seats, booster seats, seat belt) and statewide child restraint laws can greatly reduce injury or death in the event of a crash. Surveillance of pediatric restraint use and compliance with policy can inform prevention efforts. This study aims to examine time trends in pediatric restraint use and compliance with pediatric passenger laws in Iowa by rurality and age.

**Methods:** Fourteen years of Iowa observational pediatric restraint use data (2006-2019) are included in this cross-sectional study. Proportions of restrained youth by year, age, and rurality (rural, urban) were calculated. Log-linear models were used to compute the Annual Percent Change (APC) by year to explore trends in restraint use over time by rurality and by age group.

**Results:** A total of 42,007 observed pediatric passengers with complete data from 2006 to 2019 were included in this study. Restraint use increased across all years and all age groups observed, with the largest increases among the older pediatric age groups. However, restraint use was consistently highest among the youngest child passengers. With all study years combined, the odds of being compliantly restrained were 13% lower in rural areas (OR = 0.87, 95% CI = 0.80, 0.95) compared to urban areas.

**Conclusions:** Restraint use was lower in rural areas and among older pediatric passengers, suggesting targeted efforts to increase restraint use among these groups may have the greatest impact on overall occupant protection.

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**Contributions:** CH and CP contributed to the study design and formulated the study concept. CM conducted the data analysis. CH contributed to the acquisition of the data and wrote the initial draft. All authors were involved in the interpretation of the data, manuscript editing and review, and approval of the final version.

**Disclosure Statement** The authors do not have any financial interests or benefits to declare.

## Keywords

injury prevention; traffic safety; child; occupant safety; child restraint system

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## INTRODUCTION

Pediatric passenger death rates have decreased by more than 60% since 1975 (IIHS 2020a) and 43% in the past decade among those younger than 13 years old (CDC 2021). Increased pediatric occupant protection is one contributing factor to the decrease in death rates, which is attributable to efforts such as strengthening of state child passenger restraint laws, enhanced enforcement, safety seat education and distribution efforts, and improvements in safety seat design (SafeRide4Kids 2018; Sauber-Schatz et al. 2014). Despite significant progress over the past several decades, motor vehicle crashes remain a leading cause of death among the pediatric population (IIHS 2020a). Motor vehicle crashes are the leading cause of death for ages 5 to 17, 2<sup>nd</sup> cause for 1- to 4-year-olds, and 3<sup>rd</sup> leading cause for infants less than one (CDC 2020b). Nearly 2500 youth under age 18 are killed every year in motor vehicle crashes in the United States and more than 200,000 require a visit to the emergency department due to a motor vehicle occupant-related injury (CDC 2020b).

Child safety seats have been estimated to reduce the risk of injury by 71-82% for children ages 4 and younger (CDC 2020a). For children ages 4 to 8, booster seats have been estimated to reduce the risk of serious injury by 45% compared to seat belt use only (CDC 2020a). Seat belt use has also been estimated to reduce the risk of fatal injury of front seat car occupants by 45% (NHTSA 2020). However, 37% of youth age 15 and younger who were killed in motor vehicle crashes in 2018 were unrestrained (NHTSA 2020). These data show there is much room for improvement to reduce motor vehicle crash-related injuries and fatalities among youth. Similar to national statistics, 33% of Iowa youth age 17 or younger killed in motor vehicle crashes from 2015-2020 were unrestrained (Iowa Department of Transportation 2020). The large proportion of unrestrained pediatric vehicle occupant fatalities clearly indicates a need for increasing pediatric restraint use.

Surveillance of child passenger restraint is helpful to track use by characteristics such as age and location, and also to determine compliance to policies. This information can be helpful for targeting prevention efforts and for tracking changes over time with respect to implementation and amendments of policies. To that end, Iowa has conducted an annual observational pediatric passenger restraint use survey since 1988. This study aims to examine time trends in pediatric restraint use and compliance with pediatric passenger laws in Iowa by rurality and age.

## METHODS

### Study Protocol and Participants

All pediatric motor vehicle occupants are required by Iowa child passenger restraint law to be properly protected through the use of child safety seats, booster seats, and/or seat belts. Specifically, Iowa Law key points include: 1) a child under one year old and weighing less

than 20 pounds must be secured in a rear-facing child restraint system, 2) A child age one up to six years old must be secured in a child restraint system (a safety seat or booster seat—not a seat belt, 3) a child from age six up to eleven must be secured in a child restraint system or by a safety belt, and 4) rear seat occupants up to age 18 must be secured by a safety belt. See Appendix for a copy of the full Iowa law code on child passenger restraint. To track trends in pediatric restraint use and identify occupation protection gaps, the Iowa Governor's Traffic Safety Bureau (GTSB) contracts with the University of Iowa Injury Prevention Research Center (IPRC) to conduct observational pediatric restraint use surveys.

The cross-sectional survey involves observation of child restraint use and seat placement, as well as a driver survey to verify driver and child occupant age(s). The survey is conducted at gas stations and other frequented locations in communities (e.g., community swimming pool parking lot) where the surveyor can approach drivers of motor vehicles carrying passengers who appear to be up to seventeen years of age. When the surveyor approaches the vehicle, they ask the driver if they would be willing to participate in a brief child passenger safety survey. If the driver agrees, the surveyor confirms the ages of driver (16, 17, or 18+) and the pediatric passenger(s) in the vehicle and makes a visual observation of restraint use. Drivers under age 16 are not included in the study and proper installation of child safety seats and booster seats is not part of the observations. The focus of the survey is on restraint type and whether or not it is in use. The survey protocol was approved by the University of Iowa Institutional Review Board.

### Study Data and Variables

An observational pediatric passenger restraint survey has been conducted annually in Iowa since 1988. The survey was redesigned in 2005 to better represent Iowa's population and has since been conducted annually in 36 communities across the state ranging in size to represent rural and urban differences. Fourteen years of the survey data, 2006 to 2019, are included in this study. The data gathered include: driver age, vehicle type (car, pickup, pickup club cab, van, and SUV), pediatric passenger age, type of restraint (child safety seat, booster seat, seatbelt only, none/unrestrained), city/town, community size based on population (rural—1,000-2,499; town—2,500-9,999; small urban—10,000-49,999; and urban—50,000+), and youth location within the vehicle (front seat vs. back seat).

For the purposes of this study, restraint use was dichotomized to reflect whether the pediatric occupant was restrained in accordance with current Iowa law (321.446) or not (State of Iowa 2010). Specifically, those coded as 'compliant restraint' had to meet the following criteria: children aged less than 1 had to be in a child safety seat, ages 1 to 5 in child safety seat or booster, ages 6 to 11 in a child safety seat, booster, or seat belt, and ages 12 to 17 in a seat belt or booster. All others were marked as 'noncompliant restraint or unrestrained'. During the 14-year study period from 2006 to 2019 there was only one change in Iowa's child passenger restraint law. A 2010 law change expanded the requirement of rear seat safety belt use to 11- to 17-year-olds (previous requirement was up to age 10) (State of Iowa 2010). No occupant restraint use data are available for passengers ages 11 to 17 prior to 2010 because the law did not apply to that age group. Observations of pediatric passengers ages 11 to 17

started in 2010, following the 2010 state child passenger restraint law (State of Iowa Code Section 321.446) changes.

Community size was used to categorize data into rural or urban. Communities with a population of 50,000 or higher were categorized as urban, while those with populations of less than 50,000 residents were categorized as rural.

### Statistical Methods

Annual proportions of compliant restraint and noncompliant restraint/unrestrained youth were calculated for each year and by rurality (rural vs urban) and pediatric age group (<1, 1-5, 6-11, 12-17). Multivariable logistic regression models were built with year as the exposure and restraint use as the dependent variable and were stratified by rural and urban. Youth age, driver restraint use, youth location within the vehicle, and vehicle type were included as covariates to control for confounding.

We examined trends in the proportions of compliantly restrained pediatric passengers over the study period (2006-2019) in rural areas and urban areas. We also examined trends in being compliantly restrained by pediatric age group (<1, 1-5, 6 to 11 [all study years], 12 to 17 [2010-2019]). The Joinpoint regression program software, V.4.0.1, was used to test the statistical significance of the trends. We used the log-linear model which computes the Annual Percent Change (APC)(NCI 2020). All other analyses were computed using SAS and results were combined in R to create figures. These analyses were intended to look both at the trends over the study period and differences by age and rurality.

## RESULTS

Between 2006 and 2019, a total of 42,686 pediatric passengers were observed. From those, 679 (1.6%) were excluded due to missing information on rurality, age, pediatric restraint, driver restraint, seating position of the child within the vehicle, and/or vehicle type either due to refusal by participant to provide the information or due to surveyor or data entry error. The final analytical sample included 42,007 pediatric passengers. Across all years, 89.5% of youth observed were compliantly restrained in accordance with Iowa law (Table 1, Appendix Table 1A). Children under the age of one had the highest proportion of restraint (99.1%) and adolescents age 12 to 17 had the lowest (85.5%;  $p<0.001$ ). Pediatric passengers with drivers who wore seat belts had a much higher proportion of restraint (93.2%), compared to those riding with unrestrained drivers (50.2%;  $p<0.001$ ). Pediatric passenger restraint use was lower when the driver was a teenager (age 16 or 17) compared to when the driver was an adult aged 18 or older (81.3% vs 92.1%;  $p<0.001$ ). A full breakdown of restraint type by each year of age and by age group, independent of compliance status with Iowa law, can be seen in Table 2A and Figure 1A in the Appendix.

Rural areas had lower restraint use compared to urban (85.4% vs 90.4%;  $p<0.001$ ). Pediatric restraint use was lowest in pickup trucks (71.7%) and highest in vans (93.3%), though SUVs were a close second (92.6%;  $p<0.001$ ). Restraint use was higher when the pediatric passenger was located in the back seat of the vehicle (90%) compared to the front (87.5%;  $p<0.001$ ).

Among pediatric passengers who were restrained by a seat belt only, 1268 (6.1%) were not restrained in accordance with Iowa law, meaning they should have been in a booster or child safety seat. Among pediatric passengers observed in booster seats, there was 1 (0.01%) who was less than one year old who should have been in a child safety seat. There were also 4 (0.04%) youth who were in child safety seats, but were age 12 or older, aligning with ages appropriate for either a booster seat or seat belt. It is possible those 4 may have been marked erroneously (e.g., should have been marked as booster seat, not child safety seat) over the 14-year study period or there may have been some older children who were in specially designed safety seats (e.g., seats designed for children with special needs).

### Restraint Use by Rurality

The proportion of compliantly restrained pediatric passengers over time was consistently higher in urban areas compared to rural areas (Table 2). In several years there was little evidence of difference in the odds of restraint use between urban and rural areas and in one year (2017) the odds of restraint use was higher in rural areas, after adjusting for child passenger, driver, and vehicle characteristics. However, with all years of data combined, the odds of being compliantly restrained was lower in rural compared to urban areas after adjusting for youth age, driver restraint use, vehicle type, and pediatric location within vehicle.

Among pediatric passengers observed in rural areas, there was a steady and significant annual percent increase of 1.1% in the proportion compliantly restrained over the entire study period (2006-2019; Figure 1). Among pediatric passengers observed in urban areas, there was a 3.8% annual percent increase in compliant restraint use from 2006 to 2008, followed by a 0.8% annual percent increase from 2008 to 2019.

### Trends in Restraint Use by Age

The proportion of compliantly restrained pediatric passengers decreased as age increased across all included years of data (Table 3). Although restraint use was lower in older youth age categories, these older youth experienced the largest increases in being compliantly restrained over time. For example, 81.6% of 6- to 11-year-olds were compliantly restrained in 2006 compared to 96.5% in 2019 and 97.4% of children less than age 1 were compliantly restrained in 2009 compared to 99.0% in 2019.

Among children less than one year old (rural and urban areas combined), there was a non-significant annual increase in restraint use from 2009 to 2012 and a non-significant decrease from 2012-2019 (Figure 2). Among children ages 1 to 5, there was a significant annual increase of 1.0% in the proportion of compliantly restrained children from 2006 to 2019. The data showed a significant annual increase of 3.2% in the proportion of compliantly restrained children ages 6 to 11 from 2006 to 2009, followed by a significant annual increase of 0.6% from 2009 to 2019. For adolescent passengers ages 12 to 17 years old, there was a significant annual increase in being compliantly restrained of 1.7% from 2010 to 2019.

## DISCUSSION

This study examined trends in pediatric restraint use in Iowa over 14 years by age and rurality. Pediatric passenger restraint use in Iowa increased over time, which is similar to national trends (CDC 2020a; NHTSA 2020). We found that rural areas had lower proportions of compliant restraint use, but this varied somewhat by year after adjusting for child passenger, driver, and vehicle characteristics. A multistate study of child passenger restraint systems found higher rates of being unrestrained and other types of misuse (e.g., improper installation) in rural areas compared to urban (Hafner et al. 2017). Although we did not track misuse, our findings showed similar restraint use differences, with lower rates of compliant restraint use in rural areas compared to urban areas. Lower restraint use in rural areas has also been found among adults (Beck et al. 2017). These differences by rurality likely represent location-based differences in child passenger traffic safety culture.

Our results also showed older youth age groups had the lowest proportions of compliant restraint, and this was consistent over time. However, older youth age groups also saw the largest gains in compliant restraint use over time compared to younger age groups, partially because they had the greatest room for improvement. Our findings related to lower pediatric passenger compliant restraint use as age increases is consistent with prior research (Li and Pickrell 2018; Macy and Freed 2012). For example, a recent nationally-representative observational survey found 98% restraint use for ages less than one, 95% ages 1 to 3, 89% for ages 4 to 7, and 87% for ages 8 to 12 (Li and Pickrell 2018). Our study also showed premature use of seat belts among 3% of the children observed, which was lower in comparison to a nationally-representative survey that showed 20.8% of 4- to 7-year-olds were restrained by seat belt only instead of being restrained in a booster seat (Li and Pickrell 2018). However, it should be noted that premature seat belt use in Iowa only applies to children age 5 or under, whereas the national study used age 7 and under as the cut-point for premature seat belt use in their study. Therefore, the low rate observed in Iowa data may be partially explained by the difference in premature use definition.

Seat belts, booster seats, and child safety seats work to reduce and prevent injuries and fatalities when used and used appropriately (CDC 2020a). Prevention of pediatric injuries and fatalities from motor vehicle crashes can greatly benefit from maximizing restraint use. One common avenue for the promotion of restraint use is through child passenger restraint laws. All states in the U.S. have child passenger restraint laws, but the elements of those laws vary greatly from state to state (IIHS 2020b). With the exception of New Hampshire, all states also have adult seat belt laws (IIHS 2020b).

Iowa child passenger restraint laws do not meet best practice recommendations from the American Academy of Pediatrics (AAP). AAP released updates to their recommendations in 2018 via a technical report and policy statement (Durbin and Hoffman 2018a; 2018b), which removed the age criterion from when a child should change from rear to forward-facing safety seat and instead recommend 'as long as possible, up to the limits of their car safety seat'. A quantitative rating system developed to assess alignment of state child passenger restraint laws compared to best practices, currently gives Iowa a 34 out of a possible 56, placing the state 23<sup>rd</sup> in terms of alignment with best practice compared to

other states(UMTRI 2020). Iowa and many other states have laws that allow for premature movement to the next child restraint step (e.g., movement from rear-facing to forward-facing or movement from a child safety seat to a booster seat)(Klinich et al. 2017).

Iowa's current child restraint law states "A child under one year of age and weighing less than twenty pounds who is being transported in a motor vehicle subject to registration, except a school bus or motorcycle, shall be secured during transit in a rear-facing child restraint system that is used in accordance with the manufacturer's instructions (Iowa Code 321.446)." The current law relies on minimum age and weight cut-points, rather than encouraging maximization of rear-facing car seat use up to the limits of the seat per the manufacturer guidelines.

Laws that align with best practices have been shown to have the best compliance (Benedetti et al. 2017), and both the implementation of laws and their compliance are influenced by local and state traffic safety culture (AAA Foundation for Traffic Safety 2007; Ward et al. 2014). Mandatory seat belt laws have been shown to be associated with increased restraint use among teenagers (Carpenter and Stehr 2008). Aligning law with best practice recommendations presents challenges, as the recommendations necessitate considering height and weight relative to the limits of the safety seat or booster seat in question. Despite these challenges, several states have shown it is possible and have aligned their child safety and booster seat laws with the AAP best practice recommendations. For example, Washington's law aligns with best practices across all ages applicable to child safety and booster seats and Wisconsin, New Jersey, and Colorado have aligned with best practice for ages 0 to 7 (note: Colorado also meets best practice for ages 11 to 13)(UMTRI 2020). In comparison, Iowa's law aligns with best practice for ages <1, 5, and 11 to 13 only(UMTRI 2020).

## Limitations

Data on children ages 11 to 17 were not collected as part of the annual Iowa child passenger restraint survey until 2010, the same year the child passenger restraint law was strengthened to require restraint use in rear seats up to age 17 (prior was only up to age 10). Therefore, our examination of restraint use among 11- to 17-year-olds was limited to 2010-2019. However, we found consistent increases in restraint use across all age groups, suggesting that there was a trend in restraint use across time independent of any law change.

Our analysis measured restraint use as it aligns with Iowa law, which does not directly align with AAP best practice recommendations. Given this discrepancy, our results showing premature advancement of a pediatric passengers to the next restraint step (e.g., using booster seat too early) are likely underestimates in terms of gaps to be addressed.

Restraint use increased over time for all pediatric ages, with the greatest gains among the older ages. The oldest age groups and rural areas had the largest opportunity for increased restraint use, as they had the lowest restraint use rates. Prevention efforts may have the largest impact if targeted to rural areas and older children, though there is room for improvement among all ages and locations.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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## Data Availability Statement

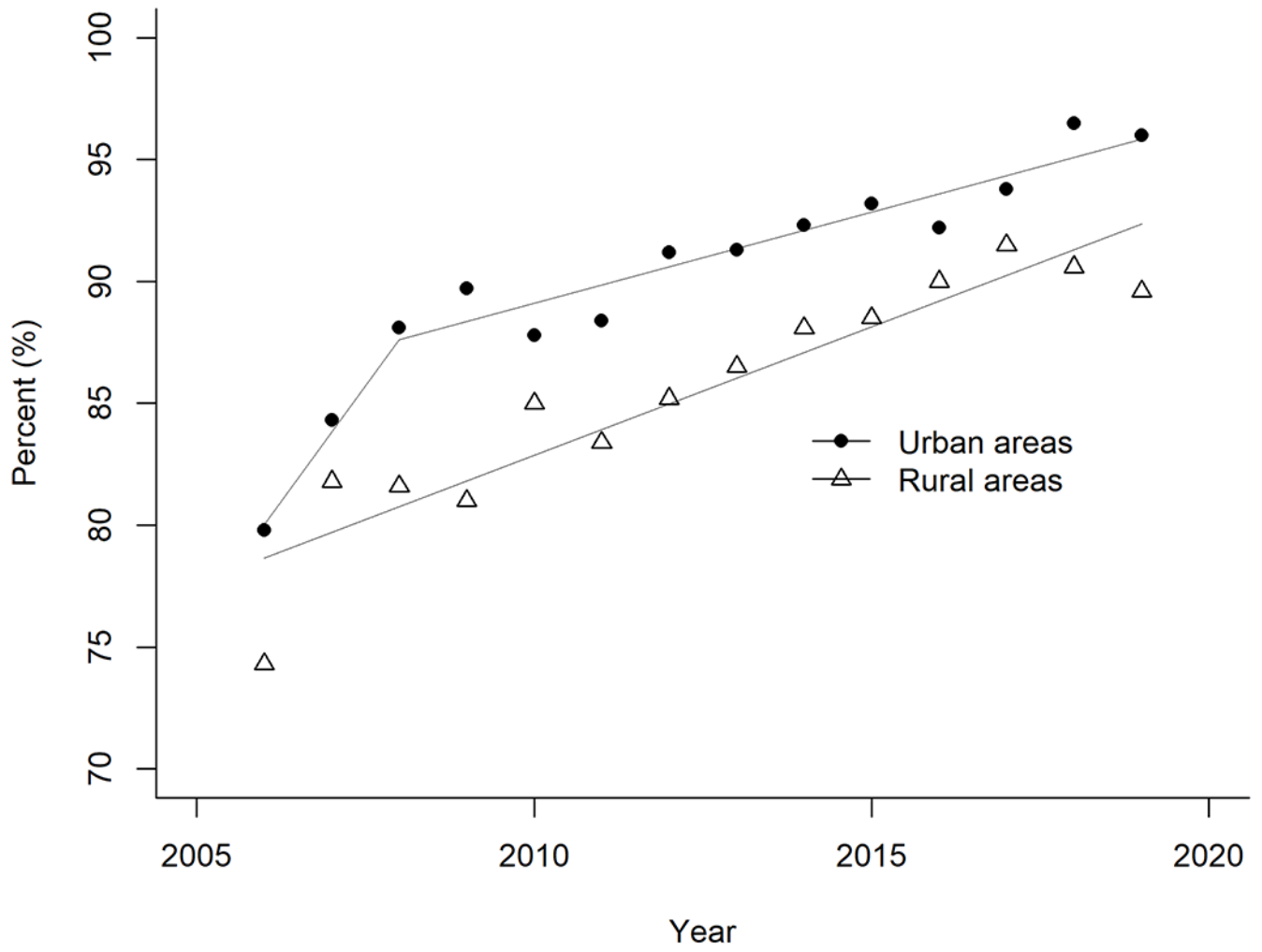
The data that support the findings of this study are available from the corresponding author, CJH, upon reasonable request.

## References

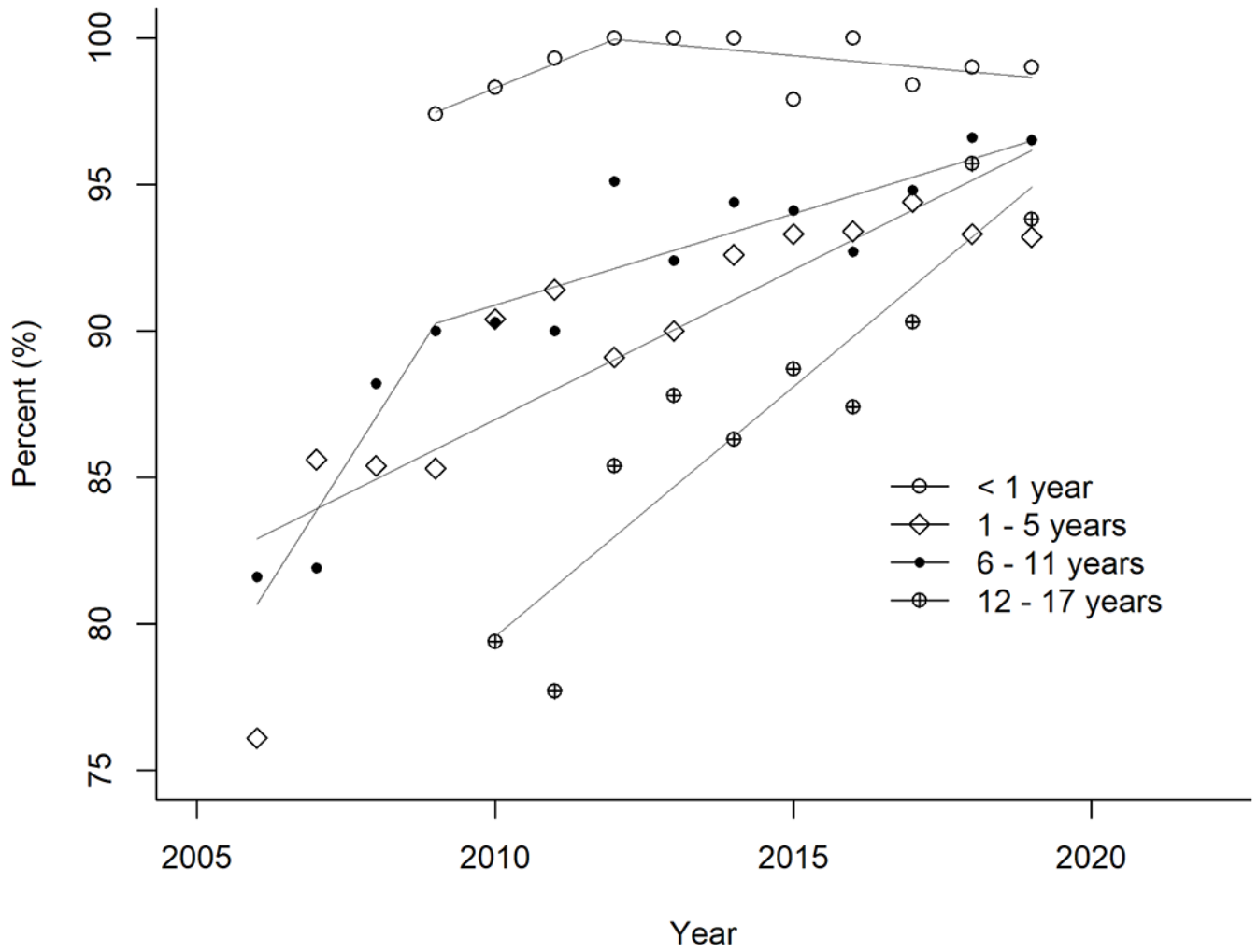
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**Figure 1.** Trends in pediatric passenger restraint compliance over time (restrained expressed by %) by rurality



**Figure 2.** Trends in pediatric passenger restraint compliance over time (restrained expressed as %) by age

**Table 1.**

Demographic and situational characteristics of pediatric passenger observations by restraint use, Iowa, 2006-2019\*

Variables	Pediatric passenger restraint		
	Compliant restraint n (%)	Non-compliant restraint or unrestrained n (%)	ALL N (%)
n	37576 (89.5)	4431 (10.5)	42007 (100)
Youth Age in Years			
<1	1219 (99.1)	11 (0.9)	1230 (100)
1 – 5	13708 (88.6)	1773 (11.4)	15481 (100)
6 – 11	14712 (90.8)	1492 (9.2)	16204 (100)
12 – 17	7937 (87.3)	1155 (12.7)	9092 (100)
Driver Belt use			
Yes	35744 (93.2)	2611 (6.8)	38355 (100)
No	1832 (50.2)	1820 (49.8)	3652 (100)

\* Full version of this table is in the Appendix, Table 1A

**Table 2:**

Distribution and odds of being compliantly restrained in a rural area compared to urban area by year

Year	Pediatric passengers		
	Rural areas	Urban areas	OR (95% CI)
	Compliant Restraint N (%)	Non-Compliant Restraint or Unrestrained N (%)	
2006	444 (74.3)	1920 (79.8)	1.00 (0.78, 1.27)
2007	473 (81.8)	1965 (84.3)	1.25 (0.94, 1.65)
2008	479 (81.6)	2113 (88.1)	0.93 (0.70, 1.22)
2009	477 (81.0)	2156 (89.7)	0.67 (0.52, 0.87)
2010	491 (85.0)	2024 (87.8)	1.00 (0.75, 1.33)
2011	453 (83.4)	2200 (88.4)	0.68 (0.50, 0.91)
2012	456 (85.2)	2227 (91.2)	0.72 (0.52, 0.99)
2013	474 (86.5)	2280 (91.3)	0.72 (0.53, 0.99)
2014	479 (88.1)	2300 (92.3)	0.90 (0.63, 1.30)
2015	486 (88.5)	2327 (93.2)	1.04 (0.71, 1.52)
2016	492 (90.0)	2263 (92.2)	1.08 (0.73, 1.59)
2017	503 (91.5)	2368 (93.8)	1.84 (1.18, 2.89)
2018	479 (90.6)	2333 (96.5)	0.49 (0.32, 0.74)
2019	493 (89.6)	2421 (96.0)	0.45 (0.30, 0.67)
All Years	6679 (85.4)	30897 (90.4)	0.87 (0.80, 0.95)

Odds ratios were adjusted for pediatric age, driver restraint use, vehicle type, and youth location within vehicle.

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**Table 3:**

Distribution of compliantly restrained pediatric passengers by age and year

Year	<1 years n (%)	1 – 5 years n (%)	6 – 11 years n (%)	12 – 17 years n (%)
2006	NA	1217 (76.1)	1147 (81.6)	NA
2007	NA	1313 (85.6)	1125 (81.9)	NA
2008	NA	1261 (85.4)	1331 (88.2)	NA
2009	74 (97.4)	1232 (85.3)	1327 (90.0)	NA
2010	58 (98.3)	854 (90.4)	926 (90.3)	677 (79.4)
2011	133 (99.3)	872 (91.4)	1003 (90.0)	645 (77.7)
2012	138 (100.0)	845 (89.1)	828 (95.1)	872 (85.4)
2013	108 (100.0)	823 (90.0)	943 (92.4)	880 (87.8)
2014	136 (100.0)	864 (92.6)	952 (94.4)	827 (86.3)
2015	139 (97.9)	913 (93.3)	925 (94.1)	836 (88.7)
2016	113 (100.0)	955 (93.4)	994 (92.7)	693 (87.4)
2017	124 (98.4)	892 (94.4)	985 (94.8)	870 (90.3)
2018	101 (99.0)	799 (93.3)	1071 (96.6)	841 (95.7)
2019	95 (99.0)	868 (93.2)	1155 (96.5)	796 (93.8)
All	1219 (99.1)	13708 (88.6)	14712 (90.8)	7937 (87.3)

Note: Data collection for 11- to 17-year-olds started in 2010.

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