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RESEARCH ARTICLE

# Booster Seat Effectiveness Among Older Children: Evidence From Washington State

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**Introduction:** The American Academy of Pediatrics has recommended that children as old as 12 years use a booster seat when riding in motor vehicles, yet little is known about booster seat effectiveness when used by older children. This study estimated the association between booster use and injuries among children aged 8–12 years who were involved in motor vehicle crashes.

**Methods:** Researchers analyzed data on all motor vehicle crashes involving children aged 8–12 years reported to the Washington State Department of Transportation from 2002 to 2015. Data were collected in 2015 and analyzed in 2016. Children who were in a booster seat were compared with children restrained by a seat belt alone. Logistic regression was used to adjust for potential confounders.

**Results:** In unadjusted models, booster use was associated with a 29% reduction in the odds of experiencing any injury versus riding in a seat belt alone (OR=0.709, 95% CI=0.675, 0.745). In models adjusted for potential confounders, booster use was associated with a 19% reduction in the odds of any injury relative to riding in a seat belt alone (OR=0.814, 95% CI=0.749, 0.884). The risk of experiencing an incapacitating/fatal injury was not associated with booster use.

**Conclusions:** Children aged 8–12 years involved in a motor vehicle crash are less likely to be injured if in a booster than if restrained by a seat belt alone. Because only 10% of U.S. children aged 8–12 years use booster seats, policies encouraging their use could lead to fewer injuries.

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## INTRODUCTION

Motor vehicle crashes (MVCs) are the leading cause of death due to injury among children aged 8–12 years in the U.S.[1] In 2015, the most recent year for which Fatality Analysis Reporting System data are available, 242 children aged 8–12 years died as a result of an MVC.[2]

Prominent groups such as the American Academy of Pediatrics and National Highway Traffic Safety Administration have suggested that children as old as 12 years should use a belt-positioning booster seat when riding in a motor vehicle,[3,4] and the use of booster seats by older children is, in fact, growing rapidly. According to the 2009 National Survey of the Use of Booster Seats, only 5% of children aged 8–12 years used a booster seat.[5] By 2013, 10% of children in this age group used a booster seat.[6]

Very little is known about the effectiveness of booster seats among children aged >8 years. Only one previous study, by Ma et al.,[7] has examined the effectiveness of booster seats compared with seat belts using data on older children. However, this study has been characterized as underpowered and potentially unrepresentative.[8] Moreover, to increase sample size, Ma and colleagues combined data on children aged 4–10 years with data on children aged 0–3 years, for whom booster seats are not recommended.

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Studies focusing on younger children provide evidence that booster seat use reduces the risk of injury.[9–12] For instance, Durbin et al.[9] examined data on children aged 4–7 years involved in an MVC. They found that booster seat use was associated with a 59% decrease in the odds of injury compared with being restrained by a seat belt alone. Using data on children aged 4–8 years involved in an MVC, Arbogast and colleagues[10] found that booster seat use was associated with a 45% decrease in the odds of an injury versus being restrained by a seat belt alone.

Drawing on crash data collected by the Washington State Department of Transportation (WSDOT) for the period 2002–2015, the effectiveness of booster seats compared with seat belts among children aged 8–12 years was examined. Logistic regression was used to adjust for factors such as seating position, direction of the impact, vehicle type, vehicle age, time of day, day of week, weather conditions, and the number of vehicles involved. Booster seat laws in the U.S. typically apply to children aged <8 years; no state currently requires children aged >8 years to use booster seats.[13]

## METHODS

### Data Sample

Data on MVCs came from WSDOT, were collected in 2015, and analyzed in 2016. The data cover all MVCs on Washington public roadways reported to law enforcement officers during the period from January 2002 through July 2015, and were obtained through a written agreement with WSDOT in accordance with the Public Records Act, RCW 42.56. They contain information on the vehicles involved in the accident, the circumstances surrounding the crash (e.g., weather conditions and time of day), and driver and passenger characteristics. The WSDOT data also include detailed information on restraint device usage and injury severity.

The focus was on occupants aged 8–12 years who rode in a passenger car or a light truck and were restrained by either a booster seat or seat belt alone. Pedestrians and children riding in vehicles such as school buses or motor homes were excluded from the analysis. From 2002 through 2015, nearly 92% of children aged 8–12 years who were involved in an MVC were passengers in a car or light truck. Children who had missing information on age, type of restraint used, or severity of injury were also excluded from the analysis.

A total of 79,859 children aged 8–12 years were observed in the WSDOT data. Of these, 5,932 (7.4%) were in a booster seat at the time of the MVC and 73,927 (92.6%) were restrained by a seat belt alone. Figure 1, which is based on the WSDOT data, shows a steep increase in booster seat use among children aged 8–12 years involved in an MVC. In 2002, only 2% of children aged 8–12 years used a booster seat. By 2015, approximately 14% of children belonging to this age group used a booster seat.

### Measures

Two outcomes were constructed, both of which were based on the 5-point KABCO scale used by WSDOT to characterize injuries sustained by people involved in an MVC. The first was an indicator for experiencing any injury, including so-called "non-evident" injuries, such as limping, momentary unconsciousness, nausea, and pain. The second was an indicator of whether the crash caused an incapacitating or fatal injury to the child. Examples of incapacitating injuries include severe lacerations, broken or distorted extremities, significant burns, unconsciousness, and paralysis. There is evidence that responding officers applying the KABCO scale often mistake minor injuries such as abrasions and contusions for incapacitating injuries, especially when there is copious bleeding.[14–16] However, responding officers are much better at distinguishing between the absence of an injury and non-evident/minor injuries.[14,15]

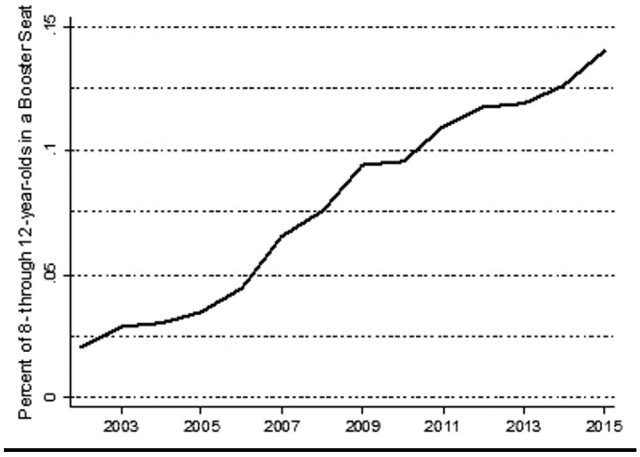


**Figure 1.** Booster seat use in Washington state.

### Statistical Analysis

Logistic regression analysis was used to estimate the effect of using a booster seat relative to being restrained by a seat belt alone. Estimates were considered to be statistically significant if their 95% CI did not include the value 0. SEs (used to calculate CIs and *p*-values) were corrected for clustering at the county level. This correction takes into account the fact that parents living in the same county may not behave independently.

Adjusted models included individual-, vehicle-, and crash-level variables. At the individual level, these were indicators for seat position (front, back left, back middle, back right, and "other" seating position), gender, and age. It is particularly important to adjust for seating position because children in a child restraint system (CRS) are more likely to ride in the back than those who are restrained by a seat belt alone.[17] The results of previous studies suggest that sitting in the back of the vehicle reduces the likelihood of being fatally injured, especially for children.[18]

Vehicle-level variables included age of the vehicle at the time of the crash and indicators for vehicle type, model year, and vehicle style. Indicators for seat belt use by the driver, injury status of the driver, whether the driver was driving without a license, and whether the driver was listed by the reporting law enforcement officer as at fault were also included and served as proxies for unobserved driver characteristics. The crash-level variables included the number of people involved in the MVC and indicators for the number of cars involved, the speed limit, direction of impact, whether the crash occurred on a rural road, the time of day, whether the crash occurred on the weekend, weather conditions, the month and year of the crash, and the county where the crash occurred.