Are Booster Seats More Effective than Child Safety Seats or Seat Belts at Reducing Traffic Fatalities among Children?

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In an effort to increase booster seat use among children, the National Highway Traffic Safety Administration is encouraging state legislators to promote stricter booster seat laws, yet there is a paucity of information on booster seat efficacy relative to other forms of restraint. Using data from the Fatality Analysis Reporting System for the period 2008-2015, the current study examines the effectiveness of booster seats relative to child safety seats and adult seat belts. For children 2 to 5 years of age, we find some evidence to suggest that booster seats are the inferior form of restraint. For children 6 to 9 years of age, all three forms of restraint appear equally effective.

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1. INTRODUCTION

Motor vehicle accidents are the leading cause of injury-related deaths among children ages one and older in the United States (Decina et al. 2008; Centers for Disease Control and Prevention 2015). To curb these high fatality rates, decades of legislation have taken aim at protecting child passengers. Early laws during the 1970s and 1980s mandated the use of child safety seats (Bae et al. 2014). More recently, states have focused on older children by passing booster seat laws (Decina et al. 2008).[1] Booster seats are intended for children who have outgrown their child safety seat but are too small to use a standard adult seat belt. While there is a large literature on the effectiveness of child safety seats (see, e.g., Kahane 1986; Partyka 1988; Hertz 1996; Elliot et al. 2006; Levitt 2008; Rice and Anderson 2009), little is known about the potential life-saving effects of boosters. Our goal is to provide the first credible estimates on the effectiveness of booster seats at reducing traffic fatalities among children.

To estimate the relationship between booster seat use and the likelihood of fatality in a motor vehicle accident, we call upon data from the Fatality Analysis Reporting System (FARS) for the period 2008-2015 and employ the sample selection correction developed by Levitt and Porter (2001). The sample selection correction addresses the fact that restraint use likely influences whether an observation is included in a data set on traffic fatalities. For children ages 2 through 9, our results generally suggest that booster seats are no more effective at decreasing

[1] Booster seat laws vary along several margins. For example, the ages covered by these laws range from 5 to 8 and some states specify weight and/or height thresholds for which a booster seat is required. The enforcement of booster seat laws also differs widely. Similar to seat belt laws, some booster seat laws are primary; police may stop vehicles solely for violating the law. In other states, booster seat laws are secondary; police must have an additional reason to make a stop. Fines range from $5 to $500 and some states count points against a driver's license or insurance for noncompliance (Decina et al. 2008). Florida is the most recent state to pass a booster seat law. As of January 1, 2015, children in Florida are required to ride in a crash-tested, federally approved car or booster seat until the age of 6 (Jacobson 2015). To date, South Dakota is the only state without booster seat legislation (Governors Highway Safety Association 2016).

the probability of fatality than are child safety seats or standard seat belts. For the younger children in our sample (2- to 5-year-olds), we find some evidence consistent with the notion that booster seats are the least effective form of restraint, suggesting that premature graduation to a booster seat from a child safety seat could be particularly dangerous (Zipp 2013; Pickrell and Choi 2014).

Our findings have clear policy relevance as funding decisions made by the National Highway Traffic Safety Administration (NHTSA) depend on information from the FARS (NHTSA 2013).[2] The NHTSA promotes public messaging campaigns intended to increase parental knowledge of booster seat safety and has also outlined booster-seat enforcement strategies that include law enforcement training and judicial outreach (Decina et al. 2008).[3] It is important that policy decisions such as these and booster seat recommendations made by the American Academy of Pediatrics (AAP) be based on reliable estimates of booster seat effectiveness (Durbin 2011).

2. BACKGROUND

Booster seats have become an increasingly popular form of restraint for children who have outgrown their child safety seat. In 1995, only 6 percent of children weighing 40 to 60 pounds used a child safety seat or a booster seat (Decina and Knoebel 1997). In 2013, 44 percent of children weighing 40 to 60 pounds and 46 percent of children 4 to 7 years of age rode in a

[2] The NHTSA's fiscal year 2016 budget request totaled $908 million and included $179 million for vehicle safety, $152 million for behavioral safety, and $577 million for state grants and high visibility enforcement support (NHTSA 2016).

[3] The NHTSA recommends that law enforcement officers complete a child passenger safety certification course, with a component in the curriculum on booster seats. The NHTSA also promotes educating local magistrates and other judiciary members to enhance their understanding of booster seat laws (Decina et al. 2008).

booster (Pickrell and Choi 2014). According to Arbogast et al. (2009), booster seats have become the most common form of restraint among 4- to 5-year-olds. The AAP has even included questions on booster seat use in their physician guidelines for well-child visits (Hagan et al. 2008).

Booster seats are made to improve seat belt fit by raising the position of the child and, for most models, by altering the route of the seat belt. Anatomically proper fit is characterized by belt placement where the force of the belt is directed onto the skeleton as opposed to soft tissues (Reed et al. 2013). If seat belts are not positioned correctly, they can slice into internal organs (O'Donnell 2011). During a crash, the lap portion of the belt should engage with the front of the pelvis and the shoulder portion of the belt should engage with the clavicle (Reed et al. 2013).[4]

Because belt positioning is critical for the safety of the child, premature graduation from a child safety seat to a booster seat or from a booster seat to a seat belt could be hazardous. Likewise, research has suggested that it is unsafe to keep a child in a particular restraint device after they have outgrown it (Pickrell and Choi 2013). Even if a child is of the appropriate age and size for a booster seat, parental error during the installation process can also complicate matters. According to the Insurance Institute for Highway Safety, many parents do not understand that the purpose of a booster seat is to ensure proper seat belt fit (O'Donnell 2011). A recent field study by the NHTSA found that roughly 10 percent of children in booster seats had

[4] Pediatricians recommend that parents use the following five-step test to determine if their child is too small for an adult seat belt:

1.) Does the child sit all the way back against the auto seat?
2.) Do the child's knees bend comfortably at the edge of the auto seat?
3.) Does the belt cross the shoulder between the neck and the arm?
4.) Is the lap belt as low as possible, touching the thighs?
5.) Can the child stay seated like this for the whole trip?

If parents answer "no" to any of these questions, then a booster seat is recommended (Pediatric Center 2005).

the lap belt sitting too high, across the child's stomach (Newman 2015). The same study found that nearly 50 percent of child safety seats were installed or used incorrectly (Newman 2015).

3. PREVIOUS STUDIES

Since Peltzman's (1975) seminal work, economists have been interested in traffic safety restraint devices and the legislation governing their use.[5] The majority of this research has focused on seat belts. For instance, Levitt and Porter (2001), Cohen and Einav (2003), and Sen and Mizzen (2007) studied the relationship between seat belt use and the risk of traffic fatality.[6] Relatedly, Sen (2001), Morrisey and Grabowski (2005), and Carpenter and Stehr (2008) estimated the reduced-form relationship between mandatory seat belt laws and traffic fatality rates in the United States.[7] In general, these studies provide support for the notion that seat belts and the laws mandating their use promote driver safety. Other research on traffic safety devices has studied the effects of air bags (Peterson et al. 1995; Levitt and Porter 2001), motorcycle helmets (Sass and Leigh 1991; Sass and Zimmerman 2000; Dee 2009; Dickert-Conlin et al. 2011), and vehicle safety inspections (Merrell et al. 1999).[8]

[5] Peltzman (1975) introduced the concept that benefits from vehicle safety regulation may be offset by a compensating increase in risky driving behaviors.

[6] Levitt and Porter (2001) found that wearing a seat belt reduces the likelihood of death by approximately 60 percent. Cohen and Einav (2003) estimated the relationship between seat belt use and traffic fatality rates at the state level, using mandatory seat belt laws as instrumental variables. Sen and Mizzen (2007) used province-level data from Canada and a similar empirical strategy. Both studies found evidence of a negative relationship between seat belt usage and traffic fatality rates.

[7] Sen (2001) found that mandatory seat belt legislation was associated with a 21 percent decline in driver fatalities. Morrisey and Grabowski (2005) focused on older drivers and found that primary seatbelt laws reduced fatalities by roughly 13 percent for 65 to 74 year olds. Carpenter and Stehr (2008) found that primary seatbelt laws reduced traffic fatalities among individuals 14 to 18 years of age by approximately 8 percent.

[8] Economists have studied a wide array of policies that influence traffic fatality rates. For example, research has focused on alcohol and drug policies (Dee 2001; Carpenter and Dobkin 2009; Grant 2010; Anderson et al. 2013), automobile insurance and accident liability laws (Cohen and Dehejia 2004), graduated driver licensing laws (Dee et al. 2005), minimum wage laws (Adams et al. 2012; Sabia et al. 2014), smoking bans (Adams and Cotti 2008), and texting bans (Abouk and Adams 2013).

The literature on child restraint devices is quite large. However, most of the research has focused on child safety seats, not boosters. In addition, the existing booster seat studies come with some serious drawbacks. For instance, they either use crash data from only one state (Anderson et al. 2017), are restricted by a small sample size (Ma et al. 2013), rely on older data during a period when booster seat use was rare (Durbin et al. 2003)[9], or focus only on traffic-related injuries (Durbin et al. 2003; Arbogast et al. 2009; Anderson et al. 2017).[10] Given the limitations of these papers, a credible estimate of the relationship between booster seat use and the probability of fatality remains absent from the literature.[11]

Using FARS data for the period 1975-2003 and the sample selection correction developed in Levitt and Porter (2001), which we describe in more detail below, Levitt (2008) found that child restraint devices do not provide a noticeable safety improvement over the use of standard adult seat belts for children ages 2 through 6.[12] Due to a recent innovation in the FARS that was unavailable to Levitt (2008), we are able to discern between child safety seats and

[9] Durbin et al. (2003) observed only 4 percent of 6- and 7-year-olds riding in booster seats in their data.

[10] Due to a relatively small number of fatalities in their data, Anderson et al. (2017) considered a serious injury category that combined incapacitating and fatal injuries.

[11] The literature on booster seat use and traffic-related injuries is mixed. Using data from insurance claims and telephone surveys, Durbin et al. (2003) and Arbogast et al. (2009) found that booster seats were associated with added safety benefits relative to standard seat belts. Using data from the National Automotive Sampling System, Ma et al. (2013) found that children who used booster seats were more likely to experience neck and thorax injuries than children who used seat belts alone. Anderson et al. (2017) used crash data from the Washington State Department of Transportation and found that booster use was associated with a reduction in the odds of any injury relative to riding in a seat belt alone. They found that the risk of experiencing an incapacitating/fatal injury, however, was not associated with booster use.

[12] Jones and Ziebarth (2016) successfully replicated Levitt's (2008) findings for the period 1975-2003 and showed that they hold for the years 2004-2011. However, they did not exploit the recent innovation in the FARS that allows researchers to discern between child safety seats and booster seats. Doyle and Levitt (2010) used data from the General Estimates Survey, the New Jersey Department of Transportation, and the Wisconsin Crash Outcome Data Evaluation System to estimate the relationship between child restraint device use and traffic-related injuries. For the two most serious injury categories ("fatal/incapacitating" and "nonincapacitating" injuries), they found no difference between child restraint devices and standard seat belts. For the least serious injury category ("possible" injuries), they found that child restraint devices outperformed seat belts. Similar to Levitt (2008), they were unable to distinguish between different types of child restraint devices.

booster seats. Prior to 2008, the FARS lumped both types of restraint into the same category. Distinguishing between restraint types is vital as booster seats are rapidly gaining in popularity, especially for use among older children. For Levitt's (2008) period of interest, children 6 years of age and older were rarely restrained by a device other than a standard seat belt.[13]

4. DATA AND EMPIRICAL STRATEGY

As mentioned above, we use annual data from the Fatality Analysis Reporting System for the period 2008-2015 to examine the relationship between booster seat use and the likelihood of fatality. These data come from the NHTSA and represent a census of all fatal injuries resulting from motor vehicle accidents in the United States.[14]

We restrict the data set along several margins. First, we limit the sample to children 2 to 9 years of age. The overwhelming majority of children under the age of 2 in the data are in child safety seats or ride unrestrained. Children over the age of 9 are almost exclusively in standard adult seat belts or ride unrestrained. Second, we limit the sample to occupants of passenger cars and light trucks.[15] This effectively excludes accidents where the only fatalities are to pedestrians, motorcyclists, or passengers of large trucks (e.g., moving trucks or semis), buses, or

[13] In the FARS data, less than 1 and 8 percent of 6-year-olds were restrained by a device other than a standard seat belt in 2000 and 2003, respectively. By 2008, over 30 percent of 6-year-olds were restrained by a device other than a standard seat belt.

[14] Information on the details of each accident comes from a variety of sources: police reports, driver licensing files, vehicle registration files, state highway department data, emergency medical services records, medical examiner reports, toxicology reports, and death certificates. Additional information on how the FARS data are collected is available at: http://www.nhtsa.gov/FARS.

[15] Based on the definition of "light trucks" from the FARS, this category includes vehicles such as SUVs, utility station wagons, vans, compact pickup trucks, and standard pickup trucks. Roughly 90 percent of children 2 to 8 years of age in the data were occupants of a passenger car or a light truck.

other nonstandard vehicles (e.g., limousines, motor homes, ATVs). Lastly, we drop individuals from the sample with unknown or missing information on age, restraint type, or injury severity.

Table 1 provides descriptive statistics on fatal injuries by restraint type. For children 2 to 9 years of age, roughly 30 percent who ride unrestrained die, and this estimate is slightly higher for the younger children in the sample. Fatality rates for children in booster seats are higher than those for children in child safety seats or standard seat belts. Child safety seats and seat belts appear similar in terms of raw fatality rates.

It is unlikely, however, that these raw fatality rates reflect causal estimates. Factors such as vehicle type, crash severity, and the driver's own risk preference could be simultaneously correlated with the choice of child restraint and the risk of being involved in a fatal accident. Child restraint device use may also influence whether a crash is included in the data set. In this regard, there is sample selection bias that is unaccounted for when focusing on simple means (Levitt and Porter 2001).

In an effort to control for factors simultaneously correlated with child restraint choice and traffic fatality risk, we estimate the following equation:

$$(1) \qquad Fatality_{ivct} = \beta_0 + \beta_1 Booster\ Seat_{ivct} + \beta_2 Child\ Seat_{ivct} + \beta_3 Seat\ Belt\ Only_{ivct} + \mathbf{X1}_{ivct}\boldsymbol{\beta}_5 + \mathbf{X2}_{vct}\boldsymbol{\beta}_6 + \mathbf{X3}_{ct}\boldsymbol{\beta}_7 + \varepsilon_{ivct},$$

where $Fatality_{ivct}$ is equal to one if child i in vehicle v, crash c, and year t died, and is equal to zero otherwise. The variables $Booster\ Seat_{ivct}$, $Child\ Seat_{ivct}$, and $Seat\ Belt\ Only_{ivct}$ are mutually exclusive indicators for the type of restraint device used.[16] The omitted category is no restraint

[16] A departure of our estimating equation from that of Levitt's (2008) is that our variable *Seat Belt Only* covers both lap-and-shoulder and lap-only seat belts. Levitt (2008) included separate indicators for each type of seat belt. For

use. The vector $\boldsymbol{X1}_{ivct}$ includes individual-level controls for seat position (front, back left, back middle, back right, back 'other'), gender, and age. It is important to control for seat position because children in booster seats and child safety seats are more likely to ride in the back than children in adult seat belts or children riding unrestrained.[17] Research suggests that sitting in a back seat may reduce the risk of death, especially for children (Smith and Cummings 2006).

The vector $\boldsymbol{X2}_{vct}$ includes vehicle-level controls for vehicle type, model year, vehicle weight, point of impact, seat belt status of the driver, the driver's injury severity, and the driver's accident and violation history. Seat belt status of the driver and the driver's accident and violation history serve as proxies for unobserved driver tastes and preferences. For instance, safer drivers may be more likely to appropriately restrain their child passengers. In interviews with nearly 1,500 parents of children 4 to 9 years of age, Bruce et al. (2011) found that the strongest determinants of the intent to use a booster seat were parental attitudes and beliefs. The severity of the driver's injury proxies for the severity of the accident.

The vector $\boldsymbol{X3}_{ct}$ includes crash-level controls for the number of persons and cars involved, the speed limit, road type, time of day, whether the crash happened on a weekend, year of the crash, and the state in which the crash occurred. The number of persons involved in the accident also serves as a proxy for crash severity. Because the FARS data only include fatal accidents, the more people who are involved in the accident, the more likely the accident is included in the

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his sample, a nearly equal proportion of children were restrained in lap-and-shoulder and lap-only belts. In our sample, children in lap-and-shoulder belts outnumber those in lap-only belts approximately 7 to 1. This reflects the fact that lap-only belts are being phased out of existence. Since 1989, the NHTSA has required that all rear outboard seats in new passenger vehicles be equipped with lap-and-shoulder belts. In 2004, the NHTSA ruled that all rear center seats in new passenger vehicles must be equipped with lap-and-shoulder belts by 2008 (NHTSA 2005). Our results change little if we drop children restrained in lap-only belts from the sample.

[17] Roughly 96 percent of children in booster seats or child safety seats were in a back seat. On the other hand, approximately 84 percent of children in adult seat belts or riding unrestrained were in a back seat.

data set (Levitt 2008). Following Levitt (2008), all regressions are estimated as linear probability models and standard errors are corrected for clustering at the vehicle level. This level of clustering takes into account the fact that there are sometimes multiple child passengers in the same vehicle.[18]

Table 2 illustrates definitions and descriptive statistics for the control variables used in the analysis. Means are provided for the full sample and for samples restricted by restraint type. Nearly 75 percent of the sample rode restrained by some type of device. This is significantly higher than the approximate 44 percent who rode restrained in Levitt's (2008) sample, reflecting an increasing trend in restraint device use. Unrestrained children were more likely to have ridden in an older vehicle and with a driver who was also unbelted, suffered a serious injury, and had been charged with a driving violation in the past 3 years. Unrestrained children were also more likely to have been in a one-car or early morning accident.

Because the FARS data include only crashes where at least one person died and restraint devices likely influence the probability of death, there is a sample selection problem. Failing to account for this problem will result in estimates that understate the true value of effective restraint devices. To address the sample selection issue, we follow Levitt and Porter (2001) and limit the sample to two-car crashes where someone in the other vehicle died.[19] Holding other factors constant, the assumption is that restraint choice in one vehicle is independent of the

[18] Following Doyle and Levitt (2010), we also control for interactions between driver seat belt status and driver injuries. To retrain sample size, we include dummy variables to indicate missing information on seat position, gender, point of contact, driver characteristics, vehicle characteristics, and crash characteristics. Finally, we experimented with clustering the standard errors at the accident level. Inference based on this level of clustering was similar to that based on clustering at the vehicle level.

[19] See Levitt and Porter (2001) for a formal treatment of the sample selection problem.

fatality outcomes in the other vehicle. This sample selection correction breaks the link between one's restraint choice and their inclusion in the data set (Levitt 2008).[20]

It is important to note that a Peltzman (1975) effect, where restraint use promotes aggressive driving, could lead to biased estimates when restraint use by the driver in the other vehicle is not taken into account. For our models based on the sample selection correction, we control for the seat belt status of the other driver. We also control for characteristics of the other vehicle (weight and type) and the other driver's accident history and prior driving violation charges.

5. RESULTS

Table 3 presents the main results of the paper. Panel I provides estimates from specifications without the sample selection correction. For each age group, estimates are shown from models with and without the covariates listed in Table 2. Across all ages and all types of restraint devices, estimates are negative and statistically significant at the one percent level. For children 2 to 9 years of age and controlling for the covariates listed in Table 2, booster seats reduce the probability of fatality by 10.3 percentage points. This equates to roughly a 34 percent decrease relative to the mean fatality rate for unrestrained children. While this represents a sizable reduction, child safety seats and standard seat belts appear more effective. In fact, across all samples, we reject the null hypotheses that the coefficient estimate on *Booster Seat* is equal to the coefficient estimate on *Child Seat* or the coefficient estimate on *Seat Belt Only*. For the full sample, child safety seats appear slightly more effective than standard seat belts. However, we

[20] Levitt (2008) importantly points out that the subset of crashes based on the sample selection correction are generally less severe than the average crash in the data set. As a result, it is not necessarily clear that estimates based on the corrected sample generalize to all crashes.

reject the null hypothesis that the coefficient estimate on *Child Seat* is equal to the coefficient estimate on *Seat Belt Only* when splitting the sample by age group.

Panel II illustrates results from our preferred specifications that are based on the sample selection correction. In general, the sizes of the coefficient estimates are smaller than those in Panel I. This reflects the fact that these crashes are typically less severe than those based on the entire sample. For children 2 to 9 years of age and controlling for the covariates listed in Table 2, riding in a booster seat is associated with a decrease in the probability of fatality by 5.8 percentage points. This represents a 50 percent decrease relative to the mean fatality rate for unrestrained children. As expected, the magnitude of the effect is larger in the sample corrected for selection. In this case, we fail to reject the null hypothesis that the coefficient estimate on *Booster Seat* is equal to the coefficient estimate on *Child Seat*. However, we can reject the null at the 10 percent level when comparing the effectiveness of booster seats to being restrained by a seat belt alone. In this case, using a seat belt alone is associated with a 67 percent decrease in the fatality rate relative to the mean for unrestrained children.

For children ages 2 through 5, the coefficient estimates on *Child Seat* and *Seat Belt Only* are double the magnitude of the effect associated with booster seats. This is consistent with the notion that premature graduation from a child safety seat to a booster seat can be particularly dangerous (Zipp 2013; Pickrell and Choi 2014). It is important to note, however, that the coefficient estimate on *Booster Seat* is measured imprecisely. While we can reject the null of equal effects sizes for booster seats compared to seat belts alone, we cannot reject the hypothesis that booster seats and child safety seats are equally effective at conventional levels of statistical significance (p-value = .152). Lastly, and consistent with Levitt's (2008) findings, child safety seats seemingly afford the same level of protection against fatal injuries as do standard seat belts for children ages 2 through 5. For older children, the estimates in Table 3 suggest that all three forms of restraint are equally effective.

In Table 4, we allow for measurement error in the type of child restraint device reported by replacing the variables *Booster Seat* and *Child Seat* with an indicator that is equal to one if the child was coded as restrained by either type of device. It is possible that reporting officers at the scene of the crash do not always correctly record the type of restraint device used by child passengers. Furthermore, it is not obvious whether this form of measurement error would be uncorrelated with the likelihood of fatality. Defining the child restraint device variable broadly also allows us to include observations where the type of child restraint device was coded as "unknown." Across all age groups, we find little difference between the effectiveness of broadly-defined child restraint devices and seat belts alone.[21]

6. CONCLUSION

In the past 20 years, booster seats have gone from almost nonexistent to one of the more popular choices of child car restraint (Decina and Knoebel 1997; Pickrell and Choi 2014). Despite this trend and an intense public interest in child traffic safety, credible estimates on the life-saving effects of booster seats remain absent from the literature.

To examine the relationship between booster seat use and the risk of fatality, we draw upon data from the Fatality Analysis Reporting System for the period 2008-2015 and employ the sample selection correction proposed by Levitt and Porter (2001). Until a recent innovation in

[21] In a previous version of this paper, based on a shorter panel of data, we rejected the null hypotheses that the coefficient estimate on *Booster Seat* was equal to the coefficient estimate on *Child Seat* or the coefficient estimate on *Seat Belt Only* at the 5 percent level of significance (Anderson and Sandholt 2016).

the FARS, researchers were unable to examine booster seat effectiveness. In 2008, the FARS began distinguishing between booster seats and child safety seats in its crash reports.

For the younger children in our sample (2- to 5-year-olds), we find some evidence to suggest that booster seats are the inferior form of restraint. In particular, child safety seats and seat belts alone appear twice as effective as booster seats in reducing the likelihood of fatality. These results are consistent with the notion that putting a child in a booster seat too soon, may be especially unsafe (Zipp 2013; Pickrell and Choi 2014). For the older children in our sample (6- to 9-year-olds), our results suggest that booster seats, child safety seats, and seat belts are equally effective at decreasing the probability of fatality.

From a policy perspective, our results are vital as federal, state, and local governments must decide on how to best allocate their budgets earmarked for traffic safety. Our findings also provide important information for state legislatures contemplating particular age ranges for their booster seat requirements.

A caveat to our results is that they reflect how booster seats are used in practice. While Newman (2015) estimated improper installation to be substantially lower for booster seats relative to child safety seats, the misuse of booster seats would cause our estimates to understate their true value.

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Table 1. Descriptive Statistics on Fatal Injuries by Restraint Type

	Full sample	*No Restraint* = 1	*Booster Seat* = 1	*Child Seat* = 1	*Seat Belt Only* = 1
Ages 2-9					
Fatality	.165	.302	.199	.104	.108
	(.371)	(.459)	(.400)	(.305)	(.310)
N	14,922	3,826	1,305	2,187	7,604
Ages 2-5					
Fatality	.185	.320	.218	.107	.122
	(.388)	(.466)	(.413)	(.309)	(.328)
N	6,411	1,809	767	1,990	1,845
Ages 6-9					
Fatality	.150	.287	.173	.076	.103
	(.357)	(.453)	(.378)	(.266)	(.304)
N	8,511	2,017	538	197	5,759

Notes: *Fatality* is equal to one if the child died in the accident, and is equal to zero otherwise. Each cell represents the percentage of children who were fatally injured. Means (with SDs in parentheses) are based on unweighted data from the Fatality Analysis Reporting System (2008-2015).

Table 2. Descriptive Statistics on Independent Variables by Restraint Type

	Full sample	*No Restraint* = 1	*Booster Seat* = 1	*Child Seat* = 1	*Seat Belt Only* = 1	Description
Individual-level characteristics						
Restraint type						
No Restraint	.256	1.00	...	...	...	= 1 if child was unrestrained, = 0 otherwise
	(.437)					
Booster Seat	.087	...	1.00	...	...	= 1 if child was in a booster seat, = 0 otherwise
	(.283)					
Child Seat	.147	...	...	1.00	...	= 1 if child was in a child seat, = 0 otherwise
	(.354)					
Seat Belt Only	.510	...	...	...	1.00	= 1 if child was in a seat belt only, = 0 otherwise
	(.500)					
Child seat position						
Front	.129	.137	.053	.035	.165	= 1 if child was sitting in the front of the vehicle,
	(.335)	(.344)	(.224)	(.183)	(.371)	= 0 otherwise
Back Left	.307	.229	.388	.374	.314	= 1 if child was sitting in the back left of the
	(.461)	(.420)	(.487)	(.484)	(.464)	vehicle, = 0 otherwise
Back Middle	.167	.216	.110	.172	.151	= 1 if child was sitting in the back middle of the
	(.373)	(.411)	(.313)	(.378)	(.358)	vehicle, = 0 otherwise
Back Right	.322	.208	.437	.406	.336	= 1 if child was sitting in the back right of the
	(.467)	(.406)	(.496)	(.491)	(.472)	vehicle, = 0 otherwise
Back Other	.046	.127	.008	.008	.022	= 1 if child was sitting in an "other" position in
	(.208)	(.333)	(.087)	(.088)	(.146)	the back of the vehicle, = 0 otherwise
Male	.509	.516	.517	.510	.504	= 1 if male, = 0 otherwise
	(.500)	(.500)	(.500)	(.500)	(.500)	
Age 2	.091	.094	.057	.332	.027	= 1 if two years of age, = 0 otherwise
	(.288)	(.292)	(.233)	(.471)	(.162)	
Age 3	.103	.120	.113	.274	.043	= 1 if three years of age, = 0 otherwise
	(.304)	(.325)	(.317)	(.446)	(.203)	
Age 4	.114	.127	.195	.193	.072	= 1 if four years of age, = 0 otherwise
	(.318)	(.333)	(.397)	(.395)	(.258)	
Age 5	.121	.132	.221	.110	.101	= 1 if five years of age, = 0 otherwise
	(.326)	(.339)	(.415)	(.313)	(.301)	
Age 6	.130	.123	.195	.057	.143	= 1 if six years of age, = 0 otherwise
	(.336)	(.328)	(.396)	(.232)	(.350)	
Age 7	.137	.139	.138	.023	.168	= 1 if seven years of age, = 0 otherwise
	(.344)	(.346)	(.345)	(.149)	(.374)	
Age 8	.150	.140	.060	.006	.211	= 1 if eight years of age, = 0 otherwise
	(.357)	(.347)	(.237)	(.077)	(.408)	
Age 9	.155	.125	.020	.004	.236	= 1 if nine years of age, = 0 otherwise
	(.361)	(.331)	(.140)	(.064)	(.424)	
Vehicle-level characteristics						
Car	.376	.341	.414	.396	.382	= 1 if vehicle was a car, = 0 otherwise
	(.484)	(.474)	(.493)	(.489)	(.486)	
Light Truck	.624	.659	.586	.605	.618	= 1 if vehicle was a light truck, = 0 otherwise
	(.484)	(.474)	(.493)	(.489)	(.486)	
Model Year ≤ 1990	.025	.045	.014	.015	.019	= 1 if vehicle model year was pre 1991, = 0
	(.155)	(.208)	(.117)	(.122)	(.136)	otherwise
1990 < Model Year ≤ 2000	.329	.419	.285	.248	.315	= 1 if vehicle model year was between 1991 and
	(.470)	(.493)	(.452)	(.432)	(.465)	2000, = 0 otherwise
Model Year > 2000	.640	.532	.692	.727	.661	= 1 if vehicle model year was post 2000, = 0
	(.480)	(.499)	(.462)	(.446)	(.474)	otherwise
Vehicle Weight (1,000s lbs.)	1.62	1.70	1.24	1.40	1.70	Vehicle weight in thousands of pounds
	(1.96)	(1.97)	(1.84)	(1.90)	(1.97)	

Point of impact						
Non-Collision	.104	.231	.060	.054	.062	= 1 if initial point of contact was classified as
	(.306)	(.422)	(.237)	(.227)	(.242)	"non-collision", = 0 otherwise
Direct Front	.471	.349	.502	.508	.517	= 1 if initial point of contact was at the direct front
	(.499)	(.477)	(.500)	(.500)	(.500)	of the vehicle, = 0 otherwise
Partial Front	.122	.111	.133	.136	.122	= 1 if initial point of contact was at the partial
	(.327)	(.314)	(.339)	(.343)	(.327)	front of the vehicle, = 0 otherwise
Direct Rear	.079	.047	.091	.094	.089	= 1 if initial point of contact was at the direct rear
	(.270)	(.211)	(.288)	(.292)	(.285)	of the vehicle, = 0 otherwise
Partial Rear	.052	.056	.053	.043	.052	= 1 if initial point of contact was at the partial rear
	(.222)	(.230)	(.224)	(.204)	(.221)	of the vehicle, = 0 otherwise
Right Side	.065	.075	.061	.060	.061	= 1 if initial point of contact was at the right side
	(.246)	(.263)	(.240)	(.237)	(.240)	of the vehicle, = 0 otherwise
Left Side	.068	.072	.069	.077	.063	= 1 if initial point of contact was at the left side of
	(.251)	(.258)	(.253)	(.266)	(.242)	the vehicle, = 0 otherwise
Other Contact Point	.021	.026	.019	.019	.019	= 1 if initial point of contact was at an "other"
	(.143)	(.158)	(.137)	(.136)	(.138)	contact point, = 0 otherwise
Driver Unbelted	.198	.447	.126	.112	.109	= 1 if driver was unbelted, = 0 otherwise
	(.398)	(.497)	(.332)	(.315)	(.321)	
Driver Uninjured	.262	.113	.217	.305	.333	= 1 if driver was uninjured, = 0 otherwise
	(.440)	(.316)	(.412)	(.461)	(.471)	
Driver Minor Injury	.322	.341	.346	.320	.309	= 1 if driver suffered a minor injury, = 0 otherwise
	(.467)	(.474)	(.476)	(.466)	(.462)	
Driver Major/Fatal Injury	.404	.529	.424	.366	.348	= 1 if driver suffered a major injury or died, = 0
	(.491)	(.499)	(.494)	(.482)	(.476)	otherwise
Driver Past Accident	.103	.097	.117	.101	.103	= 1 if driver was in a previous accident in the past
	(.303)	(.296)	(.322)	(.301)	(.304)	3 years, = 0 otherwise
Driver Past Violation	.335	.380	.321	.321	.320	= 1 if driver was charged with a driving violation
	(.472)	(.486)	(.467)	(.467)	(.466)	in the past 3 years, = 0 otherwise
Crash-level characteristics						
Persons in Crash	5.94	6.09	5.52	5.71	5.99	Number of persons involved in the crash
	(4.08)	(3.02)	(2.81)	(5.74)	(4.14)	
One-Car Crash	.345	.535	.264	.251	.289	= 1 if crash was a one-car crash, = 0 otherwise
	(.475)	(.499)	(.441)	(.434)	(.453)	
Two-Car Crash	.487	.386	.539	.544	.513	= 1 if crash was a two-car crash, = 0 otherwise
	(.500)	(.487)	(.499)	(.498)	(.500)	
Three-Plus-Car Crash	.168	.079	.196	.205	.198	= 1 if crash was a three-plus-car crash, = 0
	(.374)	(.269)	(.397)	(.404)	(.398)	otherwise
Speed Limit < 55 MPH	.379	.317	.341	.376	.418	= 1 if speed limit was less than 55 mph, = 0
	(.485)	(.465)	(.474)	(.485)	(.493)	otherwise
Rural Road	.505	.592	.515	.449	.476	= 1 if crash was on a rural road, = 0 otherwise
	(.500)	(.492)	(.500)	(.498)	(.499)	
Early Morning	.067	.111	.047	.059	.051	= 1 if crash occurred during the early morning
	(.250)	(.315)	(.211)	(.236)	(.219)	hours (1:00 a.m. to 5:59 a.m.), = 0 otherwise
Daytime	.757	.710	.818	.769	.767	= 1 if crash occurred during the daytime hours
	(.429)	(.454)	(.386)	(.422)	(.423)	(6:00 a.m. to 7:59 p.m.), = 0 otherwise
Evening	.174	.175	.134	.172	.181	= 1 if crash occurred during the evening hours
	(.379)	(.380)	(.341)	(.378)	(.385)	(8:00 p.m. to 12:59 a.m.), = 0 otherwise
Weekend	.462	.474	.411	.441	.470	= 1 if crash occurred during the weekend (Friday,
	(.499)	(.499)	(.492)	(.497)	(.499)	6:00 p.m. to Monday, 5:59 a.m.), = 0 otherwise
N	14,922	3,826	1,305	2,187	7,604	

Notes: Means (with SDs in parentheses) are based on unweighted data from the Fatality Analysis Reporting System (2008-2015).

Table 3. Booster Seats and the Probability of Fatality

	Full sample (Ages 2-9)		Ages 2-5		Ages 6-9	
Panel I: Without sample selection correction						
Booster Seat	-.103***	-.103***	-.102***	-.098***	-.114***	-.110***
	(.014)	(.015)	(.019)	(.021)	(.020)	(.021)
Child Seat	-.199***	-.190***	-.213***	-.188***	-.211***	-.190***
	(.010)	(.013)	(.013)	(.016)	(.022)	(.022)
Seat Belt Only	-.195***	-.165***	-.197***	-.171***	-.184***	-.162***
	(.009)	(.010)	(.014)	(.015)	(.011)	(.013)
Probability of death with no restraint	.302		.320		.287	
Hypothesis tests (p-values)						
Booster Seat = Child Seat	.000	.000	.000	.000	.000	.001
Booster Seat = Seat Belt Only	.000	.000	.000	.000	.000	.002
Child Seat = Seat Belt Only	.607	.010	.126	.168	.166	.148
N	14,922	14,922	6,411	6,411	8,511	8,511
Panel II: With sample selection correction	Full sample (Ages 2-9)		Ages 2-5		Ages 6-9	
Booster Seat	-.084***	-.058***	-.070**	-.026	-.100***	-.080***
	(.024)	(.021)	(.033)	(.028)	(.029)	(.027)
Child Seat	-.091***	-.067***	-.089***	-.052**	-.083**	-.069**
	(.023)	(.020)	(.029)	(.025)	(.034)	(.032)
Seat Belt Only	-.101***	-.078***	-.100***	-.056**	-.103***	-.090***
	(.022)	(.019)	(.029)	(.024)	(.028)	(.026)
Probability of death with no restraint	.116		.114		.119	
Hypothesis tests (p-values)						
Booster Seat = Child Seat	.551	.481	.251	.152	.456	.611
Booster Seat = Seat Belt Only	.099	.068	.070	.084	.817	.411
Child Seat = Seat Belt Only	.131	.239	.181	.691	.340	.289
N	3,917	3,917	1,559	1,559	2,358	2,358
Covariates listed in Table 2	No	Yes	No	Yes	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column within each panel represents results from a separate OLS regression based on data from the Fatality Analysis Reporting System (2008-2015). The dependent variable is equal to one if the child died in the accident, and is equal to zero otherwise. The estimates should be interpreted as relative to no restraint use. The models that control for the covariates listed in Table 2 also control for state fixed effects, year fixed effects, and interactions between driver injuries and driver seat belt status. The models based on the sample selection correction also control for characteristics of the other vehicle (weight and type) and the other driver (seat belt status, accident history, and prior driving violation charges) involved in the crash. Standard errors, corrected for clustering at the vehicle level, are in parentheses.

Table 4. Any Child Restraint Device and the Probability of Fatality

With sample selection correction	Full sample (Ages 2-9)	Ages 2-5	Ages 6-9
Any Child Restraint Device	-.077***	-.068***	-.087***
	(.019)	(.026)	(.026)
Seat Belt Only	-.083***	-.072***	-.091***
	(.019)	(.025)	(.026)
Probability of death with no restraint	.116	.114	.119
Hypothesis test (p-values)			
Any Child Restraint Device = Seat Belt Only	.258	.517	.599
N	5,649	2,982	2,667

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents results from a separate OLS regression based on data from the Fatality Analysis Reporting System (2008-2015). The dependent variable is equal to one if the child died in the accident, and is equal to zero otherwise. The estimates should be interpreted as relative to no restraint use. All models control for the covariates listed in Table 2, state fixed effects, year fixed effects, interactions between driver injuries and driver seat belt status, characteristics of the other vehicle (weight and type) and the other driver (seat belt status, accident history, and prior driving violation charges) involved in the crash. Standard errors, corrected for clustering at the vehicle level, are in parentheses.