



Additional Analysis of the National Child Restraint Use Special Study

Summary

Child Restraint Installation Decisions, Driver Characteristics, and Lateral Movement

The National Child Restraint Use Special Study (NCRUSS) recorded the use of car seats and belt-positioning booster seats in children up to 8 years old in 4,167 vehicles. Observers approached vehicles that carried at least one child. They interviewed the driver and recorded observations of the restraint use of one child per vehicle.

Observers collected detailed information on the driver, the vehicle, the restraint status of the child, the child's car seat (if present), the installation of the car seat, and specific use of the car seat to restrain the child (e.g., harness placement and tightness.). This included the driver's self-reported confidence in the correct installation of the car seat. Descriptive results are given in *Results of the National Child Restraint Use Special Study*, NHTSA Report No. DOT HS 812 142 (Greenwell, 2015).

In this Research Note, further analysis of the NCRUSS data targeted installation methods (lower anchors or seat belts) used to secure car seats in vehicles. Relative prevalence of both installation methods was examined. Potential predictors of these installation methods were examined, including driver characteristics and the age of the car seat. Lateral movement exhibited by the car seats was examined in association with the installation method (lower anchors or seat belts).

When all equipment is present for lower anchor installation, individuals can choose whether to install car seats with lower anchors or seat belts. When this choice is present, individuals chose lower anchor installation significantly more often than they chose seat belt installation.

Drivers of vehicles with lower-anchor-installed car seats do not differ from those with seat-belt-installed car seats by age, gender, or race. The car seats themselves are not significantly older or newer. Driver confidence, however,

is associated with lower anchor installation: Drivers who were very confident in the correct installation of the car seat were more than twice as likely to have a car seat installed using the lower anchors than seat belts, compared to drivers who were not confident.

Car seats installed with lower anchors are associated with less lateral movement than car seats installed using seat belts. This holds true across and within seat types.

Background

When installing a car seat, people must decide how to secure the seat to the vehicle. They must choose a method of attachment, locate the components on both the vehicle and the car seat, and accomplish a secure installation of the car seat into the seating position in the vehicle.

Most vehicles manufactured since 2002 include lower anchors and tether anchors for installation of car seats. The lower anchors and tethers system is intended to offer a number of benefits for child restraint installation. Among other advantages, lower anchor use was intended to simplify installation, provide solid anchors for attachment, and allow more stability when seats were installed.

In the 2011 National Child Restraint Use Special Study, data was collected by certified child passenger safety technicians at 24 nationally representative primary sampling units (PSUs) across the Nation. Previously established by the National Automotive Sampling System, the PSUs are defined geographically and can be thought of as cities, counties, or groups of adjacent counties. The PSUs include urban, rural, and suburban environments in 17 States.

Observers approached vehicles that carried at least one child. They interviewed the driver and conducted detailed observations of the restraint use of one child per vehicle.

Observers collected information on the driver, the vehicle, the restraint status of the child, the child's car seat (if present), the installation method used, the specific use of the seat's features (e.g., harness placement and tightness), and

any misuses. Descriptive results are given in *Results of the National Child Restraint Use Special Study*, NHTSA Report No. DOT HS 812 142 (Greenwell, 2015).

The NCRUSS survey offers field observations of car seats that have been installed by individuals without expectation of inspection. That is, drivers did not plan or expect inspection, and the installation of the observed car seats was not biased by any expectation, desire for self-presentation, or other contaminating behavior.

The NCRUSS data set offers the opportunity to investigate real-world installation decisions; to examine characteristics of drivers who carry car seats installed using each method; and to measure the association between installation methods and lateral (side-to-side) movement.

Research Questions

When either installation method is possible, are lower anchors or seat belts used more often? Do installation decisions vary when using different car seat types (rear-facing infant, rear-facing convertible, forward-facing)?

What driver characteristics predict lower anchor installation? Which drivers are more likely to have car seats installed with lower anchors (rather than the seat belt) when either installation method is possible? Do they differ by age, gender, or race? Are they using a newer device than those who install using seat belts? Are they more confident in their installation?

Is lower anchor use associated with less lateral movement? That is, when lateral movement is measured, do car seats installed with lower anchors move less or more than restraints installed using the seat belt?

Installation Methods

Along with other detailed information, observers recorded the installation method used to secure the car seat in the vehicle. That is, observers recorded whether the car seat was installed using lower anchors or with the seat belt; and whether the tether was used, if applicable.

All car seats could be installed using the seat belt. However, use of the lower anchor and tether system was possible only when the following features are present:

- The seating position in the vehicle provided the lower anchors and tether anchor, and
- The child's car seat provided lower anchor connectors and tether.

When either of these features was absent, the car seat could not be installed using the lower anchors. The NCRUSS data was collected in 2011, when some of the vehicle fleet predated the 2002 lower anchor system requirement. Because

of this, some vehicles did not offer lower anchors for use. Similarly, some of the car seats predated the lower anchor requirement and did not provide lower anchor connectors.

It is important to note that in 2011, the top tether should always have been used when installing a forward-facing seat with lower anchors. Installation with the lower anchors while omitting the tether was a misuse with forward-facing car seats.

At the time of this publication, the tether should always be used with all forward-facing seats, regardless of installation method.

In the majority (63%) of rear- and forward-facing seats observed, the seating position offered lower anchors, and the car seat provided lower anchor connectors. These car seats could have been installed correctly using either seat belts or lower anchors and tether.

Driver Characteristics

Interviewers collected detailed information from the vehicle driver, including demographic information and the driver's confidence in the installation. Substantial information about the driver is available.

Drivers are responsible for the restraint status of vehicle occupants. However, it cannot be assumed that the driver performed the car seat installation in every case.

Lateral Movement

Secure installation should minimize lateral movement. Observers physically pushed and pulled the car seat side-to-side and measured the distance the seat shifted. Noted in half-inch increments up to three inches, lateral movement was recorded for each observed car seat.

Analysis

The NCRUSS sampling design was complex and resulted in sample weights that were applied to adjust the results to achieve national representativeness. All analyses used the weighted data reported in Greenwell (2015).

SAS version 9.4 software and its survey procedures were used to perform the analyses. These procedures take into account the complex survey design used to collect the data and simple random sampling since the sampling design affects both the calculation of the point estimates and the standard errors of the estimates. The sampling weights affect the calculation of the point estimates and the stratification and clustering affect the calculation of the standard errors.

The survey design for the NCRUSS includes 24 primary sampling units (PSUs) and 12 strata and produced sampling weights. Three variables are included in the NCRUSS

dataset to specify the sample design and were used to generate weighted estimates with standard errors using SAS survey procedures. The significance level was $p < 0.05$ for the analyses.

Rear-facing infant seats, rear-facing convertible seats, and forward-facing seats were included for analysis, when they used either lower anchors or seat belts for installation. Forward-facing seats were included for analysis when installed either correctly with the tether, or incorrectly without the tether. No rear-facing infant seats were installed with a tether, but 8 percent of rear-facing convertible seats had been incorrectly installed using the tether and were excluded from analysis. Forward-facing seats were excluded if they were installed using the tether only, with no lower anchor or seat belt use. Booster seats were excluded from analysis. Car seats with unknown means of attachment (1% of rear facing infant seats, 1% of rear-facing convertible seats, and 3% of forward-facing seats) were excluded as well. A few car seats (2%) had been installed using both seat belts and lower anchors. These cases were excluded from the analysis.

Installation Decisions

When a seating position provides both a seat belt and lower anchors AND the car seat possesses the capability for installation using either the seat belt or lower anchor straps, individuals must choose whether to install the device using the seat belt or lower anchors. That is, individuals can choose either installation method. Did they choose one method significantly more often than the other? Did that method hold true within seat types? For forward-facing car seats, seats could have been installed correctly with the tether or incorrectly without the tether. Within tether use, were forward-facing car seats installed more often using one method? Within tether non-use, were forward-facing car seats installed more often using one method over the other?

Comparisons of installation methods were made using the Rao-Scott chi-square test, a design-adjusted version of the Pearson chi-square test appropriate for handling complex survey data. The Rao-Scott chi-square test generates an F statistic, which is reported here.

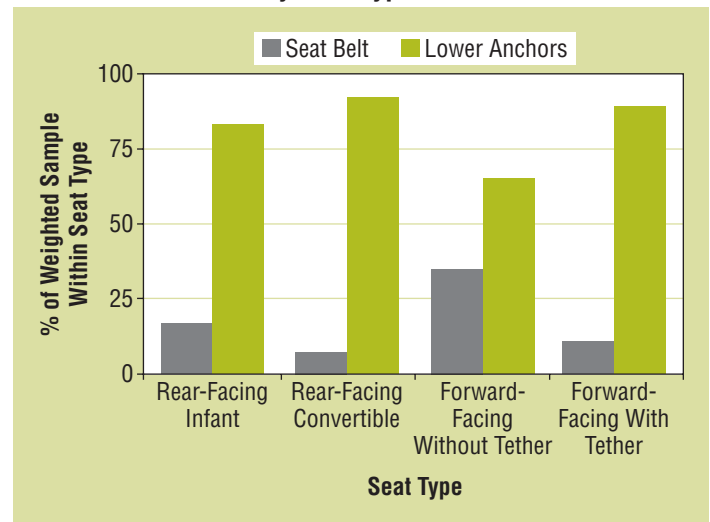
For all rear-facing and forward-facing car seats equipped with lower anchors, where individuals could choose the installation method, they choose to install the car seat using lower anchors rather than the seat belt significantly more often, $F(1, 12)=38.02$, $p < .05$, design correction=3.53.

Within each car seat type, the predominance of lower anchor installation method holds true. For rear-facing infant seats, lower anchors were used more often than seat belts, $F(1,12)=16.31$, $p < .05$, design correction=3.54. For rear-facing convertible seats, again lower anchors were used more often, $F(1, 12)=20.74$, $p < .05$, design correction=2.71.

Forward-facing car seats could be installed correctly with the top tether or incorrectly without the top tether. Within forward-facing car seats that did not use the tether, seats were installed using lower anchors more often than seat belts, $F(1, 12)=4.75$, $p < .05$, design correction=6.51. Within car seats that exhibited top tether use, seats were installed using lower anchors more often than seat belts, $F(1, 12)=246.95$, $p < .05$, design correction=1.29.

Both across and within seat types, car seats were installed using lower anchors more often than seat belts. See Figure 1.

Figure 1
Installation Methods by Seat Type



Driver Characteristics and Age of Car Seat

Given that some car seats were installed using seat belts, while most were installed using lower anchors, did characteristics of the drivers vary with installation method? Are certain drivers more likely to have car seats installed with lower anchors as compared to seat belts? Are older car seats more likely to be installed with lower anchors or seat belts?

Potential predictors of lower anchor use included the following.

- Driver Age
- Driver Gender
- Driver Race
- Driver Confidence in Correct Installation
- Age of Car Seat

A survey logistic regression (SAS PROC SURVEYLOGISTIC) tested each predictor's relationship to the installation method (lower anchor or seat belt). Driver age, driver gender, driver race, and age of the car seat were not significant predictors of the installation method.

However, driver confidence in the correct installation of the car seat was found to be a significant predictor of the installation method. Driver confidence was reported on a scale from 1 to 5, with 1=Not Confident and 5=Very Confident. The odds of installation with lower anchors rather than seat belts were 2.15 times higher for drivers who reported that they were very confident that the seat was installed correctly compared to drivers who reported that they were not confident that the seat was installed correctly ($t(12)=3.03$, $p<0.05$; Odds Ratio Point Estimate for 1 - Very Confident vs. 5 - Not Confident=2.15, 95% CI=0.27-17.22).

Lateral Movement

Secure installation seeks to minimize lateral movement. Was the choice of installation method associated with the amount of lateral movement? That is, were lower anchors associated with less (or more) lateral movement than seat belt installation?

Means were compared with SAS Least Square Means using PROC SURVEYREG. Because SAS survey procedures account for the design effects that result from the stratification and clustering used in the complex survey design, the degrees of freedom denominator for F tests and the degrees of freedom for t-tests (12) corresponds to the number of clusters (24) minus the number of strata (12). The degrees of freedom numerator for F tests remains the more familiar number of categories minus 1.

When examining all cases *regardless of the availability of lower anchors or lower anchor connectors*, seats installed with lower anchors were associated with less lateral movement than those installed using seat belts, $t(12)=10.71$, $p<.05$, standard error=0.08.

However, not all these seats and seating positions offered a choice to the installer: perhaps seating positions which lack the lower anchors are different from those with lower anchors. Alternatively, perhaps car seats without lower anchor connectors differ from those with the connectors.

All subsequent analyses include only those cases with available lower anchors in the seating position and lower anchor connectors on the car seat.

When examining only those seats that offer all equipment necessary for either installation method, seats installed with lower anchors are associated with less lateral movement than those installed using seat belts ($t(12)=5.65$, $p<.05$, standard error=0.16).

Still examining only those seats that offer all equipment necessary for either installation method, seat types were separated for analysis.

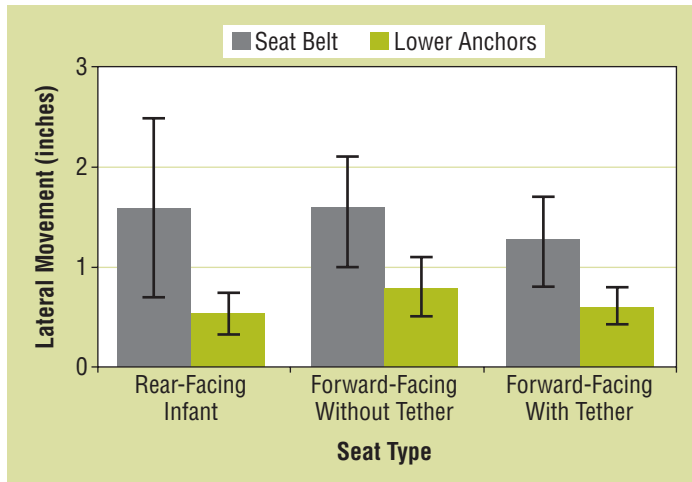
Within rear-facing infant seats, lower anchor installation was associated with less lateral movement than seat belt installation ($t(12)=2.50$, $p<.05$, standard error=0.416). The difference in average lateral movement between the two installation methods was 1.04 inches (95% CI=0.14-1.95).

Within the rear-facing convertible seats, only nine cases were installed using seat belts. These are too few cases to allow discernment of a meaningful statistical relationship, yet the means show the same pattern as the other seat types (Seat Belt Installation $\bar{M} = .55$ inches, Lower Anchor Installation $\bar{M} = .38$ inches.)

Forward-facing seats were again separated by tether use. Within forward-facing seats without tether use, lower anchor installation was again associated with less lateral movement than seat belt installation ($t(12)=3.20$, $p<.05$, standard error=0.25). The difference in average lateral movement between the two installation methods was 0.80 inch (95% CI=0.26-1.35).

Within forward facing seats that utilized the tether, lower anchor installation was similarly associated with less lateral movement than seat belt installation ($t(12)=3.79$, $p<.05$, standard error=0.18). The difference in average lateral movement between the two installation methods was 0.68 inch (95% CI=0.29-1.06).

Figure 2
Lateral Movement by Seat Type and Installation Method



Error bars are 95% confidence intervals.

Across and within seat types, seats installed with lower anchors are associated with less lateral movement than those installed using seat belts (see Figure 2).

Limitations

Causality cannot be inferred from this data. For example, we cannot conclude that lower anchor installation caused the associated reduction in lateral movement. Methodologically and statistically, causality cannot be determined.

Conclusions

Car seats installed with lower anchors showed less lateral movement than those installed with seat belts. This held true across and within car seat types. When the equipment is present for either method of installation, lower anchors were used more often. Drivers who were very confident in the correct installation of the car seat were more than twice as likely to have a car seat installed using the lower anchors rather than seat belts.

References

Greenwell, N. K. (2015, May). Results of the National Child Restraint Use Special Study (NCRUSS) (Report No. DOT HS 812 142). Washington, DC: National Highway Traffic Safety Administration. <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812142>

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