NASS-CDS Analysis of High Retention Seat Performance in Rear Impacts

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Purpose: A recent study used the Fatality Analysis Reporting System (FARS) to determine the safety performance of high retention seats in fatal rear impacts. The odds of fatal injury were reduced 46.3% (95% confidence interval [CI], 39.3–52.4, \( z = 9.982, P < .0001 \)) with high retention seats. This study extends the earlier one by establishing an exposure group of nonfatal occupants in towaway crashes using NASS-CDS.

Methods: The 2001–2008 NASS-CDS was analyzed for rear impacts of 1992 to 2008 model year GM vehicles with high retention or baseline seats using the same search strategy as in FARS. Injuries were analyzed by severity (Maximum Abbreviated Injury Scale [MAIS]). The number of fatalities from FARS and number of nonfatal occupants from NASS-CDS were used to determine the risk for fatal injury in towaway crashes with 5–7 o’clock principal direction of force (PDOF). The odds ratio for fatal injury and the change in fatality risk were determined with \( \pm 95\% \) confidence intervals, \( z \)-statistics, and significance levels. Injury risks were also determined using NASS-CDS.

Results: Based on 2001–2008 FARS and NASS-CDS, the fatality risk was 0.21% in high retention seats and 0.39% in baseline seats in 5–7 o’clock towaway crashes. The odds for fatality were 46.8% (95% CI, 39.8–53.0, \( z = 10.001, P < .0001 \)) lower with high retention seats. There was a higher trend for lower serious-to-critical injury in high retention seats than baseline seats in NASS-CDS. Six electronic cases were available in NASS-CDS with fatal injury in high retention seats. Only one involved the seat performance as a factor in the fatality, a 72-year-old belted female in a 14 mph rear delta \( V \) impact who experienced fractures of the thoracic spine. Her upper body likely wrapped around the upright seatback.

Conclusions: High retention seats significantly reduced the odds for fatal injury in towaway crashes with 5–7 o’clock PDOF. There was a trend for lower serious-to-critical injury risks, but more data are needed to determine significant differences.

Keywords: rear crashes, fatalities, seats, injury risks

Introduction

Starting in 1997, GM introduced high retention seats in new model vehicles to improve rear impact safety. The seats allowed the occupant to pocket into the seatback by an open seatback design and strong seat frame while still allowing the seatback to yield rearward in rear impacts. The first high retention seats were introduced in the 1997 Pontiac Grand Prix, 1997 Chevrolet Malibu, and other 1997 models. The GM vehicle fleet was transitioned to high retention as new models were developed. The transition occurred from 1997 to 2004 and involved more than 27 different high retention seats in GM vehicles. In this study, high retention seats were compared to baseline (earlier) GM seats. Both the baseline and high retention seats were designed to yield and absorb energy when loaded. High retention seats were designed with a stronger perimeter frame and higher and more forward head restraint (Viano 2002, 2008).

Viano (2003) reported on the initial 4-year safety trends using the 1991–2000 Fatal Analysis Reporting System (FARS). The reduction in odds of fatal injury based on seat type was 30.4% (95% CI, 0.9–51.1, \( z = 10.001, P < .0001 \)). Viano and Parenteau (2015) updated the earlier study by adding 8 years of FARS data. The 2001–2008 FARS was analyzed for rear impacts of 1992 to 2008 model year GM vehicles that transitioned to high retention seats. The fatality risk was 16.6% \( \pm 1.5\% \) (95% confidence interval) in vehicles with high retention seats and 27.1% \( \pm 1.0\% \) in vehicles with baseline seats based on 9,570 drivers and right-front passengers in fatal rear impacts. The reduction in odds for fatal injury was 46.3% (39.3–52.4%, 95% confidence interval) with high retention seats and it was statistically significant with \( z = 9.982, P < 0.0001 \). They found that the new generation of yielding seats had significantly improved occupant safety in rear impacts.

One of the weaknesses of the FARS-only studies was the lack of an exposure group involving nonfatal crashes.
study extended the earlier ones by establishing an exposure group of nonfatal occupants in towaway crashes using NASS-CDS. It used the census data on fatalities from FARS and the exposure data from NASS-CDS using the same search strategy to explore changes in risk with the high retention seats in rear direction of force crashes. Fatality risk was determined using the number of fatalities from FARS divided by the nonfatal occupant exposure in NASS-CDS using the same vehicle models and years of data. The second objective was to analyze the available NASS-CDS electronic case files for fatal injuries to occupants in high retention seats. The cases were evaluated for trends and areas of further improvement in seat design.

Methodology

**NASS-CDS Data**

NASS-CDS is a stratified sample of crashes that are prospectively selected for in-depth investigation. Most of the vehicles are towed from the scene because of damage. The data include information from NASS crash investigation teams, vehicle registration, medical records, police reports, and interviews. In this study, the data were extrapolated to national estimates using weighting factors provided by NHTSA. The 2001–2008 NASS-CDS was used to study front-seat occupants irrespective of belt use in selected GM light vehicles (≤ body type 49) with model years 1992 to 2008. Vehicles were selected by make and model to compare with the same GM passenger cars and SUVs, vans, and pickup trucks in the earlier studies of FARS; the selection criteria have been provided previously (Viano 2003; Viano and Parenteau 2015).

**Definitions**

Rear direction crashes were defined by the principal impact (DOF1) variable equal to 5, 6, and 7 o’clock. Rollovers were excluded (Rollover ≤ 0). A separate study of NASS-CDS was conducted for rear crashes where the greatest damage was to the rear of the vehicle (GAD1 = B). Rollover collisions were again excluded (Rollover ≤ 0). The following refined the search to front-outboard occupants:

- Drivers: Occupants with role = 1.
- Front-seat passengers: Occupants in seat position 11 or 13 and with role = 2.

**Injury Severity**

Injury severity of the occupant was assessed using the Maximum Abbreviated Injury Scale (MAIS) and the “TREATMNT” variable. MAIS represents the assessment of life-threatening injuries at the time of first medical evaluation and not long-term consequences. It ranges from MAIS 0 to 9, where MAIS 9 is an injury with unknown severity. MAIS 4–6 represents a severe-to-unsurvivable injury. Fatality was also used to determine whether the occupant died of injuries in the accident. To define a fatality (F), the following variables were used:

- Treatment: TREATMNT = 1 because it means that the occupant was fatally injured and not transported to the hospital.
- ISS 75: Injury Severity Score = 75 represents a fatality.
- Police injury severity: INJSEV = 4 represents a fatality from police rating.

Because fatalities can occur at any MAIS level, severely injured occupants were defined as those with MAIS 4–6 or fatality. The shorthand notation for this is MAIS 4+F.

**Weighted Data**

National estimates for the number of occupants and injuries in each category were made using the ratio weight (ratwgt) variable in NASS-CDS. All calculations were based on weighted values.

**Standard Errors**

NHTSA recommends using ratwgt and psustrat to estimate standard errors (SE) using the following command string in SAS: proc surveyfreq data = ; strata psustrat; cluster psu; weight ratwgt. NHTSA further recommends that only “if–then” statements be used. SEs were determined using the SAS procedure “surveyfreq” accounting for psu and weight factors according to NHTSA’s latest recommendation (NHTSA 2008).

**NASS-CDS Analysis**

The risk of injury and fatality was determined using NASS-CDS data by dividing the number of serious injuries or deaths by the number of occupants with known injury status, MAIS 0–6 or F (MAIS 0+F). Occupants with unknown injury were removed from the exposure group used to determine risk. Standard errors for injury rates were determined.

**NASS-CDS Electronic Cases**

All electronic cases involving fatal injury to a front-seat occupants in a GM vehicle with high retention seats and 5–7 o’clock Principal direction of force (PDOF) were downloaded from NHTSA (www.nhtsa.dot.gov). The cases were analyzed for crash circumstances and occupant injury. Photographs of the vehicle and interior were reviewed for trends and potential areas of improvement of high retention seats.

**FARS Data**

FARS is a census database that includes motor vehicle crashes resulting in the death of a vehicle occupant or nonmotorist within 30 days of the crash. In the previous study, the data were obtained for calendar years 2001–2008 and the number of fatally and nonfatally injured drivers and right-front passengers were determined (Viano and Parenteau 2015). Occupants involved in rear direction crashes with GM (18 ≤ MAKE < 24) light vehicles (0 < BODY_TYP < 50) and model years 1992 to
2008 were determined. There were 35 types of passenger cars and 22 types of SUVs, vans, or pickup trucks.

**Definitions**

Rear crashes were defined by the PRINCIPAL-IMPACT (IMPACT2) variable equal to 5, 6, and 7 o’clock. Rollovers were excluded (ROLLOVER ≤ 0). The following refined the search:

- Drivers were defined using the person type (PER_TYP = 1) variable.
- Right-front passengers were defined using seating position (SEAT_POS = 13) variable.
- Fatality was defined using the injury severity variable (INJ_SEV = 4).
- Nonfatalities were determined by subtracting the number of fatalities from the total exposed.

**FARS and NASS-CDS Analysis**

The odds for fatal injury was determined by taking the number of occupants with fatalities from FARS and dividing by the number of nonfatally exposed occupants including unknown injury severity in towaway crashes from NASS-CDS. The same search string was used in FARS and NASS-CDS. The risk for fatality was determined by taking the number of fatalities in FARS and dividing by the number of nonfatally injured occupants in NASS-CDS plus the fatalities from FARS. The significance of the difference between vehicles with high retention and baseline seats was determined using MedCalc statistical software (Version 13.0.2, Ostend, Belgium). This included the z-statistic and P value for the odds ratio and relative risk calculations using the weighted NASS-CDS data (Sheskin 2004). The 95% confidence interval for injury and fatality risks was determined using VassarStats Statistical Computation with a correction for continuity using the weighted NASS-CDS data (Newcombe 1998).

**Results**

Table 1 shows drivers and right-front passengers in crashes where the most harmful event was a 5–7 o’clock PDOF without rollover in the 2001–2008 NASS-CDS for the selected GM vehicles. There are 2 groups, those vehicles with baseline seats and other vehicles with high retention seats. The specific vehicles and model years are detailed in the Appendix of Viano and Parenteau (2015). The 8 years of NASS-CDS data involve an exposure of 254,230 nonfatally injured occupants in baseline and 162,921 in high retention seats. Table A1 (see online supplement) provides a separate analysis of NASS-CDS showing drivers and right-front passengers in crashes where the greatest area of damage was to the rear (General Area of Damage (GAD) = Back (B)) without rollover in the 2001–2008 NASS-CDS for the selected GM vehicles.

Figure 1 shows the risk of serious injury (MAIS 3), critical or more severe injury (MAIS 4+), critical to fatal injury (MAIS 4+F), and fatal injury (F) in baseline and high retention seats. There was an 83% reduction in fatality risk with high retention seats compared to baseline seats. There was a trend for a reduction in risk for MAIS 4+ and MAIS 4+F injuries but the standard errors overlap, so the trend is not statistically significant.

**Table 1.** 2001–2008 NASS-CDS crashes with 5–7 o’clock PDOF and 1992–2008 model year GM vehicles with baseline or high retention seats (n: sample size, se: standard error)

| MAIS | Baseline seats | High retention seats |
|------|----------------|----------------------|
|      | Unweighted | Weighted | SE | Unweighted | Weighted | SE |
| 0    | 168        | 121.513 | 26.888 | 138        | 77.533 | 14.744 |
| 1    | 250        | 129.408 | 42.439 | 188        | 81.934 | 20.564 |
| 2    | 15         | 1.918   | 1.233  | 13         | 2.731  | 932 |
| 3    | 10         | 258     | 127    | 2          | 259     | 237 |
| 4+   | 6          | 1.133   | 850    | 4          | 463     | 298 |
| 4+F  | 25         | 2.108   | 1.071  | 10         | 570     | 301 |
| F    | 19         | 975     | 567    | 6          | 107     | 40 |
| Unknown | 27   | 4.052   | 1.630  | 22         | 10.929  | 5.551 |
| Total | 495       | 259.256 | 68.396 | 373        | 173.956 | 34.841 |
Table 2. Change in odds of fatal injury in 5–7 o’clock PDOF crashes with high retention seats compared to baseline seats in GM vehicles

|                  | High-Retention | Baseline Seats | Odds Reduction | −95%  | +95%  | Risk Reduction | −95%  | +95%  |
|------------------|----------------|----------------|----------------|-------|-------|----------------|-------|-------|
| **FARS and NASS-CDS**          |                |                |                |       |       |                |       |       |
| 2001–2008 (Current Study)       |                |                |                |       |       |                |       |       |
| Fatal*            | 337            | 989            | 46.8%          | 39.8% | 53.0% | 46.7%          | 39.7% | 52.9% |
| MAIS 0-6**        | 162,921        | 254,230        | z = 10.001, P < 0.0001 |       |       | z = 9.998, P < 0.0001 |       |       |
| Fatal*            | 337            | 989            | 41.5%          | 33.8% | 48.3% | 41.4%          | 33.7% | 48.2% |
| MAIS 0-6***       | 125,658        | 215,603        | z = 8.496, P < 0.0001 |       |       | z = 8.493, P < 0.0001 |       |       |
| **FARS only analyses**        |                |                |                |       |       |                |       |       |
| 2001–2008 (Viano, Parenteau 2015) |                |                |                |       |       |                |       |       |
| Fatal              | 337            | 989            | 45.1%          | 37.1% | 52.2% | 37.8%          | 30.5% | 44.4% |
| Non-Fatal          | 1,743          | 2,806          | z = 8.570, P < 0.0001 |       |       | z = 8.358, P < 0.0001 |       |       |
| 1991–2008 (Viano, Parenteau 2015) |                |                |                |       |       |                |       |       |
| Fatal              | 378            | 1,977          | 46.3%          | 39.3% | 52.4% | 38.6%          | 32.1% | 44.4% |
| Non-Fatal          | 1,893          | 5,322          | z = 9.982, P < 0.0001 |       |       | z = 9.598, P < 0.0001 |       |       |
| 1991–2000 (Viano 2003)        |                |                |                |       |       |                |       |       |
| Fatal              | 41             | 988            | 30.4%          | 0.9%  | 51.1% | 23.9%          | −0.4% | 42.3% |
| Non-Fatal          | 150            | 2,516          | z = 2.011, P = 0.0443 |       |       | z = 1.934, P = 0.0531 |       |       |

*Fatal from FARS with PDOF 5-7; **MAIS 0-6 from NASS-CDS with PDOF 5-7; ***MAIS 0-6 from NASS-CDS with GAD = B.

NASS-CDS using the same years and search strategy. The risk of fatality was 0.21% in high retention seats and 0.39% in baseline seats. There was a 46.8% (95% CI, 39.8–53.0) reduction in odds for fatal injury with high retention seats. The reduction was statistically significant with z = 10.001, P < .0001. This approach to determining the fatality risk gives a reduction in odds of fatal injury that closely matches the results from the FARS only study by Viano and Parenteau (2015). A separate analysis of NASS-CDS was conducted using impact location, GAD1 = B (back) to determine the occupant exposure. The resulting reduction in odds for fatal injury was similar to that using 5–7 o’clock PDOF. FARS does not allow an analysis using impact location or GAD.

**Case Analysis**

Table 3 summarizes the 6 fatalities in high retention seats that were available from the electronic files of the NASS-CDS. Each impact in the collision sequence has a Collision Deformation Classification designation. The data are summarized for cases where the most harmful event was in the 5 to 7 o’clock PDOF. Figure 2 shows photos of the vehicle damage and interior. There is one photo of the vehicle and interior for each of the 6 fatal cases. A more complete description of each case and more photographs are provided in Appendix A2 (see online supplement). The following provides a short narrative of each case:

1. 2001–9–154A: The collision was a sideswipe into a guardrail, spinout, and rear impact. The unbelted 19-year-old male passenger moved between the front seats and ejected out the rear window in a 7 o’clock PDOF and 30 mph delta V to the rear (GAD1 = B).
2. 2002–73–157B: The vehicle slowed to a stop to make a left turn. It was impacted in the rear with a 6 o’clock PDOF and 32 mph delta V to the rear (GAD1 = B). The vehicle then yawed 180° in front of an oncoming heavy truck and there were 2 additional impacts to the right side (GAD1 = R). The 22-year-old unbelted female passenger partially ejected, impacting exterior objects, causing skull fractures and brain injuries.
3. 2002–12–115A: The rear impact occurred while the vehicle was stopped to make a left turn. The driver was a 72-year-old female and was belted. She died from T7–T8 spine fracture–dislocation, multiple rib fractures, and spinal cord injury from loading her seatback. The driver seat moved to a mid-range position. The delta V was 14 mph with 6 o’clock PDOF to the rear (GAD1 = B).
4. 2003–6–99A: The vehicle experienced a severe rear impact and then left-side impact into a utility pole. The driver experienced lung lacerations and contusions, left hemothorax, multiple left-side rib fractures, and spleen laceration from the left B-pillar. The 28-year-old male driver was belted in the 26 mph delta V rear impact (GAD1 = B) at 7 o’clock PDOF and 21 mph delta V left-side impact into the driver door at 10 o’clock (GAD1 = L, left).
5. 2004–74–14A: The vehicle lost control, yawed about 180°, and struck a pole on the driver’s door. The 21-year-old female driver was belted and experienced left lung lacerations and contusions, left hemothorax, multiple left-side rib fractures, and spleen laceration from the left B-pillar. The pole impact
Table 3. Driver and right-front passengers killed in 5–7 o’clock PDOF crashes and high retention seats

| Year | 2001 | 2002 | 2002 | 2003 | 2004 | 2005 |
|------|------|------|------|------|------|------|
| PSU  | 9    | 73   | 12   | 6    | 74   | 9    |
| ID#  | 154A | 157B | 115A | 99A  | 14A  | 185A |
| Ratwgt| 22.4 | 21.3 | 24.4 | 20.3 | 8.0  | 10.6 |
| MY   | 2002 | 1998 | 2001 | 2002 | 2001 | 2006 |
| Make/Model | Malibu | Grand Prix | Montana | Grand Prix | Malibu | Impala |

| # impacts | 2 | 3 | 1 | 2 | 1 | 5 |
| CDC | 1) 12FDLW1 | 2) 07BDEW6 | 1) 06BDEW2 | 1) 06BDEW7 | 1) 07LPAW04 | 1) 08LBLW02 |
| | 2) 03RF EW3 | 3) 05RZAW3 | 1) 06BDEW2 | 2) 10LPEW4 | 2) 07LPAW04 | 2) 07LPAW04 |
| GAD, PDOF, Delta V (mph) | 1) F, 12, unk | 1) B, 6, 32 | 1) B, 6, 14 | 1) B, 6, 26 | 1) L, 7, 22 | 1) L, 8, unk |
| | 1) R, 3, unk | 2) R, 3, unk | 1) L, 10, 21 | 1) L, 7, 21 BES | 3) R, 4, unk |
| # Occupants | 3 | 2 | 1 | 1 | 1 | 1 |
| Occupant | P | P | D | D | D | D |
| Ejection | Y | P | N | N | N | N |
| Belt Use | N | N | Y | Y | Y | Y |
| Age (yrs) | 19 | 22 | 72 | 28 | 21 | 30 |
| Gender | M | F | F | M | F | M |
| Height (in) | Unk | 69 | 67 | 73 | 69 | 64 |
| Weight (lb) | Unk | 137 | 150 | 150 | 180 | 163 |
| Region with max injury | Unk | Head | T-spine | Chest | Chest | Chest |
| MAIS | F | 4F | 5F | 4F | 4F | 6F |
| Source | Unk | Exterior | Seat | Seat | Left B-pillar | Left B-pillar |

Ejection: Y: Complete, N: None, P: Partial, Occupant: D: Driver, P: Passenger, Belt Use: Y: Yes, Lap-Shoulder Belted, N: No, Unbelted.

was 7 o’clock PDOF directly to the left-side (GAD1 = L) with 22 mph delta $V$.

6. 2005–09-185A: The vehicle lost control, yawed about 180°, and struck a utility pole on the driver’s door. The driver was a 30-year-old male and belted. He experienced laceration of the heart, torn aorta, and multiple left-side rib fractures from the B-pillar. The PDOF was 7 o’clock directly to the left-side (GAD1 = L) with 21 mph barrier equivalent speed.

Fig. 2. Fatal injury to occupants in high retention seats and crashes with 5–7 o’clock PDOF.
In 2 of the cases, the unbelted occupant ejected from the front seat area and completely or partially out of the vehicle. The fatal injury was related to vehicle yaw and movement causing the unbelted occupants to eject and experience fatal injury. The seat was not a factor in these 2 fatalities. In 3 others, the collisions involved the left side of the vehicle with the B-pillar intruding and loading the left side of the driver. The loading caused fatal injury from the B-pillar in 2 cases and B-pillar deforming the seat into the driver in the other. The seat was not a factor in these fatalities.

The last case was the 72-year-old female in a relatively minor rear impact. Her head and upper body apparently displaced off the seatback while her pelvis was restrained in the seat by the lap belt. She experienced extension forces on the spine resulting in fatal injuries. The strength of the seat allowed it to remain upright and the seatback acted like a fulcrum to cause the extension fractures of the spine. The strength of the seatback was a factor in her injury.

Discussion

A number of different methods have been used to evaluate the effectiveness of high retention seats in lowering fatality risks in rear impacts. The reduction in odds of fatality is about 40–47% based on fatal and towaway crashes (Table 2). The reductions are statistically significant, indicating that the new generation of yielding seats is an effective safety measure compared to earlier designs. There was a trend for lower serious-to-critical injury risks, but there are too few cases in NASS-CDS for the trend to be significant.

A review of electronic cases of fatal injury in NASS-CDS with high retention seats found no obvious pattern of fatality associated with the seat performance, except one case, which demonstrated 2 issues with a fatal spinal fracture-dislocation in a 72-year-old female. First, her rear impact was a 14 mph delta V. Viano and Parenteau (2008) studied serious injuries in very low (<15 mph delta V) and very high (≥35 mph) rear impacts. They found that 14% of serious injuries occurred in crashes below 15 mph delta V. Nine cases were available for review including the current case. Most involved older occupants, some of whom had stenosis of the cervical spine. These occupants experienced spinal cord injury and paralysis with or without fracture of the cervical spine. Frailty of the cervical spine and preexisting spinal degeneration were likely factors in the very-low-speed crash injuries. There was no information about preexisting conditions of the spine of the 72-year-old female, but age has been shown to be a factor for compression fractures of the lumbar spine (Kaufman et al. 2013). Second, she experienced fracture-dislocation of the thoracic spine and the driver’s seat remained upright. Viano (2011) reported on 4 crashes with lap–shoulder-belted occupants who experienced fracture-dislocation of the thoracic spine and paraplegia in a severe rear impact. The seatbacks remained upright in the crash and the occupant’s pelvis was restrained by the lap belt and pocketing into the perimeter frame. The rear impact caused the vehicle to yaw and move in a manner so that the occupant’s upper body displaced off the side or top of the seatback. The seatback frame acted like a fulcrum as the unsupported head and upper body was accelerated forward, causing extension of the spine around the seatback frame as the head and shoulders moved rearward of the frame. In each case, there was fracture-dislocation of the thoracic spine in extension with spinal cord injury resulting in paraplegia. Two occupants were overweight and 2 were obese, which increased inertial loads on the spine.

The 72-year old-female was not obese. She was 5’7” tall and weighed 150 lb. Her body mass index was 23 kg/m². However, she did experience an extension fracture of the spine. This case raises 2 issues with seats that remain upright in rear impacts. Though a design goal of high retention seats was to increase occupant retention, it was also a goal to maintain support of the head, neck, and torso. It seems that there are some crash circumstances with an oblique rear direction of force, vehicle yaw, and pitch that can result in the upper body being unsupported while the occupant is being accelerated forward. In these cases, the load applied to the occupant exceeded the spine tolerance and resulted in spinal fractures, dislocation, and cord injury with disability and death. In most of the cases, the occupant is belted and the lap belt and seat hold the pelvis while the spinal injury occurs. This is obviously an area needing further research and study.

Based on the analysis of serious-to-fatal injury in NASS-CDS, high retention seats have improved occupant protection in rear impacts. Some issues have been identified in field accidents that deserve further attention in an effort to continuously improve the safety performance of seats.

Limitations

There are a number of limitations to the type of study conducted using FARS and NASS-CDS. Because this study considered only 5–7 o’clock PDOF crashes, the data were not subdivided by restraint use or the inflation of side protection airbags and curtains. One of the fatal cases 2005–9–185A involved a chest injury from the intruding B-pillar. The side airbag and curtain deployed.

PDOF is an important variable defining a crash. However, many accidents involve a varying direction of loading on the vehicle with yaw, roll, and pitch motions in the collision. Many of the collisions involved multi-impacts, which can influence occupant motion and risks of injury. The principal direction implies the direction of greatest force. In most of the fatal crashes, the collision forces are high enough to cause intrusion with override and underride. A separate analysis was conducted in NASS-CDS using GAD1 = B (general area of damage to the back). It identified the same high retention cases as the 5–7 o’clock PDOF but removed 2 of the 6 fatal cases listed in Table 3. The 2 cases were to the left side of the vehicle (GAD1 = L).

In this study, NASS-CDS data were used as a measure of exposure to assess the fatality risk in rear impacts. NASS-CDS mostly contains data on towaway crashes with about half the weighted sample uninjured in the crash. The risk
calculation is thus based on the number of fatalities divided by the number of towaway crashes by impact direction and seating position. Other databases, such as the General Estimates System (www.nhtsa.gov), could have been used because the General Estimates System is representative of all police-reported crashes. The authors decided to use NASS-CDS because relative risks are analyzed rather than true risks.

For 2001–2008, FARS identified 989 fatalities in baseline seats and 337 in high retention seats. Using the same search strategy and vehicles, the 2001–2008 NASS-CDS gave 975 ± 567 fatalities in baseline seat. This was based on 19 unweighted cases. The weighted number closely matched the census count in FARS. However, for high retention seats, NASS-CDS gave 107 ± 40 fatalities based on 6 unweighted cases. The number is much lower than the census. The difference could mean only one or 2 unweighted cases.

Supplemental Materials

Supplemental data for this article can be accessed on the publisher’s website.

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