

# VEHICLE INCOMPATIBILITY AFFECTS OCCUPANT EXTRICATION AFTER MOTOR VEHICLE CRASHES

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## ABSTRACT

Improvements in occupant extrication techniques are required due to enhanced safety features in modern vehicles. The research questions were focused on what force directions and what vehicle types, were most highly associated with an extricated occupant. Two national databases, FARS and CIREN were queried. Principal direction of force for the occupant vehicle and vehicle weight were used as delineating variables. From FARS data, the percentage of extricated occupants increased between 1993 and 2000. Left-sided crashes account for the highest percentage of occupants requiring extrication (18.8%) compared to occupants in rear crashes (lowest at 8.6%). Occupants in vehicles less than 2500 pounds were most often extricated (19.1%) compared to vehicles greater than 3500 pounds (lowest at 11.3%). From the CIREN database, for left-sided crashes, occupants required extrication 33.0% of the time when involved in truck-into-car crashes whereas car-into-car crash victims were extricated only 27.3%. These results imply an increased risk for extrication need for those occupants struck by a vehicle that is mismatched.

## INTRODUCTION

Hundreds of thousands of vehicle crashes occur on roadways every year. In many of these crashes the occupant(s) are injured or incapacitated to the extent that assistance is required to remove the occupant from the vehicle wreck. Extrication can be defined as the use of force to bend or remove a component of the vehicle structure to remove a patient from a vehicle wreck. Extrication of occupants from a vehicle after the crash is often conducted by the local fire and rescue teams that respond first to such an incident. Unfortunately, occupant extrication techniques and the risk of secondary injury to the motor vehicle crash victim during these procedures have received little attention in the scientific literature. A study from a regional level 1 trauma center that compared 102 patients requiring extrication with 20 patients that did not indicated

those requiring extrication had a higher incidence of brain injury and lower extremity injury, and were associated with a higher incidence of post-injury complications [Siegel, et.al. 1993]. This study also concluded that a significantly greater percentage of the injuries sustained by the patient group requiring extrication were attributed to intrusion of vehicle structures.

Despite the improvements in vehicle safety over the last decade, occupant extrication techniques have remained largely unchanged. The makeup of the vehicle fleet has also significantly changed over the last decade with significant increases in sales of SUVs and light trucks. To recommend changes and improvements to extrication procedures, it is necessary to characterize the vehicle crashes that are associated with the need for occupant extrication. The purpose of this study was to examine the trends associated with the need for occupant extrication after vehicle crashes. The research questions were focused on what force directions, what vehicle types, and whether struck or striking vehicles were most highly associated with an extricated occupant.

## METHODS

The US DOT Fatality Analysis Reporting System (FARS) was queried from years 1993 to 2001. Every car crash in the US with a fatality is reported in this database. The extrication variable was examined with respect to vehicle type and type of crash. Vehicle types were classified by both vehicle weight and class code (e.g., 2-door sedan, minivan, SUV, light truck). Crash types examined were frontal, right side, left side, and rear impacts. The number of victims involved in these crashes that required extrication were counted and evaluated with respect to the total number of occupants for each crash condition and vehicle type. Thus, "risk" of extrication was determined.

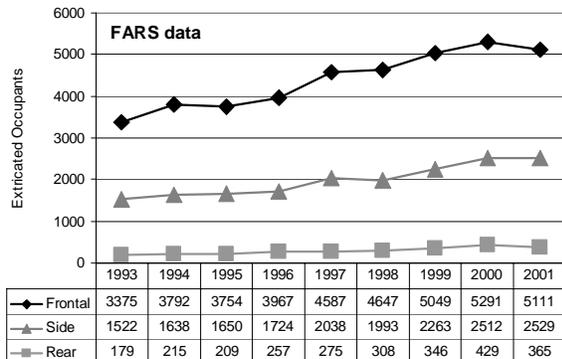
The US DOT Crash Injury Research and Engineering Network (CIREN) database was also queried for the extrication variable. The CIREN query was focused toward near side crashes. The CIREN database contains information not only on the crash variables but also detailed medical information on each case occupant. This database was also examined to determine the need for occupant extrication. The vehicle of the case occupant as well as the causal agent of the near side crash was examined. In other words, if the impacting agent was a vehicle, truck or passenger car, or a stationary object such as a pole or

tree. The type of collision was classified into four types: car-into-car, where a passenger car was the bullet vehicle and the case vehicle; truck-into-car, where a light-truck or SUV was the bullet vehicle and a passenger car was the case vehicle; car-into-other, where the case vehicle hit a pole or tree; and other, where some other combination of bullet and case vehicle occurred.

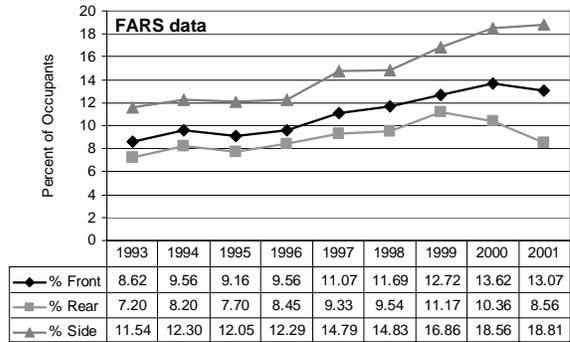
## RESULTS

From the FARS data, the trend in total number of occupant extrications increased from 1996 to 2000 (Figure 1). In general, the number of occupants that required extrication were involved in frontal impacts more than twice as often as those in side impact. This trend is reflective of the total number of frontal crashes that occur in relation to side crashes. To calculate the risk for occupant extrication, the number of extricated occupants was divided by the total occupants in a given category. This analysis demonstrates that the risk for occupant extrication is highest for side impact. The risk for occupant extrication increased from 12.3% in 1996 to 18.8% in 2001. The percentage of occupants requiring extrication from fatal vehicle crashes was 1.27 to 1.44 times higher for occupants in side compared to frontal impacts (Figure 2).

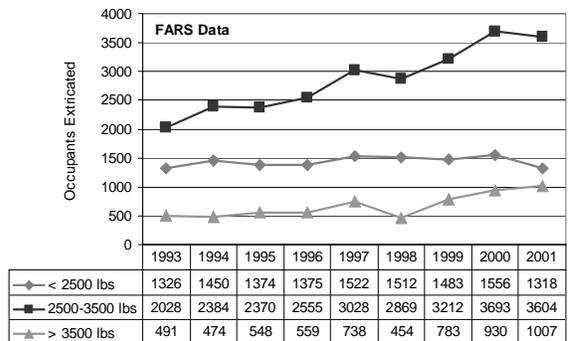
Also using the FARS database, occupant extrications were evaluated by vehicle weight (Figure 3). The total number of extrications for the 2500-3500 lb weight category increased from 2028 in 1993 to 3693 in 2001. The number of occupant extrications from heavier and lighter vehicles remained fairly constant in this time period. The risk for occupant extrication was calculated for each of the weight categories. The lightest vehicles (< 2500 lb) had the highest risk percentages for occupant extrication (Figure 4). For the years 1999 and 2000, the lighter vehicles (< 2500



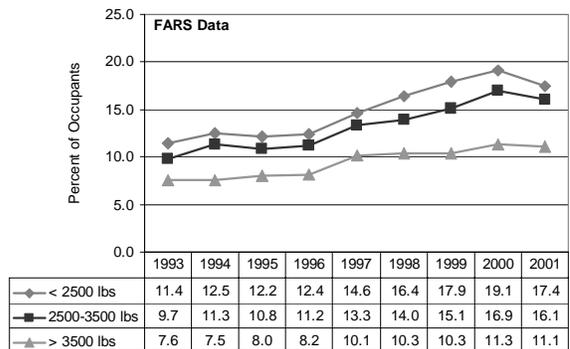
**Figure 1: Total number of occupants requiring extrication from fatal vehicle crashes (FARS data) by principal direction of primary impact.**



**Figure 2: Percentage of occupants requiring extrication from fatal vehicle crashes (FARS data) by principal direction of primary impact.**



**Figure 3: Total number of occupants requiring extrication from fatal vehicle crashes (FARS data) by vehicle weight.**



**Figure 4: Percentage of occupants requiring extrication from fatal vehicle crashes (FARS data) by vehicle weight.**

lb) had approximately 1.7 times the risk for occupant extrication than the heaviest vehicles (> 3500 lb).

The CIREN database analysis was focused on occupants involved in side impact collisions since the above FARS analysis demonstrated that this condition was the highest extrication risk. The

CIREN database produced 269 qualifying side impact crashes. Of the 269 case occupants in this set, 97 (36.1%) were extricated. Of the car-into-car crashes 27.3% of the case occupants required extrication. In contrast, for 33.0% of truck-into-car collisions the case occupant required extrication. The CIREN database also records the time of the extrication procedure. The average extrication time

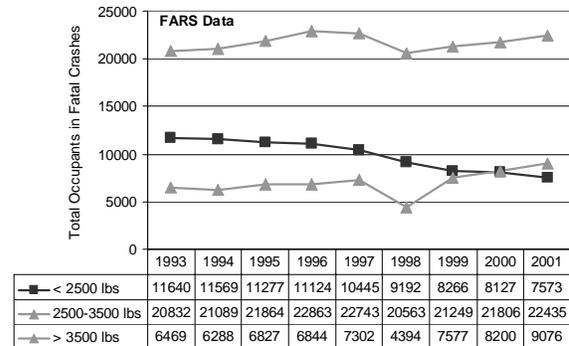
was 22 minutes with a range between 10 and 60 minutes.

## DISCUSSION

The objectives of this study were to characterize some of the variables that are associated with the need for occupant extrication after motor vehicle crashes. There was a general increasing trend from 1993 - 2001 in the total number of extrications that were conducted on occupants involved in fatal vehicle crashes. Occupants that were at highest risk for extrication were involved in side impact crashes and were in lighter weight vehicles. Extrication risk demonstrated a significant increasing trend between 1996 and 2001 for those occupants involved in a side impact fatal crash. Up to 18.81% of occupants in these crashes required extrication. For a given change in velocity, a side impact crash in general, will cause more intrusion into the occupant space than a frontal or rear crash. This result appears to be consistent with a previous study that directly associated increased occupant compartment intrusions with the need for extrication [Siegel, et.al. 1993].

Occupants that are in lighter weight vehicles have a consistently higher risk for extrication than those in heavier vehicles. After a steady rise in risk between 1996 and 2000, there seems to be a slight decrease in the need for extrication in the 2001 data. It should be noted that the total number of lighter weight vehicles involved in fatal vehicle crashes has been steadily decreasing over the last several years, while at the same time the number of heavier weight vehicles has been increasing during the same time period (Figure 5). This is probably reflective of the decreasing numbers of lighter weight vehicles on the road and the increasing number of SUVs and light truck vehicles.

Because of the changing vehicle fleet, and the FARS results of this investigation, the CIREN database was evaluated for trends in side impact crashes with vehicles that were mismatched. The CIREN database contains very detailed information on each case with over 900 data entries for each case occupant. Part of



**Figure 5: Total occupants involved in fatal vehicle crashes (FARS data) by vehicle weight.**

the inclusion criteria for CIREN cases is a victim with severe injuries (at least AIS=3) and admission to a regional level 1 trauma center. The advantage of this database is that it contains information on only later model vehicles. The information then, is directly relevant to describe emerging trends. For each of the side impact cases that were analyzed, the bullet vehicle and the case vehicle were classified either as a truck or passenger car.

The truck-into-car side impact scenario required a higher percentage of the case occupants to be extricated compared to car-into-car side crashes. This implies an increased risk for extrication need for those occupants struck by a vehicle that is mismatched. Clearly, other variables such as crash severity would need to be evaluated to more completely delineate the associated risks with vehicle incompatibility crashes.

This study represents one of only a handful of investigations into occupant extrication procedures and the associated factors. It has been documented that the extrication process involves high risk of additional injuries or aggravation of existing injuries to the victim of a motor vehicle crash [Ersson, et.al., 1999, Karbi, et.al, 1988]. The time for extrication to be completed is also a critical factor. A previous study that evaluated extrication times recommended procedures that would be less than 30 minutes [Wilkinson, et.al., 1996]. The CIREN center data demonstrates average times less than this but indicates some cases that required up to 60 minutes. The importance of the extrication procedure should not be underestimated. Additional studies that further document improvements to occupant extrication techniques should be encouraged.

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