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Comparison of pregnant and non-pregnant occupant crash and injury characteristics based on national crash data

Sarah Manoogian *

Bucknell University, One Dent Drive, Lewisburg, PA 17837, USA

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ABSTRACT

The objective of this study was to provide specific characteristics of injuries and crash characteristics for pregnant occupants from the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) database for pregnant women as a group, broken down by trimester, and compared to non-pregnant women. Using all NASS/CDS cases collected between the years 2000 and 2012 with at least one pregnant occupant, the entire pregnant data set included 321,820 vehicles, 324,535 occupants, and 640,804 injuries. The pregnant occupant data were compared to the characteristics of NASS/CDS cases for 14,719,533 non-pregnant females 13–44 years old in vehicle crashes from 2000 to 2012. Sixty five percent of pregnant women were located in the front left seat position and roughly the same percentage of pregnant women was wearing a lap and shoulder belt. The average change in velocity was 11.6 mph for pregnant women and over 50% of crashes for pregnant women were frontal collisions. From these collisions, less than seven percent of pregnant women sustained MAIS 2+ injuries. Minor differences between the pregnant and non-pregnant occupants were identified in the body region and source of injuries sustained. However, the data indicated no large differences in injury or crash characteristics based on trimester of pregnancy. Moreover, the risk of an MAIS 2+ level injury for pregnant occupants is similar to the risk of injury for non-pregnant occupants based on the total vehicle change in velocity. Overall this study provides useful data for researchers to focus future efforts in pregnant occupant research. Additionally, this study reinforces that more detailed and complete data on pregnant crashes needs to be collected to understand the risk for pregnant occupants.

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1. Introduction

Research has estimated that approximately 160,000 pregnant women are in motor vehicle crashes each year in the United States (Duma, 2011). While most of these crashes lead to no injury, it can be estimated that 160 pregnant women are killed in motor vehicle crashes and an additional 600–2600 fetuses are killed when the mother survives (Duma, 2011,b; Klinich et al., 1999a,b; Pearlman, 1997; Weiss, 1999). Since at least the 1980's, automobile crashes have been the largest cause of injury death for pregnant females and the leading cause of traumatic fetal injury mortality in the United States (Attico et al., 1986; Pearlman et al., 1990; Weiss and Strotmeyer, 2002). While the number of child deaths in motor vehicle crashes is decreasing, there is no evidence that adverse fetal outcome from motor vehicle crashes is declining with recent advancements in vehicle crashworthiness and restraint performance (Arbogast et al., 2009; Duma, 2011).

In addition to developing crash test dummies and computational modeling, researchers have focused on retrospective analysis of pregnant crash databases. To date, the most extensive reviews of significant factors for pregnant occupants in crashes have come from state records and a specialized crash database (Klinich et al., 2008; Vladutiu et al., 2013; Weiss, 2001). Using the recent state records from NC, Vladutiu et al. identified specific age, ethnic, and education groups with a high crash risk. Klinich et al. used the database obtained at the University of Michigan Transportation Research Institute (UMTRI) to relate the risk of adverse fetal outcome to crash severity, seat belt use, and maternal injury. A brief review of the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) database has been performed previously on various data sets with the most recent including data up to 2003 (Duma et al., 2006; Klinich et al., 1999b; Weiss, 1999). Primarily the early studies determined the exposure for crashes of women child bearing age to estimate the magnitude of the problem. The more recent Duma et al. study (2006) provided some insight into crash characteristics for pregnant occupants

* Tel.: +1 570 577 2778.
E-mail address: Sarah.Manoogian@Bucknell.edu (S. Manoogian).

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such as direction of impact and position within the vehicle but the focus of the research effort was to use computational modeling to assess pregnant occupant crash risk in far-side impacts.

Because the average age of the women at first birth is increasing, vehicle technology is advancing, and databases are continuously improving, an updated assessment of pregnant crash characteristics was needed. The objective of the current study is to provide up to date and detailed information from the NASS/CDS database regarding specific characteristics of injuries and crash characteristics for pregnant occupants as a group and broken down by trimester. The risk of injury for pregnant women is also compared to the risk of injury for non-pregnant women. As a result of the current study, it is possible to identify the latest trends among pregnant occupants, compare pregnant and non-pregnant risk, and highlight areas where more data collection is necessary.

2. Material and methods

Data from the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) was used to evaluate pregnant occupant crash characteristics. NASS/CDS provides a detailed record of approximately 5000 crashes investigated each year (NCSA, 2011a). To be included in NASS/CDS, at least one of the crash-involved vehicles had to be towed from the scene. The NASS/CDS database includes only crashes involving cars, light trucks, vans and sport utility vehicles; heavy vehicles and motorcycles are not included as subject vehicles in the NASS/CDS database. Occupant weight, height, and pregnancy status data reported in the NASS/CDS database are a result of one or more source including interviews, police reports, and official records (NCSA, 2011b). Information from the crash vehicle regarding occupant position, belt use, airbag deployment, and all crash reconstruction parameters are documented from the source of the vehicle inspection, scene inspection, and photographs (NCSA, 2011b). Secondary sources for a parameter such as belt use could include interviews and medical records. Injury level, source, and region are determined from the vehicle inspection, interview, and medical records (NCSA, 2011b).

A few of the terms are specific to the NASS/CDS database and those are explained further here. The principle direction of force analysis uses the PDOF1 parameter from NASS/CDS. This parameter indicates the clock direction in degrees for the principle direction of force that resulted in the highest amount of crush (NCSA, 2011b). The front of the vehicle is 0 or 360° and the rear of the vehicle is 180°. Additional impacts to the vehicle could have occurred beyond what is indicated by the PDOF1 parameter. The change in velocity (delta-v) analysis uses the DVTOTAL parameter from NASS/CDS. The lateral and longitudinal delta-v was determined by NASS/CDS and the total delta-v is a combination of these two values (NCSA, 2011b). Occupant injury severity is described using the Abbreviated Injury Severity (AIS) scale (AAAM, 2005). The AIS scale methodically rates injury on a discrete six level scale based on threat to life. In NASS/CDS, each injury acquired by an occupant is rated based on this scale. The most severe injury level an occupant sustains is termed the maximum AIS (MAIS) score which can range from no injury to maximum injury.

The complex sampling strategy used to select cases for NASS/CDS oversamples certain types of crashes including fatal crashes, crashes involving hospitalized occupants, and crashes involving late model year vehicles among other factors (NCSA, 2011a). To permit nationally representative estimates to be computed, NASS/CDS provides weighting factors which account for this complex sampling scheme. These weights were applied in the analysis which follows. The raw numbers are listed in parentheses following the weighted reporting. All statistical analyses were performed using the SAS V9.3 software package.

This research study includes all NASS/CDS cases collected between the years 2000 and 2012 with at least one pregnant occupant. This data is compared to the characteristics of NASS/CDS cases for non-pregnant females 13–44 years old in crashes from 2000 to 2012. Within the set of cases, one vehicle could have more than one occupant and one occupant could have several injuries. Similarly, a pregnant and non-pregnant occupant could be involved in the same crash. In this case, the crash would count once in each category. The analyses for the pregnant and non-pregnant occupants are indicated as by vehicle, by person, or all for the respective group. When appropriate, the analysis was conducted on the three trimester groups separately. Several of the charts do not include a separate category for pregnant women with an unknown trimester. The small sample size for this group caused the distributions to be very different than the other trimester groups and therefore they are only included in the "all pregnant" category.

First, general characteristics of the individuals in the vehicles were determined such as age, height, weight, location in the vehicle, belt use, and airbag deployment. Next, crash characteristics were determined for each vehicle. The presence of a rollover, number of events, change in velocity, and principal direction of force were tabulated for each vehicle. Then an analysis of injuries for each individual was conducted. This included the maximum injury level, injury source, injured region, and fetal mortality. Using the survey procedures in the SAS software, adjusted odds ratios with 95% confidence limits were used to identify the increased likelihood of an injury occurring for a pregnant occupant compared to a non-pregnant individual. Additionally, binary logistic regression models were used to compare the risk of injury for pregnant and non-pregnant occupants as a function of total vehicle change in velocity. The SAS software accounted for the complex survey sample design of NASS/CDS and provided 95% confidence bounds on the data.

3. Results

3.1. Individual characteristics

Using the NASS/CDS weights for each case, the entire pregnant data set includes 321,820 vehicles, 324,535 occupants, and 640,804 injuries. The non-pregnant data set includes 13,164,869 vehicles, 14,719,533 occupants, and 25,901,105 injuries (Table 1). Using the weighted frequency of occupants, the pregnant occupants were distributed with 28.9% in the first trimester, 30.9% in the second trimester and 32.6% in the third trimester. Some of the pregnant occupants were listed as unknown trimester and this was 7.6% of the data. Using the weighted frequency of occupants in crashes, 2.2% of childbearing age women in crashes were pregnant. Because the number of people, vehicles, and injuries are different, the weighted frequency of each for the different trimester groups were compiled (Table 1). The raw case numbers for the data are also listed for each analysis where it is suitable. There was not an even distribution of pregnant occupant cases collected each year and fewer cases were collected in the most recent years (Table A.1).

The minimum age for the pregnant dataset was 13 while the maximum age was 59. Six occupants were listed as over age 44. These ages were 45, 46, 46, 47, 55, and 59. The average pregnant occupant in a crash was 26 years old with a weight of 72.8 kg and a height of 163.6 cm. In order to establish a reasonable comparison group, the age range for non-pregnant occupants was limited to 16–44 years old. This age range represents 96.4% of the pregnant occupants in the NASS/CDS data. For the non-pregnant females, the mean age was 27 years old, the average weight was 66.5 kg, and the average height was 164.6 cm (Fig. A.1).

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