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Analysis of restraint use in pregnant versus non-pregnant populations involved in motor vehicle collisions

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ABSTRACT

Background: Traumatic injuries obtained by pregnant females in motor vehicle collisions present unique treatment challenges for trauma and orthopaedic surgeons. Understanding safety choices in this population can help physicians and public safety advocates in delivering effective and targeted safety messages.

Methods: A publicly available, de-identified national data set that documents crash information (NASS-CDS) was examined to identify cohorts of pregnant and non-pregnant vehicle occupants and regression analysis employed to identify factors associated with belt non-use.

Results: Pregnant women were found to have significantly lower rates of belt use compared to non-pregnant females (70.0% vs. 90.3%, Rao-Scott Sample Weighted Chi-Square $p = 0.0265$). Logistic regression identified younger age and sitting in the back seat as associated with lower rates of belt use.

Conclusion: Pregnant women wear belts at significantly lower frequencies than non-pregnant women and youth and second row seating increase noncompliance rates. This work suggests the need for targeted intervention strategies to improve belt compliance.

Background

Trauma is estimated to complicate 7% of all pregnancies and is the leading cause of non-obstetric maternal-fetal mortality.[1] The most common mode of trauma related death in pregnancy is motor vehicle accidents, injuring approximately 92,500 women a year.[2,3] Management of the pregnant trauma patient poses a unique set of challenges for the trauma team. The estimated incidence of births complicated by motor vehicle accidents is 207/100,000 live births.[4] As 77% of injury related deaths in motor vehicle collisions occur in women not wearing belts, it is important to decrease the severity of injuries from vehicle collisions by prevention strategies such as belt usage.[5]

The efficacy of belt protectiveness in pregnancy has been studied over the years, and belt noncompliance is correlated with adverse pregnancy outcomes.[2,6] Belt use reduces abdominal pressure and prevents contact with the steering wheel during collisions, reducing injury risk to the mother and the fetus.[7] Women who are properly restrained have unfavorable fetal outcomes in 29% of motor vehicle collisions compared with 50% in women who are improperly restrained.[8] Hyde et al. found that unbelted pregnant women have nearly three times the risk of fetal demise compared to belted pregnant women in accidents.[9]

The primary objective of the current study is to examine the pattern of belt usage in pregnant and non-pregnant women, to identify factors influencing belt use rates, and document general injury characteristics in both pregnant and non-pregnant populations. Additionally, the study aims to provide insight into potential strategies for targeted safety messaging to high risk groups.

Methods

Motor vehicle crashes documented in the 2011–2015 National Automotive Sampling System – Crashworthiness Data System data set (NASS-CDS) were utilized in this study. The NASS-CDS is generated under the United States National Highway Traffic Safety Administration. It is a publicly available, de-identified data set that documents crash, vehicle, and occupant information for approximately 5000 crashes per year. The NASS-CDS is a random stratified

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sample wherein the crashes are assigned a weight reflecting the probability of sampling the event. Cases selected for inclusion in the NASS/CDS over represent more severe types of crashes. The weighting factors provided by NASS/CDS account for this and allow the data to be extrapolated to represent national estimates.[10] In light of this, all statistical analysis utilized the extrapolated data. The study presented here was IRB reviewed and determined to be exempt.

The NASS-CDS data was used to create two data sets for the current study: one set containing pregnant females and the second containing non-pregnant females. These data were further filtered to limit the included ages to between 16 and 45 years old to account for women of childbearing age. The crash cases included only passenger vehicles (sedans, trucks, minivans, and SUVs) with model years of 2000 or more recent. The seat position and restraint use of each female, as determined by the NASS case investigator (rather than the police report), were included in the data set.[11] Demographic data including age, pregnancy (yes/no), Race, and ethnicity (white, black, hispanic/latino, other), seat position in the vehicle, height and weight were also included.

The belt use and injury data were compared between all pregnant and non-pregnant women. A second analysis examined these same factors in a subgroup composed of only drivers. The driver only subset provides a group with somewhat similar characteristics in terms of the vehicle environment and their active role in the controlling the vehicle.

General injury risk and belt usage rates between the pregnant and non-pregnant groups were compared using a Rao Scott Chi-Square test, which accounts for the complex sample design.[12] Logistic regression (SAS Survey Logistic) was utilized to identify factors associated with restraint use. These regression analyses only included those cases with data for all of the variables present in the regression model. In addition, cases where occupants were not sitting in designated seating positions (which have belts) or where they were sitting in the third row of the vehicle were omitted from the analysis (0.6% of the cases). A stepwise backward predictor elimination scheme was then applied, where factors in the model were sequentially removed starting with those of least significance, until a reduced model containing significant factors was achieved. An additional correlation analysis was performed to identify related predictor variables and any highly correlated variables were represented in the regression model with one of the pair. All analysis was carried out using SAS (SAS Institute, Cary, NC). Variable significance was assessed using a Wald Chi-Square. The model's fit was evaluated using the log-likelihood test and the area under the receiver operator characteristic curve (AROC).

Results

The compiled data set contained 56,789 pregnant (150 raw count) and 2.11 million non-pregnant (3711 raw count) women. The average age within each group was similar: 26.9 vs. 27.4 years for pregnant vs. non-pregnant (Table 1). In the pregnant group, 30.6% were unrestrained vs. 10.3% for the non-pregnant ($p = 0.0132$). While all of the pregnant women were reported as either restrained with the lap and shoulder belt or as unrestrained, the larger non-pregnant group included one case of a woman using only the lap belt, one case of use of only the shoulder belt, and 33 of "belt used, type not specified".

Crashes involving rollover more frequently led to polytrauma and extended hospital stays (≥3 days) for both pregnant ($p < 0.0001$) and non-pregnant ($p < 0.0003$) women. Fetal demise occurred in 0.74% of crashes, with more occurring in rollover crashes ($p = 0.0471$). The fetal demise cases were also associated with extended hospital stays and polytrauma ($p < 0.0001$). The regression analysis indicated that age and seat position were significantly associated with belt use (Table 2, first column). When non-significant variables were removed from the model the factors of weight, age, pregnancy status, and seat position were all significant or nearly significant. The correlation analysis identified a significant correlation between age and weight ($p < 0.0001$). Based on this finding, weight was removed from the predictor variables. This had the additional benefit of increasing the number of cases available for inclusion in the analysis, as weight was not recorded for all cases. The final regression analysis (reduced model) indicated age ($p = 0.0055$), seat position (front vs. second row of the vehicle) ($p = 0.0046$), and pregnancy status ($p = 0.0129$) were all significant factors in predicting belt use (Table 2). The odds of belt use, controlling for age and seat position influences, were 5.57 times higher if the occupant was a non-pregnant female as compared to a pregnant female (CI: 1.438–21.564). The model's fit to the data was significant based on the log-likelihood test ($p < 0.001$); however, the area under the receiver operator characteristic curve was 0.618 indicating a low explanatory power for the model.

The subgroup of drivers was the largest occupant group with an estimated 77.4% of the pregnant women acting as drivers, while 79.4% of the non-pregnant women were drivers. The average age was the same for both groups at 27.6 years (Table 1). The pregnant driver group was composed of 24.1% in first trimester, 28.3% in second, and 47.5% in third. In the pregnant group, 31.9% were unrestrained vs. 9.9% for the non-pregnant group ($p = 0.0265$). The median ISS for the pregnant group was not significantly different from that in the non-pregnant, at 1.53 vs. 1.66. The overall rate of polytrauma, defined as Injury Severity Score (ISS≥16), was 0.58% [95th CI 0.00–1.42%] in pregnant drivers wearing belts, which was not significantly different ($p = 0.355$) from that in non-pregnant women 0.07 [0.16–0.42]. The rate of skeletal injury in pregnant drivers using belts was 0.99%, with fractures most frequently involving the upper extremity. Mortality rates for non-pregnant females were 0.05% for restrained drivers and 0.45% for unrestrained. There were no pregnant female deaths in the sample.

Initial logistic regression analysis of the drivers did not identify pregnancy status as significant in predicting belt use (Table 3). However, once height and weight were removed from the model, a

Table 1
Demographics of study groups. Numbers in brackets are based on the raw, unweighted data.

Demographics	Non-pregnant (all)	Pregnant (all)	Non-pregnant (drivers)	Pregnant (drivers)
Caucasian (%)	42.5	51.9	54.9	73.2
African American (%)	16.7	20.5	19.6	16.3
Latino/Hispanic (%)	5.3	7.3	4.6	4.9
Other (%)	35.5	20.3	20.9	5.6
Age	27.4	26.9	27.6	27.6
Height (cm)	164.7	164.2	164.8	163.9
Weight (kg)	71.6	75.4[a]	71.4	76.6[a]

[a] Pall = 0.0006, pdrivers = 0.0115.

Table 2
Logistic regression for lap and shoulder belt use for front and second row pregnant and non-pregnant females. The raw count listed indicates the number of samples in the extrapolated data is based upon.

Predictor Variables For Use of Lap and Shoulder Belts	All Females[a] N = 1,437,637 (raw count = 2285) p value	Reduced Model All Females[b] N = 1,471,124 (raw count = 2338) p value	Reduced Model OR	Reduced Model 95th CI
Pregnancy Status *(Non-pregnant vs. pregnant)*	0.0687	0.0129	5.569	1.438–21.564
Age	0.009	0.0055	1.055	1.016–1.095
Height	0.8074	Not included	NA	NA
Weight	0.0788	Not included	NA	NA
Front vs. second row seating	0.0031	0.0046	2.527	1.221–4.799
Race/ethnic group	0.7023	Not included	NA	NA

*Extrapolated values used for regression analysis.
[a] Log-Likelihood test $p < 0.0001$, AROC = 0.628.
[b] Log-likelihood test $p < 0.0001$, AROC = 0.618.

larger data set was available for inclusion in the analysis. This analysis found pregnancy status to be nearly significant ($p = 0.0549$) and age to be a strong predictor of belt use ($p = 0.0452$). Because age was found to be a predictor of belt use, groups of drivers ages <30 and ≥ 30 were created to examine the belt/age relationship. Considering both pregnant and non-pregnant women together, the rate of belt non-use was 11.9% in the younger group vs. 7.9% in those ≥30 (based on weighted counts), however these rates were not significantly different ($p = 0.1367$).

Discussion

The current study examined belt use rates for pregnant women using a non-pregnant comparison group and demonstrates that pregnant women were less likely to wear belts as compared to non-pregnant women. The study also found that belt use was lower in younger pregnant women and women not seated in the front row of the vehicle. The sample size was not large enough to study mortality or specific injury patterns between the two groups.

Studies examining restraint use rates in pregnant women have reported values ranging widely from estimations of between 49% and 88%, 69.5%–91.4%, up to 94%.[13–16] However, national belt use rates have been steadily increasing in recent years and it is unclear whether usage in pregnant women has also increased.[17] In addition, most of these studies rely on patient reported compliance rather than direct observation. This information suggests that an analysis of more recent data that includes factors such as age, Race, and seat position in the vehicle will help identify belt use practices and opportunities for interventions for pregnant women. The finding of low belt use rates in this study is consistent with earlier survey based studies demonstrating low belt use rates in this population.[5,6] Further, the finding that seat position in the vehicle influenced belt use is consistent with roadway observational studies and case reviews that indicate belt use rates for adults seated in the second row lag rates in the front row by approximately 10%.[17,18]

While both this study and work by Manoogian found no differences in the rate of serious injury between pregnant and non-pregnant women, the frequency for fetal demise in this study (0.74%) was lower than the rate of 1.3% reported in the earlier study. This may be due to the inclusion of only newer vehicles, which presumably have improved safety performance. Additionally, earlier work did not have a fetal outcome listed for each case.[15]

Most of the pregnant women involved in the crashes examined in the current study were drivers, consistent with what has previously been reported in the literature (70% for 1994–2010 at a US trauma center, 61.6% for 2003–2011 in a sample of admissions at 1000 hospitals in the USA, and 65% for 2000–2012 in the NASS-CDS data set.[15,18,19] However, the total percentage of pregnant women involved in crashes that were drivers was higher in this study. This may possibly reflect changes in driving practices for women of childbearing age as higher rates were also observed in non-pregnant women. It may also be due to differences in the samples in regard to inclusion criteria.

There are many different variables that influence belt compliance. In general, belt usage rates are lower in states lacking restraint use laws.[17] A belt use survey conducted by Taylor et al. found that the highest risk factors for failing to correctly use restraints during pregnancy included being non-Hispanic black, lower education level, lower socioeconomic status, a younger age, and tobacco use,[13] while Luley et al. only found younger age to be significant in predicting belt use.[18] The current study did not show a significant influence based on Race/ethnicity, but did find that age was significant in predicting belt use when the occupant's seat position was taken into account, which is consistent with work done by Ball et al.[20]

This work provides some insight into factors that might help target patient education efforts, such as media aimed at younger patients and information on the benefit of using the belt when sitting in the backseat. Belt usage has been shown to decrease in

Table 3
Logistic regression for lap and shoulder belt use for pregnant and non-pregnant female drivers.

Predictor Variables For Use of Lap and Shoulder Belts	Drivers[a] N = 1,101,299 (raw count = 1564)	Reduced Model Drivers[b] N = 1,363,530 (raw count = 2054)	OR	95th CI
Pregnancy Status *(Non-pregnant vs. pregnant)*	0.5385	0.0549	4.469	0.969–20.610
Age	0.0049	0.0452	1.040	1.001–1.082
Height	0.9811	Not included	NA	NA
Weight	0.0179	Not included	NA	NA
Race/ethnic group	0.3484	Not included	NA	NA

*Extrapolated values used for regression analysis.
[a] Log-Likelihood test $p < 0.0001$, AROC = 0.581.
[b] Log-likelihood test $p < 0.0001$, AROC = 0.562.

pregnancy because women are often not counseled on correct usage and may fear restraint use will hurt the fetus.[21] This data is corroborated by McGwin et al. who found women who believed that restraints would protect their baby if involved in an accident were significantly more likely to report always wearing belts compared to those who were unsure or had a negative view of belts.[22] Additionally, receiving information on belts is correlated with their use.[6] Of the women in the McGwin et al. study, only 36.9% reported receiving information regarding restraint use during pregnancy and Vladutiu et al. found only 37–59% of pregnant women reported being given information regarding restraint use.[2,22]

There are several important limitations to this study. The data set contained a relatively small number of pregnant women but it was created from a sample that reflects national data and it provides belt use information that is more objective than patient questionnaires, which may be subject to over-reporting. Local culture and state laws may influence driver behavior in a particular region, causing belt use to be larger or smaller locally, variation that may not be reflected in the national data set. In addition, previous studies have shown socio-economic factors to influence belt compliance, but the influence of these and other factors such as numbers of previous pregnancies could not be assessed as this information is not included in the database.[2]

In summary, the current study indicates that belt usage is lower among pregnant women as compared to non-pregnant women in recent motor vehicle crashes, and characteristics such as a younger age and back seat position predict lower belt compliance. This lower belt use rate was identified in earlier studies, but it remains a factor today even as belt use rates have continued to increase across the United States.[9] It is unclear how best to effectively advocate for belt use by pregnant women. Research focused on determining the efficacy of methods to communicate the importance of belt use, especially to younger patients, might provide guidance and communication tools for use across institutions.

Declaration of competing interest

All authors report no conflicts of interest.

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