Effect of Motor Vehicle Crashes on Adverse Fetal Outcomes

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OBJECTIVE: To assess the effect of maternal involvement in motor vehicle crashes on the likelihood of adverse pregnancy outcomes and to estimate the effect of seatbelt use in reducing the occurrence of those outcomes.

METHODS: Statewide motor vehicle crash, birth, and fetal death records from 1992 to 1999 were probabilistically linked. Logistic regression was used to compare the likelihood of adverse birth and fetal outcomes including low birth weight, prematurity, placental abruption, fetal distress, excessive bleeding, fetal death, and other complications among pregnant women in crashes and those not in crashes.

RESULTS: Of 322,704 single live resident births, 8938 mothers (2.8%) experienced a crash during pregnancy. Pregnant women using seatbelts were not significantly more at risk for adverse fetal outcomes than pregnant women not in crashes. However, pregnant women who did not wear seatbelts during a crash were 1.3 times more likely to have a low birth weight infant than pregnant women not in a crash (95% confidence interval [CI] 1.0, 1.6) and twice as likely to experience excessive maternal bleeding than belted pregnant women in a crash (95% CI 1.0, 4.2). Forty-five of 2645 fetal deaths were linked to a motor vehicle crash, with unbelted pregnant women 2.8 times more likely to experience a fetal death than belted pregnant women in crashes (95% CI 1.4, 5.6).

CONCLUSION: Pregnant women should be counseled to wear seatbelts throughout pregnancy and reduce crash risk. (Obstet Gynecol 2003;102:279–86. © 2003 by The American College of Obstetricians and Gynecologists.)

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Motor vehicle crashes are the leading cause of traumatic fetal mortality.[1] With more women driving and driving more miles today than two decades ago,[2] it has been estimated that about 2% of all live births in the United States, or 79,000 children (a rate of 26 per 1000 person-years), are exposed in utero to a police-reported crash.[3] For comparison, the National Highway Traffic Safety Administration reports that there are only about 23,188 infants reported in crashes each year (a rate of six per 1000 person-years).[3] Although crashes involving pregnant women can cause obvious immediate harm, such as placental abruption, uterine rupture, or emergency premature delivery,[4] less is known about delayed effects of motor vehicle crashes on pregnancy outcomes.

Published studies on pregnancy outcomes after crashes have primarily focused on women seen at hospitals after the crash[4–8] or on fetal death reviews.[9–12] These studies have identified common problems associated with trauma during pregnancy, such as low birth weight, preterm delivery, placental abruption, and fetal death. Such studies have also shown seatbelts to successfully reduce maternal as well as fetal injury and death during pregnancy.[11,13,14] The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women should wear properly positioned safety restraints throughout pregnancy while riding in automobiles.[15]

However, according to our review of the literature (PubMed; years searched: 1966–2002; key words: "fetal/fetus crash," "fetal/fetus injury," "motor vehicle crashes and pregnancy," "crash safety and pregnancy," "trauma and pregnancy"), no studies have used linked statewide databases with a comparison group of women not in crashes to quantify the associations between motor vehicle crashes and adverse outcomes. Thus, our study objective was to assess the effect of a motor vehicle crash on the likelihood of adverse pregnancy outcomes and to estimate the effect of seatbelt use in reducing the occurrence of those outcomes.

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MATERIALS AND METHODS

The population-based state databases for this project included Utah police-reported motor vehicle crash records, birth certificates, and fetal death certificates for the years 1992–1999. This study period was chosen because of the availability of each of the statewide databases for these years. The University of Utah Institutional Review Board approved the use of each of these databases for this project.

The 1992–1999 motor vehicle crash records were obtained from the Utah Department of Transportation. These data contain information on reported motor vehicle crashes occurring on public roadways with at least one injury or fatality or at least $1000 in property damage. Reports are completed by police officers at the crash scene and include information about the crash participants, type of crash, type of vehicle, time and location of crash, and crash severity. Crash severity, a five-point scale ranging from no injuries to fatalities, is based on the police officer's assessment of the most severe injuries among those involved in a crash. Because of the limited number of outcomes, other possible crash severity variables, such as crash type and posted speed limit, were not included to ensure stability of our models.

The birth and fetal death certificate databases were obtained from the Utah Department of Health. Birth certificate data included demographic information about the mother, date and place of birth, abnormal conditions of the newborn, complications of labor and/or delivery, and medical risk factors. Only singleton resident births were included in this study. The fetal death data included all reported fetal deaths (excluding elective abortions) of 20 weeks' gestation or greater with information on demographics, cause of death, and other medical conditions.

Probabilistic linkage was used to match female drivers in motor vehicle crash records with mothers in birth and fetal death records. Probabilistic record linkage is accomplished by comparing multiple fields to calculate a probability that two records refer to the same person or event and should be linked. For this study, all pairs achieving a probability of .9 or greater were kept as "true" matches.[16] Probabilistic linkage has been described in detail elsewhere by Jaro[17] and Dean et al.[18] Linkage variables included the mother's first and last name, mother's date of birth, date of delivery and/or death of the fetus, and date of the crash. Gestational age and date of last menses were compared for each pregnancy to ensure that the crash occurred during pregnancy. Linkage was performed using CODES 2000 software (Strategic Matching Inc., Morrisonville, NY). Only pregnant drivers were analyzed in this study because motor vehicle crash police reports did not contain sufficient identifying information for nondrivers to allow for probabilistic linkage with the vital records.

Logistic regression and descriptive statistics were used to assess the effect of having a crash, with or without seatbelt use, on various adverse pregnancy outcomes. Based on previous research, the adverse outcomes that we hypothesized to be influenced by a motor vehicle crash included abruptio placentae, fetal distress, low birth weight (less than 2500 g), prematurity (birth before 37 weeks), excessive maternal bleeding, delivery within 48 hours of the crash, cesarean delivery, fetal death, and other abnormal conditions (ie, birth injury, assisted ventilation, seizures).[5,11,19] Each of these outcomes were derived from clinician determinations as indicated on the birth or death certificate. Logistic regression models controlled for the following self-reported risk factors associated with adverse outcomes in pregnancy[20]: extreme age of the mother (younger than 18 or older than 35), tobacco and alcohol use during pregnancy, race, education level, number of previous births, trimester at first prenatal care visit, weight gain during pregnancy, and seatbelt use during the crash. A woman was coded for presence of a medical risk factor if one or more medical risk factors were listed in the birth certificate or fetal death certificate, such as anemia, cardiac disease, or diabetes. All logistic analyses were performed using PROC LOGISTIC in SAS 8.2 (SAS Institute Inc., Cary, NC).

RESULTS

From 1992 to 1999 there were 322,704 singleton live births recorded among Utah residents. Of these, 8938 (2.8%) were linked to a motor vehicle crash during pregnancy. There were some statistically significant differences between pregnant women in crashes and pregnant women not in crashes, although these differences could be attributed more to large sample sizes than to important epidemiological differences (Table 1). Compared with women not involved in a motor vehicle crash during pregnancy, women who crashed were slightly younger and more likely to smoke during pregnancy, had slightly fewer previous births, and were more likely to begin prenatal care during the first trimester. Race, education, alcohol use, and weight gained during pregnancy did not significantly differ between the two groups.

When the analytic models controlled for having a motor vehicle crash, regardless of seatbelt usage, pregnant women in crashes were no more likely to experience adverse pregnancy outcomes than women not in crashes. When considering seatbelt usage, 7143 (80%) of

Table 1. Characteristics of Women in Crashes Compared With Women Not in Crashes

	Crash (n = 8938)	No crash (n = 313,766)
Age (y)	25.6*	26.3
Race (% white)	95.9	95.2
Completed high school (%)	85.9	85.6
Smoking (%)	11.5*	9.3
Alcohol (%)	1.7	1.5
No. of previous births	1.2*	1.3
Received care first trimester (%)	84.6*	83.5
Weight gain [kg (lb)]	14.0 (30.8)	13.8 (30.5)

* Significant at the $P < .05$ level.

the women drivers were reported as wearing a seatbelt at the time of the crash and 1099 (12%) were reported as not wearing a seatbelt. It was not possible to ascertain seatbelt usage for the remaining 696 women (8%). Seatbelt nonusers were approximately 2 years younger than seatbelt users, more likely to smoke during pregnancy, and more likely to drink alcohol. Seatbelt nonusers were also less likely to complete high school and less likely to have received prenatal care during the first trimester than seatbelt users (Table 2). Because of these differences, it was important to control for seatbelt usage while examining the effect of motor vehicle crashes on adverse outcomes. Table 3 shows, as an example, the logistic regression model comparing low birth weight outcomes for pregnant women in crashes with those for pregnant women not in crashes. The model demonstrates the well-known effects of these covariates on low birth weight. Table 4 summarizes the logistic analyses in this study. Unbelted women in crashes were more likely to have a low birth weight infant than pregnant women who were not in a crash (odds ratio [OR] 1.3; confidence interval [CI] 1.0, 1.6). Pregnant women who were wearing a seatbelt at the time of the crash were no more likely

Table 2. Characteristics of Unbelted Versus Belted Women in Crashes

	Unbelted (n = 1099)	Belted (n = 7143)
Age (y)	23.9*	25.8
Race (% white)	95.4	96.0
Completed high school (%)	73.2*	88.1
Smoking (%)	21.2*	9.8
Alcohol (%)	2.6*	1.6
No. of previous births	1.2	1.2
Received care first trimester (%)	78.2*	85.5
Weight gain [kg (lb)]	14.0 (30.8)*	13.9 (30.7)

* Significant at the $P < .05$ level.

Table 3. Results of Logistic Regression Model Comparing Low Birth Weight Outcomes for Pregnant Women in Crashes, Controlling for Risk Factors Including Belt Use, and Pregnant Women Not in Crashes

	Low birth weight (<2500 g) [OR (95% CI)]
Weight gained during pregnancy (7.3–20.4 kg [16–45 lb], (ref.)	
<7.3	2.43 (2.32, 2.53)*
>20.4	0.40 (0.37, 0.43)*
Hispanic origin	1.14 (1.08, 1.21)*
Nonwhite race	1.34 (1.25, 1.44)*
Completed high school	0.75 (0.71, 0.79)*
First birth	1.70 (1.64, 1.76)*
Prenatal care in first trimester	1.00 (0.96, 1.05)
Tobacco use during pregnancy	2.54 (2.42, 2.66)*
Alcohol use during pregnancy	1.27 (1.15, 1.41)*
Age of mother (18–34 y, ref.)	
>34	1.14 (1.08, 1.21)*
<18	1.03 (0.95, 1.12)
Presence of medical risk factor	3.03 (2.93, 3.13)*
Crash status (no crash, ref.)	
Belt use during crash	1.06 (0.95, 1.78)
No belt use during crash	1.30 (1.03, 1.64)*

OR = odds ratio; CI = confidence interval.
* Significant at $\alpha = .05$.

to experience adverse outcomes than pregnant women who were not involved in a motor vehicle crash.

To directly compare the differences in outcomes between belted and unbelted pregnant women, the data were subsetted to only those records that linked to a motor vehicle crash record in which belt use was known. This allowed for controlling the trimester of crash as well as the injury severity indicator. Crashes were evenly spread across trimesters, with 35% in the first trimester, 34% in the second, and 31% in the third. The trimester of crash is further broken down by seatbelt use in Figure 1. Crashes occurring during the first trimester were more likely to result in premature (OR 1.3; 95% CI 1.1, 1.6) and low birth weight (OR 1.5; 95% CI 1.0, 1.7) infants than crashes during the third trimester. Crashes during the second trimester were also more likely to result in low birth weight infants than crashes during the third trimester (OR 1.3; 95% CI 1.0, 1.7). Though severity was not significantly associated with adverse fetal outcomes in our models, police reports of crashes involving unbelted pregnant women were more likely to indicate probable and incapacitating injuries, and crashes involving belted pregnant women were more likely to indicate absence of injury (Figure 2). Logistic regression analyses for the subset of women in crashes showed that unbelted pregnant women were twice as likely to experience excessive maternal bleeding during delivery than belted pregnant women (OR 2.1; 95% CI 1.0, 4.1) (Table 4). All

Table 4. Contribution of Seatbelt Usage to the Likelihood of Adverse Outcomes for Various Models While Controlling for Other Risk Factors

	Women in crashes vs women not in crashes		Belted women in crashes vs women not in crashes		Unbelted women in crashes vs women not in crashes		Unbelted women in crashes vs belted women in crashes	
Condition	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Low birth weight	1.03	0.94, 1.14	1.06	0.95, 1.18	1.30*	1.03, 1.64	1.18	0.89, 1.56
Excessive bleeding	0.96	0.73, 1.25	0.82	0.59, 1.13	1.63	0.92, 2.90	2.06*	1.02, 4.15
Fetal distress	1.09	0.98, 1.21	1.04	0.93, 1.17	1.03	0.77, 1.39	1.07	0.78, 1.49
Placental abruption	1.00	0.81, 1.24	1.12	0.89, 1.41	1.01	0.56, 1.84	0.88	0.44, 1.76
Prematurity	1.02	0.94, 1.11	1.08	0.99, 1.18	1.13	0.91, 1.40	1.00	0.78, 1.29
Abnormal conditions	0.99	0.94, 1.04	1.040.9	0.98, 1.10	0.75*	0.63, 0.88	0.72*	0.60, 0.85
Cesarean delivery	0.96	0.90, 1.02	0.95	0.89, 1.02	0.91	0.76, 1.08	1.02	0.84, 1.23
Delivery within 48 h	NA	NA	NA	NA	NA	NA	0.76	0.36, 1.59
Other complications	0.99	0.95, 1.04	0.99	0.94, 1.04	0.83*	0.73, 0.94	0.80*	0.70, 0.93

Abbreviations as in Table 3.
* Significant at $\alpha = .05$.

other adverse birth outcomes were similar, although not wearing a seatbelt appeared to be protective of abnormal conditions and other complications.

From 1992 to 1999 there were 2645 fetal death certificates, 45 (1.7%) of which linked to a motor vehicle crash during pregnancy. No fetal deaths were reported to have occurred in the first trimester, with 41% in the second and 59% in the third (keeping in mind fetal deaths are not reported until 20 weeks' gestation). Of these, 51% of fetal deaths were linked to crashes that occurred in the first trimester, with 20% in the second and 29% in the third. However, when considering seatbelt use, six (55%) of the unbelted group of fetal deaths were linked to crashes that occurred during the third trimester, whereas only three (12%) of the belted fetal death group had third-trimester crashes. Figure 3 shows the cumulative percentage of fetal deaths by gestational age. Fetal deaths occurring to women not in crashes and belted women show a similar pattern, with the 50th percentile occurring around 25 weeks' gestation. The unbelted group, however, shows a markedly different pattern. In this group the 50th percentile occurs at 32 weeks' gestation because of the large proportion of fetal deaths occurring later in gestation. Maternal injury (28%) was the leading reported cause of fetal death for the unbelted group, whereas the belted group had reported causes that were more medical in nature (Table 5). Table 6 shows the percentage of pregnancies resulting in fetal deaths stratified by seatbelt usage. We were unable to build an adequate logistic model because of the small number of fetal deaths in which seatbelt use was known (n = 40), but an unadjusted OR calculated from this table shows that unbelted women were 2.8 times more likely to have a fetal death (95% CI 1.4, 5.6) than belted pregnant women. In only one case, involving a belted woman, did a fetal death link to a maternal death in the crash file.

Figure 1. Trimester of crash by belt use (n = 8242).

Hyde. Effect of Motor Vehicle Crashes on Fetal Outcomes. Obstet Gynecol 2003.

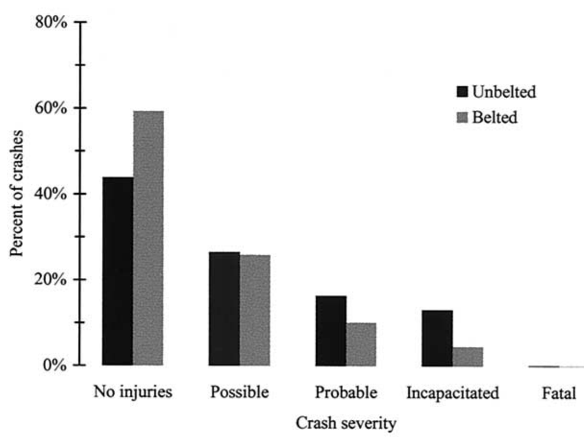

Figure 2. Distribution of crash severity and belt use ($P <$ .001).

Hyde. Effect of Motor Vehicle Crashes on Fetal Outcomes. Obstet Gynecol 2003.

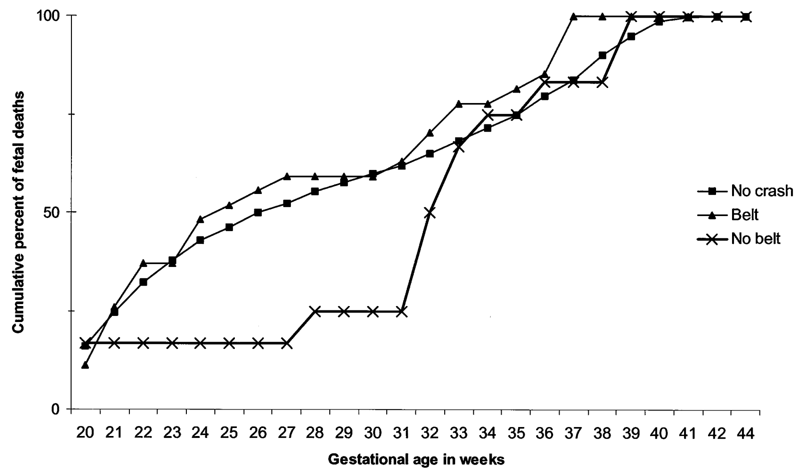

Figure 3. Cumulative percentage of fetal death by gestational age at time of fetal death.

Hyde. Effect of Motor Vehicle Crashes on Fetal Outcomes. Obstet Gynecol 2003.

DISCUSSION

In this study, the pregnancy outcomes of mothers involved in motor vehicle crashes were compared with those of mothers not involved in crashes. The main findings are that nearly 3% of births linked to motor vehicle crashes during pregnancy, that pregnant women in crashes in which the mother wore her seatbelt were not significantly more at risk for adverse fetal outcomes than pregnant women not in crashes, and that pregnant women who did not wear their seatbelts during a crash were more likely to have a low birth weight infant than pregnant women not in a crash, more likely to experience excessive maternal bleeding than belted pregnant women in a crash, and nearly three times more likely to have a fetal death than belted women in a crash.

We found that 2.8% of all live births in the state were from mothers who were exposed to a driver-related motor vehicle crash during pregnancy. Considering the absence of data on nondrivers and nonreported crashes, this suggests that in Utah more than 3% of all live births are from mothers exposed to a motor vehicle crash. The only other study known to estimate the rate of motor vehicle crash exposure during pregnancy reported it as 1% based on investigator reports from the National Automotive Sampling System Crashworthiness Data System and was thought to have underestimated.[3]

Although belt use has been shown to be effective in reducing morbidity and mortality for the mother and the fetus when comparing belted and unbelted pregnant women,[11,13,14] this study extends these findings by showing that belted pregnant women in crashes were not significantly more at risk for adverse fetal outcomes than pregnant women not in crashes. To our knowledge, no other studies have compared crash-related pregnancy outcomes with a noncrash population. Schiff et al[19] found that, compared with uninjured pregnant women, injured pregnant women were at increased risk of several adverse outcomes, including placental abruption, prematurity, low birth weight, fetal distress, and fetal death. However, their study only included women who had been hospitalized for their injuries and delivered during their hospital stay, which would indicate an overall greater severity of injuries than in our study. Because the Schiff et al study also focused on all injuries, and not just motor vehicle crashes, the authors were not able to control for severity-reducing countermeasures such as seatbelt use.

We found that unbelted pregnant women in crashes were more likely to have low birth weight infants than pregnant women who were not in crashes and more likely to experience excessive maternal bleeding during delivery than belted pregnant women in crashes. Lack of

Table 5. Cause of Fetal Death as Indicated on Fetal Death Certificates

	Unbelted (n = 12) [n (%)]	Belted (n = 28) [n (%)]	Unknown belt use (n = 5) [n (%)]	No crash (n = 2600) [n (%)]
Maternal injury	3 (25)	2 (7)	2 (40)	14 (0.5)
Asphyxia	3 (25)	5 (18)	0 (0)	307 (11.8)
Umbilical cord problems	1 (8)	5 (18)	1 (20)	519 (19.9)
Placental separation	0 (0)	3 (11)	0 (0)	191 (7.3)
Other	5 (42)	13 (46)	2 (40)	1569 (60.5)

Table 6. Percentage of Pregnancies Resulting in Fetal Death by Belt Usage

	No crash	Belted crash	Unbelted crash	Unknown
Total pregnancies	316,274	7173	1111	701
Fetal deaths	2600	28	12	5
Percentage	0.9	0.4	1.1	0.7

seatbelt use has previously been associated with low birth weight by Wolf et al,[11] who also documented an increased risk of delivery within 48 hours of the crash. We did not see an increased risk of immediate delivery in our models.

Unbelted pregnant women were nearly three times more likely to experience fetal death than belted pregnant women in crashes. Even though the small numbers of fetal deaths in our study limited our ability to more completely describe the effect of motor vehicle crash risks on fetal death, the crude OR of 2.8 was an indication that the unrestrained pregnant women were much more likely to lose their fetus in a motor vehicle crash than restrained women. Wolf et al[11] found no statistically significant increase in the risk of fetal death associated with lack of seatbelt use, despite their larger parameter estimate (4.1 versus 2.8). Another population-based study,[13] published over 30 years ago, reported that lap belt use was associated with a reduction in maternal death and maternal injury, but there was no association with fetal loss. The authors concluded, however, that lap belts were preferable to no restraint.

We found that a majority of fetal deaths (51%) were linked to crashes that occurred during the first trimester, even though all of the fetal deaths occurred during the second and third trimesters. This may be a result of the fact that first trimester crashes have up to 36 weeks to result in a fetal death, whereas the other trimesters have correspondingly less time to do so. Essentially, there was a longer exposure period of gestation in which fetal deaths could occur, whether or not those fetal deaths were related to the crash. Another possibility is that the last trimester may be offset by an increased likelihood of these infants being born through trauma- or physician-induced labor, which may have resulted in deaths not recorded in the fetal death file. Finally, the finding may suggest that the first trimester represents a sensitive period of fetal development and vulnerability to crashes, but that the fetal deaths do not occur (or are not noticed) until a few weeks later in development. Further research is warranted to better determine how gestational age impacts fetal death due to crashes.

Our findings also suggest that there is increased risk of fetal death for unbelted crashes that occur during the later weeks of gestation. When comparing gestational age and the time of fetal death, we found that the unbelted group had sharp increases of fetal deaths between 31 and 38 weeks' gestation. This may be indicative of a period of increased vulnerability to fetal death from motor vehicle crashes among unbelted drivers. One might believe that this increase is a result of more crashes during the third trimester. However, our linkage of all births involving unbelted motor vehicle crashes showed that only 25% of crashes occurred during the third trimester, the lowest percentage of any trimester. On the other hand, the majority (55%) of fetal deaths among the unbelted group linked to third-trimester crashes. Therefore, this pattern is probably a result of something different than increased crash risk. These findings have implications for health providers as well as researchers involved with crash dummy development. For instance, crash dummy testing has mainly focused on the 28–30-week gestational age period for designing the physiologic characteristics of a pregnant women and the fetus.[21,22] Our findings suggest it may be important to design dummies representing a few weeks later in gestation to more appropriately target the population that may be at the greatest risk for fetal death.

This study reaffirms the recommendations of ACOG[15] and the American Medical Association[23] that pregnant women should wear safety restraints throughout pregnancy. Current recommendations suggest that lap belts should be placed snugly under the abdomen and shoulder belts positioned diagonally across the chest.[24] Despite substantial research on the protective value of seatbelts, many women still do not wear them during pregnancy. Previous research indicates that the leading reasons for lack of seatbelt use during pregnancy include forgetting, discomfort or inconvenience, no seatbelt available, and fear that seatbelts may cause injury to the fetus or mother.[25] It is worth noting that some countries exempt pregnant women from seatbelt laws, which may be promulgating misconceptions about seatbelt use during pregnancy. Studies also show that many women are simply unaware of the correct usage and positioning of seatbelts.[26,27]

This study had several limitations. First, we were unable to include crashes that occurred outside the state, and because of a lack of identifying information in the crash dataset, we were unable to include nondriving, pregnant passengers in motor vehicle crashes. Therefore, it is likely that a portion of our noncrashed group were involved in a crash as a passenger and we were not able to identify these cases. It is also possible that the nature and severity of pregnant drivers' injuries are different from those of pregnant passengers. This study should still have captured the majority of the population, however, as studies have shown that most pregnant women in crashes are drivers.[3] A second limitation is our reliance on the birth and fetal death certificates. The diagnoses of complications such as placental abruption, fetal distress, and excessive maternal bleeding were not verified and were probably inconsistent on the birth and death certificates. Birth certificates have been shown to underestimate the complications of pregnancies,[28] and underreporting of fetal deaths is a common problem because of documentation limitations and the fact that states typically do not require reporting of fetal deaths that occur within the first 20 weeks' gestation.[29–31] Third, this study relied on self-reporting for seatbelt use during a crash. Because Utah has a law for mandatory restraint use with secondary enforcement, overreporting of belt use probably occurred. This would result in overstating the protective nature of seatbelts in preventing adverse outcomes. Information was not available on whether or not seatbelts were properly worn (according to recommendations) during pregnancy. Fourth, the inadequacy of the injury severity variable and the lack of a useful crash severity variable may have limited our ability to examine crash severity with necessary sensitivity. Police-reported injury severity information has been shown to correlate poorly with medical diagnoses.[32] With a better accounting of crash severity (perhaps through the use of a vehicle deformity variable or an estimate of delta V) and medically derived information on the extent and nature of maternal injury, one might see more of an impact among belted drivers in serious crashes. Fifth, we did not take into account sensitive periods of exposure whereby crashes occurring at certain periods of fetal development might be more or less likely to result in certain outcomes. The most obvious example is that late gestational crashes cannot by definition result in prematurity. Failure to take this into account somewhat weakens the power to show associations with this outcome. Sixth, there were not enough outcomes in our study to consider interactions with our models, such as a possible interaction between seatbelt use and gestational age. Finally, we did not try to do any postbirth follow-up; therefore, any increases in infant death or effects of more subtle neurologic injury in the infant survivors were not examined.

Despite these limitations, the major strengths of this study are the availability of statewide databases, the use of probabilistic linkage, and the use of a comparison group of pregnant women not involved in crashes. It would not be possible to do this type of study without population-based data on crashes and births. The statewide crash, birth, and fetal death databases allowed population-based tracking of a large number of crash-involved pregnant women over a wide geographic area, minimizing data collection expenses and follow-up losses. The use of probabilistic linkage allowed us to identify crashes throughout pregnancy without having to rely on clinical tests or recall bias of the mother. This study also provided a comparison group of pregnant women who have not been involved in a crash, which allowed us to measure the overall impact of motor vehicle crashes and seatbelt usage in an important way that has not been done before.

This study shows that wearing a seatbelt in a motor vehicle crash during pregnancy is a useful and effective intervention for reducing the risk of adverse pregnancy outcomes. Strategies to lessen the burden of motor vehicle crashes during pregnancy should focus on improving seatbelt usage among pregnant women and advancing motor vehicle and physiologic research. Greater public awareness and education is needed on safe driving habits and on the effectiveness of seatbelts during pregnancy, particularly among those women identified as being more at risk for adverse pregnancy outcomes (young women who smoke, do not begin prenatal care during the first trimester, and have not completed high school). Because studies have shown that states with primary seatbelt laws show higher seatbelt usage rates than those without,[33] there may also be opportunities to decrease crash-related injury and mortality through more aggressive seatbelt enforcement strategies. Overall, more research is needed to determine what strategies are effective in improving safety for pregnant women in motor vehicles. This includes evaluating the effectiveness of public education and enforcement initiatives, studying the physiologic vulnerabilities of pregnant women in motor vehicle crashes through medical research and crash dummy testing, and continuing to monitor pregnancy outcomes among women involved in motor vehicle crashes.

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