

---

# Profile of Mothers at Risk: An Analysis of Injury and Pregnancy Loss in 1,195 Trauma Patients

Danagra G Ikossi, MD, Ann A Lazar, MS, Diane Morabito, RN, MPH, John Fildes, MD, FACS,  
M Margaret Knudson, MD, FACS

---

- BACKGROUND:** Trauma is the number one cause of maternal death during pregnancy, but incidence of fetal loss exceeds maternal loss by more than 3 to 1. We hypothesized that we could identify women at risk for injury during pregnancy and focus our prevention efforts.
- STUDY DESIGN:** Women of childbearing age in the American College of Surgeon's National Trauma Data Bank served as the study population. Pregnant patients were compared with nonpregnant patients with respect to age, race, mechanism of injury, injury patterns and severity, risk-taking behaviors, and outcomes. Multivariate logistic regression analysis was used to identify risk factors for loss of pregnancy in mothers who survived their trauma.
- RESULTS:** Pregnant trauma patients (n = 1,195) were younger, less severely injured, and more likely to be African American or Hispanic as compared with the nonpregnant cohort (n = 76,126). Twenty percent of injured pregnant patients tested positive for drugs or alcohol, and approximately one-third of those involved in motor vehicle crashes were not using seatbelts. Independent risk factors for fetal loss after trauma included Injury Severity Score > 15; Adjusted Injury Score  $\geq$  3 in the head, abdomen, thorax, or lower extremities; and Glasgow Coma Score  $\leq$  8.
- CONCLUSIONS:** Young, African-American, and Hispanic pregnant women are at higher risk for trauma in pregnancy and are most likely to benefit from primary trauma prevention efforts. Those with severe head, abdominal, thoracic, or lower extremity injuries are at high risk for pregnancy loss. Reduction of secondary insults and early recognition of fetal distress may improve outcomes for both the mother and fetus in this high-risk group. (J Am Coll Surg 2005;200:49–56. © 2005 by the American College of Surgeons)
- 

Improvements in obstetric care have dramatically reduced maternal mortality associated with pregnancy. Subsequently, trauma has emerged as the leading cause

of maternal death during pregnancy.<sup>1</sup> It is estimated that approximately 7% of women are injured during their pregnancy, but the true incidence is unknown because, until recently, no comprehensive national trauma database existed.<sup>2</sup> Because trauma in pregnancy is relatively uncommon, it is well-suited for analysis using large, secondary data sources. Earlier smaller studies that have attempted to identify mothers at risk for injury during pregnancy suggest that injured pregnant patients tend to be younger, less severely injured, and are more likely to be assaulted than nonpregnant women of reproductive age.<sup>3</sup> To address the issue of fetal mortality, several limited retrospective studies have identified the following maternal factors as predictors of fetal demise: increasing Injury Severity Score (ISS), maternal acidosis, hypoxia, presence of shock, severe head injury, direct uteroplacental injury, abruptio placentae, presence of DIC, and maternal demise.<sup>4-6</sup> All efforts are made to identify and

**No competing interests declared.**

Supported by the National Center for Injury Prevention and Control CDC Grant R49/CCR903697 and the National Institutes of Health trauma training grant NIH 2T32CM08258 (DGI).

Winner, Region IX Committee on Trauma Resident Paper Competition, November 2003, Sacramento, CA.

Presented at The National Residents Trauma Paper Competition, Committee on Trauma, American College of Surgeons, Tucson, AZ, April 2004.

Received May 19, 2004; Revised September 22, 2004; Accepted September 23, 2004.

From the Department of Surgery, University of California, San Francisco, and the San Francisco Injury Center, San Francisco, CA (Ikossi, Morabito, Knudson); Department of Biostatistics, University of California, San Francisco, CA (Lazar); and Department of Surgery, University of Nevada School of Medicine, Las Vegas, NV (Fildes).

Correspondence address: M Margaret Knudson, MD, FACS, Department of Surgery, San Francisco General Hospital, Ward 3A, 1001 Potrero Ave, San Francisco, CA 94110.

**Abbreviations and Acronyms**

AIS	= Adjusted Injury Score
GCS	= Glasgow Coma Score
ISS	= Injury Severity Score
NTDB	= National Trauma Data Bank

promptly address maternal injuries but this does not ensure survival of the pregnancy, as the fetal-to-maternal death ratio in some studies approached 9 to 1.<sup>5</sup>

The purpose of the current study was to examine the largest available trauma database, the National Trauma Data Bank (NTDB), to define the population of pregnant patients at risk for injury; describe the patterns of injury sustained during pregnancy; and determine the risk factors for loss of pregnancy after injury. We hypothesized that by identifying a group of injured pregnant woman who were “at risk” for loss of their pregnancy, we could define a subpopulation of women who should be targeted in our prevention efforts. Finally, we sought to refine the existing data elements of the NTDB to optimize the utility of this powerful data source in studying trauma in pregnant women.

**METHODS**

Data used in this analysis were derived from the NTDB (1994 to 2001) with permission from the American College of Surgeons. The data provided represent the contribution of 130 trauma centers nationwide. There were 28 Level I, 21 Level II, 2 Level III, and 79 centers that were undesignated or whose designation was unknown at the time. Patient information is de-identified before receipt from the NTDB and cannot be traced to the institution or patient of origin. We queried the NTDB for all injured women of childbearing age (12 to 51 years) and the subset of those patients who had “pregnancy” coded as a “comorbid condition.” We compared pregnant women with their nonpregnant counterparts for the following variables: age, race, Adjusted Injury Score (AIS) in each body region, ISS, length of stay, ICU days, presence of shock on admission (SBP < 90 mmHg), a positive drug or alcohol screen, mechanism of injury, outcomes, and use of airbags or seatbelts in those patients who were involved in motor vehicle crashes. For pregnant patients, we examined the rate of cesarean section, vaginal delivery, dilation and curettage, and hysterectomy performed during the

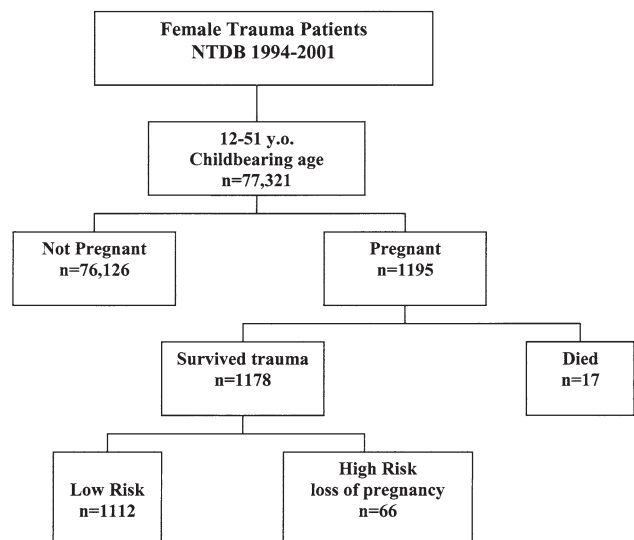
trauma admission. We then defined a group of pregnant patients as “high risk” if they survived their trauma but were delivered or underwent procedures consistent with termination of pregnancy as the result of the trauma. We compared this high-risk group with the group of pregnant patients in which the mother survived and the pregnancy continued during the trauma admission.

**Statistical analysis**

Summary statistics and the Wilcoxon Mann-Whitney tests were used for ordinal data, and chi-square analysis of contingency table and Fisher’s exact tests were used for nominal data. Univariate logistic regression was used to determine which variables served as predictors of pregnancy loss in those patients who survived. Multivariate logistic regression models were then constructed to adjust for age; ISS; shock; Glasgow Coma Score (GCS); AIS in the head, abdomen, thorax, spine, upper and lower extremities; race; and insurance status and to determine which variables remained important independent predictors in multivariate analysis.

**RESULTS**

A total of 77,321 records were examined, representing all women of childbearing age (12 to 51 years old) from 1994 to 2001, who had been submitted for inclusion in the NTDB. We compared 76,126 injured nonpregnant women with 1,195 injured pregnant patients. A break-



**Figure 1.** Summary of National Trauma Data Bank (NTDB) data where “childbearing age” is defined as 12 to 51 years of age, and the “high-risk” group is defined as all pregnant women who had a procedure resulting in delivery or pregnancy loss.

**Table 1.** Descriptive Data, Nonpregnant Versus Pregnant Injured Women

Variable	Nonpregnant (n = 76,126)	Pregnant (n = 1,195)	p Value
Mean age ( $\pm$ SD), y	30.6 $\pm$ 10.7	25.1 $\pm$ 6.1	<0.0001
Mean ISS ( $\pm$ SD)	9.7 $\pm$ 10.1	6.1 $\pm$ 8.7	<0.0001
Mortality (%)	3.8	1.4	<0.0001
Mean LOS ( $\pm$ SD), days	5.2 $\pm$ 9.0	3.4 $\pm$ 7.7	<0.0001
Shock (BP<90), %	4.2	2.9	<0.04
Alcohol (%)	37.0	12.9	<0.0001
Drugs (%)	26.5	19.6	<0.0008
Interpersonal violence (%)	10.0	11.6	<0.07
Suicide (%)	1.9	0.5	<0.001
Seatbelt use (%)	50	66	<0.0001

LOS, length of stay.

down of the patients into groups for study can be found in Figure 1.

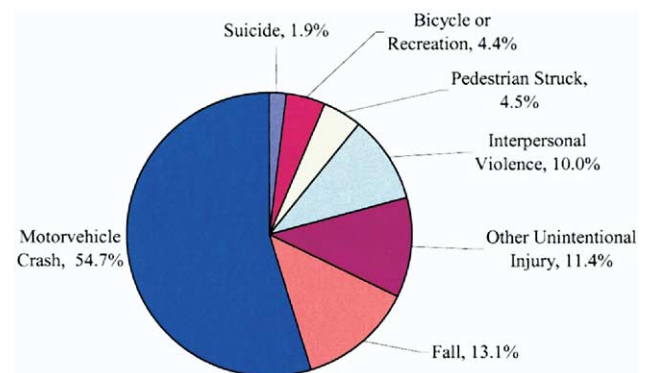
As seen in Table 1, the pregnant patients were significantly younger, more likely to be African American or Hispanic, had lower ISS, lower death rates, spent less time in the hospital after injury, and were less likely to be in shock when compared with nonpregnant patients. These differences all reached statistical significance. The presence of alcohol or drugs on admission was significantly less than in the nonpregnant patients ( $p < 0.0001$ ), but still 13% of injured pregnant patients had been drinking before the injury and, alarmingly, 20% tested positive for illegal drugs. Pregnant patients were most likely to be injured in motor vehicle crashes (70%) and although they were significantly more likely to wear seatbelts than their nonpregnant counterparts, the rate of use was still only 66% (Table 1). Injuries resulting from interpersonal violence accounted for 11.6% of the injuries in pregnant women versus 10.0% in nonpregnant women (not statistically significant,  $p = 0.063$ ). Interestingly, the rate of self-inflicted injury, including suicide attempts, was lower in pregnant women than nonpregnant women (refer to Table 1, Figs. 2, 3.)

After admission for trauma of any kind, the rate of delivery (vaginal and cesarean) was 5.1%; 75% of these deliveries were by cesarean section and 75% were performed within 24 hours of injury. An additional 10 women underwent dilation and curettage and 2 had hysterectomies during their trauma admission. Data collected on fetal monitoring practices were sparse. There is no separate field for coding of fetal monitoring in the database, making this kind of information most likely underreported; in our analysis only 3% of pregnant women had monitoring coded. It is critical to note that these data do not account for trimester of pregnancy or

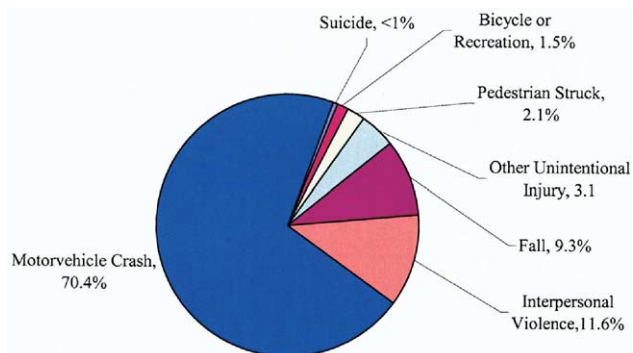
outcomes of the fetus, as this information is currently not collected in the NTDB.

To further examine issues of race and trauma in pregnancy, the subsets of Caucasian, African-American, and Hispanic patients were analyzed separately, revealing twice the rate of pregnancy at the time of trauma in minority patients compared with their Caucasian, non-Hispanic counterparts. When using insurance status as a surrogate for socioeconomic status, we found that both African-American and Hispanic women who were pregnant were significantly more likely to be underinsured (Medicaid or no insurance) compared with their nonpregnant counterparts (Table 2). African-American pregnant women were more likely to be victims of intentional injury (suicide, homicide, assault) than non-African American (19.5% versus 8.7%,  $p < 0.0001$ ). This trend toward increased intentional injury was not seen in other minority groups.

We then categorized the pregnant patients who lived but delivered during the trauma admission, required a dilation and curettage or a hysterectomy, or both, as our



**Figure 2.** Mechanism of injury data for 51,907 nonpregnant women of childbearing age.



**Figure 3.** Mechanism of injury data for 852 pregnant women of childbearing age.

high-risk group. These women were compared with pregnant patients who had good outcomes (mother survived with intact pregnancy) in univariate analysis. As seen in Table 3, nine variables were associated with loss of pregnancy: severe injuries as defined by ISS; presence of shock on admission; altered mental status on admission (GCS); presence of drugs on toxicology screening; presence of a severe head injury; severe injury to the thorax, abdomen, lower extremities, and spine. Statistical significance for all variables except presence of drugs and spinal injury was demonstrated at  $p < 0.01$ . Multivariate regression analysis was then performed to control for the influence of age; ISS; shock in the emergency department; GCS; AIS in the head, thorax, abdomen, spine, upper and lower extremities; race; and insurance status to determine which of these risk factors were independent predictors of loss of pregnancy. Use of drugs and alcohol were not included in the regression models because of a great deal of missing data in these fields. The multivariate model confirmed that all putative predictors were predictors of loss of pregnancy, with the exception of shock on admission and drug use. Significant independent predictors of loss of pregnancy were severe injuries as defined by ISS; altered mental status on admission (GCS); presence of a severe head injury by AIS; and severe injury to the thorax, abdomen, lower extremities, or spine. The model that best represents the data is shown in Table 4. It is of note that spinal injury and

**Table 3.** Univariate Analysis of the Risk of Loss of Pregnancy

Risk factor	Odds ratio	95% CI	p Value
ISS > 15	8.49	4.85–14.86	<0.0001
Shock	3.85	1.41–10.49	<0.01
GCS ≤ 8	6.76	2.71–16.87	<0.0001
Drugs	2.37	1.16–4.82	<0.02
AIS ≥ 3			
Head	4.25	2.10–8.61	<0.0001
Thorax	4.46	2.30–8.64	<0.0001
Abdomen	7.76	4.32–13.95	<0.0001
Lower extremity	5.58	3.08–10.10	<0.0001
Spine	3.92	1.29–11.94	<0.02

AIS, Adjusted Injury Score; GCS, Glasgow Coma Score; ISS, Injury Severity Score.

thoracic injury with AIS ≥ 3 were not consistently significant, depending on which predictors were included in the model. Shock approached significance as an independent predictor in several models, but did not achieve statistical significance at the  $p < 0.05$  level. Race was also an inconsistent independent predictor, with Hispanic race achieving statistical significance at  $p = 0.0386$  in one model and an odds ratio of 2.33 (CI, 1.05 to 5.21).

There were 17 pregnant patients who died and 7 of these patients underwent cesarean section before or concurrent with death. The average ISS of those who expired was  $39 \pm 17$ . Sixty-four percent of them had major head trauma (average GCS,  $6 \pm 5$ ), and severe abdominal and thoracic injuries (AIS ≥ 3) were present in 59% and 47%, respectively. Because of the relatively small number of deceased patients, it was not possible to use multivariate analysis to determine the predictors of maternal demise.

## DISCUSSION

The first goal of this study was to identify the characteristics of injured pregnant women to target our prevention efforts to those populations most at risk. We have succeeded in confirming the findings of earlier, smaller studies, demonstrating that injured pregnant patients

**Table 2.** Race and Socioeconomic Status in Pregnant Trauma Victims

Ethnicity	Pregnant (%)	Pregnant and underinsured (%)	Nonpregnant and underinsured (%)	p Value
Caucasian	1.1	48	31	<0.0001
African American	2.5	68	53	<0.0001
Hispanic	3.0	68	54	<0.001

**Table 4.** Multivariate Model of the Risk of Loss of Pregnancy

Risk factor	Adjusted odds ratio	95% CI	p Value
ISS > 15	9.17	4.81–17.50	<0.0001
GCS ≤ 8	5.24	1.74–15.81	<0.01
AIS ≥ 3			
Head	3.02	1.31–6.97	<0.01
Thorax	2.29	1.06–4.96	<0.04
Abdomen	5.63	2.85–11.10	<0.0001
Lower extremity	3.98	1.99–7.96	<0.0001

AIS, Adjusted Injury Score; GCS, Glasgow Coma Score; ISS, Injury Severity Score.

tend to be younger than their nonpregnant counterparts, are more likely to be underinsured, and are of African-American race or Hispanic ethnicity. Drost and colleagues<sup>7</sup> reported that of 318 pregnant trauma victims seen at their institution over a 4-year period, only 8% would have been admitted in the absence of pregnancy. Admission for monitoring of the fetus and high index of suspicion is likely the predominant reason for lower-than-average ISS seen in most studies, including our own. In a statewide study from Pennsylvania, including 761 injured pregnant patients, Weiss<sup>3</sup> reported that pregnant patients hospitalized after injury were significantly younger, less severely injured, and more likely to be assaulted when compared with injured, nonpregnant women of reproductive age. Investigators from San Diego used their countywide database to examine risk factors for maternal and fetal outcomes and concluded that women were at higher risk if they were younger, lacking prenatal care, or from a Hispanic background.<sup>6</sup> Motor vehicle crashes represented the primary mechanism of injury in the San Diego study, but 12% of the 114 injured pregnant patients had been assaulted. More striking was the racial disparity in assaults, with the rate of assault-related injury in “minority,” non-Caucasian populations double that of their Caucasian counterparts. Our study finds similar patterns of injury, although the rate of intentional injury is slightly lower in this analysis. We confirm the higher rate of intentional injury among African-American women, when compared with their Caucasian counterparts.

In previous retrospective reviews, the rate of interpersonal violence in pregnant women who present as trauma victims varies from 0.9% to 30%.<sup>4,8-10</sup> A retrospective review of medical examiners' reports for New York City between 1987 and 1991 demonstrated a remarkable rate of homicide (63%) among pregnant

women who died after injury.<sup>11</sup> African-American pregnant women were more likely to be victims of homicide during pregnancy than other races. Because of the relatively low mortality rate seen in our sample, we cannot assess the influence of race on homicide rates in specific. Our study has only 17 deaths in the subgroup of pregnant patients, and 10 were associated with motor vehicle crash, 1 by fire, 1 intentional firearm injury, and 1 suicide. It should be noted that coroners' data on patients who did not reach a trauma center is not included in the NTDB. Clearly, this also affects the number of women in each group whose mechanism of injury was attempted suicide. These data represent only those women who were unsuccessful in their suicide attempt and were activated as a trauma at the participating institutions. We cannot definitively say that the rate of suicide attempt is lower in pregnant women, but only that pregnant women are less likely to be admitted as trauma victims with attempted suicide as the mechanism of injury.

The issue of drug and alcohol use among pregnant women has been a focus for primary prevention efforts over the past decade. Nevertheless, a striking number of young mothers-to-be in our study consumed alcohol or used drugs just before their trauma. Although the rate of substance abuse was lower in pregnant patients than their nonpregnant counterparts, it approached 20%. This is concordant with earlier studies with a historical rate of drug and alcohol use in injured pregnant women of 12% to 20%.<sup>3,4,12</sup> Clearly, prevention programs aimed at reducing substance abuse should be part of prenatal care, especially for young women.

Another area where risk-taking behavior emerges during pregnancy is in women who drive without the use of restraint devices. We have confirmed that poor compliance with seatbelt use remains an issue. Only 66% reported using seatbelts at the time of a motor vehicle crash and we have no data on whether or not restraint devices were used properly. This is despite nationwide legislation mandating use of seatbelts and a decade of public education on the benefits of seatbelt use. A survey-based study of 450 pregnant women in a county prenatal clinic reported a 73% rate of correct use of seatbelts during pregnancy.<sup>13</sup> The authors state that the most common reason for lack of restraint use was patient discomfort (53%), followed by forgetfulness (37%). One-third of their patients were unsure of the effects of seatbelts on the fetus and 10% believed that

seatbelts would harm the fetus during a motor vehicle crash. These beliefs were associated with a lower incidence of seatbelt use and highlighted the need for patient education on the benefits of seatbelt use. It is striking that even in this compliant patient population, only 37% had received information about restraint use during pregnancy. To address the utility of education, Tyroch and colleagues<sup>14</sup> conducted a survey of pregnant women before and 3 months after a focused educational program on proper seatbelt use during pregnancy. These investigators found that although nearly 80% of these women initially reported seatbelt use, only 52% wore them correctly. After the educational intervention, correct seatbelt use increased to 62%, demonstrating the effectiveness of education in this population. Our data confirm the need for further patient education on the benefits of proper seatbelt use during pregnancy. Pregnant women must be counseled on the correct placement of seatbelts throughout pregnancy, as there have been reports of adverse fetal outcomes, including death secondary to abruption placentae, after motor vehicle crashes in which the mother was wearing her seatbelt improperly.<sup>15</sup>

Of those patients who delivered their infant during their trauma admission, 75% underwent cesarean section. This is a threefold greater rate than the national average of 13% to 22% for cesarean section deliveries.<sup>16</sup> Seventy-five percent of these cesarean sections were performed within 24 hours of admission, implying urgent operation. The indication for delivery (ie, fetal distress, maternal distress, and so forth) and outcomes of the fetus cannot be determined from this study, as the NTDB currently does not collect the information necessary to answer these questions. A large-scale, multicenter retrospective study on infant survival after cesarean section for trauma demonstrated that appropriate use of cesarean section in the trauma patient results in an infant survival rate of 75% among those infants with fetal heart tones and an estimated gestational age of 26 weeks or later.<sup>17</sup> These authors concluded that delay in recognition of fetal distress was the cause of death in 60% of those who did not survive after cesarean section. This prompted the recommendation that cardiotocographic monitoring be used in all viable infants and that there be teamwork between trauma, emergency medicine, and obstetrics to ensure that fetal distress is recognized promptly and emergent cesarean section initiated appropriately.

Even minor abdominal trauma may result in placental abruption, which can be clinically silent.<sup>18</sup> Progression of abruption after injury to > 50% of the placental surface results in fetal demise.<sup>19</sup> These factors underscore the importance of monitoring with cardiotocographic monitoring for at least 6 hours after trauma in those whose pregnancies are potentially viable if delivered (ie, > 25 weeks gestation).<sup>20</sup> In our study, fetal monitoring appears to be underused, although this is likely underreported and difficult to interpret without knowing the trimester of pregnancy, also not included in the NTDB at this time.

It is significant to note that there have been several studies and case series that suggest there may be severe or even fatal injuries to the fetus concurrent with relatively minor maternal injury and well-compensated maternal vital signs.<sup>21-23</sup> This is likely a result, in part, of uterine hypoperfusion and hypoxia secondary to uterine vessel vasoconstriction, which has deleterious effects on the fetus, although providing hemodynamic compensation to the mother. Monitoring the mother for overt signs of shock is notoriously unreliable as an indicator of fetal well-being. Several studies have shown that maternal pulse, blood pressure, and PO<sub>2</sub> are not reliable predictors of fetal demise.<sup>21,24</sup> Scorpio and colleagues<sup>24</sup> recommended use of serum bicarbonate measurement in monitoring the mother for signs of compensated shock as, in their multivariate logistic regression analysis of the clinical data of 76 injured pregnant patients, only ISS and serum bicarbonate levels on admission showed statistically significant correlation with fetal loss.

With this analysis, we have succeeded in identifying mothers at risk for pregnancy loss, including those with ISS > 15; those with major injuries to the thorax, abdomen, or lower extremity (AIS  $\geq$  3); and those with severe head injury, as defined by GCS  $\geq$  8 or AIS in the head of  $\geq$  3. As suggested by Kissinger and colleagues,<sup>4</sup> pregnant patients with head injuries are particularly vulnerable and these patients with viable fetuses certainly require monitoring for fetal distress. The association between thoracic injury and fetal loss has not been described previously and may be related to maternal and fetal hypoxia. As described previously, severe abdominal and lower extremity injuries are confirmed as risk factors for fetal loss.

Because of limitations in the database, it was not possible to address the issue of risk factors for fetal morbidity and mortality. In the study by Shah and colleagues<sup>6</sup>

that included 114 injured pregnant patients, factors associated with fetal loss included maternal death, severe maternal injury, severe abdominal injury, and presence of hemorrhagic shock.<sup>6</sup> Ali and others<sup>25</sup> reported on 20 pregnant patients with ISS > 12, where overall fetal mortality was 65%, with only one maternal death. They cited high ISS, blood loss, presence of abruptio placentae, and DIC as the most significant predictors of fetal mortality. A 1991 study by Hoff and colleagues<sup>5</sup> evaluated 73 pregnant trauma victims and concluded that the maternal factors associated with fetal mortality were increasing ISS, face and abdominal AIS, increasing fluid requirements, maternal acidosis, and maternal hypoxia. In a study of fetal death registries from 16 states, 240 traumatic fetal deaths were identified, with motor vehicle crashes as the leading cause of death related to maternal trauma.<sup>26</sup> Placental injury was associated with 100 cases (42%) and maternal death was noted in 27 cases (11%) of fetal deaths. Kissinger and colleagues<sup>4</sup> confirmed the importance of direct uteroplacental injury, maternal shock, pelvic fracture, and hypoxia. Our study confirms the unique finding first suggested by Kissinger and his coauthors that severe maternal head injury is associated with fetal demise. These studies also suggest that the ratio of fetal to maternal death ranges from 3:1 to 9:1.<sup>4-6,25,26</sup>

The finding that head injury alone is associated with loss of pregnancy is relatively novel. One explanation for this finding might be an alteration in the function of the hypothalamic-pituitary-adrenal axis after severe head injury. Clinical studies in the neurosurgical literature have demonstrated hormonal derangements in head-injured patients.<sup>27,28</sup> Kelley and colleagues<sup>28</sup> examined the function of both the anterior and posterior pituitary of 22 head-injured patients of both sexes. The authors demonstrated some degree of hypopituitarism in 40% of patients with moderate-to-severe head injury, with growth hormone and gonadotrophic deficiencies being the most common.<sup>28</sup> Further study on the role of the function of the hypothalamic-pituitary-adrenal axis after head injury in pregnant trauma patients is warranted, as it may be necessary to provide supplemental hormonal support to optimize pregnancy outcomes. To better delineate the relationship between head injury and loss of pregnancy, a prospective multicenter trial may be necessary to achieve adequate sample size and collect more detailed information with respect to neurologic and hormonal function.

To facilitate future research on the topic of fetal outcomes of trauma in pregnancy and further delineate the maternal predictors of fetal demise, we recommend augmentation of the existing data elements in the NTDB. The data set should include the estimated gestational age of the fetus and any signs or symptoms of fetal distress. Additionally, the indication for delivery or termination of the pregnancy should be recorded. To improve the data collection, we recommend that results of urine or serum  $\beta$ -HCG testing be included in the national database for all women of childbearing age (12 to 51 years of age). As demonstrated by Bochicchio and colleagues,<sup>29</sup> nearly 3% of all female trauma victims of childbearing age are pregnant, with 11% discovered at the time of injury, and some picked up incidentally during the Focused Abdominal Sonogram for Trauma, an ultrasonography examination for trauma.<sup>29</sup> We recommend that a subset of fields be activated within the NTDB for all pregnant patients, to include information on the week of gestation, fetal heart rate, and reasons for delivery or termination of pregnancy. It would be helpful if the fetus could be linked to the mother within the database, to facilitate future study on the maternal predictors of fetal outcomes after trauma.

In conclusion, the NTDB is a powerful tool for the study of relatively uncommon populations of injured patients. With this, the largest report to date on trauma in pregnancy, we have identified the demographics of the women who are injured during pregnancy and the risk factors associated with loss of pregnancy after injury. Young, African-American, and Hispanic pregnant women are at higher risk for trauma in pregnancy and are most likely to benefit from primary trauma prevention efforts. Those with severe head, abdominal, thoracic, or lower extremity injuries are at high risk for pregnancy loss. Reduction of secondary insults and early recognition of fetal distress may improve outcomes for both the mother and fetus in this high-risk group. We have also identified areas where improved data collection could better target both treatment and prevention efforts in women during their reproductive years. Broadening the scope of information collected on pregnant trauma victims and their infants will facilitate further study.

#### Author Contributions

Study conception and design: Ikossi, Knudson

Analysis and interpretation of data: Ikossi, Lazar, Morabito, Knudson

Drafting of manuscript: Ikossi

Critical revision: Morabito, Fildes, Knudson

Statistical expertise: Lazar

Obtaining funding: Morabito, Knudson

Supervision: Ikossi, Knudson

**Acknowledgment:** The sole data source for this article was The National Trauma Data Bank, provided with permission of the American College of Surgeons, to whom we extend our appreciation.

## REFERENCES

- Fildes J, Reed L, Jones N, et al. Trauma: the leading cause of maternal death. *J Trauma* 1992;32:643–645.
- Peckham CH, King RW. A study of intercurrent conditions observed during pregnancy. *Am J Obstet Gynecol* 1963;87:609–624.
- Weiss HB. Pregnancy-associated injury hospitalizations in Pennsylvania, 1995. *Ann Emerg Med* 1999;34:626–636.
- Kissinger DP, Rozycki GS, Morris JA Jr, et al. Trauma in pregnancy. Predicting pregnancy outcome. *Arch Surg* 1991;126:1079–1086.
- Hoff WS, D'Amelio LF, Tinkoff GH, et al. Maternal predictors of fetal demise in trauma during pregnancy. *Surg Gynecol Obstet* 1991;172:175–180.
- Shah KH, Simons RK, Holbrook T, et al. Trauma in pregnancy: maternal and fetal outcomes. *J Trauma* 1998;45:83–86.
- Drost TF, Rosemurgy AS, Sherman HF, et al. Major trauma in pregnant women: maternal/fetal outcome. *J Trauma* 1990;30:574–578.
- Gazmararian JA, Lazorick S, Spitz AM, et al. Prevalence of violence against pregnant women. *JAMA* 1996;275:1915–1920.
- Gazmararian JA, Adams MM, Saltzman LE, et al. The relationship between pregnancy intendedness and physical violence in mothers of newborns. The PRAMS Working Group. *Obstet Gynecol* 1995;85:1031–1038.
- Poole GV, Martin JN Jr, Perry KG Jr, et al. Trauma in pregnancy: the role of interpersonal violence. *Am J Obstet Gynecol* 1996;174:1873–1877; discussion 1877–1878.
- Dannenber AL, Carter DM, Lawson HW, et al. Homicide and other injuries as causes of maternal death in New York City, 1987 through 1991. *Am J Obstet Gynecol* 1995;172:1557–1564.
- Parsons LH, Harper MA. Violent maternal deaths in North Carolina. *Obstet Gynecol* 1999;94:990–993.
- McGwin G, Russel SR, Rux RL, et al. Knowledge, beliefs and practices concerning seat belt use during pregnancy. *J Trauma* 2004;56:670–676.
- Tyroch AH, Kaups KL, Rohan J, et al. Pregnant women and car restraints: beliefs and practices. *J Trauma* 1999;46:241–245.
- Bunai Y, Nagai A, Nakamura I, Ohya I. Fetal death from abruptio placentae associated with incorrect use of a seatbelt. *Am J Forensic Med Pathol* 2000;21:207–209.
- Gould JB, Davey B, Stafford RS. Socioeconomic differences in rates of cesarean section. *N Engl J Med* 1989;321:233–239.
- Morris JA Jr, Rosenbower TJ, Jurkovich GJ, et al. Infant survival after cesarean section for trauma. *Ann Surg* 1996;223:481–488; discussion 488–491.
- Kettel LM, Branch DW, Scott JR. Occult placental abruption after maternal trauma. *Obstet Gynecol* 1988;71:449–453.
- Dahmus MA, Sibai BM. Blunt abdominal trauma: are there any predictive factors for abruptio placentae or maternal-fetal distress? *Am J Obstet Gynecol* 1993;169:1054–1059.
- Curet MJ, Schermer CR, Demarest GB, et al. Predictors of outcome in trauma during pregnancy: identification of patients who can be monitored for less than 6 hours. *J Trauma* 2000;49:18–24; discussion 25.
- Esposito TJ, Gens DR, Smith LG, et al. Trauma during pregnancy. A review of 79 cases. *Arch Surg* 1991;126:1073–1078.
- Fries MH, Hankins GD. Motor vehicle accident associated with minimal maternal trauma but subsequent fetal demise. *Ann Emerg Med* 1989;18:301–304.
- Agran PF, Dunkle DE, Winn DG, Kent D. Fetal death in motor vehicle accidents. *Ann Emerg Med* 1987;16:1355–1358.
- Scorpio RJ, Esposito TJ, Smith LG, Gens DR. Blunt trauma during pregnancy: factors affecting fetal outcome. *J Trauma* 1992;32:213–216.
- Ali J, Yeo A, Gana TJ, McLellan BA. Predictors of fetal mortality in pregnant trauma patients. *J Trauma* 1997;42:782–785.
- Weiss HB, Songer TJ, Fabio A. Fetal deaths related to maternal injury. *JAMA* 2001;286:1863–1868.
- Segal-Lieberman G, Karasik A, Shimon I. Hypopituitarism following closed head injury. *Pituitary* 2000;3:181–184.
- Kelly DF, Gonzalo IT, Cohan P, et al. Hypopituitarism following traumatic brain injury and aneurysmal subarachnoid hemorrhage: a preliminary report. *J Neurosurg* 2000;93:743–752.
- Bochicchio GV, Napolitano LM, Haan J, et al. Incidental pregnancy in trauma patients. *J Am Coll Surg* 2001;192:566–569.