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ELSEVIER

Accident Analysis and Prevention 40 (2008) 1088–1095

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The epidemiology of pregnancy-associated emergency department injury visits and their impact on birth outcomes

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Received 3 August 2007; received in revised form 19 October 2007; accepted 30 November 2007

Abstract

Objective: Describe the demographics, injury types, mechanisms, and intents of emergency department (ED) injury visits by pregnant women and to quantify their risk of adverse birth outcomes.

Methods: Through a retrospective cohort study design, Utah ED, birth, and fetal death records were probabilistically linked to identify women seen in an ED with an injury during pregnancy among births and fetal deaths from 1999 to 2002. Logistic regression was used to assess the effect of having an injury-related ED visit on various adverse pregnancy outcomes.

Results: 7350 (3.9%) women experienced an injury-related ED visit during pregnancy. Motor vehicle occupant injuries were the leading mechanism of ED injury visits (22.4%). Controlling for known risks, pregnant women with an injury-related ED visit were more likely than non-injured pregnant women to experience preterm labor (OR = 1.22, 95% CI = 1.12–1.34), placental abruption (OR = 1.33, 95% CI = 1.08–1.65), and cesarean delivery (OR = 1.27, 95% CI = 1.19–1.36). Infants born to women who were injured during pregnancy were more likely to be born preterm (OR = 1.23, 95% CI = 1.12–1.34) and have low birth weight (OR = 1.22, 95% CI = 1.1–1.35).

Conclusions: Most injured pregnant women are treated and released from the ED; however, significant increased risks remain for several maternal complications and birth outcomes.

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Keywords: Injury; Pregnancy; Emergency department; Motor vehicle crash; Utah

1. Introduction

1.1. Background

During peak reproductive years (ages 15–35), the leading cause of death for women in the United States in 2004 was unintentional injury ($n = 7545$) and the second and third causes were malignant neoplasms ($n = 2970$) and suicide (1774), respectively (NCIPC, 2007). Non-fatal injuries are also common for women aged 15–35 in the U.S. with 4,540,585 non-fatal emergency department visits reported in 2005 among a population of 42,332,721 women (10.7%) (NCIPC, 2007). The Agency for

Healthcare Research and Quality reported in the 2004 Medical Expenditure Panel Survey Component that “Trauma-related disorders” ranked third in total costs among all conditions for medical services (excluding costs for normal births) for women age 15–39 (Agency for Healthcare Research and Quality, 2007).

With this important prevalence of medically treated injury among women of reproductive age, it should not be surprising that injury is also the leading cause of death during pregnancy in the U.S. (Fildes et al., 1992; Grossman, 2004). Recent reports of population-based hospitalized injury and motor vehicle injury during pregnancy have also documented the incidence and risks resulting from hospitalized injury during pregnancy for the offspring including: substantially increased fetal mortality, neonatal deaths, placental abruption, prematurity, low birth weight, birth defects, and other adverse birth outcomes (El-Kady et al., 2004; Greenblatt et al., 1997; Hyde et al., 2003;

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Kuo et al., 2007; Schiff and Holt, 2005; Weiss, 1999; Wolf et al., 1993). However, it is important to note that most medically treated injuries do not result in hospitalizations and hospitalizations due to maternal injuries are more likely to include late gestational age cases when the fetus is viable. In addition, several studies have shown that regardless of the severity of the woman's injury and even in minor or no maternal injury circumstances, the pregnancy and/or fetus may experience adverse outcomes and even fetal death (Agran et al., 1987; Baerga-Varela et al., 2000; Esposito et al., 1991; Fries et al., 1989; Grossman, 2004; Poole et al., 1996; Schiff and Holt, 2002; Schiff and Holt, 2005; Schiff et al., 2002). Therefore, a more complete understanding of the epidemiology of injury during pregnancy is needed and should emerge by studying emergency department cases. However, no population-based study of pregnancy-associated emergency department injury visits has been published.

1.2. Importance

As the first population-based study of pregnancy-associated emergency department injury visits, this study is critical to better understand the impact and how injury during pregnancy affects the pregnant woman and fetus. This is because this study is more encompassing of minor injuries and less susceptible to case selection bias than previous inpatient and trauma center studies that have focused concerns on older gestational age and viable fetuses. Less severe injuries (emergency department visits versus hospitalization) may still result in adverse outcomes, yet these have not been well documented in population-based studies. The main implication of this study is that an injury may lead a pregnant woman to visit the emergency department at any stage of the pregnancy. If increased risks were possible across gestational ages, this would indicate the need to more closely follow and monitor the pregnancy regardless of the stage of the pregnancy at the time of injury.

1.3. Goals of this investigation

Exclusionary case definitions, difficulties capturing pregnancy status, diagnosis coding limitations, and lack of follow-up for pregnancy outcomes have all contributed to an inadequate understanding of pregnancy-associated injury in many clinical settings (Weiss, 2006). This study overcomes many of these limitations through probabilistic linkage of emergency department billing records with birth and fetal death certificate data. The goals of this study were to describe the demographics, injury types, mechanisms and intents; along with a statistically valid and controlled comparison of reproductive outcomes of pregnant women treated in an emergency department for an injury versus pregnant women not treated for an injury. The secondary aims were to further explore the outcomes of interest in the women who experienced the most prevalent injuries during pregnancy and to determine differences in outcomes and injury types by trimester at the time of injury.

2. Methods

2.1. Study design, setting, and participants

We used a retrospective cohort design. This study was determined to be exempt by the University of Pittsburgh Institutional Review Board and approved by the University of Utah Institutional Review Board. The study used Utah Department of Health records from three different computerized databases: (1) emergency department billing records (1998–2002), (2) live births, and (3) fetal deaths. The first year of emergency department data (1998) was used to identify and capture injury emergency department visits by pregnant women who delivered or experienced a fetal death in 1999. The study period was chosen because of the availability of each of the statewide databases for these years.

The study participants consisted of women with birth outcomes reported to the Utah state vital statistics system from 1999 to 2002. Probabilistic linkage was used to match the records of female emergency department patients with related records in the birth and fetal death files. Probabilistic record linkage compares multiple variable fields to calculate a probability that records refer to the same person and should be linked. For this study, all pairs achieving a probability of 0.9 or greater were kept as matches (Cook et al., 2001). Linkage variables utilized were robust and included the pregnant woman's first and last name, date of birth, date of delivery and/or death of the fetus, and date of the emergency department visit. Probabilistic linkage has been described in detail elsewhere (Dean et al., 2001; Jaro, 1989).

To identify cases for which the emergency department visit occurred during pregnancy the following case selection was applied: If the gestational age (in weeks) at birth or fetal death was available, we looked back in time for an emergency department visit within the gestational age plus 1 week. If only the date of last menses was noted and the date of last menses occurred after the woman's emergency department visit the case was excluded. The few records without any indication of gestational age or last menses were excluded. Linkage was performed using LinkSolv software (Strategic Matching Inc., Morrisonville, NY).

2.2. Data collection and processing

Utah emergency department billing records contain standardized demographic information (gender, date of birth, admission data, and admission hospital); information about the emergency department visit including up to nine ICD-9 codes, a separate external cause of injury field (E-code), and the patient's discharge status. Birth certificate data included maternal demographic information, date and place of birth, abnormal conditions of the newborn, complications of labor and/or delivery, and medical risk factors. Injury was defined by the presence of an injury diagnosis (ICD9-CM diagnosis code) with or without an accompanying E-code. Only singleton resident births were included in this study since multiple birth is itself a risk factor for adverse birth outcomes. The fetal death data included all

reported fetal deaths (excluding elective abortions) of 20 weeks gestation or greater.

2.3. Primary data analysis

Descriptive statistics were combined with population and annual birth denominators to compute incidence rates. Logistic regression was used to assess the effect of having an injury-related emergency department visit on various adverse pregnancy outcomes. Based on previous research (Dahmus and Sibai, 1993; Kuo et al., 2007; Schiff et al., 2002; Wolf et al., 1993) we hypothesized that maternal injury during pregnancy would increase the odds of placental abruption, fetal distress, low birth weight (less than 2500 g), preterm birth (birth before 37 weeks gestation), cesarean delivery, fetal and infant death, hypoxia, preterm labor, labor induction, premature rupture of the membranes, and meconium at delivery. Outcomes were derived

from clinician determinations as indicated on the birth or fetal death certificate. Logistic regression models controlled for the following self-reported risk factors associated with adverse outcomes in pregnancy (Martin et al., 2002). Extreme age of the mother (younger than 20 or older than 35), tobacco use during pregnancy, alcohol use during pregnancy, parity, trimester at first prenatal care visit, injury during pregnancy, marital status, and race. The model was not adjusted for educational level due to a high correlation between age and educational level. All logistic analyses were performed using PROC LOGISTIC in SAS 9.1.3 (SAS Institute Inc., Cary, NC).

3. Results

In Utah, for the birth cohort years 1999–2002, there were 7350 (3.9%) women with an injury-related emergency department visit during pregnancy among all live births and fetal

Table 1
Mechanism and intent of injuries by admission status among pregnant women treated in an emergency room for an injury who experienced a live birth or fetal death in Utah 1999–2002

	Outpatient		Admitted		Total	
	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)
Mechanism						
MVT occupant	1,597	22.2	47	28.7	1,644	22.4
Fall	1,294	18.0	24	14.6	1,318	17.9
Cut/pierce	730	10.2	5	3.0	735	10.0
Struck by, against	731	10.2	1	0.6	732	10.0
Overexertion	574	8.0	2	1.2	576	7.8
No E-code	385	5.4	7	4.3	392	5.3
Other specified and classifiable	366	5.1	7	4.3	373	5.1
Not grouped	320	4.5	41	25.0	361	4.9
Poisoning	197	2.7	15	9.1	212	2.9
Unspecified	198	2.8	1	0.6	199	2.7
MVT unspecified	191	2.7	4	2.4	195	2.7
Bites and stings	190	2.6	1	0.6	191	2.6
Other specified, not elsewhere classifiable	105	1.5	0	0.0	105	1.4
Hot object/substance	103	1.4	1	0.6	104	1.4
Transport, other	78	1.1	3	1.8	81	1.1
Machinery	31	0.4	0	0.0	31	0.4
MVT pedestrian	21	0.3	2	1.2	23	0.3
Fire/flame	22	0.3	0	0.0	22	0.3
Other natural/environmental	17	0.2	0	0.0	17	0.2
Pedal cyclist, other	13	0.2	1	0.6	14	0.2
MVT motorcyclist	6	0.1	1	0.6	7	0.1
Firearm	4	0.1	0	0.0	4	0.1
MVT other	4	0.1	0	0.0	4	0.1
Suffocation	3	0.0	1	0.6	4	0.1
MVT pedal cyclist	3	0.0	0	0.0	3	0.0
Pedestrian, other	3	0.0	0	0.0	3	0.0
Total	7,186	100.0	164	100.0	7,350	100.0
Intent						
Unintentional	5,958	82.9	99	60.4	6,057	82.4
Assault	418	5.8	6	3.7	424	5.8
No E-code	385	5.4	7	4.3	392	5.3
Not grouped	320	4.5	41	25.0	361	4.9
Self-inflicted	84	1.2	11	6.7	95	1.3
Undetermined	15	0.2	0	0.0	15	0.2
Other	6	0.1	0	0.0	6	0.1
Total	7,186	100.0	164	100.0	7,350	100.0

Table 2

Demographics of injured and non-injured pregnant women who experienced a live birth or fetal death

	Not injured 183,305		ED outpatient 7,186		ED admitted 164		Total ED 7,350	
	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)
Age								
Not reported	12	0.0	0	0.0	0	0.0	0	0.0
<20	15,160	8.3	1,199	16.7	23	14.0	1,222	16.6
20–29	117,977	64.4	4,729	65.8	101	61.6	4,830	65.7
30–34	33,850	18.5	868	12.1	23	14.0	891	12.1
35+	16,306	8.9	390	5.4	17	10.4	407	5.5
Race/ethnicity								
White	148,571	81.1	5,744	79.9	120	73.2	5,864	79.8
Black	1,249	0.7	83	1.2	3	1.8	86	1.2
Asian/Pacific Islander	5,481	3.0	179	2.5	2	1.2	181	2.5
American Indian	2,035	1.1	133	1.9	4	2.4	137	1.9
Hispanic white	23,345	12.7	903	12.6	32	19.5	935	12.7
White unknown	32	0.0	2	0.0	0	0.0	2	0.0
Multiple	1,250	0.7	92	1.3	3	1.8	95	1.3
Not reported	1,342	0.7	50	0.7	0	0.0	50	0.7
Education category								
Not reported	2,464	1.3	94	1.3	1	0.6	95	1.3
<12	27,009	14.7	1,820	25.3	44	26.8	1,864	25.4
12	57,363	31.3	2,835	39.5	56	34.1	2,891	39.3
>12	96,469	52.6	2,437	33.9	63	38.4	2,500	34.0
Marital status								
Single	30,591	16.7	2,424	33.7	54	32.9	2,478	33.7
Married	152,713	83.3	4,761	66.3	110	67.1	4,871	66.3
Not reported	1	0.0	1	0.0	0	0.0	1	0.0

deaths. Among the non-injured women, 182,378 had live births and 927 experienced a fetal death (5.08 fetal deaths per 1000 live births). Among the injured women, 40 experienced a fetal death (5.47 fetal deaths per 1000 live births). Of the pregnant women with an injury-related emergency department visit who experienced a live birth, 7148 (97.8%) were outpatients and 162 were hospitalized (2.2%). Of the 40 pregnant women who had an injury-related emergency department visit and experienced a fetal death, 2 (5%) were admitted for their injury.

The types of injuries sustained among the pregnant injured women were primarily sprains and strains (2072 (28.2%)) followed by superficial/contusions (1706 (23.2%)), open wounds (1148 (15.6%)), fractures (414 (5.6%)), and systemic and late effects (386 (5.3%)). Their injuries were primarily to the extremities (3008 (40.9%)) followed by the spine and back (1048 (14.3%)), torso (897 (12.2%)), and head and neck (781 (10.6%)). The leading mechanism of injury among pregnant women was occupant in a motor vehicle crash (22.4%) followed by falls (17.9%), cutting/piercing (10%), being struck by or against an object (10%), and overexertion (7.8%). The remaining cases were due to other injury mechanisms, none of which accounted for greater than 5.3% of the cases (Table 1).

The mean age of the pregnant women treated for an injury in the emergency department was 24.6 years. The average gestational week of injury during pregnancy was 21 weeks (interquartile range = 12–30 weeks gestation). The average number of days between injury during pregnancy and delivery was 158 days (standard deviation = 79.2). Other demographic and clinical characteristics for injured (not admitted, admitted, and

total) and non-injured women are shown in Tables 2 and 3, respectively.

In the logistic model, injured pregnant women were more likely than uninjured pregnant women to experience cesarean delivery (19.4% vs. 16.0%, respectively) and preterm labor (11.1% vs. 8.1%, respectively) (Table 4). Infants of injured pregnant women were more likely than infants of uninjured pregnant women to be born preterm (gestational age less than 37 weeks at birth) (11.1% vs. 8.1%, respectively) and low birth weight (birth weight less than 2500 g) (7.8% vs. 5.4%, respectively). Table 4 also presents the logistic regression results for the odds of adverse maternal outcomes for different parameters. Women with an injury-related emergency department visit during pregnancy were more likely than women who did not have an injury-related emergency department visit to experience preterm labor (OR = 1.22, 95% CI = 1.12–1.34), placental abruption (OR = 1.33, 95% CI = 1.08–1.65) and cesarean delivery (OR = 1.27, 95% CI = 1.19–1.36). There were no significant differences for premature rupture of the membranes and labor induction. Infants born to women who were injured during pregnancy were more likely to be born preterm (OR = 1.23, 95% CI = 1.12–1.34), and have low birth weight (OR = 1.22, 95% CI = 1.1–1.35) than infants of women who were not injured during pregnancy. There were no significant differences between infants of injured women compared to infants of uninjured women with regards to meconium at delivery, fetal distress, hypoxia, fetal death, and infant death.

To further explore motor vehicle crashes and falls, the most prevalent injuries during pregnancy, indicator variables

Table 3
Clinical characteristics of injured and non-injured pregnant women who experienced a live birth or fetal death

	Not Injured 183,305		ED Outpatient 7,186		ED Admitted 164		Total ED 7,350	
	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)
Prenatal smoking								
No	168,892	92.1	5,710	79.5	146	89.0	5,856	79.7
Yes	13,440	7.3	1,447	20.1	18	11.0	1,465	19.9
Not reported	973	0.5	29	0.4	0	0.0	29	0.4
Prenatal drinking								
No	180,290	98.4	7,010	97.6	160	97.6	7,170	97.6
Yes	1,969	1.1	146	2.0	4	2.4	150	2.0
Not reported	1,046	0.6	30	0.4	0	0.0	30	0.4
Gravidity								
1	56,248	30.7	2,245	31.2	49	29.9	2,294	31.2
2	48,891	26.7	1,906	26.5	35	21.3	1,941	26.4
3+	78,166	42.6	3,035	42.2	80	48.8	3,115	42.4
Parity								
1	66,026	36.0	2,737	38.1	65	39.6	2,802	38.1
2	53,213	29.0	2,074	28.9	34	20.7	2,108	28.7
3+	64,066	35.0	2,375	33.1	65	39.6	2,440	33.2
Trimester prenatal care started								
1	141,763	77.3	5,370	74.7	114	69.5	5,484	74.6
2	27,861	15.2	1,207	16.8	28	17.1	1,235	16.8
3	7,975	4.4	346	4.8	9	5.5	355	4.8
None	829	0.5	37	0.5	1	0.6	38	0.5
Not reported	4,877	2.7	226	3.1	12	7.3	238	3.2
Gestational age								
Not reported	351	0.2	13	0.2	1	0.6	14	0.2
<27 weeks	1,061	0.6	42	0.6	1	0.6	43	0.6
28–32 weeks	1,595	0.9	91	1.3	6	3.7	97	1.3
33–36 weeks	12,030	6.6	650	9.0	15	9.1	665	9.0
37+ weeks	168,268	91.8	6,390	88.9	141	86.0	6,531	88.9
Insurance								
Commercial	a	a	4,409	61.4	115	70.1	4,524	61.6
Medicaid	a	a	1,418	19.7	35	21.3	1,453	19.8
Other	a	a	641	8.9	7	4.3	648	8.8
Self/charity	a	a	718	10.0	7	4.3	725	9.9

^a Values missing because insurance data were taken from ED records and these women did not have an ED visit.

Table 4
Counts and percents of outcomes and odds ratios for women injured during pregnancy by maternal and infant outcomes

Outcomes	Total injured 7,350		Uninjured 183,305		Unadjusted odds ratio		Adjusted odds ratio ^a	
	Number	Percent (%)	Number	Percent (%)	Odds ratio (95% CI)	S.E.	Odds ratio (95% CI)	p-Value
Maternal								
Labor induction	2,423	33.0	59,995	32.7	1.01 (0.96–1.06)	0.03	1.06 (0.998–1.12)	0.0583
Cesarean delivery	1,426	19.4	29,396	16.0	1.26 (1.20–1.32)	0.03	1.27 (1.19–1.36)	<.0001
Preterm labor	813	11.1	14,860	8.1	1.41 (1.33–1.48)	0.04	1.22 (1.12–1.34)	<.0001
Premature rupture of membranes (>24 h)	192	2.6	3,953	2.2	1.22 (1.07–1.36)	0.07	1.03 (0.87–1.22)	0.7268
Placental abruption	123	1.7	2,293	1.3	1.34 (1.16–1.53)	0.09	1.33 (1.08–1.65)	0.0070
Infant								
Preterm birth (<37 weeks gestation)	813	11.1	14,848	8.1	1.41 (1.34–1.49)	0.04	1.23 (1.12–1.34)	<.0001
Meconium at delivery	455	6.2	12,055	6.6	0.94 (0.84–1.03)	0.05	0.91 (0.82–1.02)	0.0947
Low birth weight (<2500 g)	572	7.8	9,919	5.4	1.48 (1.39–1.56)	0.04	1.22 (1.10–1.35)	0.0002
Fetal distress	382	5.2	8,064	4.4	1.19 (1.09–1.30)	0.05	1.12 (1.00–1.26)	0.0490
Hypoxia	193	2.6	4,650	2.5	1.04 (0.89–1.18)	0.07	0.93 (0.78–1.10)	0.4011
Fetal death	40	0.5	927	0.5	1.08 (0.76–1.39)	0.16	0.87 (0.58–1.30)	0.4989
Infant death	42	0.6	807	0.4	1.30 (0.99–1.61)	0.16	1.15 (0.79–1.67)	0.4631

^a Adjusted for extreme maternal age, prenatal smoking, prenatal drinking, parity, first trimester prenatal care, marital status, and race.

for each replaced the injury variable in the logistic regression models. The regression results showed that falls increased the odds for cesarean delivery (p -value < 0.0001) and low birth weight (p -value 0.038) when compared to pregnant women not involved in a fall or motor vehicle crash. To further investigate these two mechanisms among the population of injured women, non-injured women were removed. Additionally, a trimester of injury variable was included. Women experiencing an injury during the third trimester of pregnancy (25+ gestational weeks) were less likely to experience preterm labor (OR = 0.603, p -value < 0.0001), placental abruption (OR = 0.491, p -value 0.0069), cesarean delivery (OR = 0.811, p -value 0.0146), preterm birth (OR = 0.603, p -value < 0.0001), and low birth weight (OR = 0.628, p -value 0.0004) and more likely to have meconium present at delivery (OR = 1.574, p -value 0.0014) compared to women experiencing an emergency department treated injury during the first trimester. Women injured during the second trimester (13–24 gestational weeks) did not experience a significant increase in risk for any of the outcomes compared to women with an emergency department treated injury during the first trimester.

The timing of injuries by gestational age was explored by normalizing the percent of injuries by mechanism and by gestational age at injury. This showed that motor vehicle crashes and falls (the two most common injury mechanisms) peak in the middle gestational ages and then taper off at the later gestational ages; whereas, falls, cut or pierced, struck by or against, overexertion, and injuries overall mostly continue to increase with gestational age. A rapid decline in injuries late in pregnancy was observed, but it is due to a majority of infants being delivered after week 36 resulting in fewer infants remaining at risk (See supplementary Fig. 1 online).

4. Discussion

Although there have been many studies that focus on trauma during pregnancy (Aitokallio-Tallberg and Halmesmaki, 1997; Baerga-Varela et al., 2000; Bowman et al., 1989; Drost et al., 1990; El-Kady et al., 2004; Galle and Anderson, 1997; Greenblatt et al., 1997; Hartl and Ko, 1996; Kingston et al., 2003; Kissinger et al., 1991; Klinich et al., 2000; Kuo et al., 2007; Legros et al., 2000; LeSher and O'Connor, 1992; Metz and Abbott, 2006; Occelli et al., 1998; Rainio and Penttila, 2003; Sandy and Koerner, 1989; Schiff et al., 2001; Schiff and Holt, 2005; Sherer et al., 1993; Weiss, 1999; Williams et al., 1990), our study is the first to describe on a population basis the epidemiology of emergency department treated injured pregnant women. Most emergency department treated injured women are not hospitalized, thus studies that only include inpatient records are not looking at the whole picture. Secondly, even though emergency department treated injuries may not be as severe as injuries requiring hospitalization, there are still significant increased risks observed for preterm labor, placental abruption, cesarean delivery, preterm birth, and low birth weight among these women.

Our study showed that including non-admitted injuries greatly increases coverage of the population of pregnant women

that are exposed to an injury. Kuo et al. (2007) recently published a hospitalization study that utilized the Healthcare Cost and Utilization Project's Nationwide Inpatient Sample that reported 0.41% of pregnant women were hospitalized for injuries during the year 2002. Our emergency department based study reported almost 10 times that exposure. In addition, similar to most hospitalization studies, our study showed that motor vehicle crashes were the primary injury mechanism and unintentional injuries were the primary injury intent among pregnant women who visited a Utah emergency department from 1999 to 2002.

Interestingly, our study findings show that injury during the first trimester, when compared to injury during the third trimester is related to increased risk for several important maternal and fetal outcomes including cesarean delivery, placental abruption, preterm birth, preterm labor, and low birth weight. This further supports the observation by Sperry et al. (2006), which utilized a much smaller trauma center patient population, that the women who were injured in the first 24 weeks of gestation had a higher risk of preterm delivery. These increased risks are important to highlight because injury during early pregnancy is often given less consideration than injury during late pregnancy. Studies that focus mainly on women late in pregnancy are potentially missing a sensitive period of early fetal development and a crucial time frame for injury to affect the pregnancy.

4.1. Limitations

An important limitation of this study was that the emergency department data were limited to the first episode where the patient was treated; therefore, the impact of any repeat visits was not assessed. Furthermore, not all adverse outcomes could be captured in our study. For instance, a fetus may sustain a neurological injury that might not be detected until the child is much older. Another limitation was the inability to account for severity of injury in this study since severity data were not available. To address this, the authors attempted to crudely quantify injury severity based on whether or not a woman was admitted to the hospital for her injury; however, we were not able to classify injury severity as we would have liked to (such as through the Injury Severity Score).

The authors recognize that certain injuries would likely have a greater effect on the pregnancy than others, but based on the analyses there is still an increased risk of several adverse maternal and infant outcomes with injury during pregnancy, regardless of injury severity. We assume that a majority of the injuries to the pregnant women were minor since most of the pregnant women were treated and released from the ED. Assuming the injuries were mostly minor and because we still saw an association between injury during pregnancy and adverse outcomes, we do not think that the fact that our study was missing an injury severity indicator was a serious limitation. However, we suggest future studies should attempt to assess injury severity and injury type in more detail to further tease out the associations between injury and adverse maternal and infant outcomes.

Another limitation is that the Hosmer–Lemeshow tests of the logistic regression suggested that a few of the maternal and infant outcomes were not well predicted by the variables in the model.

This implies that there are other factors that are contributing to some of the adverse outcomes that were not assessed in this study. Further research is needed to determine what these factors are.

A final limitation is that not all injured women will go to an emergency department for their injuries. Women who are injured but do not report to an emergency department could be a source of exposure misclassification in this study. Although, a majority of injured women who do not seek medical attention will most likely have minor injuries such as a cut, a bruise from running into an object, or other such minor injuries that should not adversely affect the pregnant woman or the fetus. The missed cases of concern would be cases of domestic abuse, minor motor vehicle crashes, or other mechanical force producing events. However, it is generally believed that pregnant women are more likely to seek medical attention, even for minor injuries, during pregnancy due to their concern for the well being of the fetus. Therefore, the authors believe that any amount of misclassification that may be present in this study is not enough to alter the results or bias the study.

4.2. Public health implications

There are several implications of this research. The first ties into an important maternal and child health issue, the continual rise in the number of preterm births and low birth weight infants. The percentage of preterm births has risen 20% since 1990 from 10.6% to 12.7% in 2005 and low birth weight has also increased by more than 20% since the mid-1980 (Hamilton et al., 2007). This is significant because preterm infants have a higher mortality rate than term infants (Mathews and MacDorman, 2006). Our study showed that infants born to women who were injured during pregnancy have increased odds of being born preterm and/or low birth weight. Therefore, injury during pregnancy is likely a contributor to the number of preterm births and low birth weight infants and may play a partial role in the rising incidence. If this is the case, injury prevention efforts targeted toward pregnant women might help to reduce the increase in preterm births and infants born low birth weight, as well as protect the woman and fetus from other adverse effects of injury.

Another implication is that non-severe maternal injury and injury early in pregnancy can still result in adverse fetal outcomes. Physicians and pregnant women should be educated about the risks of any level of injury during pregnancy and in the event of an injury the proper care and follow-up (Grossman, 2004; Shah et al., 1998; Tweddale, 2006) should be administered. Finally, motor vehicle crashes and falls continue to be the leading mechanisms of injury during pregnancy; therefore, focusing prevention efforts on them is needed.

5. Conclusions

This study shows that it is feasible to link emergency department records to birth and fetal death data to better track pregnancy-associated injuries. In Utah, approximately 3.9% of all pregnancies experienced an injury-related emergency department visit. Most women injured during pregnancy are treated and

released from the emergency department; however, significant increased risks remain for the injured pregnant women and fetus including preterm labor, placental abruption, cesarean delivery, preterm birth, and low birth weight. Moreover, injury exposure appears to be a significant risk factor throughout pregnancy. Further studies are needed to determine other ways in which injuries during pregnancy, especially injuries that are minor enough to be treated in the emergency department and those that occur early in pregnancy, adversely affect pregnancy, the pregnant women, the fetus, and the child.

Acknowledgements

This research was sponsored in part by the Centers for Disease Control and Prevention National Center for Injury Research and Control under an Injury Control Research Center grant (grant # CCR323155).

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.aap.2007.11.011.

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