The Effect of Hospital Trauma Level on Outcomes for Injured Pregnant Women and their Neonates in Washington State, 1995 to 2012.

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A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Public Health

University of Washington

2015

Committee:

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Program Authorized to Offer Degree:

School of Public Health - Epidemiology

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Abstract

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BACKGROUND: Trauma occurs in 6 to 7% of all pregnancies, however, no studies have evaluated the effect of the trauma certification level of the hospital as it relates to maternal and neonatal outcomes for injured pregnant women who are hospitalized in a trauma center.

METHODS: We performed a population-based, retrospective cohort study evaluating the association between trauma designation Levels 1 and 2 (Level 1-2) and Levels 3 and 4 (Level 3-4) and maternal and neonatal birth outcomes. Study subjects were pregnant women hospitalized for injury identified by linking Washington State birth and fetal death certificate data and the Washington State Comprehensive Hospital Abstract Recording System (CHARS). As the start date of the study was chosen to correspond with the initiation of the trauma hospital designation system in Washington State, this study evaluated injured pregnant women from 1995 through 2012. Injury was identified using International Classification of Diseases, Ninth Revision (ICD-9) injury diagnosis and external causation (E) codes. Specific types of injuries and mechanisms of injury were abstracted from the database. The association between higher-level trauma hospital designation and risk of adverse maternal and neonatal birth outcomes was analyzed using logistic regression to estimate odds ratios and 95% confidence intervals (CI), adjusting for Injury Severity Score.

RESULTS: Following exclusions, 2,492 injured pregnant women hospitalized in a trauma center were identified for analysis. With few exceptions, maternal and neonatal birth outcomes showed no association with trauma hospital level designation. Women treated at trauma Level 1-2 hospitals had an adjusted odds ratio of preterm labor of 1.43 (95% CI: 1.15-1.79, $p < 0.01$). Neonates of women treated at trauma Level 1-2 hospitals had an adjusted odds of meconium at delivery of 1.66 (95% CI: 1.05-2.61, $p < 0.01$). Neonates of women with severe injuries, ISS ≥ 9, treated at trauma Level 1-2 hospitals had an adjusted odds of low birth weight, < 2, 500 grams, of 2.52 (95% CI: 1.12-5.64, $p < 0.01$). All other maternal and neonatal birth outcomes showed no association with trauma hospital level designation.

CONCLUSION: The majority of maternal and neonatal outcomes had no association with hospitalization at a Level 1-2 trauma center compared to a Level 3-4 trauma center. This study can inform state trauma systems, guide allocation of trauma resources and pre-hospital patient care.

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ACKNOWLEDGEMENTS

The author expresses sincere gratitude to the Washington State Department of Health for data access, Mr. Bill O'Brien for the dataset preparation, Dr. Melissa A. Schiff of the University of Washington, Dr. Michele A. Soltis of Madigan Army Medical Center, and Dr. Andrew R. Wiesen of Madigan Army Medical Center for their invaluable contributions to this research endeavor.

Chapter I: Introduction

Trauma occurs at a rate of 6-7% among all pregnancies in the United States [1] and is the leading cause of non-obstetrical maternal deaths in the United States [1, 2]. In a large, population-based retrospective cohort of pregnant women hospitalized for trauma in California from 1991 to 1999, for every 1000 live births, there were an estimated 2.1 injury-related hospitalizations [3]. Injury hospitalizations were not stratified by trauma hospital classification in that study. The risk of poor maternal and fetal outcomes after injury has been well documented [4, 5]. Poor neonatal outcomes have been recorded even after mild traumatic events, to include increased risks of placental abruption, uterine rupture, maternal death, and fetal death [3, 6]. Among pregnant women who sustained severe injuries, a 17-fold increased risk of placental abruption and a 30-fold increased risk of fetal death was reported [7].

Trauma hospitals are specialized medical centers that offer a range of medical and surgical services specific to the care of injured patients. Level 1 and Level 2 trauma hospitals offer comprehensive trauma services, such as the initiation of definitive care for trauma patients and immediate 24-hour coverage by trauma surgeons. Level 3 and Level 4 hospitals have dedicated trauma rooms staffed by Emergency Medicine physicians, but may only have a trauma surgeon on-call and are often times located in less populated areas. Many states employ a regionalized approach to trauma care, with designations of both trauma and non-trauma centers [8]. For injured non-pregnant adults, treated at large trauma centers in an inclusive trauma system, reduced mortality and improved functional outcomes one year after injury were demonstrated in comparison to non-trauma centers

[7]. Level 1 trauma hospitals have also been shown to have improved outcomes, even when adjusted for injury severity, compared to lower-level trauma hospitals, regardless of the number of patients seen in Level 1 or Level 2 trauma hospitals [9].

The Washington State Department of Health assigns trauma level designations to trauma centers. Level 1 and Level 2 trauma centers both provide definitive care for any trauma patient. Level 1 is also an academic teaching center, only one Level 1 trauma center exists in Washington State. Level 3 hospitals have immediate coverage by Emergency Medicine Physicians and availability of general surgeons and Level 4 hospitals have basic Emergency Department facilities and 24-hour laboratory coverage [10]. Level 5 hospitals provide initial evaluation and stabilization and prepare patients for transfer to higher levels of care. There are 9 different Level 1 and Level 2 trauma centers and 56 Level 3 and Level 4 trauma centers in Washington State.

The Injury Severity Score (ISS) is a standardized anatomical scoring method of severity of traumatic injury based on the worst injury of 6 body systems. The six anatomic regions are head and neck, face, chest, abdomen, extremity, and external. Each region is assigned an abbreviated injury scale score from 0 to 6, where a score of 6 is a lethal injury. The scores from the 3 most severely injured body regions are squared and added together to produce the ISS score, which will range from 0 to 75. In the adult non-pregnant population ISS correlates linearly with mortality, morbidity, hospital stay and other measures of severity [11].

The Kotelchuck Index measures the adequacy of prenatal care utilization. The Kotelchuck Index incorporates both the timing of prenatal care initiation and the number of prenatal visits received until delivery, as recorded in the birth certificate. The number of prenatal visits is compared to the expected number of visits for the period of care initiation to delivery to classify the adequacy of prenatal care. The expected number of visits is based on the American College of Obstetricians and Gynecologists' prenatal care standards for uncomplicated pregnancies and is adjusted for gestational age at delivery and gestational age when care began. A ratio of observed to expected visits is calculated and grouped into four categories including, inadequate, intermediate, adequate, and adequate plus [12].

We found no studies in the English language literature that examined the influence of treatment at higher trauma level hospitals on the risk of adverse maternal and neonatal outcomes after injury. This study will assess if injured pregnant women treated at a Level 1 or Level 2 trauma hospital have improved maternal and neonatal outcomes as compared to those treated at a Level 3 or Level 4 trauma hospital, after adjustment for injury severity.

Chapter II: Methods

We performed a population-based, retrospective cohort study evaluating the association between trauma designation Levels 1 and 2 (Level 1-2), or Levels 3 and 4 (Level 3-4) and maternal and neonatal outcomes. Study subjects were pregnant women hospitalized for injury identified by linking Washington State birth and fetal death certificate data, Washington State death records, and the Washington State Comprehensive Hospital Abstract Recording System (CHARS). A checklist for method of delivery, complications of labor and delivery, and abnormal conditions of the newborn is included in the Washington State birth and fetal death certificates. Since Washington State initiated its trauma hospital designation system in 1995, our study evaluated injured pregnant women from 1995-2012.

To determine that the injury occurred during pregnancy, we calculated the time difference from the gestational age at delivery and the gestational age at injury and hospitalization. Only injured patients with a time difference less than 40 weeks were included. Injury was identified using International Classification of Diseases, Ninth Revision (ICD-9) diagnosis codes 800 to 999.99 or an external causation code (E code) included with diagnosis codes in CHARS. In order to focus on injury caused by kinetic forces and outcomes measured within our dataset by birth and death records and avoid potential confounding we excluded ICD-9 and E code diagnoses of late effects of trauma (905-909, E929), trauma complications (958), poisonings/medicinal toxicity (960-989), medical/surgical complications (996-999), accidental poisonings (E850-E869), medical/surgical misadventures (E870-E879), late effects of injuries (E929), and adverse effects of therapeutic interventions (E930-E949).

In addition, subjects who were injured and had a spontaneous abortion prior to 20 weeks gestation were excluded from this study as a birth or fetal death certificate was not issued. To better represent trauma care received, the 81 subjects who had been transferred to or from another hospital after their index injury were also excluded from this study. These data contained no personal or hospital identifiers, and were determined to be exempt from review by the Washington State Institutional Review Board as Project E-041014-H.

The two exposure groups were injured pregnant women hospitalized in a Level 1-2 trauma center, and injured pregnant women hospitalized in a Level 3-4 trauma center. To maintain hospital and patient de-identification and to categorize trauma centers by those that provide definitive care, we chose to group Level 1 and Level 2 trauma centers together in our analysis. Levels 3 and 4 are both resourced to provide initial resuscitation and stabilization. Level 3 and Level 4 trauma centers were categorized together in our analysis of smaller trauma centers with similar resources among Level 3 and Level 4 trauma centers but with fewer resources than the larger Level 1 and Level 2 trauma centers. Patients treated at Level 5 hospital data were excluded in this analysis due to the primary role of Level 5 hospitals stabilizing trauma patients for transfer to other facilities in addition to the limited number of pregnant trauma cases treated in those facilities.

The Minimum Detectable Difference (MDD) was calculated from a prior estimated sample size of 600 subjects in the Level 1-2 trauma center exposure group and 1,800 subjects in the Level 3-4 trauma center exposure group. We calculated the MDD for an 80% power to reject the null hypothesis, with a two-sided α level of 0.05. Risk for specific maternal and neonatal outcomes estimated from prior data had relative risks that ranged from 1% to 30%. The MDD ranged from 1.9% to 6.3%.

Data regarding specific types of injuries sustained, including fractures/dislocations/sprains/strains (800-849), intracranial injuries (850-854), internal injuries to thorax (860-862), internal injuries of the abdomen (863-866, 868), internal injuries of the pelvis (867), open wounds (870-897), injury to blood vessels (900-904), superficial injuries/contusions/crushing injuries (910-929), and nerve and spinal cord injuries (950-957) were abstracted from the records. Subjects included in our study were analyzed for the mechanism of their trauma. External causation codes (E-codes) were used to identify the mechanisms of injury of subjects included in our cohort, including: motor vehicle accidents (E810-E829, E846-848), falls (E880-E888), struck accidentally by object, person, or in-between objects (E916-918), accidents by machinery or tools (E919-920), firearms (E922), overexertion and strenuous movements (E927), suicide attempts and self-inflicted injury (E950-E959), assaults (E960-E969), and other injuries including non-specified injuries (E830-845, E849, E923-926, E928, E980-989). We also calculated the injury severity score (ISS) using ICD-9 codes for each subject entered into the ICDMAP-90 software program (Tri-Analytics Inc., Bel Air, MD) [13].

We identified the maternal and neonatal outcome data as recorded in the birth certificate, fetal death certificate, Washington death records, and/or the maternal and neonatal ICD-9 diagnosis and procedure codes for the hospitalization that resulted in delivery. The maternal outcomes collected included placental abruption (listed on the birth or fetal death certificate or ICD-9 diagnosis code 641.2), preterm labor, less than 37 weeks gestation (determined by the use of tocolysis on the birth or fetal death certificate or ICD-9 diagnosis code 644.0 or 644.2), Cesarean delivery (listed on the birth or fetal death certificate or ICD-9 procedure codes 74-74.2), induction of labor, (listed on the birth or fetal death certificate or ICD-9 procedure code 734 or 7301), and premature rupture of membranes, defined as rupture more than 24 hours before labor onset (ICD-9 procedure code 658.2). The Washington State death records were linked to the study dataset to determine maternal death. A maternal death in this study would include a severely injured pregnant woman at greater than 20 weeks gestation who initially survived the injury, was admitted to a trauma hospital, and then died during the injury hospitalization.

We collected data for neonatal birth outcomes that included prematurity (defined as gestational age < 37 weeks recorded on the birth or fetal death certificate), low birth weight (birth weight < 2,500 grams recorded on the birth certificate), the presence of meconium at delivery (recorded on the birth or fetal death certificate or ICD-9 diagnosis code 763.84), fetal distress (ICD-9 diagnosis codes 768.2, 768.3, or 768.4), fetal death (fetal death at ≥ 20 weeks gestation, recorded on the fetal death certificate), neonatal death (a death recorded on the death certificate within 28 days of delivery), or Neonatal Respiratory Distress Syndrome (recorded on the birth or fetal death certificate or as ICD-9 diagnosis code 769).

Data Analysis:

We compared demographic, obstetric, and injury characteristics of subjects at trauma Level 1-2 and Level 3-4 hospitals using chi-squared testing. The demographic and obstetric characteristics of the injured pregnant women included maternal age (<20 years, 20-34 years, > 34 years), race (White, Black, Hispanic, Asian, American Indian, Unknown/Other), years of education (≤12 years, 13-15 years, ≥ 16 years), marital status (single/divorced, married), median family income (< $25,000/year, $25,000 – $55,000/year, > $55,000/year), insurance (Medicaid/Medicare, Self/Charity, Commercial/HMO, Service Contractor, Other), prenatal smoking (yes, no), parity (1, 2, ≥ 3), gestational age at injury (0-19, 20-27, 28-32, 33-36, 37-43 weeks), gestational age at delivery (20-27, 28-32, 33-36, 37-43 weeks), the Kotelchuck adequacy of prenatal care index (inadequate, intermediate, adequate, adequate plus) [12], and the Injury Severity Score (0, 1-8, 9-15, ≥ 16) [11, 13, 14]. The types and mechanisms of injury were compared for Level 1-2 and Level 3-4 trauma hospitals using counts and proportions.

We analyzed the association of adverse maternal and neonatal morbidity outcomes by level of trauma hospital with logistic regression to estimate odds ratios and 95% confidence intervals (CI). We used a logistic regression model for each maternal and neonatal outcome. The exposure and outcome data were dichotomous. Crude odds ratios were calculated from single-predictor logistic regression analysis. After univariate analysis, we used a forward selection approach of stepwise regression to build a multiple logistic regression model to control for the influence of potential confounding variables [15]. Variables were considered true confounders if the model resulted in a greater than 10% change in estimate between the crude and adjusted odds ratios for each exposure and outcome relationship [16]. Potential confounders were based on prior literature of pregnancy and trauma [14, 17]. All outcomes were adjusted for Injury Severity Score *a priori* as adjusted in prior literature [4]. Variables considered as potential confounders included maternal age, years of education, income level, Kotelchuck Index, prenatal smoking, and gestational age at birth [3, 12, 18]. Additionally, meconium at delivery was adjusted for income level, a socioeconomic indicator, due to a greater than 10% change in estimate from the crude odds ratio. Neonatal respiratory distress was adjusted for income and Kotelchuck Index. We performed a sub-analysis of patients with severe injury, ISS ≥ 9, to measure the effect of the exposure, treatment at Level 1-2 or Level 3-4 trauma hospitals, on birth outcomes within the stratum of severe injury. Low birth weight in severely injured women was additionally adjusted for income and Kotelchuck index due to a greater than 10% change in estimate from the crude odds ratio.

CHAPTER III: Results

Characteristics of women who were treated at a trauma Level 1-2 hospitals (n=675) were generally similar to those who were treated at trauma Level 3-4 hospitals (n=1,817) with respect to age, education, marital status, median family income, type of insurance, smoking, gestational age at delivery, parity, and adequacy of prenatal care index (Table 1). A greater proportion of subjects treated at trauma Level 1-2 hospitals were black (10.3% vs. 3.8%) compared to women treated at trauma Level 3-4 hospitals correlating with greater percentages of black residents who live in urban areas where Level 1 or 2 trauma centers are located nearby. In addition, a greater proportion of women with severe injury (ISS ≥ 9) were treated at trauma Level 1-2 hospitals (28.7% vs. 18.6%) compared to trauma Level 3-4 hospitals.

Among the 541 injured pregnant women with recorded ICD-9 injury diagnoses treated at trauma Level 1-2 hospitals, 80.0% women (n=433) had 1 recorded injury, 14.6% women (n=79) had two injuries, 4.1% women (n=22) had three injuries, and 1.3% of women (n=7) had 4 or more injuries at the time of hospitalization. Among the 1,247 injured women with recorded injuries treated at trauma Level 3-4 hospitals, 86.1% women (n=1,074) had 1 recorded injury, 10.7% of women (n=134) had 2 injuries, 2.7% of women (n=34) had 3 types of injuries, and 0.4% of women (n=5) had 4 or more types of injuries. The two most common types of injuries at trauma Level 1-2 hospitals and trauma Level 3-4 hospitals were fractures, dislocations and sprains (54.7% and 49.8%, respectively) and superficial, contusion and crush injuries (30.9% and 30.7%, respectively) (Table 2). Open wound injuries accounted for 12.6% of trauma Level 1-2 hospital injury diagnoses and 10.7% of trauma Level 3-4 hospital injury diagnoses.

The leading two injury mechanisms among injured pregnant women at Levels 1-2 were motor vehicle crashes (42.6%) and falls (24.6%) (Table 3). For Levels 3-4, 32.5% of injury mechanisms were motor vehicle crashes and 36.8% were falls. Overexertion and strenuous movements, to include muscle, ligament, and back strains and sprains, accounted for 10.4% of injury mechanisms in patients at Levels 1-2, and accounted for 7.9% among women at Levels 3-4.

No association was noted between the maternal and neonatal outcomes of placental abruption, cesarean delivery, induction of labor, premature rupture of membranes, maternal death, pre-term birth, low birth weight, fetal distress, fetal death, neonatal death, or neonatal respiratory distress and receiving care in either a Level 1-2 or Level 3-4 trauma center.

Pregnant women treated at trauma Level 1-2 hospitals had an adjusted odds ratio of preterm labor of 1.43, (95% CI: 1.15-1.79, $p < 0.01$) compared to women treated at trauma Level 3-4 hospitals (Table 5). Neonates of women treated at trauma Level 1-2 hospitals had an adjusted odds ratio of meconium at delivery of 1.66 (95% CI: 1.05-2.61) compared to Level 3-4 hospitals. Neonates of the women with severe injuries, ISS $\geq$ 9, treated at trauma Level 1-2 hospitals had an adjusted odds of low birth weight, < 2, 500 grams, of 2.52 (95% CI: 1.12-5.64) compared to Level 3-4 hospitals.

CHAPTER IV: Discussion and Conclusion

Our data shows that hospitalization in a Level 1-2 trauma center compared to a Level 3-4 trauma center for injured pregnant women was not associated with maternal or neonatal adverse birth outcomes, to include placental abruption, cesarean delivery, induction of labor, premature rupture of membranes, pre-term birth, low birth weight, fetal distress, fetal death, neonatal death, or neonatal respiratory distress. We found the most common types of injuries among injured pregnant women at both Level 1-2 and Level 3-4 hospitals included fractures, dislocations and sprains as well as superficial, contusion and crush injuries. The most common mechanisms of injury were motor vehicle accidents and falls. We found increased odds of preterm labor and of meconium at birth in neonates of women treated at higher-level trauma hospitals (Level 1-2) compared to those treated at lower level trauma hospitals (Level 3-4) and increased odds of low birth weight among women with severe injuries, ISS $\geq$ 9, treated at Level 1-2 compared to Level 3-4.

The types and mechanisms of injuries among pregnant women in our study were similar to those of injured pregnant women in prior studies [19]. The two most common types of injuries in our study were the same as those found in a larger retrospective study by El-Kady et al. The most common types of injuries were fractures, dislocations, sprains, and strains followed by superficial injuries, contusions, and crushing injuries [3]. The two most common mechanisms of injury among admitted injured pregnant women in a study of Emergency Department visits were motor vehicle crashes (28.7%) and falls (14.6%) [20]. The two most common mechanisms of injury in hospitalized pregnant patients in our study were also motor vehicle crashes and falls. Another analysis of maternal and fetal outcomes in trauma during pregnancy demonstrated motor vehicle crashes (48%) and falls (25%) as the two leading mechanisms of injury for pregnant women [21].

We found an association with higher odds of preterm labor and meconium at birth among injured women treated at trauma Level 1-2 hospitals and higher odds in neonates with low birth weight among severely injured, ISS $\geq$ 9, women. We found no prior literature that compares maternal and neonatal outcomes among injured pregnant women who were admitted at different hospital trauma levels. The greater odds of preterm labor and meconium at birth among the pregnant patients treated at Level 1-2 trauma hospitals may be explained by placental or uterine injury. Although we adjusted for ISS in our analysis, the ISS does not include placental or uterine injury as part of the scoring system, which could have led to residual confounding of injury severity. The higher percentage of motor vehicle crashes and a larger percentage of severe injury, ISS $\geq$ 9, could also contribute to confounding. When adjusted for severe injury, we found that preterm labor and meconium at delivery moved closer to the null hypothesis. Types of injury among patients at both levels of trauma hospitals were similar in proportion. A greater proportion of neonates were less than 20 weeks gestation at time of injury among women treated at Level 1-2 hospitals. Among the most severely injured patients, ISS $\geq$ 9, more neonates of women treated at Level 1-2 hospitals had low birth weight, < 2,500 grams. It is possible that severe injury early in pregnancy effects early fetal development. Weiss, et al, demonstrated in a retrospective cohort of injured pregnant women that those injured in the first trimester compared to the third trimester had increased risk for preterm labor and low birth weight [20]. While the gestational age at delivery between Level 1-2 and Level 3-4 hospitals was similar, the gestational age at injury was younger among those treated at Level 1-2 than Level 3-4 hospitals. El-Kady et al., in a retrospective study large population of over 10,000 deliveries, showed that women at gestational ages under 28 weeks sustaining a severe injury were at the highest risk of adverse birth outcomes that may result from fetal response to the physiologic stress of trauma [3].

The majority of maternal and neonatal outcomes, including placental abruption, cesarean delivery, induction of labor, premature rupture of membranes, maternal death, prematurity, low birth weight, fetal distress, and neonatal respiratory distress did not differ among women treated at either Level 1-2 or Level 3-4 trauma hospitals, indicating no advantage from treatment at a higher level trauma hospitals. Our findings are in contrast to recent trauma literature, based on the adult non-pregnant population, that show higher trauma level care improve health outcomes [9, 22]. This lack of advantage with higher level trauma care may be explained by the finding that most of the injured pregnant women in this study had ISS < 15 and may have had good outcomes regardless of the level of trauma center at which they were admitted. Literature supports the advantage of higher tiered trauma centers among the most severely injured with ISS greater than 15. Demetriades et al. studied a population from the national Trauma Data Bank of over 130,000 patients from 256 trauma centers, and showed that severely injured patients, ISS > 15, who were treated in Level I trauma centers had better survival outcomes than those treated in Level 2 trauma centers [22]. Higher and lower trauma level hospitals share similarities in treatment protocols, maternal and fetal monitoring, trauma staff training, and surgical and obstetric capabilities. A retrospective study that used data from the Pennsylvania Trauma Outcomes Study registry of over 200,000 patients admitted to 28 Level 1 and Level 2 trauma centers showed less severely injured patients with a ISS ≤ 15 had a similar risk of mortality in Level 1 and in Level 2 trauma centers, while the severely injured patients, ISS > 15, admitted to Level 1 hospitals had a lower risk of mortality compared with those admitted at Level 2 hospitals [23].

Our study's limitations included the inability to measure the means, e.g. private vehicle or EMS, by which patients arrived or were directed to the different trauma level hospitals. This study focused on short-term pregnancy-related birth outcomes among women admitted to a trauma hospital and cannot be extended to evaluate pre-hospital transport methods, pre-hospital treatment, or pre-hospital triage decisions, nor did our study evaluate post-birth outcomes. Residual confounding is a limitation in this retrospective cohort in cases where more severely injured pregnant women are directed to Level 1-2 trauma centers and less severely injured pregnant women are directed to Level 3-4 trauma centers. ISS may not completely capture true injury severity in the pregnant patient with traumatic injury, to include fetal and placental injuries in the developing fetus. Non-differential misclassification of neonatal and maternal outcomes due to limited ascertainment of exposure and outcomes from CHARS and birth and fetal death certificates in this retrospective study may have introduced bias by attenuating the birth outcomes toward the null hypothesis. While residual confounding from unmeasured risk factors to include non-ascertained placental and uterine injury would attenuate the observed associations, accuracy for mechanisms of injury and ICD-9 diagnose codes in obstetric patients when compared with hospital records have been shown to be accurate [24, 25]. This population based retrospective cohort study of injured pregnant women cannot be generalized to women who were treated at non-trauma designated hospitals, with pregnancy loss earlier than 20 weeks of gestation or to injured pregnant women with less severe injuries who may have been evaluated, treated, and discharged home from a clinic or from an Emergency Department but did not require hospitalization.

In conclusion, while most of the maternal and neonatal birth outcomes measured showed no association between hospitalization at larger trauma centers, Level 1-2, and smaller trauma centers, Level 3-4, we did find increased odds of preterm labor and meconium at birth among injured pregnant women treated at higher-level trauma hospitals (Level 1-2) and increased odds of low birth weight among severely injured pregnant women, ISS > 9, treated at higher-level trauma hospitals (Level 1-2) compared to Level 3-4. The similarities among all levels of trauma hospitals in maternal resuscitation and monitoring, training, and staffing may contribute to the similar birth outcomes among injured pregnant women. Further research in the pre-hospital trauma care and time from injury to hospital arrival of injured pregnant patients can enhance triage decisions, decrease unnecessary transfers of pregnant patients from smaller trauma centers to larger trauma centers, and examine treatment protocols for injured pregnant women. This study can inform state trauma systems, guide allocation of trauma resources and pre-hospital patient care.

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Table 1 Demographic and Obstetric Characteristics Among Injured Pregnant Women Treated at Trauma Centers in Washington State 1995-2012.

	Trauma Level 1 & 2 N = 675		Trauma Level 3 & 4 N = 1,817	
	No.	%	No.	%
Age (years)				
<20	98	14.5	219	12.0
20-29	384	56.9	1,064	58.6
30-34	117	17.3	354	19.5
35+	76	11.3	180	9.9
Race/ethnicity				
White	480	72.7	1,308	73.5
Black	68	10.3	67	3.8
American Indian	27	4.1	91	5.1
Asian	46	7.0	83	4.7
Hispanic white	39	5.9	230	12.9
Education (years)				
≤ 12	341	53.1	957	54.2
13-15	204	31.8	532	30.1
≥ 16	97	15.1	277	15.7
Marital Status				
Single	328	48.6	846	46.6
Median Family Census Income				
<$25, 000	39	6.6	114	7.5
$25,000 - $55,000	469	79.8	1,085	71.3
>$55,000	80	13.6	322	21.2
Insurance				
Medicaid/Medicare	353	52.3	863	47.5
Self/Charity	7	1.0	33	1.8
Commercial/HMO	184	27.3	610	33.6
Service Contractor	116	17.2	273	15.0
Other	15	2.2	35	1.9
Prenatal Smoking				
Yes	112	17.1	297	16.6
Parity				
1	288	44.7	694	38.6
2	170	26.4	571	31.7
≥ 3	186	28.9	534	29.7
Gestational Age at Injury (weeks)				
0-19	135	20.2	210	11.6
20-27	102	15.2	360	19.9
28-32	123	18.4	350	19.3
33-36	126	18.9	368	20.3
37-43	182	27.3	522	28.9

Table 1 Continued

	Trauma Level 1 & 2 N = 675		Trauma Level 3 & 4 N = 1,817	
	No.	%	No.	%
Gestational Age at Delivery (weeks)				
20-27	13	2.0	18	1.0
28-32	17	2.5	46	2.5
33-36	124	18.6	293	16.2
37-43	514	76.9	1,453	80.3
Kotelchuck Prenatal Care Index				
Inadequate	86	14.8	235	14.9
Intermediate	122	21.0	295	18.7
Adequate	243	41.8	636	40.3
Adequate Plus	130	22.4	413	26.1
Injury Severity Score				
0	96	15.9	456	27.5
1 to 8	335	55.4	895	53.9
9 to 15	157	25.9	295	17.8
≥ 16	17	2.8	14	0.8

Table 2 Pregnant Women with ICD-9-CM Recorded Injuries Treated at Trauma Centers in Washington State 1995-2012.

ICD-9-CM Injury Classification	**Trauma Level 1 & 2 N = 541**		**Trauma Level 3 & 4 N = 1,247**	
	No.	%	No.	%
Fractures, dislocations, sprains (800-848)	296	54.7	621	49.8
Intracranial Injury excluding skull fractures (850-854)	27	5.0	41	3.3
Internal injury of intrathoracic organs (860-862)	14	2.6	13	1.0
Internal injury of abdominal organs (863-866, 868)	26	4.8	21	1.7
Internal injury of pelvic organs (867)	5	0.9	17	1.4
Open wound (870-897)	68	12.6	134	10.7
Blood vessel injury (900-904)	16	3.0	18	1.4
Superficial, contusion, crushing (910-929)	167	30.9	383	30.7
Effects of foreign body entering orifice (930-939)	2	0.4	3	0.2
Nerve or spinal cord injury (950-957)	22	4.1	38	3.0
Other injuries not specified (959)	45	8.3	176	14.1

Table 3 Mechanisms of Injury Among Pregnant Women Treated at Trauma Centers in Washington State 1995-2012.

External Cause of Injury	**Trauma Level 1 & 2 N = 627**		**Trauma Level 3 & 4 N = 1,658**	
	No.	%	No.	%
Motor Vehicle Accidents E810-829, E846-848	267	42.6	539	32.5
Falls E880-888	154	24.6	610	36.8
Struck accidentally by object or person E916-918	12	1.9	68	4.1
Accidents by machinery or tools E919-920	12	1.9	21	1.3
Firearms E922	2	0.3	2	0.1
Overexertion and strenuous movements E927	65	10.4	131	7.9
Suicide attempts, Self-inflicted injury E950-959	8	1.3	6	0.4
Assault, purposely inflicted injury E960-969	43	6.9	68	4.1
Other E830-845, 849, 923-926, 928, 980-989	64	10.2	213	12.8

Table 4 Maternal and Neonatal Outcomes Among Injured Pregnant Women Treated at Trauma Hospitals in Washington State 1995-2012.

Outcomes	Trauma Level 1 & 2 N = 675		Trauma Level 3 & 4 N = 1,817		Adjusted Odds Ratio (95% Confidence Interval)
	No.	%	No.	%	
Maternal					
Placental Abruption	37	5.5	84	4.7	1.00 (0.64, 1.56)[1]
Preterm Labor	172	25.5	376	20.7	1.43 (1.15, 1.79)[2]
C-section	188	27.9	569	31.3	0.86 (0.70, 1.06)[2]
Induction of Labor	185	27.4	529	29.1	0.97 (0.79, 1.20)[2]
Premature Rupture of Membranes	35	5.2	87	4.8	0.98 (0.61, 1.56)[3]
Maternal Death	5	0.7	10	0.6	1.14 (0.34, 3.87)[2]
Neonatal					
Gestational Age < 37 Weeks	93	13.8	207	11.4	1.23 (0.93, 1.62)[2]
Low Birth Weight < 2,500 grams	64	9.5	147	8.1	1.24 (0.90, 1.72)[1]
Meconium at delivery	45	6.7	78	4.3	1.66 (1.05, 2.61)[3]
Fetal Distress	38	5.6	100	5.5	0.93 (0.61, 1.40)[2]
Fetal Death	12	1.8	17	0.9	1.47 (0.64, 3.36)[2]
Neonatal Death	9	1.3	18	1.0	1.09 (0.45, 2.68)[2]
Neonatal Respiratory Distress	17	2.5	35	1.9	1.28 (0.56, 2.92)[4]

[1]Adjusted for injury severity score, education
[2]Adjusted for injury severity score
[3]Adjusted for injury severity score, income
[4]Adjusted for injury severity score, income, Kotelchuck index

Table 5 Maternal and Neonatal Outcomes Among Injured Pregnant Women, ISS ≥ 9, Treated at Trauma Centers in Washington State 1995-2012.

Outcomes	Trauma Level 1 & 2 N = 174		Trauma Level 3 & 4 N = 309		Adjusted Odds Ratio (95% Confidence Interval)
	No.	%	No.	%	
Maternal					
Placental Abruption	14	8.0	17	5.5	0.94 (0.31, 2.83)[1]
Preterm Labor	41	23.6	51	16.5	1.58 (0.99, 2.51)[2]
C-section	49	28.2	108	35.0	0.70 (0.46, 1.05)[2]
Induction of Labor	41	23.6	104	33.7	0.69 (0.45, 1.06)[2]
Premature Rupture of Membranes	6	3.4	14	4.5	0.81 (0.30, 2.18)[2]
Maternal Death	4	2.3	1	0.3	4.59 (0.46, 45.77)[2]
Neonatal					
Gestational Age < 37 Weeks	31	17.8	41	13.3	1.38 (0.80, 2.37)[2]
Low Birth Weight < 2,500 grams	25	14.4	27	8.7	2.52 (1.12, 5.64)[4]
Meconium at delivery	12	6.9	14	4.5	1.52 (0.68, 3.38)[2]
Fetal Distress	15	8.6	16	5.2	1.79 (0.65, 4.90)[1]
Fetal Death	8	4.6	8	2.6	1.52 (0.54, 4.27)[2]
Neonatal Death	3	1.7	4	1.3	0.80 (0.14, 4.44)[2]
Neonatal Respiratory Distress	5	2.9	9	2.9	1.19 (0.27, 5.17)[5]

[1]Adjusted for injury severity score, education, Kotelchuck index, smoking
[2]Adjusted for injury severity score
[3]Adjusted for injury severity score, income
[4]Adjusted for injury severity score, income, Kotelchuck index
[5]Adjusted for injury severity score, Kotelchuck index