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The Association Between Birth Delivery Method and Sudden Infant Death Syndrome

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Bachelor of Science
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2008

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A thesis submitted to the Faculty of the
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Abstract

THE ASSOCIATION BETWEEN BIRTH DELIVERY AND SUDDEN INFANT DEATH SYNDROME

By Amanda Overholt

Objectives: Sudden Infant Death Syndrome (SIDS) is sudden death of an infant less than one year of age that cannot be explained after a thorough investigation is conducted, including a complete autopsy, examination of the death scene, and review of the clinical history. Risk factors for SIDS have been identified, including maternal behavioral and health factors and certain infant health factors; however, mode of delivery has not been sufficiently studied to rule it out as a risk factor. Studies have found conflicting information on the safety of cesarean sections, which are occurring at increasing rates within the United States. This study examines whether infants born via cesarean are at increased risk for SIDS.

Methods: Period linked birth-infant death files for 2005 and 2006 were used to obtain a final study population of 1,254 cases and 3,148,977 controls. Delivery method was categorized as vaginal or cesarean section. Odds ratios and risk ratios were examined using three separate models: 1) only pregnancy characteristics 2) pregnancy and maternal characteristics 3) pregnancy, maternal, and infant characteristics.

Results: Cesarean births accounted for 29.82% of all SIDS cases. Infants born via cesarean were not at increased chance of SIDS with the largest odd ratio of 1.10 which occurred when only pregnancy and maternal characteristics were adjusted for. Separating births into vaginal, vaginal delivery after previous cesarean (VBAC), primary cesarean, and repeat cesarean did not influence results.

Discussion: The results of this study suggest that birth delivery method does not influence SIDS independent of maternal and infant conditions that might necessitate a cesarean delivery. However, since the data do not include whether a cesarean was elective or done as an emergency procedure, further research into elective cesareans is warranted.

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BACKGROUND

The term Sudden Infant Death Syndrome (SIDS) was originally used in 1969 (1). Unlike most other causes of deaths, SIDS is a diagnosis of exclusion, i.e., SIDS is determined to be the cause of death after all other potential causes are ruled out. Currently, the Centers for Disease Control and Prevention defines SIDS as "sudden death of an infant less than one year of age that cannot be explained after a thorough investigation is conducted, including a complete autopsy, examination of the death scene, and review of the clinical history (2)." This creates problems with differentiating between SIDS and other potential causes, such as suffocation (1), as it relies heavily on the investigator's interpretation of evidence and the quality of the death scene investigation as well as the autopsy performed. Recent analysis of US period-linked birth/infant death data estimated that SIDS accounted for approximately 14.4% of 111,191 infant deaths from 1989 to 1991 (3). Improved infant death investigations have resulted in a reduced reported SIDS rate, from 14.4% in 1989 to 8.9% in 2001 (3). Currently, approximately half of the 4,500 annual sudden unexpected infant deaths are attributable to SIDS (2).

In addition to improved cause of death classification, the reported SIDS rate has actually declined in recent years. One major movement that had an apparent impact on SIDS was the "Back to Sleep Campaign" beginning in 1994, which recommended infants be placed in the supine or lateral position since sleeping in the prone position was associated with an increased risk for SIDS. In 1992, it is estimated that only about 28% of infants were placed in the supine or lateral position compared to 85% in 2004 (4). SIDS deaths have declined by over 50% after the recommendation emerged (1).

However, the mechanism that causes SIDS is still unknown. Theories on why prone sleeping may increase an infant's risk include interference with thermal regulation (5) and decreased arousability (6). As of 2004, roughly 0.51 per 1,000 live births resulted in SIDS despite the campaign (4) with the peak of deaths occurring between 2 to 4 months of age, and the majority occurring before 7 months (7). It is believed that some infants placed in prone sleeping positions may be at higher risk of death than other infants with similar sleeping patterns. Previous studies (after the Back to Sleep Campaign) have identified many potential risk factors for SIDS though how they increase an infant's risk is still unknown. These risk factors can be divided into four groups: maternal factors, infant physiology, environmental factors, and pregnancy related events.

With respect to maternal factors, there are multiple reasons behind why parents may continue to place their infants in the prone position while sleeping. One potential reason is that new mothers may not know about the dangers of prone sleeping. Young mothers, mothers with lower education levels, and those with other children were found to be more likely to place their infants in prone sleep position (8). In a study addressing maternal assessment of physicians, 16% of mothers did not feel their physician was qualified to give sleep advice (9). Those who felt their physician was qualified were twice as likely to follow the advice on placing their infant in supine when sleeping (9). Parents may also feel that it causes discomfort for their infants to be in another position. A survey in Germany found that parents who place their infant in the prone position claim they "sleep better" while in that position especially when their infants are very young (8). The greatest proportion of deaths has been found to occur in infants whose mothers were African American (2,10,11) and Native American (2,10)/Alaskan Native

(2). Studies have shown that African American infants are twice as likely to die from SIDS than Caucasian infants while Native American/Alaskan Natives were three times as likely (2) while Hispanic mothers were found to have the lowest risk (10). Infants of mothers who had lower levels of education, were younger than 20 years or were unmarried (10,12) seem to have higher SIDS risk than infants born to better educated, older, or married women. Unmarried mothers are less likely to seek adequate prenatal care and have also been shown to be at greater risk than married mothers for experiencing negative birth outcomes including premature birth, stillbirth, early and late neonatal deaths, and SIDS (12). Gravidity and parity also appear to influence risk of SIDS (6,13); mothers who have had more than 5 previous pregnancies were 3.6 times as likely to have an infant die of SIDS compared to those having their first child (9). Other maternal factors include: smoking (4,10,11,13,14) and drinking (4,10,13) during pregnancy, socioeconomic status (4), history of miscarriage (11), and prenatal care (11,14).

With respect to infant factors, certain characteristics of an infant at birth appear to increase their risk for SIDS. Small for gestational age infants were 1.7 times as likely to die of SIDS while being a large for gestational age infant was found to be protective (10). In one study, six times as many SIDS cases were low birth weight compared to non-SIDS survivors (15). Post-term births were found to be protective against SIDS, before adjusting or other factors (15). Also, infants that are born preterm (4,10), have low birth weight (4,5,11,15), and male (4,10,11) were found to have an increased SIDS risk.

After birth, additional risk factors appear for infants. Infants that eventually died of SIDS were found to have more frequent and longer episodes of apnea, moved less, and had more obstructive breathing events compared to infants who were still alive (13).

SIDS cases were also found to have had more admissions to the hospital (7) and have a family history of anemia (15) compared to non-SIDS infants.

Environmental factors include use of a pacifier which has been found to decrease the risk of SIDS in infants (5,14); however, only 60% of mothers felt their physician was qualified to give advice on pacifier use (9). Use of pillows (5,14) and sheepskin, which have been found to increase rebreathing and asphyxiation, were found to only increase the risk for facedown infants (5). Also, infants who died from SIDS were 2.7 times as likely to share a bed with one or more other individuals, but only 1.9 times as likely when the other person was the mother or both mother and father together (14). In a study using the data from the Chicago Infant Mortality Study (CIMS) 57.9% of SIDS cases were bedsharing compared to 37% of control infants with bedsharing mothers being less educated, less likely to be married, more likely to smoke and have younger infants compared to those that did not bedshare (16). Only 78% of mothers receiving recommendations from the physician to not bedshare felt their physician was qualified to give advice of that nature (9). Also, SIDS infants were found to be more likely to have a runny nose or upper respiratory infection two days prior to death (14). Other potential environmental factors include room temperature, soft/loose bedding (14), winter months (4), and overheating (4).

Some pregnancy related complications have also been studied. When controlling for other factors, the risk for SIDS was twice as much for pregnancies with placental abnormalities defined as placental abruption or placenta previa (11). Another risk factor may be preeclampsia or eclampsia (11).

There have been few studies on whether birth delivery method may be a potential risk factor for SIDS (7,15). The four major types of delivery are vaginal, cesarean, forceps use, and vacuum. Cesarean births have been a topic of debate recently due to the risks involved as it is a surgical procedure. This method can be elective when the cesarean section is planned well before the due date or non-elective when events during pregnancy or delivery make having a cesarean a medical decision based on safety for either mother or her fetus. Cesarean birth rates have increased in the United States since 1996 after being in decline during the early 1990s (16,17). In 2010, cesarean births accounted for 32.8% of all births, the first decrease in a decade from 32.9% in 2009 (18). An analysis of births in Washington state found that cesarean delivery rates for nuliparous Caucasian, African American, Hispanic, and Native American women ranged from 17 – 24% while vaginal delivery rates were 76 – 83% (19). Potential benefits and risks for this delivery method for both the mother and infant have been a debate for over 2 decades. One study found that prenatal growth resulting in low or high maternal birth weight is a risk factor for cesarean delivery (19). Risks to the mother include infection, hemorrhaging, organ injury, mortality, and scar tissue forming in the pelvic regions causing complications during the next pregnancy (20).

Concerns continue for pregnant woman who have had a C-section in a prior pregnancy. There has been an ongoing debate is whether it is safe for a woman to attempt a vaginal birth after having a cesarean (VBAC). Having a choice for a trial of labor (TOL) for women that have had a previous cesarean began to be offered in the 1980s through 1996 where the VBAC rates began to decline though success rate for TOL has been found to be between 60 – 80% (21). Trends in the rate of repeat cesarean sections are similar for women regardless of what their risk for adverse events such as uterine rupture, with an estimated 90% of each risk group having a repeat cesarean in 2002 (17). Though uterine rupture occurs in less than 1% of VBAC attempts, it still remains a large enough concern to for practitioners to avoid the attempt (21). In fact, those with no indicative risk for adverse events had a small but significantly higher rate than all women combined and those determined to be at low-risk (17). Maternal death is reported to be higher for those having an elective cesarean compared to those that undergo a TOL (3.8/100,000 versus 13.4/100,000) (21). Recently the American College of Obstetricians and Gynecologists released a report stating that a VBAC may be safe for women who have had even two previous cesareans (22). In a study examining mothers who have had more than two prior cesareans, a higher number of previous C-sections were associated with increased morbidities for the mother (23).

Risks to the infant during a cesarean include premature birth if the gestational age isn't calculated accurately, breathing problems, low Apgar scores, and injury during the incision (20). In a study comparing gestational age at time of C-section, those under 37 weeks were 5.81 times as likely to have respiratory complications and 45.5 times as likely to suffer hypothermia compared to those infants who were 38 weeks or more at time of the C-section (24). Seidman et. al. found that infants born to mothers who have had 3 or more prior cesareans had lower birth weight, gestational age, Apgar scores and respiratory distress syndrome than those born to mothers who had fewer than 3 previous cesareans (25). However, the majority of preterm births and neonatal morbidities were associated with non-elective cesareans (25). Zhou et. al. found an increased incidence of rehospitalization within 1 month of birth for those delivered by C-section with 3.33% of cesarean births being hospitalized compared to only 0.67% of those born vaginally (26). Contrary to previous studies, two studies found no difference in the risk for pneumonia or other respiratory morbidity between those delivered cesarean and those delivered vaginally (26,27). In terms of infant mortality, neonatal mortality rate was 36% higher for those delivered by repeat cesarean compared to those delivered by VBAC with the greatest difference occurring before 7 days (17). Compared to those delivered vaginally, infants born by repeat C-section were 30% more likely to have lower Apgar scores (28). In another study, no significance in Apgar scores, prevalence of major handicap, were found in one study comparing survival rates of infants based on delivery method (29).

There have also been risks found specific to the reasons and timing of a C-section during labor and delivery. In one study, 26% of mothers that had a second stage cesarean section suffered from postoperative pyrexia compared to only 5% of those that were having a first stage cesarean (30). Neonatal morbidity was also higher among those born by a second stage cesarean that included increased admission to the neonatal unit as well as neonatal encephalopathy (30). When adjusting for other factors, one study found that women carrying male infants were 2.2 times as likely to have a C-section compared to women carrying female infants (31).

There have also been studies that have found protective effects of having a C-section for infants. One study found infants born via C-section to be more mature and to weigh more than infants born vaginally (29). When comparing those born by elective cesarean to those born vaginally, Apgar scores of above 7 at both 1 and 5 minutes were seen more often in those born by elective C-section (32). The same study found obstetrical traumas to occur 4 times as often in planned vaginal deliveries leading to the conclusion that planned vaginal deliveries have higher neonatal risks compared to elective C-sections (32).

Very little is known about potential effects that being born via cesarean may have on an infant past the first few days of life. Due to increased rates of C-sections being performed, it is important to consider all potential risks that this procedure may have on the infant as well as the mother to further assess the safety of having one. Studies mentioned above have found conflicting results on increased rates of neonatal complications and deaths to infants that were delivered by C-section. Some of the increased risks found for those born by cesarean are some of the same risk factors for SIDS including preterm birth, respiratory issues, and a larger number of previous pregnancies. It is not known however if children born by C-section have an increased risk for SIDS as no studies have focused on delivery method as a potential factor. While the actual procedure may not be the reason for the potential risk, those born by cesarean may have underlying risks that may not be present in those born vaginally. The aim of this study is to determine whether mode of delivery increases an infant's risk for SIDS.

METHODS

Study Population

The purpose of this case control study is to determine whether the birth delivery method is associated with SIDS. Data for this study were obtained from National Center for Health Statistics period linked birth-infant death certificate files for the years 2005 and 2006. Because this is a publicly available dataset that contains no personal identifiers, no IRB approval was necessary.

In 2003, a revised birth certificate began to replace the 1989 version. By 2005, 12 states had implemented the revised version, accounting for 31 percent of all births (33). By 2006, 19 states had implemented it, accounting for 49% of all births (34). Some characteristics of interest (prenatal care, education, diabetes, and hypertension) are not comparable between the 2003 and 1989 versions, because of rewording, re-categorizing, or use of check boxes. Further, the 2003 version includes more detailed information on delivery method. For these reasons, analysis was limited to births with information from the 2003 version. Only singleton births were used for analysis creating a starting population of 3,224,971 births and 1,449 SIDS cases.

The deaths were limited to cases with linked death and birth certificates. As the case definition of SIDS requires that an autopsy be performed, 153 additional cases were excluded because an autopsy was not performed or autopsy status was unknown. Those with unknown delivery method, or where the delivery is stated as being VBAC or repeat cesarean but also stated that it was their first birth were also excluded (4142 births and 3 SIDS cases). If the number of total or live births were not known, they were excluded (16 births and 13 SIDS cases). Births coded as the current birth is the 20^{th} birth or higher for the mother (12,824 births and 0 SIDS cases) were excluded. Births where it is stated that the total number of previous C-sections are unknown, or where the total number of C-sections was greater than the total number of births were excluded (4,980 births and 7 SIDS cases). If the total births is greater than if the mother had 1 birth a year starting at age 11 (for example, if it is stated that the birth is the 8th one for a 17 year old mother) they were excluded due to higher chance of being an error in entry (94 births and 0 SIDS cases). Infants with unknown gestational age (23,946 births and 11 SIDS cases) are also excluded from the study. Due to increased health problems associated with extreme preterm infants, infants born prior to 20 weeks' gestation were excluded (877 births and 0 SIDS cases). Those in which the mother's educational attainment is not known were also excluded (29,105 births and 8 SIDS cases). The final dataset includes 3,148,977 total births, of which there were 1,254 SIDS cases. Other infant deaths were not excluded from the analysis.

Variables

Pregnancy, Labor, and Delivery:

Current pregnancy characteristics include delivery method, total birth order, prenatal care, pre-pregnancy or gestational diabetes or hypertension, and eclampsia. Labor and delivery events include premature rupture of membrane, whether the birth took place at a hospital or not, precipitous or prolonged labor, if labor was augmented or induced, if the infant was in a non-vertex position, fetal intolerance to labor, and whether there was attempted forceps, vacuum, or trial of labor.

Birth delivery method, the exposure of interest, is categorized as a vaginal birth or cesarean section for the main analysis. It is also categorized as vaginal, VBAC, primary c-section, and repeat c-section for additional analysis. Total births is categorized as 1 (i.e. the current birth is the mother's first), 2, 3, and 4 or more. A mother was determined to have received prenatal care if she started prenatal care during her first or second trimester. A mother was determined to have not received prenatal care if prenatal care began in the third trimester, it is stated she had received none, or if it is unknown. All other variables are classified as yes or no with unknowns included in the no category.

Maternal:

Maternal characteristics in this study include age, race/ethnicity, educational attainment, whether she smoked during her pregnancy, and marital status (at time of delivery). Maternal age is categorized into 9 categories: under 15, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, and 49 or older. Race/ethnicity is categorized as Caucasian (non-Hispanic White), African-American (non-Hispanic Black), Native American/ Alaskan Native, Asian, or Hispanic. Maternal education level is categorized as low (high school graduate or less), or high (having at least some college education).

Infant:

Infant characteristics include gestational age, size at birth, five minute Apgar score, gender, whether they required assisted ventilation, and abnormality in the amount of surfactant. For deceased infants, their age at death, manner of death, location, and month of death are also included.

Gestational age includes very preterm (32 weeks or less), preterm (33 to 36 weeks), term (37 to 42 weeks), and post term (over 42 weeks). Using the weight groups as defined by Alexander et al (35), an infant was determine to be small for gestational age (SGA) if the birthweight was below the 10^{th} percentile for gestational age and large for gestational age (LGA) if the birthweight was above the 90^{th} percentile for gestational age.

Appropriate for gestational age (AGA) was birthweight between the 10^{th} and 90^{th} percentiles. Assisted ventilation and surfactant are categorized as yes or no with unknowns included in the no category. Five minute Apgar scores are categorized as low if the score was less 7 and high if the score was 7 and over or unknown.

Analysis

Modeling strategy:

Since factors behind a mother having a cesarean section include a number of the same variables also believed to be associated with SIDS, multiple models were used to analyze the data. The models are as follows and further detailed in Figure 1:

1. Labor and pregnancy characteristics
2. Labor, pregnancy and maternal characteristics
3. Labor, pregnancy, maternal, and infant characteristics

Since the outcome is whether the infant died of SIDS or not, logistic regression is used to analyze the data. Unadjusted and adjusted odds ratios (ORs), relative risks, and their corresponding 95% confidence intervals (CIs) are also calculated. The full models include all the available characteristics for known to be associated with SIDS based on previous literature. First, a likelihood ratio test was performed to assess for any potential interaction. Confounding was then assessed by dropping each characteristic individually and seeing if the OR for delivery method changed by greater than 10%. The final models were determined after evaluation of any possible collinearity. Analysis was performed using SAS version 9.3.

RESULTS

Variable Categories

Pregnancy characteristics are shown in Tables 1 and 4. Maternal characteristics are shown in Tables 2 and 5. Infant characteristics are displayed in Tables 3 and 6. Due to only 1 of the case mothers having eclampsia (Table 1), this variable was not included in analysis. Also, only 3 SIDS infants had surfactant issues (Table 3), and therefore the analysis did not include surfactant. Due to some categories of variables having a low number of SIDS cases, some variable categories were combined in order to avoid having too few cases in any one category. Originally, hypertension and diabetes were sorted by pre-pregnancy and gestational (results not shown); however, due to low numbers for each among SIDS cases, pre-pregnancy and gestational were combined into one group as shown in Table 1. Also, since there were no mothers older than 44 for cases and only 3 that were under 15, these groups were combined with the next category to create two categories of under 20 and over 39, making a total of 6 age categories. Since Alexander et. al. did not include an Asian category and had no data for Native American infants under 29 weeks in their determinants for SGA, AGA, or LGA, only the overall average for all race/ethnic groups combined was used for these populations to determine if an infant was SGA, AGA, or LGA as opposed to using each individual race and gender.

Maternal age of 25-29 was used as the reference category due to the largest percentage of mothers having given birth at this age as well as being Caucasian. For infants, average weight for gestational age and being born at term were the reference categories. Being the first born was also used as the reference group. All other variables were dichotomous and the category that has been shown in previous studies to not increase risk of SIDS were used as the reference group including: female infants, having a high Apgar score, the mother having received prenatal care, married, not smoking, and having higher education. A vaginal birth was also considered the reference group for this study.

Interaction, Confounding, and Collinearity Assessment

Analysis of interaction for each of the three models showed no significant interactions between delivery method and the potential confounders after performing a chunk test for each model (Table 10). Therefore, interaction terms were not included in any further analysis.

When dropping each potential confounder separately in each model, there was no evidence of confounding by the variable (Table 11). However, since most of these potential confounders have been shown to be risk factors for SIDS, all were kept in the models for analysis to ensure accurate assessment of the effect of delivery method on SIDS.

Collinearity diagnostics were done for each model. There were no collinearity issues with any of the models and therefore the final models were determined to include all variables but no interaction terms (Figure 2).

Variable Significance

Infants born via cesarean had an unadjusted OR of 0.97 (95% CI 0.86, 1.09) compared to those infants born vaginally (Table 1). Controlling for pregnancy characteristics, infants born via cesarean had an adjusted OR (aOR) (the OR for each of the characteristics after the other characteristics are included and adjusted for), of 0.95 (95% CI 0.85, 1.08). When maternal characteristics are added, the aOR for SIDS increased to 1.10 (95% CI 0.97, 1.24). Adding infant characteristics decreased the aOR to 1.04 (95% CI 0.92, 1.18) (Table 4). C-section births accounted for 29.82% of SIDS births compared to 30.49% of all births being a C-section (Table 14). When delivery method was categorized as vaginal, VBAC, primary C-section, and repeat C-section, there was no significant difference between the methods for SIDS cases and controls (Table 12). This remained the case when adjusted for each of the models with the largest aOR being a primary C-section when only pregnancy and maternal characteristics were examined (OR 1.11 95% CI 0.96, 1.29) (Table 13). When vaginal births were categorized by whether the assistance of a vacuum or forceps was necessary, there was still no significance found.

The average age for a mother giving birth via C-section was 24.56 years as compared to 28.34 years for a SIDS mother giving birth vaginally (Table 14). As maternal age increased, the odds for SIDS decreased which was consistent for all three models. Very preterm infants had the highest odds for SIDS (OR 2.68) (Table 3) but dropped when adjusting for other variables (aOR 1.97) (Table 6) which is still significant. Those infants when required assisted ventilation after birth had significant odds when unadjusted (OR 1.38 95% CI 1.09, 1.74) (Table 3), however, when adjusting for other factors, the aOR was not significant (aOR 0.92 0.72, 1.18) (Table 6). Odds ratios for infants from mothers who smoked during pregnancy went from a crude OR of 4.72 (95% CI 4.19, 5.31) (Table 2) times as likely to die from SIDS compared to infants who were not exposed to smoking during pregnancy to an aOR of 2.43 (95% CI 2.13, 2.78) times as likely when adjusting for all other factors (Table 5).

When examining relative risks for each of the variables, all were very similar, if not the same, as the OR and aOR for each variable in each model (Tables 7, 8, and 9).

DISCUSSION

Numerous studies published since the Back to Sleep Campaign began and have examined pregnancy, infant, and maternal characteristics to find additional potential factors that could influence SIDS deaths. One potential factor not previously studied extensively is delivery method. C-Section births have to shown to increase an infant's risk for other morbidities (17,20,25). Unlike most studies, this study used national birth certificate data which includes all births in the U.S. from 2005 and 2006 that had a 2003 birth certificate and for SIDS cases, a death certificate that could be linked to their birth certificate.

Delivery method does not appear to increase an infant's odds of dying from SIDS as adjusted odds ratios ranged from 0.96 to 1.10, depending on variables included for adjustment. The largest OR of 1.10 was seen when there was adjustment for pregnancy and maternal factors only, and infant factors were not adjusted for. Since the delivery method is associated with infant factors, such as gestational age, fetal distress, and respiratory issues, it's possible that the underlying risk for SIDS is associated with fetal characteristics independent of delivery method. With further categorization into primary C-section, VBAC, repeat C-section, and vaginal deliveries, delivery method still remained a nonsignificant predictor for SIDS cases. When the adjusted relative risks were assessed, all were very similar to the adjusted ORs since for rare conditions such as SIDS the OR approximates the RR.

One potential reason for finding of no effect on SIDS by delivery method is that infants are at risk for various other morbidities during the first year of life in which the same risk factors for SIDS can also increase their risk for other events, especially during the first week. Therefore, the infant may have died from other causes before they would have potentially died from SIDS.

One limitation to this study is that there was a large proportion of deaths classified as SIDS (153/1,449 or 10.56%) which did not meet the formal definition because of lacking an autopsy record. Since SIDS is a diagnosis of exclusion, lack of an autopsy may cause an over-estimation of SIDS cases as an alternative cause may have been found with an autopsy. This has also been mentioned by Shapiro-Mendoza et. al. as being an issue, especially in studies involving using only death certificate data which rely on interpretation by certifiers (1).

Consistent with previous studies, an infant's birth order (10) and male gender (4,10,11) appeared to increase an infant's chance of SIDS. Also as found in previous studies (4,10,11,13), smoking continued to have an effect on SIDS deaths regardless of other potential confounders though there was a large percentage of unknown smoking status (958718 of controls and 252 of cases). Unlike previous literature (11,14), prenatal care did not appear to have a significant role in SIDS. This however could be due to how prenatal care was categorized for this study where prenatal care was categorized as yes if the mother stated she had received prenatal care during the first or second trimester regardless of how many visits she had. Previous studies may have overestimated the impact of prenatal care by including women who reported entering prenatal care in the third trimester (since women delivering preterm who have not yet begun prenatal care would be more likely to be among the cases whereas women who delivered fullterm would be more likely to be among the controls).

Also consistent with previous literature (10,11), there was a significant association between SIDS and young mothers under the age of 24 that remained when adjusting for both maternal and infant factors. When adjusting for all potential factors, infants born to mothers under the age of 20 were 2.69 times as likely to die from SIDS compared to mothers aged 25 to 29. With respect to maternal race or ethnicity, infants born to African American mothers were at significantly higher risk; however, this significance went away when adjusting for all other potential factors. The greatest risk for both adjusted models was seen for Native American/Alaskan Native infants, while Hispanic infants had the lowest risk which is consistent with previous literature (2,10,11). Unmarried mothers were twice as likely to have an infant die from SIDS compared to unmarried mothers, although the risk was reduced to 1.47 when adjusting for all other factors.

Maternal hypertension remained significant when adjusting for both pregnancy, and pregnancy and other maternal characteristics. However, maternal hypertension may be a precursor of infant morbidity which is more directly associated with SIDS, as controlling for infant characteristics reduced the hypertension association (aOR1.23 95% CI 0.98, 1.54). Diabetes became significant after maternal and infant characteristics were included in the model but not when only pregnancy characteristics were included in the model. Further analysis focusing on these factors need to be done to be conclusive.

<u>Strengths</u>

This study used all births using the 2003 revised birth certificate in the United States for the two most recent years available online at the time analysis of the data began. Examining only those with the 2003 revision maximized measurement precision for the analyzed variables. Recall bias is not an issue with respect to SIDS, since data were collected at birth; however, for complicated pregnancies and deliveries (e.g. preterm), recall bias might affect information on maternal characteristics such as education and prenatal care. There may have been some selection bias if SIDS deaths that were not matched to birth certificates are different from those that are, or if some of the deaths excluded because of lack of autopsy were both SIDS and different by characteristics from SIDS with autopsy.

Limitations

In addition to concerns about missing data and excluding cases without autopsy data, this study is limited by the number of characteristics on the birth certificate known to be associated with SIDS. The birth certificate does not include any environmental characteristics that have been known to be associated with SIDS, most notably infant sleep position. Other environmental factors include whether the infant was sharing a bed or the type of bedding the infant was on when found.

The reason for delivery method is not provided on the birth certificate. A mother could have a C-section for multiple reasons including: complications during labor and delivery, electing to have one, or having had one previously. If a C-section is planned, additional risks to the infant can occur when the estimated gestational age is not correct (20). Also, the majority of morbidities have been shown to be associated with non-elective C-sections (20) which could not be assessed in this study.

Another limitation is due to the birth files including all births, SIDS cases were also included in the births dataset. However, since the number of cases issmall (1,254 SIDS cases compared to 3,148,977 total births), this should not have influenced the results on a large scale. Also, since only those with the 2003 revised birth certificate were used, a large portion of the population was not included, especially for the year 2005.

Future Directions

Though birth delivery method has not been shown to be associated with SIDS in this study, further research needs to be done on this potential risk factor. Important environmental characteristics need to be examined to fully assess delivery method as a potential risk factor through parental interviews. More in depth analysis of the type of cesarean, which could not be analyzed with the data available for this study, needs to be performed as there is the potential that an elective versus an emergency cesarean may influence the results. An elective C-section has the risk of delivering an infant early due to a potential incorrect estimation of gestational age. An emergency C-section has the additional risk of poor infant outcomes due to extra stress on both mother and infant during delivery.

There are other risk factors that have not been studied in depth here that could also influence the risk of SIDS. For example, infants born to mothers who had prepregnancy and/or gestational hypertension or diabetes were shown to have an increased risk for SIDS in this study depending on what other factors were adjusted for.

Also, eclampsia could not be used in this analysis due to it being present in only 1 case. Eclampsia and environmental factors need to be adjusted for in order to fully assess delivery method and risk for SIDS.

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TABLES AND FIGURES

Table 1: Selected Pregnancy Events of SIDS Cases and Births for 2005 and 2006 and Unadjusted OR

	SIDS Cases		Births		OR Unadjusted	95% CI	
	No.	%	No.	%			
C-Section	374	29.82	959997	30.49	0.97	0.86	1.09
Birth order							
1[a]	326	26.00	1067677	33.91	1.00		
2	360	28.71	908067	28.84	1.30	1.12	1.51
3	255	20.33	582886	18.51	1.20	1.10	1.30
4+	313	24.96	590347	18.75	1.20	1.14	1.27
Diabetes	1254		3148977				
Yes	63	5.02	142422	4.52	1.12	0.87	1.44
No[a]	1191	94.98	3006555	95.48	1.00		
Hypertension							
Yes	86	6.86	160305	5.09	1.37	1.10	1.71
No[a]	1168	93.14	2988672	94.91	1.00		
Prenatal care							
Yes[a]	964	76.87	2343932	74.43	1.00		
No	290	23.13	805045	25.57	0.88	0.77	1.00
Eclampsia	1	0.08	4166	0.13	-		

[a] Reference Category

Table 2: Selected Maternal Characteristics of SIDS Cases and Births for 2005 and 2006 and Unadjusted OR

	SIDS Cases		Births		OR Unadjusted	95% CI	
	No.	%	No.	%			
Maternal Age							
<20	264	21.05	345763	10.98	2.43	2.05	2.87
20 - 24	518	41.31	818733	26.00	2.01	1.74	2.33
25 – 29[a]	272	21.69	864006	27.44	1.00		
30 - 34	131	10.45	691671	21.96	0.60	0.49	0.74
35 - 39	56	4.47	351189	11.15	0.51	0.38	0.68
>39	13	1.04	77615	2.46	0.53	0.30	0.93
Maternal race/ ethnicity							
Caucasian[a]	740	59.01	1654160	52.53	1.00		
African American	279	22.25	385969	12.26	1.62	1.41	1.85
Native American/ Alaskan Native	23	1.83	15333	0.49	1.83	1.49	2.25
Asian	29	2.31	150474	4.78	0.76	0.67	0.86
Hispanic	183	14.59	943041	29.95	0.81	0.78	0.85
Marital Status							
Married[a]	468	37.32	1948418	61.87	1.00		
Unmarried	786	62.68	1200559	38.13	2.73	2.43	3.06
Education Level							
Low	890	70.97	1602726	50.90	2.36	2.09	2.67
High[a]	364	29.03	1546251	49.10	1.00		
Smoking							
Yes	396	31.58	280710	8.91	4.72	4.19	5.31
No[a]	858	68.42	2868267	91.09	1.00		

[a] Reference Category

Table 3: Selected Infant Characteristics of SIDS Cases and Births for 2005 and 2006 and Unadjusted OR

	SIDS Cases		Births		OR Unadjusted	95% CI	
	No.	%	No.	%			
Weight							
SGA	233	18.58	298032	9.46	2.13	1.84	2.46
AGA[a]	944	75.28	2567387	81.53	1.00		
LGA	77	6.14	283558	9	0.86	0.77	0.97
Gestational Age							
Very preterm	61	4.86	65916	2.09	2.68	2.07	3.47
Preterm	210	16.75	281158	8.93	1.47	1.37	1.59
Term[a]	934	74.48	2703984	85.87	1.00		
Post term	49	3.91	97919	3.11	1.10	1.02	1.18
5 minute APGAR score							
Low	45	3.59	45540	1.45	2.54	1.88	3.42
High[a]	1209	96.41	3103437	98.55	1.00		
Sex							
Male	760	60.61	1613375	51.23	1.46	1.31	1.64
Female[a]	494	39.39	1535602	48.77	1.00		
Assisted Ventilation	74	5.90	137204	4.36	1.38	1.09	1.74
Surfactant	3	0.24	8524	0.27	-		

[a] Reference Category

Table 4: Adjusted Odds Ratios for Pregnancy Events

	Model 1 OR Adjusted[b]	95% CI		Model 2 OR Adjusted[c]	95% CI		Model 3 OR Adjusted[d]	95% CI	
C-Section	0.96	0.85	1.08	1.10	0.97	1.24	1.04	0.92	1.18
Birth order									
1[a]	1.00			1.00			1.00		
2	1.31	1.13	1.52	1.77	1.52	2.07	1.80	1.54	2.11
3	1.44	1.23	1.70	2.25	1.89	2.69	2.28	1.91	2.72
4+	1.75	1.50	2.04	3.00	2.51	3.60	2.98	2.49	3.57
Diabetes									
Yes	1.03	0.80	1.33	1.35	1.05	1.75	1.37	1.05	1.77
No[a]	1.00			1.00			1.00		
Hypertension									
Yes	1.41	1.13	1.76	1.41	1.13	1.76	1.23	0.98	1.54
No[a]	1.00			1.00			1.00		
Prenatal care									
Yes[a]	1.00			1.00			1.00		
No	0.88	0.78	1.01	1.09	0.95	1.25	1.07	0.94	1.23
Eclampsia									

[a] Reference Category

[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[d]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 5: Adjusted Odds Ratios for Maternal Characteristics

	Model 2 OR Adjusted[b]	95% CI		Model 3 OR Adjusted[c]	95% CI	
Maternal Age						
<20	2.78	2.27	3.40	2.69	2.20	3.29
20 - 24	1.84	1.58	2.13	1.82	1.56	2.12
25 – 29[a]	1.00			1.00		
30 - 34	0.66	0.53	0.81	0.66	0.53	0.81
35 - 39	0.51	0.38	0.69	0.51	0.38	0.68
>39	0.48	0.27	0.84	0.47	0.27	0.82
Maternal race/ ethnicity						
Caucasian[a]	1.00			1.00		
African American	1.19	1.03	1.39	1.09	0.94	1.27
Native American/ Alaskan Native	2.02	1.33	3.07	2.05	1.35	3.07
Asian	0.85	0.58	1.25	0.82	0.56	1.19
Hispanic	0.41	0.35	0.49	0.41	0.34	0.49
Marital Status						
Married[a]	1.00			1.00		
Unmarried	1.50	1.31	1.72	1.47	1.28	1.68
Education Level						
Low	1.32	1.15	1.52	1.29	1.12	1.48
High[a]	1.00			1.00		
Smoking						
Yes	2.61	2.28	2.98	2.44	2.13	2.79
No[a]	1.00			1.00		

[a] Reference Category
[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age
[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 6: Adjusted Odds Ratios for Infant Characteristics

	Model 3 OR Adjusted[b]	95% CI	
Weight			
SGA	1.75	1.51	2.03
AGA[a]	1.00		
LGA			
Gestational Age			
Very preterm	1.97	1.49	2.61
Preterm	1.82	1.57	2.12
Term[a]	1.00		
Post term	1.19	0.89	1.59
5 minute APGAR score			
Low	1.56	1.14	2.15
High[a]	1.00		
Sex			
Male	1.51	1.35	1.70
Female[a]	1.00		
Assisted Ventilation	0.92	0.72	1.18
Surfactant	-		

[a] Reference Category
[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 7: Relative Risks for Pregnancy Events of SIDS Cases and Births for 2005 and 2006

	RR Unadjusted	95% CI		Model 1 RR Adjusted[b]	95% CI		Model 2 RR Adjusted[c]	95% CI		Model 3 RR Adjusted[d]	95% CI	
C-Section	0.97	0.86	1.09	0.96	0.85	1.08	1.10	0.97	1.24	1.04	0.92	1.18
Birth order												
1[a]	1.00			1.00			1.00			1.00		
2	1.30	1.12	1.51	1.31	1.13	1.52	1.77	1.52	2.07	1.80	1.54	2.11
3	1.43	1.22	1.69	1.44	1.23	1.70	2.25	1.89	2.69	2.28	1.91	2.72
4+	1.74	1.49	2.03	1.75	1.50	2.04	3.00	2.51	3.59	2.98	2.49	3.56
Diabetes												
Yes	1.12	0.87	1.44	1.03	0.80	1.33	1.35	1.05	1.75	1.37	1.06	1.77
No[a]	1.00			1.00			1.00			1.00		
Hypertension												
Yes	1.37	1.10	1.71	1.41	1.13	1.76	1.41	1.13	1.76	1.23	0.98	1.54
No[a]	1.00			1.00			1.00			1.00		
Prenatal care												
Yes[a]	1.00			1.00			1.00			1.00		
No	0.88	0.77	1.00	0.88	0.78	1.01	1.09	0.95	1.25	1.07	0.94	1.23

[a] Reference Category

[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[d]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 8: Relative Risks for Maternal Characteristics of SIDS Cases and Births for 2005 and 2006

	RR Unadjusted	95% CI		Model 2 RR Adjusted[b]	95% CI		Model 3 RR Adjusted[c]	95% CI	
Maternal Age									
<20	2.42	2.05	2.87	2.78	2.27	3.40	2.69	2.20	3.28
20 - 24	2.01	1.73	2.33	1.84	1.58	2.15	1.82	1.56	2.12
25 – 29[a]	1.00			1.00			1.00		
30 - 34	0.60	0.49	0.74	0.66	0.53	0.81	0.66	0.53	0.81
35 - 39	0.51	0.38	0.68	0.51	0.38	0.69	0.51	0.38	0.68
>39	0.53	0.31	0.93	0.48	0.27	0.84	0.47	0.27	0.82
Maternal race/ ethnicity									
Caucasian[a]	1.00			1.00			1.00		
African American	1.62	1.41	1.85	1.19	1.03	1.38	1.09	0.94	1.27
Native American/ Alaskan Native	3.35	2.21	5.07	2.02	1.33	3.06	2.04	1.35	3.10
Asian	0.43	0.30	0.62	0.85	0.58	1.24	0.82	0.56	1.19
Hispanic	0.43	0.37	0.51	0.41	0.35	0.49	0.41	0.34	0.49
Marital Status									
Married[a]	1.00			1.00			1.00		
Unmarried	2.72	2.43	3.21	1.50	1.31	1.72	1.47	1.28	1.68
Education Level									
Low	2.36	2.09	2.66	1.32	1.15	1.52	1.29	1.12	1.48
High[a]	1.00			1.00			1.00		
Smoking									
Yes	4.71	4.18	5.31	2.61	2.28	2.98	2.43	2.13	2.78
No[a]	1.00			1.00			1.00		

[a] Reference Category
[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age
[d]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 9: Relative Risks for Infant Characteristics of SIDS Cases and Births for 2005 and 2006

	RR Unadjusted	95% CI		Model 3 RR Adjusted	95% CI	
Weight						
SGA	2.13	1.84	2.45	1.75	1.51	2.03
AGA[a]	1.00			1.00		
LGA	0.74	0.59	0.93	0.78	0.62	0.99
Gestational Age						
Very preterm	2.68	2.07	3.47	1.97	1.49	2.60
Preterm	2.16	1.86	2.51	1.82	1.56	2.12
Term[a]	1.00			1.00		
Post term	1.45	1.09	1.93	1.19	0.89	1.59
5 minute APGAR score						
Low	2.54	1.88	3.41	1.56	1.13	2.15
High[a]	1.00			1.00		
Sex						
Male	1.46	1.31	1.64	1.51	1.35	1.69
Female[a]	1.00			1.00		
Assisted Ventilation	1.38	1.09	1.74	0.92	0.72	1.18
Surfactant	-			-		

[a] Reference Category

[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[d]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 10: Results of Chunk Test for Models 1, 2, and 3

Model	Full Model	Reduced Model	Difference	Degrees Freedom	Significant (Y/N)
Model 1[a]	22076.773	22078.799	2.026	4	N
Model 2[b]	20931.988	20943.947	11.959	9	N
Model 3[c]	20748.038	20764.963	16.925	14	N

[a]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 11: Confounding Assessment for Models 1, 2, and 3

	OR of exposure	CI lower	CI upper	Length
Model 1[a]				
Full Model	0.955	0.846	1.079	0.233
No prenatal	0.956	0.847	1.080	0.233
No diabetes	0.956	0.847	1.080	0.233
No hypertension	0.968	0.858	1.093	0.235
No birth order	0.952	0.843	1.075	0.232
Model 2[b]				
Full Model	1.099	0.973	1.243	0.270
No prenatal	1.098	0.972	1.242	0.270
No diabetes	1.086	0.948	1.243	0.295
No hypertension	1.114	0.986	1.259	0.273
No birth order	1.068	0.945	1.207	0.262
No maternal age	1.007	0.892	1.138	0.246
No race/ethnicity	1.099	0.973	1.242	0.269
No smoking	1.110	0.982	1.255	0.273
No education	1.099	0.973	1.243	0.270
No marital status	1.100	0.974	1.244	0.270
Model 3[c]				
Full Model	1.045	0.923	1.183	0.260
No prenatal	1.044	0.923	1.182	0.259
No diabetes	1.052	0.930	1.190	0.260
No hypertension	1.054	0.932	1.192	0.260
No birth order	1.019	0.901	1.246	0.345
No maternal age	0.959	0.848	1.084	0.236
No race/ethnicity	1.040	0.919	1.177	0.258
No smoking	1.052	0.929	1.190	0.261
No education	1.044	0.923	1.182	0.259
No marital status	1.044	0.923	1.182	0.259
No gestational age	1.071	0.947	1.212	0.265
No birthweight	1.053	0.931	1.192	0.261
No Gender	1.053	0.930	1.191	0.261
No Apgar	1.049	0.927	1.187	0.260
No Ventilation	1.042	0.921	1.178	0.257

[a]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[b]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[c]Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 12: Extended Delivery Method of SIDS Cases and Births for 2005 and 2006

	SIDS Cases		Births		OR Unadjusted	95% CI	
	No.	%	No.	%			
Repeat or Primary							
Vaginal [a]	866	69.06	2154490	68.42	1.00		
VBAC	14	1.12	34490	1.10	1.01	0.60	1.71
Primary C-Section	233	18.58	619339	19.67	0.94	0.81	1.08
Repeat C-Section	141	11.24	340658	10.82	1.03	0.86	1.23
Assisted Methods							
Spontaneous [a]	829	66.11	2036971	64.69	1.00		
Forceps	7	0.56	28334	0.90	0.61	0.29	1.28
Vaccuum	44	3.51	123675	3.93	0.87	0.65	1.18
C-Section	374	29.82	959997	30.49	0.96	0.85	1.08

[a] Reference Category

Table 13: Adjusted Odds Ratios for Extended Delivery Method of SIDS Cases and Births for 2005 and 2006

	Model 1 OR Adjusted[b]	95% CI		Model 2 OR Adjusted[c]	95% CI		Model 3 OR Adjusted[d]	95% CI	
Repeat or Primary									
Vaginal [a]	1.00			1.00			1.00		
VBAC	0.85	0.50	1.45	0.98	0.57	1.66	0.94	0.55	1.60
Primary C-Section	0.98	0.85	1.14	1.11	0.96	1.29	1.03	0.89	1.20
Repeat C-Section	0.91	0.76	1.09	1.08	0.90	1.29	1.06	0.88	1.27
Assisted Methods									
Spontaneous [a]	1.00			1.00			1.00		
Forceps	0.67	0.32	1.40	0.65	0.31	1.38	0.65	0.31	1.37
Vaccuum	0.96	0.71	1.31	0.97	0.72	1.32	0.98	0.72	1.33
C-Section	0.95	0.84	1.07	1.09	0.97	1.24	1.04	0.92	1.18

[a] Reference Category

[b] Model includes: delivery method, birth order, diabetes, hypertension, prenatal care

[c] Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age

[d] Model includes: delivery method, birth order, diabetes, hypertension, prenatal care, maternal ethnicity, maternal education, marital status, smoking during pregnancy, maternal age, infant gender, gestational age, size at birth, assisted ventilation, 5 minute Apgar

Table 14: Comparison of C-Section Characteristics

	C-Section		P Value	Vaginal		P Value	P Value (C-Section and Vaginal)
	SIDS	Births		SIDS	Births		
Total births (%)	29.82	30.49	-	70.18	69.51	-	0.6110
Average Maternal Age	24.56	28.34	0.0053	23.65	26.68	<0.0001	<0.0001
SGA (%)	20.86	9.95	<0.0001	17.61	9.25	<0.0001	<0.0001
Prenatal Care (%)	78.07	75.67	0.2789	76.36	73.89	0.0951	0.0477
Smoking (%)	34.22	8.59	<0.0001	30.45	9.06	<0.0001	<0.0001
Marital Status	37.17	64.41	<0.0001	37.39	60.76	<0.0001	<0.0001

Figure 1: Initial models before interaction, confounding, and collinearity assessment

Model 1 – Labor and Pregnancy Characteristics

Logit P(X) = α + β(delivery method) + γ_1(prenatal care) + γ_2(diabetes) + γ_3(hypertension) + γ_4(total birth order) + δ_1(delivery method)(prenatal care) + δ_2 (delivery method) (diabetes) + δ_3 (delivery method) (hypertension) + δ_4 (delivery method) (total birth order)

Model 2 – Labor, Pregnancy, and Maternal Characteristics

Logit P(X) = α + β(delivery method) + γ_1(prenatal care) + γ_2(diabetes) + γ_3(hypertension) + γ_4(total birth order) + γ_5 (maternal ethnicity) + γ_6 (maternal education)+ γ_7 (marital status) + γ_8 (smoking during pregnancy) + γ_9 (maternal age) + δ_1(delivery method)(prenatal care) + δ_2 (delivery method) (diabetes) + δ_3 (delivery method) (hypertension) + δ_4 (delivery method) (total birth order) + δ_5 (delivery method) (maternal ethnicity)+ δ_6 (delivery method) (maternal education) + δ_7 (delivery method) (marital status) + δ_8(delivery method) (smoking during pregnancy) + δ_9(delivery method)(maternal age)

Model 3 – Labor, Pregnancy, Maternal, and Infant Characteristics

Logit P(X) = α + β(delivery method) + γ_1(prenatal care) + γ_2(diabetes) + γ_3(hypertension) + γ_4(total birth order) + γ_5 (maternal ethnicity) + γ_6 (maternal education)+ γ_7 (marital status) + γ_8 (smoking during pregnancy) + γ_9 (maternal age) + γ_{10} (gender) + γ_{11} (gestational age) + γ_{12} (size at birth) + γ_{13}(assisted ventilation) γ_{14}(5 minute Apgar) + δ_1(delivery method)(prenatal care) + δ_2 (delivery method) (diabetes) + δ_3 (delivery method) (hypertension) + δ_4 (delivery method) (total birth order) + δ_5 (delivery method) (maternal ethnicity)+ δ_6 (delivery method) (maternal education) + δ_7 (delivery method) (marital status) + δ_8(delivery method) (smoking during pregnancy) + δ_9 (delivery method)(maternal age) + δ_{10} (delivery method)(gender) + δ_{11} (delivery method)(gestational age) + δ_{12} (delivery method)(size at birth) + δ_{13} (delivery method) (assisted ventilation) + δ_{14} (delivery method) (5 minute Apgar)

Figure 2: Final models after interaction, confounding, and collinearity assessment

Model 1 – Labor and Pregnancy Characteristics

$$\text{Logit } P(X) = \alpha + \beta(\text{delivery method}) + \gamma_1(\text{prenatal care}) + \gamma_2(\text{diabetes}) + \gamma_3(\text{hypertension}) + \gamma_4(\text{total birth order})$$

Model 2 – Labor, Pregnancy, and Maternal Characteristics

$$\text{Logit } P(X) = \alpha + \beta(\text{delivery method}) + \gamma_1(\text{prenatal care}) + \gamma_2(\text{diabetes}) + \gamma_3(\text{hypertension}) + \gamma_4(\text{total birth order}) + \gamma_5 (\text{maternal ethnicity}) + \gamma_6 (\text{maternal education}) + \gamma_7 (\text{marital status}) + \gamma_8 (\text{smoking during pregnancy}) + \gamma_9 (\text{maternal age})$$

Model 3 – Labor, Pregnancy, Maternal, and Infant Characteristics

$$\text{Logit } P(X) = \alpha + \beta(\text{delivery method}) + \gamma_1(\text{prenatal care}) + \gamma_2(\text{diabetes}) + \gamma_3(\text{hypertension}) + \gamma_4(\text{total birth order}) + \gamma_5 (\text{maternal ethnicity}) + \gamma_6 (\text{maternal education}) + \gamma_7 (\text{marital status}) + \gamma_8 (\text{smoking during pregnancy}) + \gamma_9 (\text{maternal age}) + \gamma_{10} (\text{gender}) + \gamma_{11} (\text{gestational age}) + \gamma_{12} (\text{size at birth}) + \gamma_{13}(\text{assisted ventilation})\ \gamma_{14}(\text{5 minute Apgar})$$

APPENDICES

EMORY UNIVERSITY

Institutional Review Board

March 9, 2012

RE: Determination: No IRB Review Required
Title: The Association Between Birth Delivery Method and Sudden Infant Death Syndrome
PI: Amanda Overholt

Dear Ms. Overholt:

Thank you for requesting a determination from our office about the above-referenced project. Based on our review of the materials you provided, we have determined that it does not require IRB review because it does not meet the definition(s) of "research" involving "human subjects" or the definition of "clinical investigation" as set forth in Emory policies and procedures and federal rules, if applicable. Specifically, in this project, you will be conducting a secondary analysis of non identifiable data.

This determination could be affected by substantive changes in the study design, subject populations, or identifiability of data. If the project changes in any substantive way, please contact our office for clarification.

Thank you for consulting the IRB.

Sincerely,

Andrea Goosen, MPH, CIP
Research Protocol Analyst
This letter has been digitally signed

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