

Fear in the Delivery Room: A Predictive Model of How Medical Liability, Midwifery Care, and
Reproductive Education Affect Cesarean Section Rates in the United States

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Fear in the Delivery Room: How Medical Liability, Midwifery Care, and Reproductive
Education Affect Cesarean-Section Rates in the United States

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ABSTRACT

Fear in the Delivery Room: How Medical Liability, Midwifery Care, and Reproductive Education Affect Cesarean-Section Rates in the United States, a Predictive Model

Elizabeth Walsh

The United States has one of the highest cesarean section delivery rates in the world, yet distribution of cesarean section rates for U.S. counties vary drastically. This research presents a model which identifies counties with a cesarean section delivery rate level for first-born singleton births of greater than 30%. The research presents the role of fear as a determinant for cesarean delivery rates. The proposed model includes three main drivers of cesarean section deliveries: fear of litigation, maternal fear of childbirth, and broader structural forces. Birth data from 2012 are analyzed, along with county demographics data, medical liability premiums, midwifery care, and reproductive education for 511 counties within the United States. Logistic univariate analysis identified high maternal age, low gestational age, high rate of diabetes, high medical liability premiums, lack of reproductive education, lack of support for midwifery care, census region, rural/urban classification, and high levels of income inequality as significantly associated with high cesarean section rates, for first-birth singleton deliveries at the county level. Data was split into training/sample and test/out-of-sample sets and multivariable logistic regression analysis was used to develop a predictive model on the sample set to accurately identify counties with a high cesarean section rate in the test/out-of-sample data set. The model accurately predicted 72% of records. The results suggest that fear of litigation on behalf of the provider and a maternal fear of childbirth influence the rate of cesarean section deliveries at the county level.

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Chapter One: Introduction and Guiding Research Question

Introduction

In the United States, one-third of births occur by cesarean section, representing one of the highest rates among developed nations. Why is it so high, and why do some counties have higher rates of cesarean section deliveries while others have lower rates?

The Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), provides access to data related to births in the United States through the natality public-use data on the CDC Wonder Online Database (Division of Vital Statistics, 2012). In 2012, there were 3.5 million births, and of these, over 1.5 million births were identified as first born, singleton births. Since the likelihood of cesarean delivery increased with multiparity (Fuglenes, Aas, Botten, Øian, & Kristiansen, 2011) and multiple gestation (Ginsberg & Levine, 2003), this research focuses on primary, first-born, singleton births. In 2012, the cesarean delivery rate for primary singleton births was 30.8% (see Table 1).

Table 1: 2012 U.S. Births by Delivery Method - Singleton First Live Births

2012 U.S. Births by Delivery Method – Singleton First Live Births

<u>Delivery Method</u>	<u>2012 Count</u>	<u>Percent</u>
Vaginal	1,062,261	69.1%
Cesarean	473,086	30.8%
Not Stated	1838	0.1%
Total	1,537,185	100%

Source: CDC/NCHS, National Vital Statistics System

The rise in cesarean-section deliveries has not reduced the rate of infant or maternal mortality, and the rate of morbid complications during childbirth has increased in connection with rising cesarean deliveries (Silver, 2012). Research has followed to determine risk factors associated with cesarean deliveries at the individual level. These risk factors include maternal

demographics of height, weight, and gestational age (Chen, Uryasev, & Young, 2004), maternal diabetes (Rosenberg, Garbers, Lipkind, & Chiasson, 2005), and existing health conditions and maternal comorbidities (Huesch, Currid-Halkett, & Doctor, 2014). Most research in the area has been focused on analyzing risk factors at the individual level. There is little research addressed at community level cesarean-section rates. To fill this gap in literature, this research seeks to understand county-level determinants of cesarean-section rates. This research project uses a variety of data sets to build a model that predicts which counties in the United States had high rates of cesarean-section deliveries in 2012.

Guiding Research Question

Why are cesarean section deliveries higher in some counties than in others? Recent research from Sweden (Nilsson, Lundgren, Karlström, & Hildinsson, 2012) and the United States (Arcia, 2013) identified a fear of childbirth (FOC) as a factor that increases the likelihood of cesarean-section delivery in low-risk pregnancies. Chen et al. (2004) identified maternal and infant health characteristics as predictors for cesarean births. Miller and Shriver (2012) identified structural economic forces as contributing to cesarean deliveries. Can we build a model that takes these aspects into consideration to determine which counties in the United States are at greater risk for high cesarean delivery births?

Significance

Cesarean-section births carry risks, including infection, hemorrhaging, injury to organs, extended hospital stays, and extended recovery time (American Pregnancy Association, 2008). Mothers who have a cesarean delivery are more likely to have post-delivery health problems such as severe bleeding, infection, pain, longer recovery, and difficulty breastfeeding (American College of Nurse-Midwives, 2012). Cesarean deliveries are intended to save the health of the

mother or baby, but the rate of morbid complication during childbirth has increased because of the rising rate of cesareans in the United States (Silver, 2012).

Globally, these risks are known within the medical and midwifery professions but may not be known to women preparing to give birth. An Australian study found that most women who elect a cesarean-section were unaware that the procedure could cause complications for the baby and the mother after birth (Chen & Hancock, 2012) or that the health complications of the child can continue through childhood. The Norwegian Mother and Child Cohort Study, which examined the associations between delivery by cesarean-section and development of respiratory illness, found increased risk of asthma at 36 months of age for children who were delivered by cesarean section (Magnus et al., 2011). These odds are greater for children delivered at 37–38 gestational weeks than later (Nir, Nadir, & Feldman, 2012).

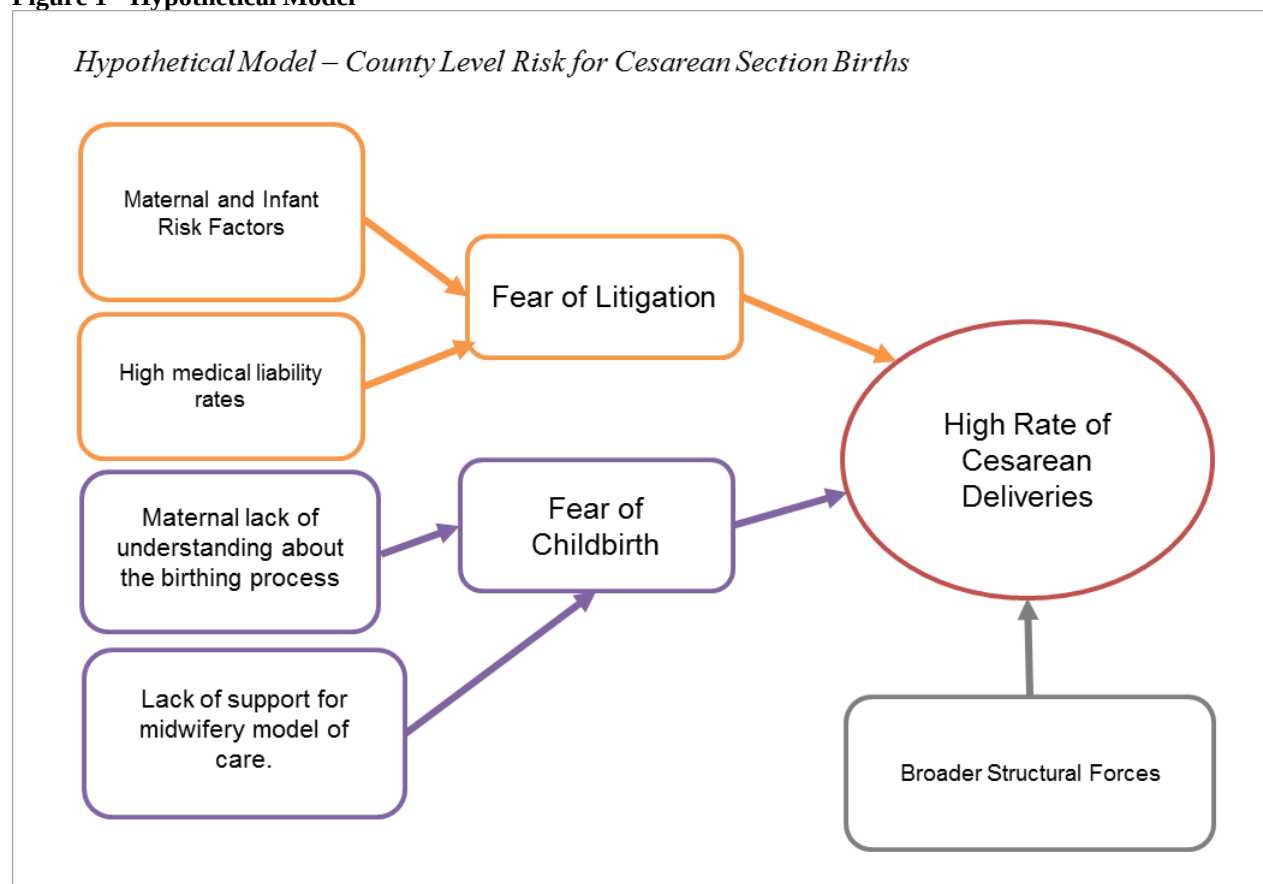
The high rate of cesarean section deliveries has economic implications as well as health consequences. Payments for care are nearly 50% greater for women who have cesarean deliveries (Garvey, 2013). Assuming an average differential of \$20,000 between a vaginal and a cesarean delivery (The Lamp, 2013), moving the U.S. average from 32.8% to 30% could represent an annual savings of over \$2 billion dollars.

Hypothetical Model

This study aims to create a model that will predict the severity of cesarean-section deliveries at the county level using attributes that have previously been associated with cesarean-section rates, while introducing variables that contribute to fear associated with childbirth. The hypothetical model presented here demonstrates a pathway to cesarean section deliveries which includes three main aspects. The first aspect is *Fear of Litigation*, fueled by high rates of maternal and infant risk factors along with rates of medical liability premiums. The second aspect, *Fear of*

Childbirth, includes reproductive education and support for midwifery care as influencing maternal fear of childbirth. A third aspect, *Broader Structural Forces*, is considered and includes elements that are external to the decision-making process of the mother or the medical provider, such as access to care and socio-economic status (see Figure 1).

Figure 1 - Hypothetical Model



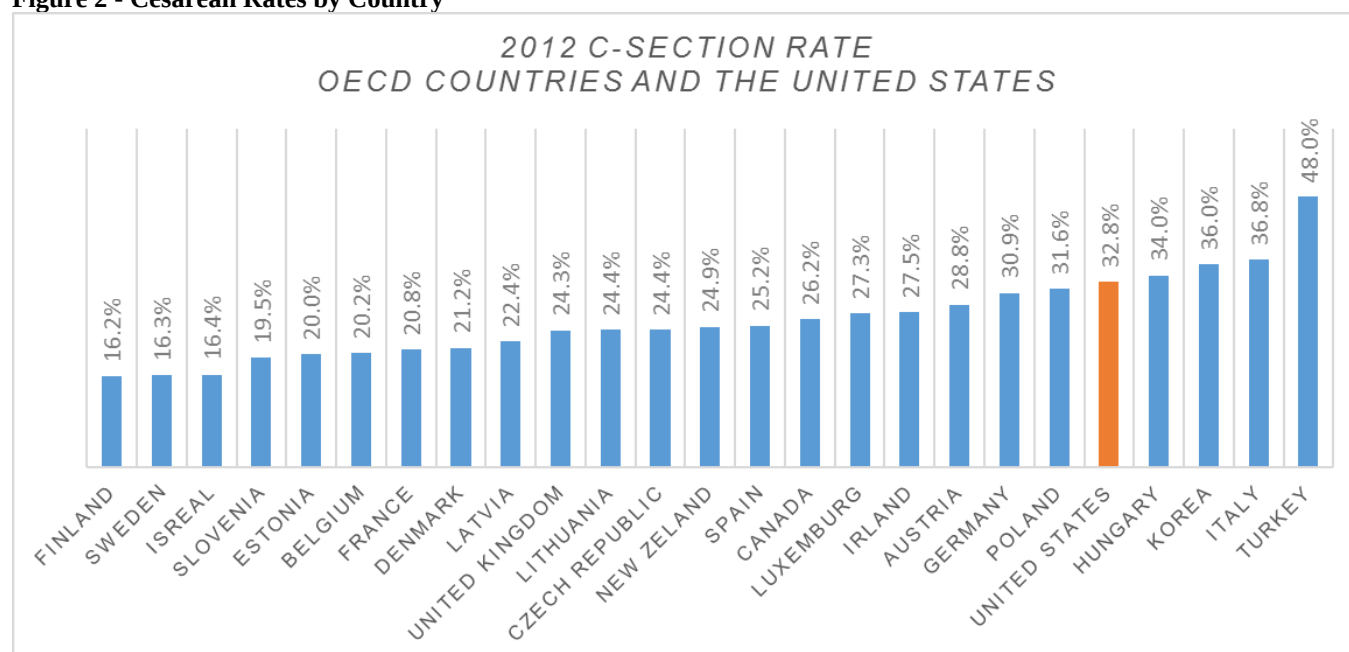
The goal of this research is to provide a model which will give health care providers, educators, and community organizations insights to shape community-wide initiatives and strategies for improving the childbirth experience for low-risk women, with the goal of reducing unnecessary cesarean-section deliveries.

Chapter Two: Literature Review

Trends in Cesarean-Section Rates in the United States

In 2012, more than 3.9 million births occurred in the United States, with almost 1.3 million delivered via cesarean section. The United States had one of the highest rates of cesarean deliveries among developed nations, with a rate of 32.8% compared to an average of 26.9% for member countries of the Organization for Economic Co-operation and Development (OECD; see Figure 2).

Figure 2 - Cesarean Rates by Country



source: Organization for Economic Co-operation and Development

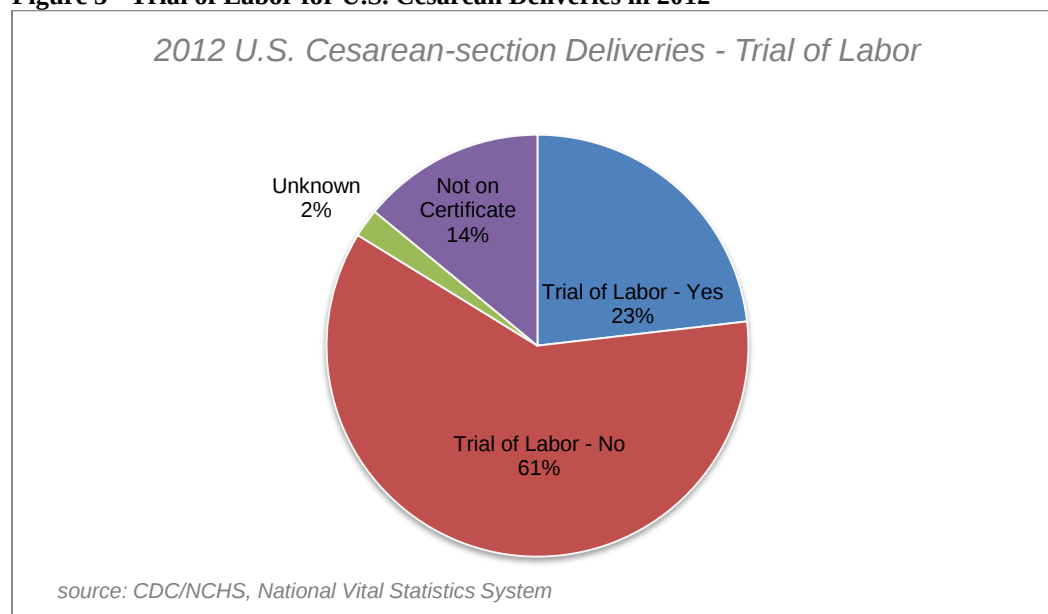
Cesarean-section is a delivery method intended to address emergency health problems for the mother or the baby. A planned cesarean delivery is one that is scheduled in advance of the due date due to risk factors of the mother or infant. Planned cesarean births may also be a result of maternal request. However, recent research demonstrated that approximately 90% of women prefer to deliver vaginally in the absence of maternal or infant risk (Yee et al., 2015). The rate of

planned cesarean sections, rather than emergency cesarean sections, is not available. Reviewing the rate of cesarean without trial of labor provides an approximation of the rate of planned cesarean births.

Trial of Labor

Trial of labor occurs when labor is allowed, augmented, or induced with plans for vaginal delivery (Centers for Disease Control and Prevention [CDC], 2012). Trial of labor data are available on the aggregate level for the United States. Most of the cesarean-section deliveries in the United States occur without attempting labor. In the United States, trial of labor occurred in less than one-third of the cesarean deliveries (23%) in 2012 (see Figure 3).

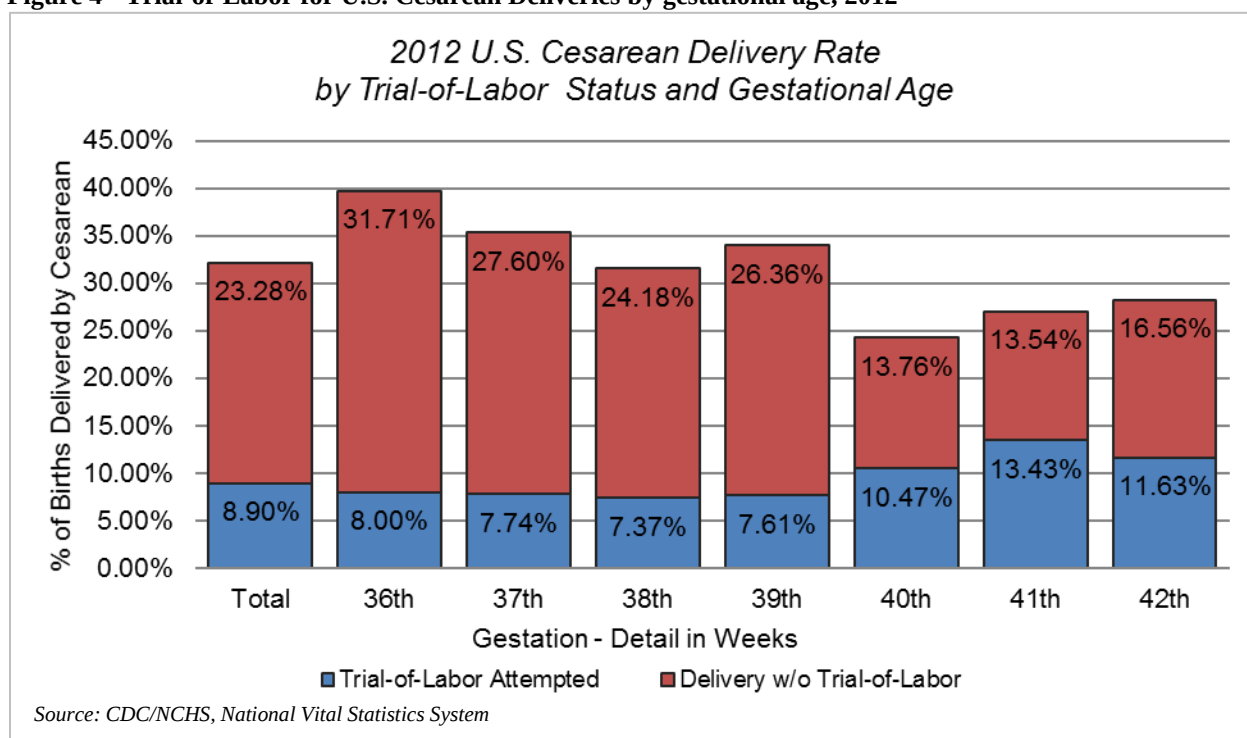
Figure 3 - Trial of Labor for U.S. Cesarean Deliveries in 2012



The most common reason for a cesarean following trial of labor was that labor was not progressing as fast as expected (American College of Nurse-Midwives, 2012). The American Colleges of Obstetrics and Gynecologists encourage health care providers to wait until at least 39 weeks of gestation before performing elective cesarean deliveries (Oshiro et al., 2013). However,

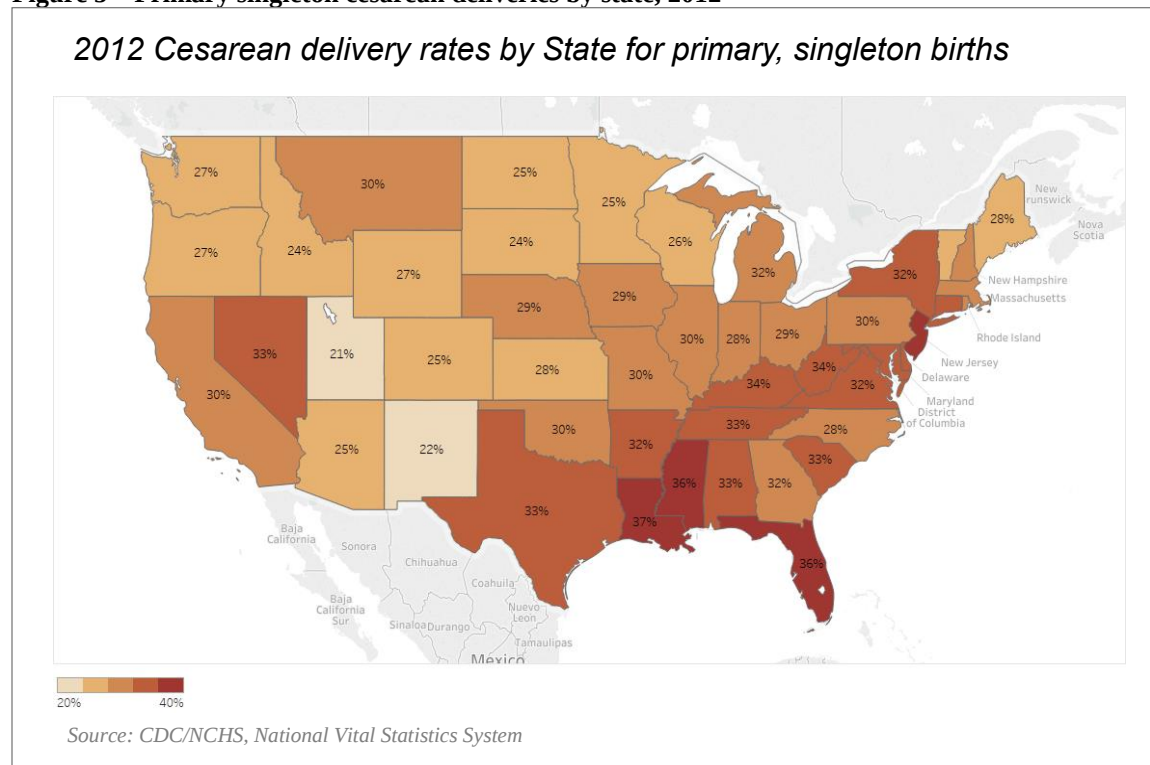
per data from the CDC/NCHS, National Vital Statistics System, cesarean-section delivery rates without trial of labor are noticeably higher for births occurring before 39 weeks than births occurring at week 40 and later. Normal pregnancy length has been conventionally defined as delivery between 37 weeks and 42 weeks (Spong, 2013). Week 36 is the last week before a pregnancy is considered full-term. The rate of cesarean delivery for 36 weeks of gestation is 40% and has the highest rate of cesarean deliveries without trial of labor (see Figure 4).

Figure 4 - Trial-of-Labor for U.S. Cesarean Deliveries by gestational age, 2012



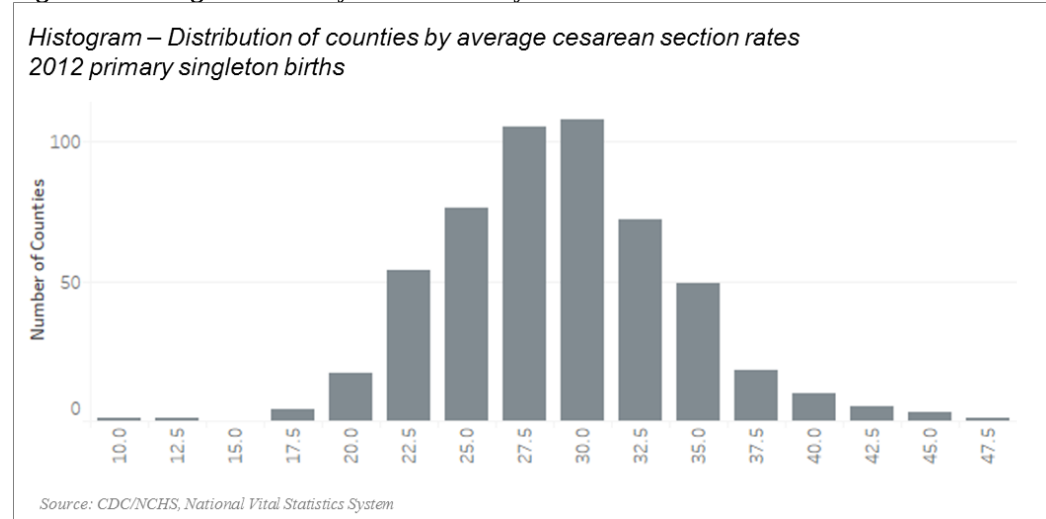
Dispersion of County Cesarean Rates

Rates for cesarean-section deliveries vary widely across the United States. In 2012, the state with the lowest cesarean-section rate for primary singleton births was Utah at 21% compared to the highest, Louisiana, at 37% (see Figure 5).

Figure 5 – Primary singleton cesarean deliveries by state, 2012

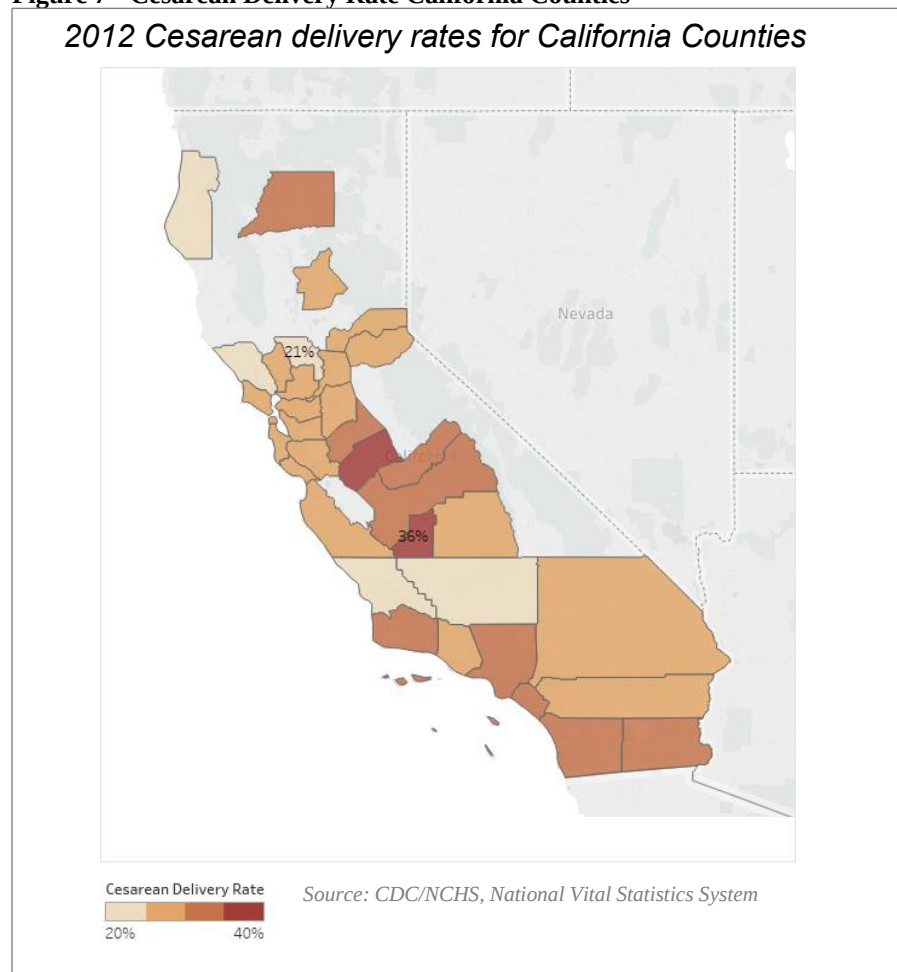
County data are available for counties with a population of at least 100,000 (CDC, 2012).

The average cesarean section rate varies across the United States, with the greatest frequency between 30% and 32.5% (see Figure 6).

Figure 6 - Histogram: County distribution by rate of cesarean

Within a state, the range of cesarean delivery rates by county can vary drastically. For example, California has a state cesarean delivery rate of 30% for primary singleton births, and cesarean rates across counties range from as low as 21% in Yolo County to as high as 36% in Kings County (see Figure 7).

Figure 7 - Cesarean Delivery Rate California Counties



Maternal and Infant Risk Factors

Chen, Uryasev, & Young (2004) presented a predictive model for identifying cephalopelvic disproportion/failure to progress and cesarean delivery in a middle-class practice in a low-risk primipara population. The model identified maternal height, age, weight, and gestational age as predictors for a cesarean delivery, with a higher probability of cesarean delivery

for shorter, older, more obese women. Diabetes has been shown to increase the risk of cesarean delivery (Ehrenberg, Durnwald, Catalano, & Mercer, 2004).

Medical Liability and Fear of Litigation

Rising medical liability premiums have been shown to affect medical professionals' decision making. Between 2001 and 2005, the median liability premiums in the United States increased from \$40,093 to \$74,447, and this increase had a negative impact on selection rates of obstetrics-gynecology as a career choice by U.S. medical graduates (Nuthalapaty, Shirazi, Paden, & Higdon, 2014). Many medical students found that they were unprepared for the litigious environment of medicine and indicated that they did not receive formal education in liability/malpractice issues during residency; they identified liability-related issues as influencing decision-making in their residency practice (Blanchard et al., 2012). Providers, therefore, find themselves practicing "defensive medicine." Studdert et al. (2005) defined "defensive medicine" as "a deviation from sound medical practice that is induced primarily by threat of liability." Actions associated with defensive medicine include excessive diagnostic procedures and tests as well as avoidance of procedures that are perceived to increase the risk of litigation. In their research, Studdert et al. found that defensive medicine was strongly correlated with the perceived burden of insurance premiums. Murthy, Grobman, Lee, and Holl (2007) found that higher rates of primary cesarean delivery were associated with increased medical professional liability premiums for OB-GYNs in the state of Illinois.

Physicians operating in an environment of high medical premiums rates may be "primed" by fears of litigation. According to Minkoff (2012), there are nine common causes of medical malpractice suits, six of which may involve a potential allegation to perform a cesarean section in a timely manner. "Therefore, it is not surprising, that in the minds of many obstetricians, the

performance of a cesarean section when there is any doubt about the baby's health, or even before there is any doubt, will have a salutary effect on their chance of being successfully sued" (Minkoff, 2012, p. 392). The analysis for this project examines the impact of medical liability premiums on mode of delivery.

Midwifery, Reproductive Education, and Fear of Childbirth

Expectant mothers tend to experience more supportive care under a midwife. Focusing on the psychological well-being of the expectant mother can help prepare the woman for the childbirth experience. Women under midwife-led care have reported fewer instances of severe fear of childbirth than women who receive obstetric care (Hall et al., 2009), and a preference for cesarean-section has been shown to be greater among women who are more fearful of delivery (Arcia, 2013). Tully and Ball (2013) suggested that the current perception of childbirth as "unpredictable, frightening and/or potentially dangerous" (Tully & Ball, 2013, p.109) is what leads to high rates of obstetric intervention.

Very little research has been conducted in the United States regarding the influence of fear of childbirth on delivery outcomes. The most comprehensive research on the subject comes from the Nordic countries, where researchers are attempting to understand the effect of fear of childbirth on delivery outcomes while exploring various treatment options (Salmela-Aro et al., 2014). A Norwegian study of 2,206 women who planned a vaginal delivery found that labor lasted longer in women with a fear of childbirth than in women without a fear of childbirth (Adams, Eberhard-Gran, & Eskild, 2012).

Recent research in Australia explored the concept of fear of childbirth. One such study found that the expectant mothers' fear of childbirth was associated with nulliparity (first birth) and multiparity where the previous birth was operative (Toohill, Fenwick, Gamble, & Creedy, 2014).

A longitudinal study of a region of Sweden and a region of Australia found that pregnant women who were considered “fearful” of birth were over three times more likely to prefer a caesarean than women who were not identified as “fearful” (Haines, Rubertsson, Pallant, & Hildingsson, 2012). Another study on fear of childbirth found that concerns about control and safety and a “devaluing of the female body and birth process” were the main reasons women requested cesarean section during a healthy and normal first pregnancy (Fenwick et al., 2008).

Education and intervention have been shown to mitigate fear of childbirth in expectant mothers. In a randomized trial in Finland, women identified as having severe fear of childbirth were provided either psycho-educative group therapy or conventional treatment for the remainder of their pregnancy. The group receiving intervention therapy had far fewer cesarean-sections than the conventional group and reported having a very positive delivery experience (Rouhe et al., 2013). In a Finish study of nulliparous women with a severe fear of childbirth, individualized treatment for fear of childbirth was shown to drastically reduce elective cesarean-section procedures (Sydsjö et al., 2014).

Since education and intervention have been shown to minimize fear of childbirth, this study will explore midwifery care and reproductive education as mitigating factors on fear of childbirth.

Fear of Childbirth and the Midwifery Model of Care

In the United States, the support for midwifery practice is minimal in comparison to the support for obstetric care. Per analysis conducted by Truven Health Analytics for the *New York Times*, the key reason for the high costs of births in the United States is due in part to the predominance of obstetricians over midwives (The Lamp, 2013). Comparison of midwife-led units with obstetric-led units shows that the obstetric-led units have a greater likelihood of operative delivery for self-rated “no-” and “low-” risk pregnancies (Symon, Paul, Butchart, Carr,

& Dugard, 2007). Women who experienced continuity of care by a primary midwife have been shown to have lower rates of operative birth (Mclachlan et al., 2012).

In the Netherlands, where low-risk pregnancies receive midwife-led care (Geert et al., 2014), the cesarean-section rate is 15.6% (OECD, 2013), less than half the rate in the United States. The correlation between midwife care and low cesarean rates is apparent in other countries as well. Where there is state support for midwifery practice and midwifery education, the rate of cesarean sections is at a rate that is closer to the World Health Organization's (WHO) ideal rate of 10%-15% (Soltani & Sandall, 2012).

The difference in outcomes between obstetric-led and midwife-led care expands beyond the labor and delivery room. There are distinguishable differences between the two modes of care throughout the pregnancy. The midwifery model of care provides comprehensive prenatal care, education, and supports the psychological and social well-being of the mother during the entire childbearing cycle (Midwives Alliance of North America [MANA], 2012). Midwife-led education and psychological intervention have been shown to reduce fear of childbirth among expectant mothers (Fenwick, Staff, Gamble, Creedy, & Bayes, 2008) and this may be the reason why cesarean section births are lower in midwife-led units.

Under the midwifery model of care, perspectives on the role of the attending medical provider during the childbirth process differ from the obstetric model. The major differences lie in the involvement of interventions during labor, and in the goals and objectives of care (Rooks, 1999). In the midwifery model, birth is treated as a natural process in which the woman is empowered to experience birth with minimum intervention (Sandall, Soltani, Gates, Shennan, & Devane, 2013). The midwifery model of care views labor pain as a normal and manageable part of the birthing process, while the biomedical model view is that pain must be controlled with

anesthesia or analgesia (Gibson, 2014). This concept appears to be supported by the 2012 birth data in the United States, which show that births attended by a midwife have a lower rate of augmentation, anesthesia, or induction of labor than births attended by a doctor of medicine or a doctor of osteopathy (see Table 2).

Table 2 : 2012 U.S. Births by Attendant, Location, and Medical Intervention

2012 U.S. Births				
Augmentation, Anesthesia, or Induction by Birth Location and Attendant at Birth				
Attendant at Birth / L&D Augmentation, Anesthesia, or Induction				
	Doctor of Medicine (MD) & Doctor of Osteopathy (DO)		Certified Nurse Midwife (CNM) & Other Midwife	
	Y	N	Y	N
In Hospital	80.41%	19.59%	69.78%	30.22%
Not in Hospital	17.75%	82.25%	4.17%	95.83%
Grand Total	80.37%	19.63%	61.93%	38.07%

Data Source: CDC/NCHS, National Vital Statistics System

Under the midwifery model of care, the pregnant mother has an active role in the baby's delivery; and is encouraged to take a greater position of control. The safe delivery of the child and the support of the woman through the pregnancy process are primary objectives under midwifery care (Rooks, 1999). As such, women who are more likely to prefer the midwifery model of care are those who view their own active participation as essential to the childbirth process (Arcia, 2013).

In the continuity of care under a midwife, the mother receives all care from a midwife practice throughout the pregnancy, during labor, and after birth. In contrast, continuous support during labor in hospital settings has become an exception, and the likelihood for operative birth has increased (Hodnett, Gates, Hofmeyr, & Salaka, 2005). For a hospital birth a mother may find that she must schedule the birth date if they want to deliver with their chosen provider.

MANA emphasizes a model of care that monitors the psychological and social well-being of the mother while providing individualized education (MANA, 2012). These measures may be responsible, in part, for a reduced cesarean-section rate among midwife-led births. Expectant mothers who prepare for out-of-hospital births tend to have fewer operative outcomes. Garvey (2013) found that the risk of cesarean delivery was significantly lower for women who initiated birth at a birth center, even for those who are transferred to a hospital. In a Netherlands study of midwife-led births, women who planned and completed a home birth reported a greater sense of control and less fear of giving birth than women who planned and completed a hospital birth (Geert et al., 2014). Low-risk women who plan home births experience high rates of physiologic birth, low rates of intervention, and no increase in adverse outcomes (Cheyney et al., 2014).

It appears that midwifery care is associated with a higher level of supportive care for the mother, but simply having a midwife assigned to the birth does not account for the difference in birth outcome. It is the care during the entire pregnancy process that prepares the woman for birth. This type of care was the subject of a multi-center trial in Germany, where an intervention of midwife-led care was introduced. The study found that women who did not receive supportive procedures from midwives (including dedicated attention by the midwife, continuity of care, and hands-on techniques for improving maternal comfort) were significantly more likely to have a cesarean or operative delivery (Knape, Mayer, Schnepf, & Sayn-Wittgenstein, 2014).

Fear of Childbirth and Reproductive Education

Psychological well-being and feelings of preparedness of the expectant mother has benefits that extend beyond the birth. Nulliparous women who feel prepared for childbirth were predicted to have positive experiences of motherhood after the birth (Salmela-Aro et al., 2014).

The World Health Organization has established a link between maternal education and maternal mortality (Karlsen et al., 2011). The question remains as to whether the level of the mother's reproductive education has an impact on birth outcomes. In one Latin American study on health education intervention during pregnancy, women who received intervention education showed significant improvement in knowledge of labor-onset signals and alarm signs (Belizán et al., 1995). Maternal understanding of the signs of onset of labor can ensure that the mother goes to the hospital during active labor, rather than pre-active or false labor. When women are admitted during active labor rather than pre-active labor, the likelihood of having a cesarean birth is reduced (Neal et al., 2014).

The degree to which a community is comfortable with discussing pregnancy and reproductive health may have an impact on the level of fear about childbirth and subsequently affect cesarean-section rates for the community. In developing countries, women who exchange reproductive health information with friends and family are less likely to undergo a cesarean section birth (Leone, Padmadas, & Matthews, 2008).

The level of comfort and social acceptance in discussing reproductive health varies across communities in the United States. Fear of childbirth among female college students has been associated with a lack of knowledge about childbirth (Cleeton, 2001). And contrary to popular belief, high school students lack the understanding of the specifics of how contraceptives work to prevent pregnancy (Smith, Realini, Buzi, & Martinez, 2011). Students appreciate facilitators of sex education who allow open dialog (Smith et al., 2011). However, in communities where parents and school officials favor an "abstinence-only" curriculum, teachers have expressed fear that discussing controversial sex education topics, including contraception, could jeopardize their careers (Donvan, 1998). The fear of communication on part of the school officials may lead to

fewer open and honest conversations about reproductive health, thereby reducing the transfer of knowledge on reproductive issues such as childbirth.

Broader Structural Forces

Miller and Shriver (2012, p. 709) found that women's birth preferences are ultimately shaped "by broader structural forces, particularly economic position and availability of birth options."

As Medicaid has become the nation's largest payer of maternity-related services, paying for approximately 44% of births in the United States in 2012 (CDC, 2012), many women may feel that their childbirth options are limited. The certified nurse-midwife Medicaid reimbursement rates, relative to physician reimbursement rates, vary by state (American College of Nurse-Midwives, 2013). In many cases, women who prefer a home birth with a midwife find themselves unable to afford it, and therefore feel economically coerced into a birth practice they find risky and objectionable because their insurance or Medicaid only covers hospital birth with a physician (Miller & Shriver, 2012).

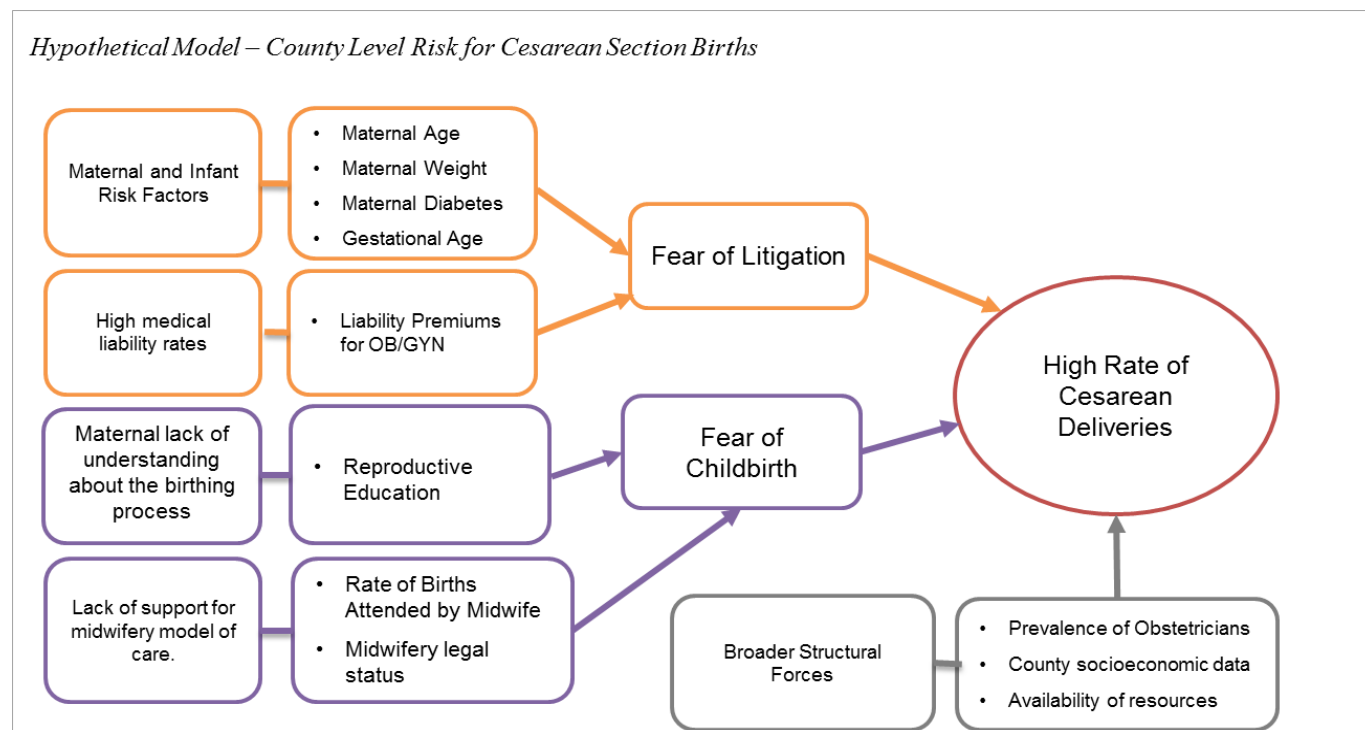
The odds of operative births are greater when the birth is in a hospital, since hospitals deliver both high- and low-risk births. But after adjusting for socio-demographic and clinical factors, hospital practices and culture are shown to affect cesarean delivery rates (Caceres et al., 2013). Lauer, Betrán, Merialdi, and Wojdyla (2010) found that in developed nations, health system factors have stronger aggregate-level effects on cesarean-section rates than income do (based on GDP per capita). In their report for the World Health Organization, the researchers demonstrate a "supply-driven" model, where the number of obstetricians in the health system ("suppliers" of cesarean delivery) has a substantial influence on rising cesarean-section rates in developed nations (Lauer et al., 2010). They also suggest that cesarean delivery rates may be responsive to health system

changes. Health system factors are important aggregate-level determinants of cesarean-section rates for developed countries. The number of obstetricians in the health system has a substantial influence on the cesarean-section rates for developed nations (Lauer et al., 2010). This research examines societal forces of income inequality, community health, and rural classification of each county as a means of explaining larger social structural forces within the county.

Summary

This study explores the impact of fear of childbirth and fear of litigation on cesarean-section rates at the county level within the United States. Research studies conducted outside of the United States have identified a relationship between fear of childbirth and mode of delivery (Haines et al., 2012). Maternal fear of childbirth has been associated with lack of knowledge (Cleeton, 2001). Since the midwife model of care includes maternal education about the birth process, this research uses existing data on reproductive education policies in public schools, along with the prevalence of midwife care as mitigating factors for maternal fear of childbirth.

The analysis considers three main aspects contributing to county level cesarean section rates (see Figure 8). The first aspect, *Fear of Litigation* explores the role of maternal and infant risk factors along with medical liability rates. The second aspect, *Fear of Childbirth* considers the reproductive education and the prevalence of midwifery care as mitigating factors on reducing fear of childbirth. The third aspect, *Broader Structural Forces*, considers access to medical care, socioeconomic demographics and the urban/rural ranking of the county. The proposed hypothetical model and variables are outlined below in Figure 8.

Figure 8 - Hypothetical Model and Variables

Chapter Three: Data Collection and Research Methods

Data Collection

Since 1985, the WHO has considered the ideal rate for cesarean sections to be between 10% and 15% (WHO, HRP). The aim of this project is to create a predictive model that will identify counties within the United States with a cesarean delivery rate above 30% (twice the WHO recommended level) for first born singleton births.

Based on information obtained during the review of existing literature, this research sought data related to medical liability premiums, prevalence of midwifery and obstetric care, reproductive education, and demographic characteristics for births, by county, within the United States for the year 2012. This research included data from multiple sources. Not all sources are updated annually. For example, United States Census data were available for 2010, and the most recent data file from the Department of Agriculture was from 2013. Therefore, 2012 was determined to be the best year for representative data sets. The final model includes data from the CDC, the United States Census Bureau, MANA, the American College of Nurse-Midwives (ACNM), reproductive health education data from the Guttmacher Institute, and medical liability insurance premium data from Medical Liability Monitor (MLM). Census data are available for counties with at least 10,000 births in the given year. For this research, 511 counties within the United States were included. Below is additional information on specific data sources considered for the final model.

Birth Data from the Centers for Disease Control and Prevention. The National Vital Statistics System (NVSS) is the system by which the NCHS collects and publicly disseminates national vital statistics. State laws require that birth certificates are completed for all births. Aggregated county-level data were retrieved via the NVSS for 2012 births. Data from the CDC NVSS include the

total number of cesarean-section deliveries by county, birth order, maternal age, percent of births by gestational age segments, and percent of births attended by attending medical specialist.

Demographic data from the United States Census Bureau. The United States Census Bureau provides information on population, housing, economic, and geographic information for communities within the United States. Information was obtained through the United States Census American FactFinder (U.S. Department of Commerce, 2010).

Rural-Urban Continuum Codes from the United States Department of Agriculture Economic Research Service. Rural-Urban Continuum Codes distinguish metropolitan counties by the population size of their metro area and nonmetropolitan counties by the degree of urbanization and adjacency to metro areas (USDA Economic Research Service, 2013). Codes are available for 2003 and 2013. For this research, 2013 classification was used.

Medical liability insurance premium data from Medical Liability Monitor. MLM collects and publishes news about medical malpractice (MLM, 2012). The MLM's *Annual Rate Survey* provides information on nationwide trends in physician malpractice costs along with state-by-state and county-level professional liability rates for major malpractice carriers. Rates are available for internal medicine and OB/GYN specialties.

Reproductive education data from the Guttmacher Institute. The Guttmacher Institute is a nonprofit organization dedicated to research and public education to advance sexual and reproductive health. Data on reproductive education in public school were collected from the "State Policies in Brief – Sex and HIV Education" (Guttmacher Institute, 2012).

Midwifery data from the American College of Nurse-Midwives and the Midwives Alliance of North America. ACNM is a professional association dedicated to advancing midwifery care in

the United States (ACNM, 2013). The ACNM reviews research and publishes information studies on the support for midwifery care across the United States. ACNM published information on the amount of fee-for-service reimbursement for certified midwives and nurse-midwives under state Medicaid programs relative to physician reimbursement rates (2013). This research identified states where the reimbursement rates for midwives were 100% or 90%-99% relative to physician reimbursement rates. Information on midwifery laws for each state was obtained through the Midwives Alliance of North America (MANA, 2012). For this analysis, counties are identified as having midwifery licensing if located within a state that regulates and provides licensure for midwifery care.

Demographic data from the U.S. Department of Health and Human Services. The U.S. Department of Health and Human Services makes available Area Health Resource Files (AHRF) data downloads from data provided by the Bureau of Health Professionals (U.S. Department of Health & Human Services, 2014). The data files contain information on the number of health professionals, health facilities, utilization rates, expenditures, population estimates, and environment information for states and counties within the United States.

Variables for model consideration.

Once all variables were obtained, they were grouped per facets outlined in the hypothetical model. Maternal and infant health risks include maternal age, infant gestation, and percent of county female population identified as diabetic (see Table 3).

Table 3: Variable List - Maternal and Infant Risk Factors

Variable Name	Variable Description	Data Source
RF: Maternal Age 40plus	Percent of births to mothers aged 40 or more	CDC NVSS

RF: Gestation Under 37wks	Percent of births with gestational age of less than 37wks	CDC NVSS
RF: Health Female Diabetic	Percent of women in county that are diabetic.	Census Fact Finder

Medical liability rates were grouped together. Premium rates for internal medicine and OB/GYN specialties were considered (see Table 4).

Table 4: Variable List – Medical Liability Rates

Variable Name	Variable Description	Data Source
ML: Internal	Medical Liability Premiums for Internal Practice	Medical Liability Monitor
ML: OB GYN	Medical Liability Premiums for OB/GYN Practice	Medical Liability Monitor

Five variables from the Guttmacher Institute are included for variable consideration. These variables represent education at the junior high or high school level (see Table 5).

Table 5: Variable List – Reproductive Education

Variable Name	Variable Description	Data Source
RE: Medically Accurate	When provided, sex or HIV education must be medically accurate (y=1).	Guttmacher Institute
RE: Sex in marriage	When provided, sex education must include information on the importance of sex only within marriage.	Guttmacher Institute
RE: Life Skills Healthy Decision Making	When provided, sex education must include life skills for healthy decision-making.	Guttmacher Institute
RE: Contraceptive Education	State has policy for providing contraceptive education to public high school students as part of health education courses.	Guttmacher Institute
RE: Communication	When provided, sex education must include life skills for family communication.	Guttmacher Institute

Variables related to support for midwifery care are obtained from MANA along with birth data from the CDC (see Table 6). Percent of births attended by a midwife was calculated by dividing the number of births attended by a midwife or certified nurse midwife by the number of records where the attending provider was recorded for first-born singleton births.

Table 6: Variable List – Midwifery Care

Variable Name	Variable Description	Data Source
MW: Medicaid 100	Medicaid covers midwifery care at a rate equal to physicians.	American College of Nurse Midwives

ME: Medicaid 90-100	The Medicaid reimbursement rate for midwives was 90% or greater.	American College of Nurse Midwives
MW: Medicaid 80-89%	The Medicaid reimbursement rate for midwives was between 80% and 89%.	American College of Nurse Midwives
MW: Medicaid 70-79%	The Medicaid reimbursement rate for midwives was between 70% and 79%.	American College of Nurse Midwives
MW: CNM License	Midwifery Licensure is available within the state.	Midwives Alliance of North America
MW: Attending	Percent of births attended by a midwife	CDC NVSS

Broader structural forces include the prevalence of obstetricians within the county, socio-economic indicators, income inequality, and census region (see Table 7). Census region was included for consideration to account for regional differences in attitudes toward cesarean section births. To bifurcate the data, the Midwest and West were combined as having the lowest rates, leaving the South and Northeast in the remaining category.

Table 7: Variable List – Broader Structural Forces

Variable Name	Variable Description	Data Source
SF: Deep Poverty	Percent of county living in deep poverty	DHHS Area Health Resource Files
SF: Poverty	Percent of population that lives in poverty	DHHS Area Health Resource Files
SF: OB per 100 births	Calculated number of registered obstetricians per 100 births	DHHS Area Health Resource Files
SF: Region MW	County is within the Midwest Census Region	DHHS Area Health Resource Files
SF: Region NE	County is within Northeast Census Region	DHHS Area Health Resource Files
SF: Region S	County is within the South Census Region	DHHS Area Health Resource Files
SF: Region W	County is within the West Census Region	DHHS Area Health Resource Files
SF: Region W or MW	County is within the West or Midwest Census Region	DHHS Area Health Resource Files
SF: Female No Insurance	Percent of adult female population without insurance	Census Fact Finder
SF: Female Pop	County population of adult females	Census Fact Finder
SF: GINI	GINI estimate for county.	Census Fact Finder
SF: Health Disability	Percent of adults with a disability	Census Fact Finder
SF: Per Capita Income	County income per capita in 2012.	Census Fact Finder
SF: Urban Rural 1	County is in a metro area with a population of 1 million or more	ERS 2013

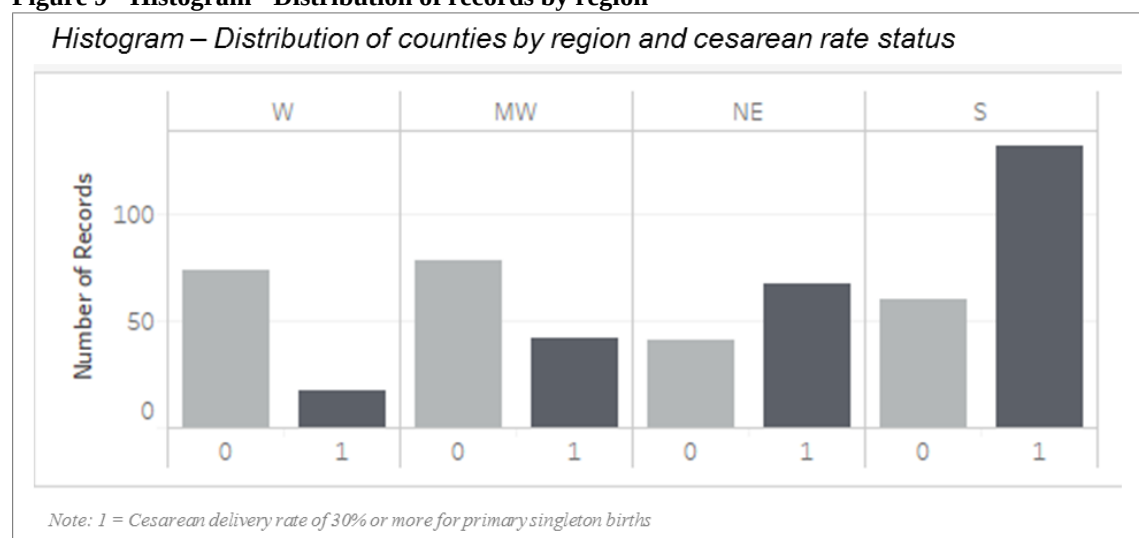
SF: Urban Rural 2	County is in metro area of a population of 250,000 to 1 million	ERS 2013
SF: Urban Rural 3	County is in a metro area with a population fewer than 250,000	ERS 2013
SF: Urban Rural 4	Urban population with a population of 20,000 or more, adjacent to a metro area	ERS 2013
SF: Urban Rural 5	Urban population with a population of 20,000 or more, not adjacent to a metro area	ERS 2013

Research Methods

The cesarean-section rate in the United States in 2012 was 32.8% for all births and 30.8% for primary singleton births. The goal of this research was to develop a predictive model to identify counties with a cesarean-section delivery rate above 30% for first born singleton births.

The final list of collected data included 511 counties. CDC county birth data is only available for counties with a population of at least 100,000 people. Birth data from the CDC contained information for 524 counties. Thirteen counties were omitted due to inability to match CDC data with ERS and/or DHHS sources. Each observation in the data set was randomly assigned to a training/sample or test/out-of-sample set. Three hundred thirty seven observations were included in the training/sample set, and 174 observations were included in the test/out-of-sample set. Exploratory data analysis uncovered a noticeable difference between regions (see Figure 9).

Figure 9 - Histogram - Distribution of records by region



To ensure that the test and sample sets were representative of the entire data set, the records were split based on region, then random sampling was applied within census region subsets (see Figure 10).

Odds ratios were calculated for each discrete variable against the dependent variable of First Born Singleton Cesarean Rate > 30%. As recommended by Hosmer and Lemeshow (2000), any variable whose univariate test has a p-value of < 0.25 was a candidate for the multivariable model.

Variables were evaluated within their respective model group of Maternal and Infant Risk Factors, Medical Liability, Reproductive Education, Support for Midwifery Care, and Broader Structural Forces. Variables were then ranked based on performance within the respective category. Top-performing variables were included in final model consideration.

The final multivariable logistic model was created using the “glm” function in the stats package in R. Final variable selection was based on Variation Inflation Factors (seeking VIF scores of less than 2 for all variables), a low Akaike information criterion (AIC) score, and out-of-sample model performance.

Chapter Four: Results

The tables below list the variables that were considered for the final model based on a univariate test with a p-value of <0.25.

Univariate Logistic Results and Variable Selection

Maternal and Infant Risk Factors. High maternal age, low gestational age, and high rates of female diabetes at the county level have higher odds of a county cesarean section rate of 30% or greater for first born singleton births (see Table 9).

Table 9: Univariate Results – Maternal and Infant Risk Factors

Variable Name	Variable Description – Yes=1	n (of sample)	OR	p-value
RF: Maternal Age 40plus - high	Discretized - % of births to mothers age 40 and greater was higher than 1.1%	178	2.28	0.000
RF: Gestation Under 37wks	Discretized - % of births with gestational age of less than 37wks was greater than 10.1%	103	2.73	0.000
RF: Health Female Diabetic	Discretized - % of women in county that are diabetic was greater than 7.1%	264	2.77	0.000

Medical Liability. High rates of medical liability premiums for internal and OB/GYN specialists at the county level have higher odds of a county cesarean section rate of 30% or greater for first born singleton births (see Table 10).

Table 10: Univariate Results – Medical Liability

Variable Name	Variable Description – Yes=1	n (of sample)	OR	p-value
ML: Internal Rates- High	Discretized - Medical Liability Premiums for Internal Practice greater than \$15,759	119	4.19	0.000
ML: OB GYN Rates High	Discretized – Medical Liability Premiums for OB/GYN practice was greater than \$69,450	130	3.35	0.000

Reproductive Education. Counties with reproductive education standards that include life skills for family communication, require that the education is medically accurate, and/or include skills for healthy decision making, are less likely to have a primary singleton cesarean delivery rate of greater than 30%. Counties with reproductive education focusing on abstinence have a greater likelihood of having a cesarean delivery rate greater than 30% for primary singleton births. Contraceptive education was not significant in the univariate analysis but was considered for the multivariable analysis (see Table 11).

Table 11: Univariate Results – Reproductive Education

Variable Name	Variable Description – Yes=1	n (of sample)	OR	p-value
RE: family communication	When provided, sex education must include life skills for family communication.	91	0.275	0.000
RE: Abstinence	When provided, sex education must include information on the importance of sex only within marriage.	176	2.172	0.000
RE: Medically Accurate	When provided, sex or HIV education must be medically accurate (y=1).	113	0.42	0.003
RE: Life Skills Healthy Decision Making	When provided, sex education must include life skills for healthy decision-making.	152	0.498	0.002
RE: Contraceptive Education	State has policy for providing contraceptive education to public high school students as part of health education courses.	131	0.762	0.226

Midwifery Support. Counties where midwives attend more than 7.3% of births or where Medicaid reimbursement rate is at least 90% of physician reimbursements, are less likely to have a primary singleton cesarean delivery rate of greater than 30%. Where Medicaid coverage is not extended to midwives on par with physicians, the odds are greater that the county will have a primary singleton cesarean rate of 30% or greater (see Table 11).

Table 12: Univariate Results – Midwifery Care

Variable Name	Variable Description – Yes=1	n (of sample)	OR	p-value
MW: Attending	Discretized - Percent of births attended by a midwife was greater than 7.1%	158	0.407	0.000
ME: Medicaid 90-100	The Medicaid reimbursement rate for midwives was 90% or greater.	239	0.341	0.000
MW: Medicaid 100	Medicaid covers midwifery at a rate equal to physicians.	176	0.464	0.001
MW: Medicaid 80-89%	The Medicaid reimbursement rate for midwives was between 80% and 89%.	68	2.236	0.005
MW: Medicaid 70-79%	The Medicaid reimbursement rate for midwives was between 70% and 79%.	30	3.307	0.008

Broader Structural Forces. Counties located in the West or Midwest have greater odds of high cesarean rates than counties in the South or Northeast. Large metropolitan areas with a high population of adult women have higher odds of high cesarean rates than less populated metro areas. High degree of income inequality, as measured by the county's GINI score, has higher odds of high cesarean rates than counties with lower inequality (see Table 13).

Table 13: Univariate Results – Broader Structural Forces

Variable Name	Variable Description – Yes=1	n (of sample)	OR	p-value
SF: Region W or MW	County is within the West or Midwest Census Region	139	0.232	0.000
SF: Region W	County is within the West Census Region	60	0.193	0.000
SF: Region S	County is within the South Census Region	127	2.957	0.000
SF: Region MW	County is within the Midwest Census Region	79	0.503	0.009
SF: Region NE	County is within Northeast Census Region	71	1.784	0.350
SF: Urban Rural 1	County is in a metro area with a population of 1 million or more	145	2.473	0.000
SF: Urban Rural 2	County is in metro area of a population of 250,000 to 1 million	103	0.723	0.171
SF: Urban Rural 3	County is in a metro area with a population fewer than 250,000	81	0.414	0.001
SF: Female Pop High	Discretized - County population of adult females greater than 115,785	149	2.21	0.000
SF: GINI - high	Discretized - GINI estimate for county greater than 0.4864	49	2.93	0.002
SF: Per Capita Income High	Discretized - County income per capita in 2012 greater than \$40,894	168	1.48	0.072
SF: Poverty High	Discretized - Percent of population that lives in poverty greater than 6.1%	167	0.71	0.116

Multiple regression model. The final model identifies seven variables that accurately predicted 72% of out-of-sample observations. Results from the multiple logistic regression model are outlined in Table 14.

Table 14: Results: Multivariable Logistic Model

Variable Name	Variable Description	estimate	SE	Pr(> z)		OR	95% CI(OR)
(Intercept)	(Intercept)	-0.1061	0.4545	0.81542		0.90	0.37 - 2.19
RF: Gestation Under 37wks	Discretized - % of births with gestational age of less than 37wks was greater than 10.0%	0.9388	0.3174	0.00310		2.56	1.38 - 4.82
RF: Maternal Age 40plus	Discretized - % of births to mothers age 40 and greater was higher than 1.1%	0.8056	0.3005	0.00734	**	2.24	1.25 - 4.07
ML: Internal Rates- High	Discretized - Medical Liability Premiums for Internal Practice greater than \$15,759	0.9339	0.2898	0.00127	**	2.54	1.45 - 4.52
MW: Attending	Discretized - Percent of births attended by a midwife was greater than 7.1%	-0.7707	0.2688	0.00414	**	0.46	0.27 - 0.78
ME: Medicaid 90-100	The Medicaid reimbursement rate for midwives was 90% or greater.	-0.7833	0.3101	0.01155	**	0.46	0.25 - 0.84
RE: Abstinence	When provided, sex education must include information on the importance of sex only within marriage.	0.6726	0.2912	0.02092	*	1.96	1.11 - 3.49
SF: Region W or MW	County is within the West or Midwest Census Region	-0.8536	0.2779	0.00213	*	0.43	0.25 - 0.73
SF: Urban Rural 1	County is in a metro area with a population of 1 million or more	0.609	0.312	0.05097	**	1.84	1.00 - 3.41
SF: Urban Rural 3	County is in a metro area with a population fewer than 250,000	-0.5006	0.3527	0.15586	.	0.61	0.30 - 1.20

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
(Dispersion parameter for binomial family taken to be 1)

Null deviance: 466.51 on 336 degrees of freedom
Residual deviance: 351.39 on 327 degrees of freedom

AIC: 371.39
GLM, Family=binomial
n=337
in sample accuracy: 0.748
test accuracy: 0.724
final accuracy: 0.740

The confusion matrix shows the model's slight tendency to identify counties as having a cesarean rate below 30% for singleton primary births. The confusion matrices in Table 15, Table 16, and Table 17 demonstrate that the model is more likely to classify counties as having a cesarean delivery rate of less than 30% for primary singleton births. Nonetheless, the model could identify counties with high cesarean rates, above 30%, for about 65% of the high cesarean rate counties.

Table 15 : Multivariable Model Confusion Matrix - in Sample

Confusion Matrix – Sample n=337	Actual: No	Actual: Yes
Predicted: No	136 (84%)	60
Predicted: Yes	25	116 (66%)

Table 16 : Multivariable Model Confusion Matrix – out of Sample

Confusion Matrix – Test n=174	Actual: No	Actual: Yes
Predicted: No	74 (80%)	30
Predicted: Yes	18	52 (63%)

Table 17 : Multivariable Model Confusion Matrix – Full Data Set

Confusion Matrix – n=511	Actual: No	Actual: Yes
Predicted: No	210 (83%)	90
Predicted: Yes	43	168 (65%)

Chapter Five: Conclusion and Discussion

Conclusion

This research presents a model for understanding the variation in cesarean section rates across the United States, for primary singleton births, at the county level. This study shows that medical liability premiums, reproductive education, midwifery care, along with socioeconomic and demographic factors, work in concert to influence the mode of delivery for nulliparous births in the United States. This research supports previous work identifying midwifery care and medical liability as influencers on cesarean section rates in the United States. The additional consideration of reproductive education, or lack thereof, along with a county level analysis, supports the hypothetical model that a maternal fear of childbirth combined with a fear of medical liability is contributing to high cesarean section rate for nulliparous births in the United States.

Since most low-risk mothers prefer to deliver vaginally, more research should be dedicated to understanding the gap between the desired and actual modes of delivery in the United States. Fear of litigation and fear of childbirth are subjects that require more research. Aggregate level data are not currently available for a woman's intended mode of delivery, feelings about childbirth prior to labor, and the risk status of the infant or mother pre-labor. Having such data sets would allow for further research on the impact of fear on mode of delivery.

Discussion

The desire to mitigate risk at the individual level has resulted in a more medicalized system which presents macro-level evidence of has increased risk. Women who fear childbirth tend to give up control to medical providers who in turn, out of fear of malpractice suits, give up control to a risk-evaluated playbook. Mothers who desire continuous care under the obstetric model may be more likely to schedule a cesarean as a way of ensuring continuous care and as a means of

avoiding the probability of having such an intimate event attended by an unknown medical provider.

To turn the trend, a greater focus on reproductive education, medical malpractice training, and pregnancy support is needed. It is time to improve the system of reproductive education by ensuring that all citizens have access to information that is medically accurate, encourages open and honest community communication, and minimizes distorted and missing information often associated with abstinence education.

Low-risk women should be encouraged to participate in a pregnancy health programs that follow the midwifery model of care. Educating the mother about the birth process, with the goal of reducing fear and encouraging the mother to take an active role in her pregnancy and labor, can reduce the number of unnecessary cesarean deliveries.

In today's medical landscape, medical practitioners need improved training on how to work through a malpractice lawsuit so that the experience of a suit does not cause undue fear on the practitioner. Improved societal, maternal, and practitioner may improve the system, allowing expectant mothers to achieve the higher rate of vaginal deliveries that they desire.

Dedicating resources toward reproductive education may have an impact on lowering rates of cesarean section deliveries. It is apparent from these results that encouraging an environment of open communication regarding reproductive health and childbirth, through public education and continuous supportive pregnancy care, has implications for reducing unnecessary costly delivery outcomes.

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