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Risk Factors for Cesarean Section in a Predominantly Cherokee Population in Rural Oklahoma

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Risk Factor for Cesarean Section
in a Predominantly Cherokee Population
in Rural Oklahoma

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An Abstract of
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Abstract

Risk Factors for Cesarean Section
In a Predominantly Cherokee Population
In Rural Oklahoma

BY
David Gahn

Objective: With evidence to indicate that the American Indian population is not a homogenous group, the objective of this study is to identify and describe the prevalence of risk factors for cesarean section among a predominantly Cherokee population in order to decrease the cesarean section rate.

Methods: The study is a retrospective review of 809 consecutive deliveries in 2011 at Cherokee Nation Hastings Hospital in northeastern Oklahoma. Data were analyzed to describe the incidence of cesarean section, diabetes, hypertension, body mass index at delivery, pre-pregnancy body mass index, induction of labor, and ethnicity. Odds ratios were calculated for cesarean section and birth weight greater than 4000 grams using diabetes, hypertension, Cherokee descent, obesity at delivery, morbid obesity at delivery, induction, and gestational age.

Results: The results showed comparable rates of diabetes and obesity in relation to population data on American Indians. Rates of induction of labor and cesarean section were higher than the national average. The strongest predictors for cesarean section were morbid obesity at delivery, hypertension and obesity at delivery. The strongest predictors for birth weight greater than 4000 grams were gestational age of 40+ weeks, diabetes, and morbid obesity at delivery.

Conclusion: Maternal characteristics do not distinguish this patient population served by Hastings Hospital from population data on US American Indians. Decreasing the cesarean section rate will require a combined approach of sustained public health measures to address pre-conception health and clinical interventions during prenatal care.

Risk Factors for Cesarean Section in a Predominantly Cherokee Population in Rural Oklahoma

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A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health in Healthcare Outcomes
2012

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Contents

Abbreviations

ACOG	American Congress of Obstetricians and Gynecologists
BMI	Body mass index
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
CNHH	Cherokee Nation Hastings Hospital
IHS	Indian Health Service
L&D	Labor and Delivery
OR	Odds ratio
RPMS	Resource and Patient Management System
TOLAC	Trial of labor after cesarean section
VBAC	Vaginal birth after cesarean section

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Risk Factors for Cesarean Section in a Predominantly Cherokee Population in Rural Oklahoma

Introduction

Cesarean section rates in the US reached 32.9% in 2009, the 13th consecutive year of increasing rates and this increase continues to defy explanation at the population level.[1,2] At Cherokee Nation Hastings Hospital (CNHH) in Tahlequah, OK, unpublished performance improvement data show that the cesarean section rate for the American Indian population served is higher than the national average. (Figure 1) Despite the clinical monitoring practices at CNHH, the dramatic change in the cesarean section rate from 2009 to 2010 is unexplained.

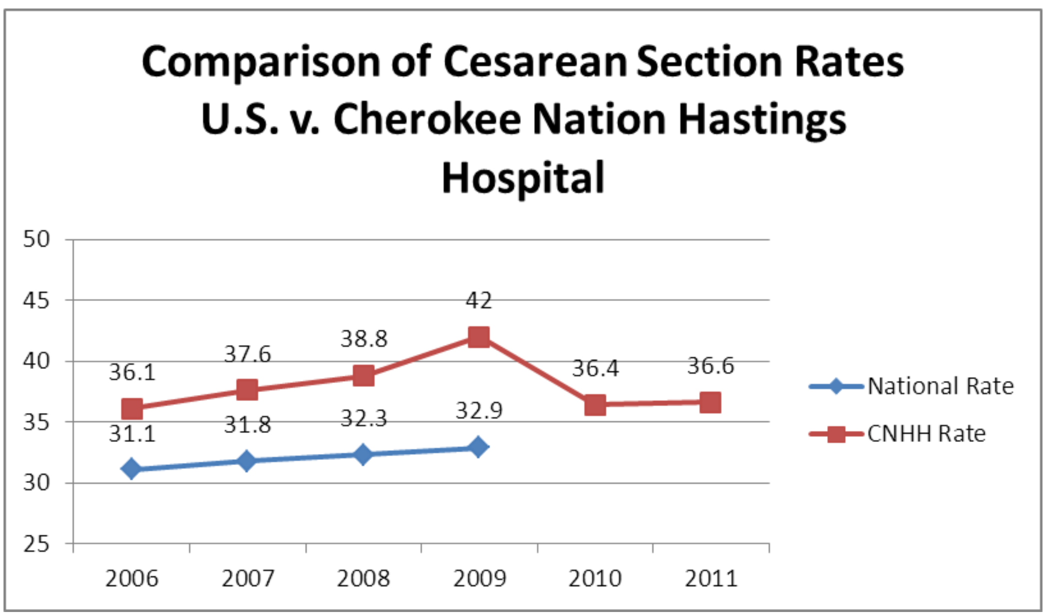

Figure 1: Cesarean section rates 2006-2011 at Cherokee Nation Hastings Hospital and the US

Pregnancy and childbirth are obviously a natural process and not a disease state, however appropriate interventions based on medical evidence can greatly reduce maternal and newborn morbidity and mortality. Cesarean section is a life-saving intervention in many instances but it is not without risks. The American Congress of Obstetricians and Gynecologists Task Force on Cesarean Section Rates published a report in 2000 which outlined distinctly the risks of cesarean section. Intra-operative and post-operative complications include maternal hemorrhage, uterine rupture, placenta accreta, injuries to the gastrointestinal and urinary tracts, and infection. Additionally, having a cesarean section results in increased risks of these complications in future pregnancies as well. Maternal mortality is 3-7 times greater in cesarean section cases than with vaginal delivery, although some of this increased risk is a result of selection bias in the indication for cesarean section and not a result of the procedure itself.[3]

Risk factors for cesarean section have been studied extensively, but there are little data concerning American Indians and no published data on Cherokees. Additionally, Alexander, et al. demonstrated that American Indians are not a homogenous group, but display regional variations in health epidemiology.[4] Cherokee Nation struggles with this issue both in clinical services as well as in the numerous public health programs with the concern that evidence-based interventions described in other populations may not benefit this culturally and genetically unique population.

Understanding that "American Indian data" may not apply to women in the Cherokee Nation, this study aims to identify and describe the prevalence of risk factors for cesarean section among the predominantly Cherokee population in northeastern Oklahoma that is served by Cherokee Nation Health Services at the tribally-operated community hospital CNHH, with the particular emphasis on modifiable risk factors of the mother that can be altered through either clinical or public health measures with the overall goal of safely decreasing the cesarean section rate.

Contextual Considerations

CNHH is a 60 bed community hospital that operates in Tahlequah, OK, a small community of approximately 14,000 people, but has a service population covering several counties. For obstetrics, health care beneficiaries include any woman of American Indian decent (as evidenced by a Certificate of Degree of Indian Blood), or non-American Indian women who are pregnant by an American Indian man. CNHH, as a community hospital, if possible avoids delivering women whose gestation is not beyond 36 weeks as it does not have the capacity to care for premature infants for extended periods. Women presenting to the hospital who are less than 36 weeks gestation and require delivery are usually transferred to a tertiary care center in Tulsa which is about 60 miles from Tahlequah. Obstetric staff during the study period included 5 permanent board-certified Ob/Gyn physicians, 7 certified nurse midwives, 2 Nurse Practitioners, and a skilled team of obstetric nurses. Annual delivery numbers range from 800 to nearly 1,000 babies most of which are >36 weeks, alive, and in the appropriate presentation (head down) for a normal vaginal delivery. Of note, CNHH does not offer a trial of labor after cesarean section (TOLAC), also referred to as vaginal birth after cesarean (VBAC), which is a significant contributor to the cesarean section rate.

Literature Review

In the face of steadily rising cesarean section rates, the published literature contains many studies on risk factors for cesarean sections in various populations. The factors most studied include obesity, induction of labor, diabetes, and physician factors. The studies cover various populations world-wide, and there is a small body of literature on American Indians which will be reviewed.

Obesity

In published the literature regarding maternal obesity and outcomes, authors focused on three areas: pre-pregnancy body mass index (BMI), maternal weight gain or BMI at delivery, and maternal birth weight. In a study of approximately 1,800 women, Addo showed that women deemed to be obese (BMI > 30) at delivery were at an increased risk of cesarean section as well as requiring induction of labor.[5] Likewise, Dennedy, et al. prospectively studied several thousand Irish pregnant women and arrived at the same conclusion.[6] Marshall, et al. studied 64,000 births looking at maternal superobesity (BMI >50) as well as other categories of obesity and again documented an increased risk for cesarean section. Women suffering from superobesity incurred an alarming cesarean section rate of 50%.[7] Also of note, Gilead, et al. in a study of over 173,000 deliveries did not find an increase in perinatal complications from cesarean section in women with isolated obesity (women with no other high-risk diagnoses) versus non-obese patients.[8]

In the area of maternal weight gain and BMI during pregnancy, most authors, using the Institute of Medicine (IOM) guidelines on recommended weight gain during pregnancy, showed poorer outcomes with poor weight gain and weight gain in excess. Durie, et al. as well as Gawade showed that weight gain during pregnancy and maternal obesity were independently associated with an increased risk of cesarean section.[9,10] Alternatively, Jang et al. showed that failure to meet the IOM guidelines did not predict cesarean section, but that an increased pre-pregnancy BMI or weight gain in excess of 18 kilograms were associated with increased cesarean section risk.[11] Takimoto came to the same conclusion in his study of 1,600 women in Taiwan.[12] In a unique study, Yazdani, et al. measured the BMI of 1,000 women in the first trimester of gestation. They found that a BMI above 25 (overweight and above) increased the risk of cesarean section.[13] Shy, et al. took a singular approach of attempting to predict cesarean section using the mother's birth weight.[14] These investigators found that maternal birth weights of less than 2500 grams or greater than 4000 grams increased her risk of cesarean section. It is important to mention as well that these studies showed that maternal obesity and weight gain also increased the risks of diabetes, hypertension, induction of labor, and a multitude of adverse fetal malformations and macrosomia.

Induction of Labor

Induction of labor generally occurs when the health care team determines that ending the pregnancy before the natural onset of labor will benefit the mother, baby, or both. This is termed either a medical induction or an indicated induction. In the 1990's there was a significant increase in non-medically indicated induction of labor before 39 weeks of gestation usually done for the convenience of the woman and her family and at times for the convenience of the physician. While non-medically indicated rates of induction are falling[2], the cause for the overall increase in labor inductions has not been determined.[15] Much research has been done to study the impact of induction rates on cesarean section rates.

A common indication for induction is termed "post-dates" induction. This usually occurs after 41 weeks of gestation although there is some question as to whether inducing labor nearer the due date at 40 weeks is more beneficial. The definition of "post-dates" varies in studies, ranging from any woman beyond 40 weeks gestation to only women beyond 42 weeks gestation. Alexander, et al. looked at the risk of cesarean section in 1,325 women induced at 42 weeks and found a significantly increased risk of cesarean section.[16] Bodner-Adler et al. studied the same issue, but used 41 weeks and 3 days of gestation as the definition of post-dates. They found that while there was an increased risk of cesarean section, the woman's Bishop score was a significant predictor.[17] Bishop score is a 10 point scale derived from the examination of a woman's cervix and was developed to determine a woman's likelihood of a successful induction of labor and her risk of cesarean section. Caughey, et al. performed an extensive review of the literature and determined that waiting beyond 41 weeks gestation to induce labor did not increase the risk of cesarean section, but could not demonstrate a clear benefit of inducing labor earlier than 41 weeks.[18] Sue, et al. similarly reviewed the literature to examine post-dates induction of labor versus medical induction and found no significant increase in cesarean section rates between those induced at 41 and 42 weeks of gestation.[19] In a study of 5,600 women, Schuitt, et al. developed a prediction model for determining the risk of cesarean section and determined that induction of labor (all indications) was a significant independent predictor of cesarean section in addition to many other maternal and fetal characteristics.[20] Yeast, et al. specifically studied the issue of early elective inductions. They studied 18,000 pregnancies at a single community hospital. As the induction rate increased from 32% to 43% over 8 years, the researchers found no change in cesarean section rates.[21] Seyb, et al. compared elective versus medical induction in

1,561 women and found an increase in the cesarean section rate in women undergoing elective induction.[22]

With the issue of induction still rather unclear, many researchers sought to determine if one method of induction may be superior to another. The most common methods of induction include amniotomy (artificially rupturing the fetal membranes), intravenous oxytocin, and various forms of vaginal prostaglandin preparations. The method of induction is dependent more on the clinical experience of the provider and the woman's Bishop score because the clinical evidence, while demonstrating safety, does not clearly support one method over another. Gagnon-Gervais, et al. in a small study of 143 women looked at amniotomy early in the course of induction versus late amniotomy and found no difference in cesarean section rates.[23] Conversely, Lee, et al. studied 500 women with term singleton pregnancies and found that early amniotomy (amniotomy occurring when the cervix was dilated to less than 4 centimeters) increased the cesarean section rate to 24 % compared to 10% in women with late amniotomy.[24] Nicholson et al. developed a risk-based protocol for providers to determine the need for induction and in a study of 2,000 women was able to demonstrate a decrease in the cesarean section rate from 11.8% to 5.3% between those women under the protocol and those not subject to the guidelines.[25]

Diabetes

Diabetes affects 2% to 5% of pregnancies in the US general population with American Indians noted to be at increased risk.[26] Diabetes is classified in pregnant women as pre-existing diabetes if the disease was present before pregnancy, or as gestational diabetes if it develops during pregnancy. Because obesity is associated with diabetes, the studies mentioned above studied diabetes as an independent predictor for cesarean section and found a consistent positive association. Two additional recent studies focused on diabetes in pregnant women. Gorgal, et al studied 880 women (220 with diabetes) who reported to labor and delivery at term in labor with spontaneous rupture of membranes. Those women with diabetes had a risk ratio for cesarean section of 1.52 compared to women without diabetes.[27] Watabi, et al. studied 3,157 women with pre-existing diabetes and compared them to women without diabetes. He reported an odds ratio for cesarean section of 2.67 for women with pre-existing diabetes.[28]

Provider Factors

The evidence in regards to provider factors does not reveal significant insight into additional risk factors for cesarean section as the study designs often lead to incomplete understanding. For example, Luthy, et al. conducted two observational studies that included 13,000 women and concluded that risk for induction and cesarean section varies between physicians, and that physician-managed labor increased the risk of cesarean section.[29,30] At most, this study brings to light the lack of clear clinical guidelines on induction and cesarean section as clinical scenarios are varied and treatment requires a subjective interpretation of a patient's condition. At a community hospital, Poma discovered that physicians with lower cesarean section rates were more likely to offer their patients a trial of labor after cesarean section as well as more likely to perform an operative vaginal delivery (both vacuum delivery and forceps delivery).[31] In more of a social science context, Sakala interviewed midwives that provided in-hospital and out of hospital labor services and found that midwives feel that physicians are often confronted with clinical data that lead to "pseudo-problems" and an increase in cesarean sections.

Data on American Indians

Four studies on American Indian women regarding risks for cesarean section were reviewed. It has been well documented that American Indians as an ethnic group have lower rates of cesarean section than other groups. Schiff and Rogers reviewed birth certificate data documenting the birth events of American Indians in New Mexico in 1994 and documented that although these women had higher rates of known medical risk factors for cesarean section, the rate of cesarean section was well below the national average.[32] Likewise, Mahoney and Malcoe documented the same evidence in American Indian women delivering in an Indian Health Service hospital in New Mexico via a case-control design and hospital chart reviews.[33] Both groups posited that there may be something unique about Indian Health Service practice patterns that contributed to the low cesarean section rate. This model, which has been in use at CNHH for more than a decade, includes management of women in labor by certified nurse midwives, with the physician supervising the care and otherwise being consulted as needed. The theory put forth by Schiff and Mahoney, however, lacks evidence to support this theory.[34] Leeman and Leeman studied 1,132 American Indians in New Mexico with a 7% cesarean section rate. This population-based historical cohort study revealed that there was a decrease in the indication for cesarean section of labor dystocia, and also that women with diabetes and preeclampsia as individual cohorts had lower risks for cesarean section than national averages. This leads to the possibility that this American Indian population in New Mexico has a unique characteristic or characteristics which enhances the women's ability to safely deliver more babies normally. They also noted that in this population, trial of labor after cesarean was universally accepted by both the culture and the health care institution resulting in a 93% rate of TOLAC.

Alexander, et al. in a nation-wide study of births using birth certificate data from the National Center for Health Statistics, documented much of what is noted above, but were to first to note regional variations in sudden infant death syndrome. This led the authors to postulate that American Indians and Alaska Natives are not a homogenous ethnic group.[4]

Summary and Conclusions of the Literature.

The first section of the literature review reveals the clinical evidence supporting several risk factors for cesarean section. These risk factors include maternal obesity, induction of labor, diabetes, and other medical diagnoses. Most of the studies are observational and retrospective. Ethical considerations in the study of a vulnerable population often require researchers to use this study design in obstetrics. The data on American Indians reveal that most of the studies have been conducted in New Mexico, but they very well documented that in this cohort of women, the decrease in cesarean section rates remains largely unexplained.

Cherokee Nation Hastings Hospital has a cesarean section rate higher than the national average which is in sharp contrast to the evidence provided above regarding American Indians. This study aims to both document the prevalence of known risk factors in this genetically and culturally distinct population, and determine if these are important risk factors for cesarean section.

Design and Methodology

This study is a retrospective cohort study of women delivering at Cherokee Nation Hastings Hospital in calendar year 2011. After a review of the literature, the conceptual model below was developed (Figure 2). This depicts the several influences and timing of factors that affect the outcome of mode of delivery (vaginal delivery versus cesarean section). During the pre-conception period, a woman's overall health is impacted by her environment, chronic diseases, and socio-economic status. At this time in a woman's life, public health measures would have the biggest impact on outcomes, although pre-conception counseling from a trained provider also has the potential for positive influence. During the antepartum (prenatal) period, a woman's interaction with the health care system is crucial to a health mom and baby. Access to care, quality of care, availability of education and support, and control of chronic diseases all impact outcomes and these factors are often out of the patient's control. During the time of labor and delivery, hospital management guidelines, staffing practices, care models, and quality of care have immediate impact of the ultimate outcome.

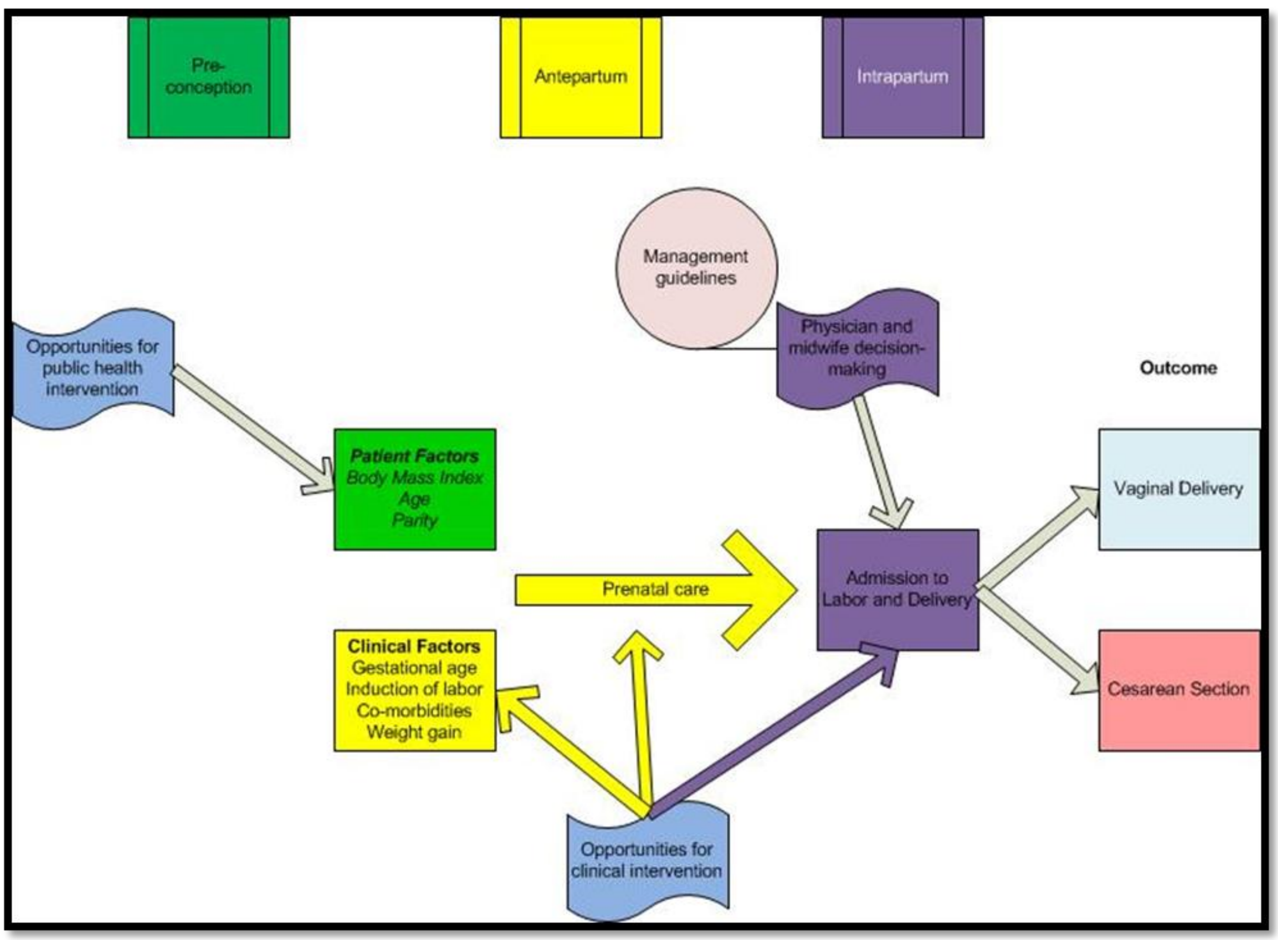

Figure 2: Conceptual model of the study

Women included in the study were all women who presented to labor and delivery at greater than 36 weeks gestation with living, singleton pregnancies. This cohort was studied to determine the presence of risk factors reviewed in the literature. Since CNHH does not offer a trial of labor after cesarean section, women with previous cesarean sections were excluded from the second cohort, as well as women with babies not in cephalic presentation (malpresentation) as current practice guidelines and clinical evidence suggest that cesarean section is the safest route for delivery. The outcome variable was cesarean section. Data on several predictor variables were collected from various sources which are further discussed in the next section. Variable selection was determined by the review of the literature as well as the availability, accuracy, and reliability of the data. From these variables, BMI was calculated, and this and other variables were further categorized for regression analysis.

The strength of this model is that it captures several hundred consecutive deliveries of a distinct population, and the data on this cohort is readily available. This design allows for a detailed analysis of the prevalence of suspected risk factors and calculation of odds ratios for an easily defined outcome. Also, the timeliness of the data for the study gives the results increased credibility and acceptability to the stakeholders in the study, namely the providers and the patients.

The primary weakness of this design is that the original recording of data in the various sources is not as dependable in a retrospective design as with a prospective study. A prospective study would have allowed for development of protocols for measuring height and weight as well as documenting reasons for induction or cesarean section that at times can be unclear.

Data Collection, Analysis, and Results

Data Collection

Several sources were used to collect the data. The list of patients, dates of birth, dates of delivery, and tribal affiliation for calendar year 2011 were extracted from the Cherokee Nation Resource and Patient Management System (RPMS) which is a proprietary database developed by the Indian Health Service several decades ago. This list of patients was then compared to the Labor and Delivery log. The L&D log is a paper ledger kept on labor and delivery. When a woman delivers a child, the woman's nurse completes a data sheet, and the information is transcribed into the log. Data on the following variables were abstracted from the logbook:

- Gravidity – total number of pregnancies, including current pregnancy
- Parity – number of previous pregnancies that went beyond 20 weeks gestation
- Gestational age – in weeks
- The presence of hypertension or diabetes – this included all forms of hypertension related to pregnancy (gestational hypertension, pre-eclampsia, eclampsia) as well as pre-existing hypertension (chronic hypertension)
- Induction of labor – method of induction was not recorded
- Mode of delivery – an operative vaginal delivery was noted as a vaginal delivery
- Fetal weight – in grams

Logbook data is considered very reliable which was confirmed by a review of 10% of the medical records which revealed no discrepancies. All patients noted in the RPMS query were included in the L&D log. The only variable of concern was the occurrence of induction of labor. A comparison of medical records with the log revealed several instances of a woman being noted as undergoing induction of labor when the woman was actually early in the labor process and her labor was being augmented, not induced. This prompted a 100% review of all women who were noted in the log to have induction of labor with the data appropriately corrected. Unfortunately, Bishop score was not consistently recorded. As noted above, Bishop score is a significant indicator for successful induction, so post-dates inductions could not be evaluated in the study population.

Although CNHH has an electronic health record which is an application derived from RPMS, care received on Labor and Delivery is documented on paper while prenatal care is documented both in the EHR and on a standard paper prenatal flow sheet. It is also important to note that many women who deliver at CNHH receive prenatal care from other non-obstetrician providers at one of 8 Cherokee Nation clinics in the 14 county tribal jurisdictional service area. In the case where a woman is having a normal prenatal course, her care is transferred to CNHH at 36 weeks. Otherwise, high risk pregnancies are referred to CNHH earlier. After data were extracted from RPMS and the L&D log, individual medical records were reviewed and the following variables abstracted. Each variable has unique issues which are discussed.

- Pre-pregnancy weight – these data are either a self-reported weight recorded at the initial prenatal flow sheet. If the pre-pregnancy weight was not recorded on the paper flow sheet, the EHR was reviewed and, if available, a non-pregnant weight recorded within a year of the pregnancy under study was used. If this was not available, then the variable remained empty.
- Height – similar to pre-pregnancy weight, height is recorded on the paper flow sheet at the initial prenatal visit. If absent, the EHR was reviewed. As the patient's height has

little variation during pregnancy, any height recorded during prenatal care was used. Only one patient that had no prenatal care did not have a height recorded anywhere in the various medical records.

- Weight at delivery – Since the patients' weights are not recorded when they are admitted to labor and delivery, the weight at delivery was approximated by using the weight at the last prenatal visit which was reliably within one week of delivery.

Analysis

Using SAS 9.3 (SAS Institute Inc., Cary, NC), descriptive statistics were produced from the first cohort which included all women with singleton pregnancies and gestations ≥ 36 weeks. These statistics included an analysis of age, gravidity, body mass index, cesarean section rate, presence of diabetes or hypertension, and distribution of tribal affiliation. Likewise, the second cohort which excluded women with a previous cesarean section and those with malpresentation was described in a similar manner. These variables were selected because some are reported in other populations but also because, based on observations, the clinicians felt they were likely contributors to the cesarean section rate.

The decision was made to use logistic regression to determine odds ratios to better examine interaction and confounding among the predictor variables, and also because logistic regression is more efficient at separate analysis for each exposure and for analyzing categorical variables with multiple levels. Categorizing the variables into clinically significant models facilitates translation to clinical care and process improvement efforts as the categories allow for patient stratification into appropriate intervention groups. Using mode of delivery as the primary outcome variable, the following variables were categorized as described:

- Pre-pregnancy obesity – Body mass index (weight in kilograms/height in meters squared) was derived from maternal height and pre-pregnancy weight. Women with a BMI ≥ 30 were categorized as obese. Others were categorized as not obese.
- Morbid obesity at delivery – This variable was derived similar to pre-pregnancy obesity. Women with a BMI ≥35 were categorized as obese. Because of the high prevalence of obesity at delivery, the variable was changed to morbid obesity to better help identify potential risk factors.
- Appropriate weight gain – Using weight recommendations promulgated by the American College of Obstetricians and Gynecologists[35], it was determined if women met the recommendations or not and appropriately dichotomized into meeting the recommendations or not. Distinction was not made between women who exceeded the maximum weight gain recommendations or failed to meet the minimum. The recommendations are noted in Table 1.
- Cherokee descent – This is a dichotomous variable. 22 other tribes were represented in the sample in small numbers. Also, women all have varying degrees of Indian heritage and many have ancestors from more than one tribe. The other tribes represented are listed in Appendix 3.
- Presence of diabetes – includes pregestational and gestational diabetes
- Induction of labor – This is also a dichotomous variable

Category	BMI	Recommended total weight gain in kilograms
Low	<19.8	12.5 – 15
Normal	19.8 – 26	11.5 – 16
High	26 – 29	7 – 11.5
Obese	>29	At least 7

Table 1: Recommended ranges of total weight gain for pregnant women by pre-pregnancy body mass index for singleton gestations.[35]

Each independent variable was modeled as the primary predictor. Using stepwise backward elimination, the variables were tested for interaction while ensuring the individual variables remained in the model using the "include" option in SAS PROC LOGISTIC. No interaction was discovered in any of the models. The variables were then tested for confounding. Where confounding was discovered, that variable was kept in the model to decrease the bias in the resulting odds ratios. Because obesity at delivery, diabetes, and induction are known risk factors for cesarean section, these variables were kept in the models. SAS PROC REG was used to test for collinearity among the categorical variables which revealed no statistical evidence of collinearity. Although some variation proportions were elevated, Eigenvalues and condition indexes were both consistently low as described in Table 2. Despite the lack of statistical significance, pre-pregnancy obesity and morbid obesity at delivery are obviously related and could possibly cause disruption in the regression model. Because the literature showed that obesity at delivery is a stronger predictor of cesarean section than pre-pregnancy obesity, this variable was kept in the model and pre-pregnancy obesity removed, except where pre-pregnancy obesity was the primary predictor.

Collinearity Diagnostics (intercept adjusted)								
	Eigenvalue	Condition Index	Proportion of Variation					
			Pre-pregnancy obesity	Appropriate weight gain	Morbid obesity at delivery	Cherokee descent	Diabetes	Induction
1	1.86764	1.00000	0.103	0.004	0.105	0.000	0.009	0.058
2	1.09619	1.30528	0.003	0.484	0.000	0.000	0.360	0.034
3	1.02090	1.35255	0.006	0.013	0.001	0.809	0.068	0.062
4	0.89759	1.44247	0.028	0.197	0.016	0.175	0.449	0.166
5	0.85418	1.47867	0.007	0.265	0.015	0.009	0.111	0.679
6	0.26350	2.66231	0.850	0.034	0.862	0.003	0.000	0.000

Table 2: Collinearity test results

95% confidence intervals were calculated as well as the p value for all odds ratios. A p value of 0.05 or less was considered significant. The final models for the regression analysis on cohort 2 are described in Table 3.

Primary Predictor	Controls (Confounders)
Pre-pregnancy obesity	Induction, Diabetes
Diabetes	Induction, Morbid obesity at delivery
Appropriate weight gain	Morbid obesity at delivery, Induction, Diabetes
Induction	Morbid obesity at delivery, Diabetes
Cherokee descent	Obesity at delivery, Induction, Diabetes
Morbid obesity at delivery	Induction, Diabetes

Table 3: Regression models used for analysis

Results

Descriptive analysis of the cohorts

In 2011, 809 women were admitted to CNHH Labor and Delivery. Of the 25 women excluded, 5 women suffered from intrauterine fetal demise and 20 delivered prior to 36 weeks of gestation. The remaining 784 women had singleton, live gestations ≥36 weeks gestation. For this cohort

(cohort 1) the cesarean section rate was 37.1%. Of particular note, 42% of the women were nulliparous and 29.4% of the women went from not obese before pregnancy to obese at delivery. After excluding women with prior cesarean section and women with fetal malpresentation (179 women), a primary cesarean section rate for this cohort (cohort 2) was calculated to be 18.7%. Other characteristics are noted in Table 4.

Variable	Cohort 1 (N= 783)		Cohort 2 (N=604)	
	n	Percent (95% CI) or Mean (SD)	n	Percent(95% CI) or Mean (SD)
Age	783	25.7 years (5.5)	604	25.2 years (5.5)
American Indian	620	79.2% (76.3,82.0)	473	78.3% (75.0,81.6)
Cherokee	509	65.0%(61.6,68.3)	399	66.0% (62.3,69.8)
Pre-pregnancy obesity	271	34.6% (31.3,37.9)	198	32.8%(29.0,36.5)
Obesity at delivery	501	64.0% (60.6,67.4)	377	62.4% (58.6,66.3)
Morbid obesity at delivery	269	34.4% (31.0,37.7)	205	33.9% (30.2,37.7)
Diabetes	54	6.9% (5.1,8.7)	34	5.6% (3.8,7.5)
Hypertension	80	10.2% (8.1,12.4)	67	11.1% (806,13.6)
Induction	206	26.3% (23.2,29.4)	203	33.6% (29.8,37.4)
Cesarean section	290	37.1% (33.7,40.6)	113	18.7 (15.6,22.1)

Table 4: Descriptive analysis of cohorts 1 and 2

Odds ratios for selected predictors

Because CNHH does not offer vaginal birth after cesarean section, further analysis was conducted on cohort 2. Using the models described above, odds ratios were calculated for the selected predictors (Table 5). The analysis revealed that, controlling for confounders (induction and diabetes), women with morbid obesity at delivery incurred the highest odds of receiving a cesarean section (OR 2.4, 95% CI 1.6, 3.7). Additionally, pre-pregnancy obesity (OR 1.69, 95%

CI 1.1, 2.6), and women undergoing induction (OR 1.65, 95% CI 1.1, 2.5) incurred a modest increase in odds.

Risk Factor	Odds ratio	95% confidence interval	P value
Pre-pregnancy obesity	1.67	1.10,2.59	0.017
Diabetes	1.38	0.62,3.11	0.433
Inappropriate weight gain	1.10	0.67,1.82	0.705
Cherokee descent	1.56	0.98,2.49	0.061
Induction	1.65	1.07,2.54	0.023
Morbid obesity at delivery	2.39	1.56,3.68	<0.0001

Table 5: Odds ratios for selected risk factors for primary cesarean section among the study population

Discussion

This study shows that the study population has higher rates of risk factors for cesarean section and that the contributors to cesarean section are not unique compared to other populations. The descriptive analysis of the complete cohort revealed a diabetes rate of 6.9% which is only slightly higher than the rate of diabetes reported by the National Center for Health Statistics in 2009 for all races (4.8%) and is similar to the rate for Native Americans (6.6%) in the US.[1] The cesarean section rate of 37.1% is significantly higher than the rate for all races (32.9%) and for American Indians (28.5%). This study failed to demonstrate an adequate explanation for the higher rates of cesarean section. The percent of women who were nulliparous seems high; however there is not an equivalent comparator available in the literature. First-birth rate is the most common descriptor for this metric and is calculated as a rate of the number of women delivering their first child per 1,000 women age 15-44.[1] Since the data presented here are from one of several hospitals serving the population, calculation of this statistic is not appropriate.

Morbid obesity at delivery was the most significant predictor of cesarean section in the study population with pre-pregnancy obesity reaching statistical significance as well. To address these risk factors will require both long-term public health interventions in the preconception period as well as clinical interventions in the prenatal period. Cherokee Nation should continue its public health efforts to improve nutrition and promote physical activity to improve reproductive health among its people. The induction rate of 26.3 % (95% CI 29.4%, 23.2%) is slightly higher than the rate for all races (23.2%) and significantly higher than for Native Americans (21.9%). The increased rate of induction may indicate a possible issue with practice patterns or maternal characteristics that have yet to be discovered and warrants further study. Patient attitudes towards delivery during the prenatal period may have a significant influence on provider decision-making. As well, patient education during the prenatal period should be examined for additional behavioral risk factors (nutrition, physical activity, barriers to adherence to provider recommendations) that may decrease the indications for induction.

Individual provider characteristics were not studied as patients are not assigned primary providers and are delivered by the midwife on call (in the case of a vaginal delivery) or by the physician (in the case of a cesarean section. Since physicians rarely perform vaginal deliveries, physician-specific cesarean section rates are all near 100%. Additionally, during the labor process, a woman may have 2 or more different providers. In this practice model, the study of individual provider characteristics is not possible.

One weakness in the study is that women classified as Cherokee or American Indian are not necessarily 100% Cherokee or Native American. As such, it is difficult to definitively characterize the reproductive characteristics of the Cherokee women. Other American Indian populations may be more homogenous genetically. However, these data are useful to the providers for surveillance of risk factors and will help target clinical interventions to reduce the cesarean section rate.

Overall, the characteristics of the complete cohort and the risk factors for primary cesarean section in the second cohort are similar to the Native American population and the with data reported in the literature on other populations. The population served by Cherokee Nation Hastings Hospital, in regards to reproductive health, does not appear to be distinct from the general Native American population. Additional research in maternal and perinatal outcomes, cultural attitudes, patient care models, and environmental factors (education, socio-economic status, birth control) will help shed additional light on the unexplained elevated cesarean section rates in this population.

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Appendix 1 – Journal Article

Risk Factors for Cesarean Section in a Predominantly Cherokee Population in Rural Oklahoma

David Gahn MD, Brian McCarthy MD MSc MPH, Edmond Becker, PhD

Abstract

Objective: With evidence to indicate that the American Indian population is not a homogenous group, the objective of this study is to identify and describe the prevalence of risk factors for cesarean section among a predominantly Cherokee population in order to decrease the cesarean section rate. Methods: The study is a retrospective review of 809 consecutive deliveries at Cherokee Nation Hastings Hospital in northeastern Oklahoma. Results: The results showed comparable rates of diabetes and obesity in relation to generalized data on American Indians. Rates of induction of labor and cesarean sections were higher than the national average. The strongest predictors for cesarean section were pre-pregnancy obesity, morbid obesity at delivery, and induction of labor. Conclusion: Maternal characteristics do not distinguish the patient population served by Hastings Hospital from generalized data on US American Indians. Decreasing the cesarean section rate will require a combined approach of sustained public health measures to address pre-conception health and clinical interventions during prenatal care.

Introduction

Cesarean section rates in the US reached 32.9% in 2009, the 13th consecutive year of increasing rates and this increase continues to defy explanation.[1, 2] Cherokee Nation Hastings Hospital (CNHH) is a community hospital located in rural northeastern Oklahoma and performs 800-900 deliveries annually. Prenatal care is provided by a cadre of Obstetricians/Gynecologists, Family Medicine physicians, Certified Nurse Midwives and Nurse Practitioners located at CNHH as well as several surrounding clinics operated by Cherokee Nation. Labor and Delivery is staffed by a cadre of well-trained, experienced nurses. Laboring patients are generally managed by a Certified Nurse Midwife under the supervision of a physician. Women eligible for obstetric care include American Indian women and non-American Indian women when the father of the baby is American Indian.

Cesarean section is a life-saving intervention in many instances but it is not without risks. The American Congress of Obstetricians and Gynecologists Task Force on Cesarean Section Rates published a report in 2000 which outlined distinctly the risks of cesarean section. Intra-operative and post-operative complications include maternal hemorrhage, uterine rupture, placenta accreta, injuries to the gastrointestinal and urinary tracts, and infection. Additionally, having a cesarean section results in increased risks of these complications in future pregnancies as well. Maternal mortality is 3-7 times greater in cesarean section cases than with vaginal delivery, although some of this increased risk is a result of selection bias in the indication for cesarean section and not a result of the procedure itself.[3]

In response to increasing cesarean section rates, the literature clearly shows several important risk factors for cesarean section in various populations. Regarding maternal obesity and outcomes, authors focused on three areas: pre-pregnancy body mass index (BMI), maternal weight gain or BMI, and maternal birth weight. In a study of approximately 1,800 women, Addo showed that women deemed to be obese (BMI > 30) at delivery were at an increased risk of cesarean section as well as requiring induction of labor.[4] Likewise, Dennedy, et al.

prospectively studied several thousand Irish pregnant women and arrived at the same conclusion.[5] Marshall et al. studied 64,000 births looking at maternal superobesity (BMI >50) as well as other categories of obesity and again documented an increased risk for cesarean section. Women suffering from superobesity incurred a cesarean section rate of 50%.[6]

In the area of maternal weight gain and BMI during pregnancy, most authors, using the Institute of Medicine (IOM) guidelines on recommended weight gain during pregnancy, showed poorer outcomes with poor weight gain as well as weight gain in excess. Durie, et al. as well as Gawade showed that weight gain during pregnancy and maternal obesity were independently associated with an increased risk of cesarean section.[7, 8] Alternatively, Jang et al. showed that failure to meet the IOM guidelines did not predict cesarean section, but that an increased pre-pregnancy BMI as well as weight gain in excess of 18 kilograms were associated with increased cesarean section risk.[9] In a unique study, Yazdani, et al. measured the BMI of 1,000 women in the first trimester of gestation. They found that a BMI above 25 (overweight and above) increased the risk of cesarean section.[10] Shy et al. took a singular approach of attempting to predict cesarean section using the mother's birth weight.[11] These investigators found that maternal birth weights of less than 2500 grams or greater than 4000 grams increased her risk of cesarean section. It is important to mention as well that these studies showed that maternal obesity and weight gain also increased the risks of diabetes, hypertension, induction of labor, and a multitude of adverse fetal malformations and macrosomia. Fortunately, Gilead, et al. in a study of over 173,000 deliveries did not find an increase in perinatal complications from cesarean section in women with isolated obesity versus non-obese patients.[12]

Similar to cesarean section rates, rates of induction of labor have also been on the rise.[1] While non-medically indicated rates of induction have been falling, the cause for an overall increase in labor inductions has not been determined. [2, 13] Alexander, et al. looked at the risk of cesarean section in 1,325 women induced at 42 weeks and found a significantly increased risk of cesarean section.[14] Caughey, et al. performed an extensive review of the literature and determined that waiting beyond 41 weeks gestation to induce labor increased the risk of cesarean section, but could not demonstrate a clear benefit of inducing labor earlier than 41 weeks. [15] Sue, et al. similarly reviewed the literature to examine post-dates induction of labor versus medical induction and found no significant increase in cesarean section rates between those induced at 41 and 42 weeks of gestation.[16] In a study of 5,600 women, Schuitt, et al. developed a prediction model for determining the risk of cesarean section and determined that induction of labor (all indications) was a significant independent predictor of cesarean section in addition to many other maternal and fetal characteristics.[17] Yeast et al. specifically studied the issue of early elective inductions. They studied 18,000 pregnancies at a single community hospital. As the induction rate increased from 32% to 43% over 8 years, the researchers found no change in cesarean section rates.[18] Similarly, Seyb, et al. compared elective v. medical induction in 1,561 women and found an increase in the cesarean section rate in women undergoing elective induction.[19]

At CNHH, unpublished performance improvement data show that the cesarean section rate for the American Indian population served is consistently higher than the national average. The limited data in the literature on risk factors for cesarean section in American Indians reveal a consistently lower rate of cesarean sections without clear explanation.[20-22] At Cherokee Nation Health Services, there is always a concern that American Indian data do not necessarily correlate to the population served by Cherokee Nation. Alexander observed regional variations in childbirth outcomes postulating that American Indian groups are distinct entities that may not share characteristics as described in national health data.[23]

This study aims to determine if the prevalence of maternal medical high factors in Cherokee Nation are comparable to national data on American Indians and the general US population and which risk factors for cesarean section predominantly affect the cesarean section rate.

Methods

Data were abstracted from 809 consecutive deliveries at CNHH in calendar year 2011. Inclusion criteria included women with singleton gestations ≥36 weeks gestation. This cohort was used to describe demographics and prevalence of diabetes, hypertension, induction rate, and cesarean section rate. Since CNHH does not offer trial of labor after cesarean section and since clinical guidelines recommend cesarean sections for fetuses with malpresentation, a second study cohort was developed excluding women with previous cesarean sections or malpresentation.

Data were collected on mode of delivery and several descriptors and predictors for cesarean section based on the literature. The diagnosis of diabetes included pregestational diabetes as well as gestational diabetes, and hypertension included all forms of pregnancy-associated hypertension and chronic hypertension. To determine appropriate weight gain, guidelines published by the American Congress of Obstetrics and Gynecology were used. [24] Obesity was defined as a body mass index ≥30 and morbid obesity as a body mass index ≥35. Variables were categorized and logistic regression analysis was performed using SAS 9.3 (SAS Institute, INC. Cary, NC). Analysis included tests for interaction and confounding, and factors that were known to be risk factors for cesarean section were left in the regression models for control. A p-value of ≤0.05 was considered statistically significant.

Results

784 women met the inclusion criteria for the first cohort. The cesarean section rate was calculated at 37.1% compared to a 2009 rate of 32.9% for US general population and 28.5% for American Indians/Alaska Natives. The average age of the women was 25.7 years and 42.1% of the women presented for delivery of their first child. 79.1% of the women were American Indian, and 65% described themselves as Cherokee. The pre-pregnancy obesity rate (body mass index ≥30) was 34.5 % and the morbid obesity rate (body mass index ≥35) at delivery was 34.5%. 6.9% of the women suffered from diabetes compared to 4.8% for the US general population and 6.6% for Native Americans/Alaska Natives. 10.2% of the first cohort suffered from hypertension. The characteristics of the second cohort, which excludes women with previous cesarean section or malpresentation, are described in Table 1. The distribution of parity in the cohorts is described in Table 2.

Variable	Cohort 1 (N= 783)		Cohort 2 (N=604)	
	n	Percent (95% CI) or Mean (SD)	n	Percent(95% CI) or Mean (SD)
Age	783	25.7 years (5.5)	604	25.2 years (5.5)
American Indian	620	79.2% (76.3,82.0)	473	78.3% (75.0,81.6)
Cherokee	509	65.0%(61.6,68.3)	399	66.0% (62.3,69.8)
Pre-pregnancy obesity	271	34.6% (31.3,37.9)	198	32.8%(29.0,36.5)
Obesity at delivery	501	64.0% (60.6,67.4)	377	62.4% (58.6,66.3)
Morbid obesity at delivery	269	34.4% (31.0,37.7)	205	33.9% (30.2,37.7)
Diabetes	54	6.9% (5.1,8.7)	34	5.6% (3.8,7.5)
Hypertension	80	10.2% (8.1,12.4)	67	11.1% (806,13.6)
Induction	206	26.3% (23.2,29.4)	203	33.6% (29.8,37.4)
Cesarean section	290	37.1% (33.7,40.6)	113	18.7 (15.6,22.1)

Table 1: Maternal characteristics of the two cohorts

Distribution of parity		
Parity	**Percent in first cohort N=784**	**Percent in second cohort N= 604**
0	42.1	52.5
1	33.1	26.3
2	16.7	13.7
3	4.7	4.1
4	1.9	2.0
5	0.6	0.5
6	0.4	0.5
7	0.1	0.2
8	0.1	0.2

Table 2: Distribution of parity among the two cohorts

After excluding women from the analysis who had a previous cesarean section or malpresentation, odds ratios were calculated. Controlling for induction and diabetes, morbid obesity produces an odds ratio of 2.39 (95% CI 1.56,3.68) followed by pre-pregnancy obesity with an OR of 1.67 (95% CI 1.10,2.59) and induction of labor with an OR of 1.65 (95% CI 1.07,2.54). Diabetes, inappropriate weight gain, and Cherokee descent were not statistically significant predictors of cesarean section in the second cohort. Complete results are described in Table 3.

Risk Factor	Odds ratio	95% confidence interval	P value
Pre-pregnancy obesity	1.67	1.10,2.59	0.017
Diabetes	1.38	0.62,3.11	0.433
Inappropriate weight gain	1.10	0.67,1.82	0.705
Cherokee descent	1.56	0.98,2.49	0.061
Induction	1.65	1.07,2.54	0.023
Morbid obesity at delivery	2.39	1.56,3.68	<0.0001

Table 3: Odds ratios for selected risk factors for primary cesarean section among the study population

Discussion

This study shows that the study population has higher rates of risk factors for cesarean section and that the contributors to cesarean section are not unique compared to other populations. The descriptive analysis of the complete cohort revealed a diabetes rate of 6.9% which is only slightly higher than the rate of diabetes in reported by the National Center for Health Statistics in 2009 for all races (4.8%) and is similar to the rate for Native Americans (6.6%) in the US.[1] The cesarean section rate of 37.1% is significantly higher than the rate for all races (32.9%) and for Native Americans (28.5%).

Morbid obesity at delivery was the most significant predictor of cesarean section in the study population with pre-pregnancy obesity reaching statistical significance as well. To decrease the cesarean section rate would require both long-term public health interventions as well as clinical interventions in the prenatal period. As obesity remains a national public health priority, Cherokee Nation should continue its efforts to improve nutrition and promote physical activity to improve reproductive health among its people. The induction rate of 26.3 % (95% CI 29.4%,23.2%) is slightly higher than the 2009 rate for all races (23.2%) and significantly higher than for American Indians (21.9%). The increased rate of induction may indicate a possible issue with practice patterns or maternal characteristics that have yet to be discovered and warrants further study.

Individual provider characteristics were not studied as patients are not assigned primary providers and are delivered by the midwife on call (in the case of a vaginal delivery) or by the physician (in the case of a cesarean section. Since physicians rarely perform vaginal deliveries, physician-specific cesarean section rates are all near 100%. Additionally, during the labor process, a woman may have 2 or more different providers. In this practice model, the study of individual provider characteristics is not possible.

A weakness of the study is that women classified as Cherokee or American Indian are not necessarily 100% Cherokee or Native American. As such, it is difficult to definitively characterize the reproductive characteristics of the Cherokee women. Other American Indian populations may be more homogenous genetically. However, these data are useful to the providers for surveillance of risk factors and will help target clinical interventions to reduce the cesarean section rate.

Overall, the maternal characteristics of the complete cohort and the risk factors for primary cesarean section in the study population are similar to the Native American population and the with data reported in the literature. The population served by Cherokee Nation Hastings Hospital, in regards to reproductive health, does not appear to be distinct from the general American Indian population.

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Appendix 2 – SAS Code

```
LIBNAME c 'C:\Documents and Settings\david-gahn\Desktop\Thesis\SAS\Attempt1';

*** This dataset includes all the patients beyond 36 weeks who delivered at
Hastings;
** First look at the contents **;

PROC CONTENTS DATA=c.thesis;
RUN;

PROC PRINT DATA=c.thesis (obs=50);
RUN;

ODS RTF FILE='C:\Documents and Settings\david-
gahn\Desktop\Thesis\SAS\Attempt1\DescripTotal.rtf' BODYTITLE;
      TITLE 'Description of the population including all patients';*



************************************************;
************************************************;
****  Descriptive Statistics Section   *********;
************************************************;
************************************************;

****  AGE   ****;

PROC MEANS DATA=c.thesis
      N NMISS MIN Q1 MEAN MEDIAN Q3 MAX STD MAXDEC=1;
      VAR AGE;
RUN;

PROC UNIVARIATE DATA=c.thesis PLOT;
      VAR AGE;
      HISTOGRAM AGE / NORMAL;
      INSET MEAN;
RUN;

PROC SGPLOT DATA=c.thesis;
      VBOX AGE;
RUN;

**** PARITY ******;

PROC MEANS DATA=c.thesis;
      VAR P;
RUN;

PROC FREQ DATA=c.thesis;
      TABLES p;
```

```
RUN;


**** Age and Parity ****;

SYMBOL VALUE=circle color=blue;
PROC GPLOT DATA=c.thesis;
      PLOT age*p;
RUN;

**** Tribal Affiliation ****;

*What tribes are represented?*;

PROC FREQ DATA=c.thesis;
      TABLES tribe;
RUN;

*What percent are Native American?;

DATA c.thesis1;
      SET c.thesis;
      IF TRIBE = 'n' Then Tribe1=2;
      ELSE Tribe1 = 1;
RUN;


PROC FREQ DATA=c.thesis1;
      TABLES TRIBE1/BINOMIAL;

RUN;


*What percent are Cherokee?;

DATA c.thesis2;
      SET c.thesis1;
      IF Tribe='CHEROKEE' THEN Tribe2=1;
      ELSE TRIBE2=2;
RUN;

PROC FREQ DATA=c.thesis2;
      TABLES TRIBE2/Binomial;
      TITLE 'What percent of the women are Cherokee?';
RUN;

*What percent of the Native Americans are Cherokee?;

PROC SORT DATA=c.Thesis2;
      BY TRIBE1;
RUN;

PROC FREQ DATA=c.thesis2;
      BY Tribe1;
      TABLES Tribe2/BINOMIAL;
      TITLE 'What percent of the Native Americans are Cherokee?';
```

```
RUN;
TITLE '';

**** Pre-Pregnancy Weight *****;

PROC MEANS DATA=c.Thesis2
      N NMISS MIN MEAN Q1 MEDIAN Q3 MAX STD;
      VAR PPBMI;
RUN;

PROC UNIVARIATE DATA=c.thesis2 PLOT NOPRINT;
      VAR PPBMI;
      Title 'Distribution of pre-pregnancy body mas index';
      HISTOGRAM PPBMI / NORMAL;
      INSET MEAN MIN MAX;
RUN;
TITLE '';

PROC SGPLOT DATA=c.thesis2;
      VBOX PPBMI;
RUN;

      * WHat percent of the women were overweight or bigger when they got
pregnant?;

DATA c.thesis3;
      SET c.Thesis2;
      IF PPBMI >= 25 THEN PPBMI1=1;
      ELSE PPBMI1 = 2;
RUN;

PROC FREQ DATA = c.Thesis3;
      TABLES PPBMI1;
      TITLE 'What percent of the women were overweight or bigger when they
got pregnant?';
RUN;

      *What percent of the women were obese or bigger when they got
pregnant?;

DATA c.thesis4;
      SET c.thesis3;
      IF PPBMI >= 30 THEN PPBMI2=1;
      ELSE PPBMI2=2;

RUN;

PROC FREQ DATA = c.Thesis4;
      TABLES PPBMI2/BINOMIAL;
      TITLE 'What percent of the women were obese or bigger when they got
pregnant?';
RUN;
Title '';

**** Delivery Weight *****;
```

```
PROC MEANS DATA=c.Thesis4
      N NMISS MIN MEAN Q1 MEDIAN Q3 MAX STD;
      VAR DBMI;
RUN;

PROC UNIVARIATE DATA=c.thesis4 PLOT;
      VAR DBMI;
      HISTOGRAM DBMI / NORMAL;
      INSET MEAN;
RUN;

PROC SGPLOT DATA=c.thesis4;
      VBOX DBMI;
RUN;

      * What percent of the women had a BMI >30 at delivery?;

DATA c.thesis5;
      SET c.Thesis4;
      IF DBMI >= 30 THEN DBMI1=1;
      ELSE DBMI1 = 2;
RUN;

PROC FREQ DATA = c.Thesis5;
      TABLES DBMI1/BINOMIAL;
      TITLE 'What percent of the women who had a BMI >30 at delivery';
RUN;

      *What percent of the women had a BMI >35 at delivery?;

DATA c.thesis6;
      SET c.thesis5;
      IF DBMI >= 35 THEN DBMI2=1;
      ELSE DBMI2=2;
RUN;

PROC FREQ DATA = c.Thesis6;
      TABLES DBMI2/BINOMIAL;
      TITLE 'What percent of the women had a BMI >35 at delivery?';
RUN;
Title '';

**** Weight Gain *****;

PROC MEANS DATA=c.Thesis6
      N NMISS MIN MEAN Q1 MEDIAN Q3 MAX STD;
      VAR WtGn;
RUN;

PROC UNIVARIATE DATA=c.thesis6 PLOT;
      VAR WtGn;
      HISTOGRAM WtGn / NORMAL;
      INSET MEAN;
RUN;

PROC SGPLOT DATA=c.thesis6;
```

```
      VBOX WtGn;
RUN;

****  Now we will look at how women adhered to weight gain recommendations.*;
****  First I will make the appropriate categories using WtCat1 which is pre-
pregnancy
Weight categories;

DATA c.thesis7;
      SET c.thesis6;
      IF PPBMI <19.8 THEN WtCat = 1;
      ELSE IF PPBMI >=19.8 and PPBMI < 26 THEN WtCat = 2;
      ELSE IF PPBMI >=26 and PPBMI < 29 THEN WtCat = 3;
      ELSE IF PPBMI >=29 THEN WtCat=4;
RUN;


**** Each weight category has different weight gain recommendations.  Let's
see how
many women kept within the guidelines ***;

DATA c.Thesis8;
      SET c.thesis7;
      IF WtCat=1 and WtGn >=12.5 and WtGn <=18 THEN GoodWt = 1;
      ELSE IF WtCat=2 and WtGn >=11.5 and WtGn <=16 THEN GoodWt=1;
      ELSE IF WtCat=3 and WtGn >=7 and WtGn <=11.5 THEN GoodWt=1;
      ELSE IF WtCat=4 and WtGn >7 and WtGn <=11.5 THEN GoodWt=1;
      ELSE GoodWt=2;
RUN;

PROC FREQ DATA=c.Thesis8;
      TABLES WtCat;
RUN;

PROC FREQ DATA=c.thesis8;
      TABLES GoodWt;
RUN;

PROC FREQ DATA=c.thesis8;
      TABLES WtCat*GoodWt;
RUN;

***************************************************************************
****  Now, some c-section rates *******************************************
***************************************************************************;

*First, I will see the overall c-section rate;

PROC FREQ DATA=c.thesis8;
      TABLES DELIVERY;
RUN;

*To get a primary c-section rate, I have to remove the repeat c-sections and
the c-sections done for breech;

DATA c.THESIS9;
```

```
      SET c.Thesis8;
      IF REPEAT=1 THEN NORMAL=2;
      ELSE IF MALP=1 THEN NORMAL=2;
      ELSE NORMAL=1;
RUN;

PROC FREQ DATA=c.Thesis9;
      WHERE NORMAL=1;
      TABLES DELIVERY;
RUN;

** Describe rates of Diabetes, but I have to make the variable 1 and 2
instead of 0 and 1;

DATA C.Thesis10;
      SET c.Thesis8;
      IF DM=0 THEN DM1 = 2;
      ELSE DM1 = DM;
RUN;

PROC FREQ DATA=c.thesis10;
      TABLES DM1 / BINOMIAL;
      TITLE 'What percent of the women had diabetes?';
RUN;

*** Same for Hypertension *;

DATA C.Thesis11;
      SET c.Thesis10;
      IF HTN=0 THEN HTN1 = 2;
      ELSE HTN1 = HTN;
RUN;

PROC FREQ DATA=c.thesis11;
      TABLES HTN1/BINOMIAL;
      TITLE 'What percent of the women had hypertension?';
RUN;

*What percent had both Diabetes and Hypertension?';

DATA c.Thesis12;
      SET c.Thesis11;
      IF DM1=1 and HTN1=1 THEN DMHTN=1;
      ELSE DMHTN=2;
RUN;

PROC FREQ DATA=c.thesis12;
      TABLES DMHTN / BINOMIAL;
      TITLE 'What percent of women had both DM and HTN?';
RUN;

*What percent of women underwent induction?;

DATA c.Thesis13;
      SET c.Thesis;
      IF Induction = 0 THEN Ind1=2;
```

```
      ELSE Ind1=1;
RUN;

PROC FREQ DATA=c.Thesis13;
      TABLES Ind1 / Binomial;
      TITLE 'What percent of women underwent induction?';
RUN;

RUN;

PROC FREQ DATA=c.Thesis13;
      WHERE Repeat=0;
      TABLES Ind1 / Binomial;
      TITLE 'What percent of women underwent induction?';
RUN;

DATA c.Thesis14;
      SET c.thesis13;
      IF PDates=0 THEN PDates1=2;
      ELSe PDATES1=PDates;
RUN;

PROC FREQ DATA=c.Thesis14;
      TABLES PDATES1 / BINOMIAL;
      TITLE 'What percent of women had a post-dates induction?';
RUN;

PROC SORT DATA = c.thesis14;
      BY IND1;
RUN;

PROC FREQ DATA=c.Thesis14;
      BY IND1;
      TABLES PDATES1 / BINOMIAL;
      TITLE 'What percent of inductions had a post-dates induction?';
RUN;

*Cesarean Section Rate*;

DATA c.Thesis15;
      SET c.thesis14;
      IF delivery=1 THEN del1=2;
      ELSE IF Delivery=2 THEN DEL1=1;
RUN;

PROC FREQ DATA=c.thesis15;
      TABLES Del1/binomial;
      TITLE 'C-section rate, c-section=1';
RUN;



ODS RTF CLOSE;
```

Comparative analysis of cohort 2

```
PROC CONTENTS DATA=c.thesis;
RUN;

PROC PRINT DATA=c.thesis (OBS=50);
RUN;


*****************************************************************************
**
****************   ANALYSIS SECTION
*******************************************
*****************************************************************************
**;

*** Create variable PPObese for pre-pregnancy obesity ***;

DATA c.ThesisA;
      SET c.Thesis;
      IF PPBMI < 30 THEN PPObese=0;
      ELSE PPObese=1;
RUN;


*** Create variable for weight category, then determine if weight gain met
ACOG criteria ***;

DATA c.thesisB;
      SET c.thesisA;
      IF PPBMI <19.8 THEN WtCat = 1;
      ELSE IF PPBMI >=19.8 and PPBMI < 26 THEN WtCat = 2;
      ELSE IF PPBMI >=26 and PPBMI < 29 THEN WtCat = 3;
      ELSE IF PPBMI >=29 THEN WtCat=4;
RUN;

DATA c.ThesisC;
      SET c.thesisB;
      IF WtCat=1 and WtGn >=12.5 and WtGn <=18 THEN GoodWt = 0;
      ELSE IF WtCat=2 and WtGn >=11.5 and WtGn <=16 THEN GoodWt=0;
      ELSE IF WtCat=3 and WtGn >=7 and WtGn <=11.5 THEN GoodWt=0;
      ELSE IF WtCat=4 and WtGn >7 and WtGn <=11.5 THEN GoodWt=0;
      ELSE GoodWt=1;
RUN;

*** Create a new variable for weight at delivery DelObese ***;

DATA c.thesisD;
      SET c.ThesisC;
            IF DBMI < 35 THEN DelObese=0;
            ELSE DelObese=1;
RUN;
```

```
*** Create a new variable for Native American **********;

DATA c.ThesisE;
      SET c.ThesisD;
      IF TRIBE = 'n' THEN NatAm=0;
      Else NatAm=1;
RUN;

**** Create a variable for Cherokee *****;

DATA c.ThesisF;
      SET c.ThesisE;
      IF Tribe='CHEROKEE' THEN Cherokee=1;
      ELSE Cherokee=0;
RUN;

**** Create a variable for patients with both DM and HTN ****;

DATA c.ThesisG;
      SET c.ThesisF;
      IF DM=1 and HTN=1 THEN DMHTN=1;
      ELSE DMHTN=0;
RUN;


*****   Take a look at the final data set before starting logistic regression
***;

PROC CONTENTS DATA=c.ThesisG;
RUN;

PROC PRINT DATA=c.ThesisG (Obs=100);
RUN;

ODS RTF FILE = 'C:\Documents and Settings\david-
gahn\Desktop\Thesis\SAS\Attempt2\Analysis\Analysis.rtf' BODYTITLE;

*************************************************************************;
****   Modeling for Logistic Regression    ******************************;
*************************************************************************;

*************************************************************************;
*** Model 1 - Delivery = PPOBese                                    ****;
*************************************************************************;

*** Use automatic backward elimination so I can check for confounding**;

Title 'Model 1';

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese Goodwt DelObese Cherokee DM Induction
                                    PPOBese*Goodwt PPObese*DelObese
PPObese*Cherokee
                                    PPObese*DM  PPObese*Induction/ backward
Include=6;
```

```
RUN;

***  No interaction terms remain, so I need a model to check for confounding
**;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese Goodwt DelObese Cherokee DM Induction;
RUN;

** Gold standard is .791 **
** Goodwt is the least sig, so I'll test that first**;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese DelObese Cherokee DM Induction;
RUN;

*No confounding, so remove Goodwt *;
*Next is DM *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese DelObese Cherokee Induction;
RUN;

*No confounding, so leave remove DM *;
*Next is Cherokee *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese DelObese Induction;
RUN;

*No confounding, so remove Cherokee *;
*Next is Induction;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese DelObese;
RUN;

*No confounding, remove Induction*;
*Next is DelObese*;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = PPObese;
RUN;

*Bigtime confounding but obvious co-linearity, so I need to keep PPObese
and DelObese out of the same models.*;

***** FINAL MODEL IS DELIVERY = PPObese;
TITLE '';
***********************************************************************;
****           MODEL 2 Delivery = DM    *****************************;
***********************************************************************;
TITLE 'Model 2';
PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM Goodwt DelObese Cherokee PPObese Induction
                                    DM*Goodwt DM*DelObese  DM*Cherokee
```

```
                                              PPObese*DM  DM*Induction/ backward
Include=6;
RUN;

* No interaction.  Test for confounding *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM Goodwt DelObese Cherokee PPObese Induction;
RUN;

* Gold standard is 1.471 *
*Goodwt is least significant, so test this first;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM DelObese Cherokee PPObese Induction;
RUN;

*No confounding so remove Goodwt;
*Next is PPOBese *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM DelObese Cherokee Induction;
RUN;

*No confounding, so remove it;
*Next is Cherokee *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM DelObese Induction;
RUN;

*No confounding so remove Cherokee;
* Next is Induction *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM DelObese;
RUN;

*No confounding, so remove it.
* Next is DelObese*;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DM;
RUN;

*No confounding**;
******FINAL MODEL IS DELIVERY = DM ***;
TITLE'';
*************************************************************************;
****              MODEL 3   Delivery=Goodwt           ******************;
*************************************************************************;
TITLE 'Model 3';

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DM DelObese Cherokee PPObese Induction
```

```
                                    DM*Goodwt Goodwt*DelObese
Goodwt*Cherokee
                                    Goodwt*PPObese  GoodWt*Induction/
backward Include=6;
RUN;

** No interaction.  Test for confounding **;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DM DelObese Cherokee PPObese Induction;

RUN;

* Gold standard is 1.089 *;
* PPObese goes first ;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DM DelObese Cherokee Induction;

RUN;

*No confounding so remove PPObese;
* DM is next *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DelObese Cherokee Induction;
RUN;

* No confounding so remove DM;
* Cherokee next;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DelObese Induction;
RUN;

*No confounding so remove Cherokee.;
*Induction is next;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt DelObese;
RUN;

*No confounding so remove Induction;
* Delobese is last;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Goodwt;
RUN;

*DelObese is a confounder, so keep and use adjusted estimate*;

********** FINAL MODEL DELIVERY = Goodwt DelObese; **************;

TITLE '';
******************************************************************************
*********;
```

```
**************            MOEDEL 4    DELIVERY=Cherokee
************************;
*****************************************************************************
*********;
TITLE 'Model 4';

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DM DelObese Goodwt PPObese Induction
                                    Cherokee*DM Cherokee*DelObese
Goodwt*Cherokee
                                    Cherokee*PPObese Cherokee*Induction/
backward Include=6;
RUN;

*No interaction*;
*Test for confounding*;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DM DelObese Goodwt PPObese Induction;
RUN;

** Gold standard is 1.581 **
** Remove Goodwt first;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DM DelObese PPObese Induction;
RUN;

*No confounding, so remove goodwt;
* Next is PPObese;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DM DelObese Induction;
RUN;

*No confounding so remove PPObese;
* Next is DM;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DelObese Induction;
RUN;

*No confounding, so remove DM;
*Next is Induction;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee DelObese;
RUN;

*No confounding, so remove induction;
*Next is DelObese;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Cherokee;
RUN;
```

```
*No confounding, so remove;

************ FINAL MODEL   DELIVERY = CHEROKEE ***;

TITLE '';

*****************************************************************************;
**********   MODEL 5   Delivery = Induction   *****************************;
*****************************************************************************;
TITLE 'Model 5';

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DM DelObese Goodwt PPObese Cherokee
                                    Induction*DM Induction*DelObese
Induction*Cherokee
                                    Induction*PPObese Induction*Goodwt/
backward Include=6;
RUN;

*No interaction, test for confounding*;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DM DelObese Goodwt PPObese Cherokee;
RUN;

* Gold standard is 1.678;
*First is Goodwt;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DM DelObese PPObese Cherokee;
RUN;

*No confounding, so remove goodwt;
*Next is PPObese;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DM DelObese Cherokee;
RUN;

*No confounding, so remove PPObese;
*Next is DM;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DelObese Cherokee;
RUN;

*No confounding, so remove DM;
*Next is Cherokee;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction DelObese;
RUN;

*No confounding, so remove Cherokee;
*Last is Delobese;
```

```
PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = Induction;
RUN;

*Confounding is present, so keep it in the model;
**********  FINAL MODEL Delivery=Induction DelObese *******;

TITLE '';

******************************************************************************
*********;
***********        MODEL 6  Delivery = DelObese
********************;
******************************************************************************
*********;
Title 'Model 6';

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese DM Induction Goodwt Cherokee
                                    DelObese*DM Induction*DelObese
DelObese*Cherokee
                                    DelObese*Goodwt/ backward Include=5;
RUN;

*No interaction, test for confounding *;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese DM Induction Goodwt Cherokee;
RUN;

*Gold standard is 2.366;
*Goodwt is least significant again, so remove first;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese DM Induction Cherokee;
RUN;

*No confounding, so remove goodwt;
*Next is DM;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese Induction Cherokee;
RUN;

*No confounding, so remove it;
*Next is Cherokee;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese Induction;
RUN;

* No confounding, so remove Cherokee;
*Next is Induction;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL DELIVERY = DelObese;
```

```
RUN;
*Induction is a confounder, so keep induction *;
***************** FINAL MODEL  Delivery=DelObese Induction ****************;
Title '';

***Adjusting for know risk factors, the final models are calculated below*;
TITLE 'FINAL MODELS';
*Model 1;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery=PPObese Induction DM;
RUN;

*Model 2;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery=DM Induction DelObese;
RUN;

*Model 3;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery= Goodwt DelObese Induction DM;
RUN;

*Model 4;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery=Cherokee DelObese Induction DM;
RUN;

*Model 5;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery=Induction DelObese DM;
RUN;

*Model 6;

PROC LOGISTIC DATA=c.ThesisG DESCENDING;
      MODEL Delivery=DelObese Induction DM;
RUN;

ODS RTF CLOSE;
*****************************************************************************
******;
***********               END PROGRAM
**************************;
*****************************************************************************
******;


LIBNAME c 'C:\Documents and Settings\david-
gahn\Desktop\Thesis\SAS\Attempt2\Analysis';
```

```
*****************************************************************************
*******;
***********  Using PROC REG to test for collinearity in categorical variables
******;
*****************************************************************************
*******;


* The variables below are all categorical*;

PROC REG DATA=c.thesisG;
      MODEL DELIVERY = PPObese Goodwt DelObese Cherokee DM Induction / COLLIN
COLLINOINT;
RUN;
```

Appendix 3 – Tribes represented in the sample

Tribe		
Tribe	**Number**	**Percent**
APACHE	2	0.26
CADDO	1	0.13
CHEROKEE	509	65.01
CHEYENNE	1	0.13
CHEYENNE-ARAPAHO	6	0.77
CHICKASAW	6	0.77
CHOCTAW	24	3.07
Creek	41	5.24
DOYON	1	0.13
KICKAPOO	1	0.13
KIOWA	2	0.26
KLAMATH	1	0.13
NAVAJO	4	0.51
OSAGE	3	0.38
PEORIA	1	0.13
POARCH BAND OF Creek	1	0.13
PONCA	1	0.13
POTAWATOMI	6	0.77
SAC AND FOX	1	0.13
SEMINOLE	3	0.38
SHAWNEE	1	0.13
UNITED KETOOWAH BAND	4	0.51