An Evaluation of Group Prenatal Care for High-Risk Obstetric Patients

Joshua Baker

Research indicates that poor infant health has adverse short- and long-term outcomes.[1] Clinicians and health systems can improve these outcomes and the costs associated with care by implementing interventions earlier.[2] Interventions before birth, rather than during early childhood, theoretically exhibit even greater cost-saving value in mitigated adverse health outcomes. However, not all interventions improve health equally for all populations, and evidence-based policy measures are required for clinicians and health systems to successfully provide cost-effective, successful treatment. Evidence suggests that one such intervention—CenteringPregnancy, a group prenatal care program—reduces costs and improves health outcomes for low-risk obstetric patients.[3]

CenteringPregnancy, the original model of group prenatal care, is used internationally and is the most widely studied model, with other programs often adapted from it. A literature review compiled by the Centering Healthcare Institute found more than 100 studies and peer-reviewed articles about CenteringPregnancy.

CenteringPregnancy began in 1993. The program is characterized by essential standardized elements that guide the structure and content of group sessions and emphasize health-promoting behaviors.[4] Model specifics will be discussed in greater detail in the following sections. Generally, CenteringPregnancy is an effective model of preventive prenatal care for low-risk obstetric patients, incorporating the three components of prenatal care—risk assessment, education, and support—into one entity.[5]

This report explores whether CenteringPregnancy improves birthing outcomes at the usual margins—premature; low birth weight (LBW)—and more extreme margins—very premature; very low birth weight (VLBW)—for low- and high-risk obstetric patients. The magnitude of improvement in health outcomes and health care expenditures is potentially greater among the high-risk population. I use data collected from the Waco Family Health Center in central Texas to make generalizable claims about the efficacy of group prenatal care for low- and high-risk obstetric patients.

A substantial barrier to studying CenteringPregnancy as a treatment model for high-risk obstetric patients is that the observed characteristics distinguishing a high-risk patient from a low-risk patient may also correlate with birthing outcomes. The presence of numerous risk factors may correlate with worse health outcomes regardless of whether the treatment is applied. Comparatively, an evaluation of CenteringPregnancy for low-risk women would likely consist of treatment and control groups that are more similar in their distribution of observed characteristics. Simply comparing the health outcomes for high-risk CenteringPregnancy patients to a general population of CenteringPregnancy patients' outcomes may mislead the researcher to conclude the treatment correlates with a greater probability of adverse health outcomes than if it were not implemented. A study by Christine Piette Durrance and

Melanie Guldi encountered similar limitations when evaluating the efficacy of bed rest with maternal health and birthing outcomes.[6] However, matching methods can limit this fallacy, which this study seeks to implement.

When matching individuals based on observable factors, unobserved factors can bias the results. Factors include variables such as the patient's perspective of the treatment, nontraditional care received outside the clinic, and lifestyle differences. For example, additional care and a positive perception of the treatment might bias health outcomes favorably. Conversely, a poor lifestyle and a negative perception of the treatment could bias health outcomes adversely.

Furthermore, high-risk obstetric patients may continue to seek traditional prenatal care throughout their pregnancy, effectively obscuring the treatment's impact. In addition, because of variation in the time of assignment to a CenteringPregnancy group (the duration of the treatment is distributed discretely between zero and 10 sessions) and patient compliance with the program, the number of sessions attended varies. This could influence the magnitude of the treatment's effect on the outcome variables analyzed.

To address these issues, first I collect a sizable sample of observable characteristics including socioeconomic and demographic factors and health conditions that can influence birthing outcomes. However, the bias imposed on the calculations due to unobserved variables potentially remains. Second, this study controls for the number of prenatal visits in addition to the duration of treatment (the number of CenteringPregnancy sessions attended) to isolate the treatment's effect from other preventive interventions. Third, this study limits the sample of women analyzed to those with a high-risk designation as diagnosed by a trained medical provider. Because of CenteringPregnancy's relative novelty and the prevalence of traditional models of prenatal care, not all high-risk patients are assigned a CenteringPregnancy group. This difference in treatment assignment allows for the comparative study of the treatment to traditional forms of care. I employ matching techniques—namely, propensity score matching—to compare birthing outcomes among observationally similar women whose CenteringPregnancy participation varies.

In the next sections, I summarize general US pregnancy outcomes and group prenatal care, specifically CenteringPregnancy. I then describe this study's methods. Next, I examine and document the relationship between the observable characteristics and the likelihood that a woman is assigned to CenteringPregnancy. Then I present the regression results, examining the relationship between CenteringPregnancy participation and birth outcomes. I present the results of the matching techniques and compare these results with the regression outcomes. I conclude with back-of-the-envelope calculations on potential cost savings and discuss the implications of this study's findings.

Background on Pregnancy Health Outcomes

The following section discusses background information including health care statistics and risk factors that are relevant to current pregnancy health outcomes.

Health Care Statistics. The statistics reveal potentially worrisome trends regarding birthing outcomes—notably, an increased prevalence of adverse health outcomes in Texas, where the clinic used in this study (Waco Family Health Center) is located, compared to the nation's. In the United States in 2017, 9.93 percent of infants were born prematurely (before 37 weeks). This marks a 1 percent rise from 2016 and the third straight year of increases in this rate. (The rate was 9.57 percent in 2014.)[7] In the distribution, the percentage of infants born very prematurely (before 34 weeks) has remained unchanged at 2.76 percent between 2015 and 2017.

Furthermore, a rise in the percentage of infants born late preterm (34–36 weeks) caused the majority of the increase in the total preterm birth rate. The marked increase in preterm births between 2016 and 2017 nationwide is attributed to eight states, including

Texas. In the same period, 8.28 percent of infants were born with a LBW (less than 2,500 grams), an increase for the third year. Furthermore, similar to the trend in very premature births, the percentage of VLBW infants (less than 1,500 grams) remained at 1.41 percent between 2015 and 2017. These similar trends with gestational age (GA) and birth weight are not surprising and are logically correlated.

In 2017, the Texas Department of State Health Services issued a report that estimated a provisional preterm birth rate of 10.6 percent.[8] This indicates an increase from 10.2 percent in 2015 and is higher than the national average. Texas experienced an increase in the percentage of early preterm births (2.9 percent in 2017, up from 2.8 percent in 2015) and late preterm births (7.7 percent in 2017, up from 7.3 percent in 2015). The percentage of infants born with a LBW in Texas during the same period held constant at 8.4 percent. Data collected in 2014 in McLennan County, Texas—where Waco Family Health Center is located—show that 12.33 percent of infants were born prematurely and 10.86 percent were born with a LBW.[9] These reports reveal that Texas has a higher incidence of preterm and LBW deliveries compared to the national average, with McLennan County reporting even higher figures.

The second leading cause of infant death is short gestation and LBW. In 2014, the National Vital Statistics System reported a mortality rate of 104.6 per 100,000 live births for preterm and LBW infants.[10] Further, preterm birth is significantly related to adverse health outcomes. Preterm infants are more likely to require intensive care or respiratory support, and late preterm infants (those born relatively near full term) have a likelihood of mortality that is 12 times that of a term infant.[11]

According to an Institute of Medicine report, the estimated annual societal economic burden associated with US preterm birth was at least $26.2 billion in 2005, or $51,600 per infant born preterm.[12] More recent figures describing the costs in the United States are not identified; however, a 2014 study completed by Karissa M. Johnston et al. in Canada reported costs of $67,467 for early preterm infants, $52,796 for moderate preterm infants, and $10,010 for late preterm infants over the first 10 years of an infant's life.[13]

Given the large economic burden, interventions such as CenteringPregnancy, which minimize the percentage of preterm and LBW deliveries, can improve health outcomes and reduce expenditures. Further, CenteringPregnancy's relative efficacy can be measured by analyzing its effect on the prevalence of these discrete birthing outcomes, which is a goal of this study.

Risk Factors. Several high-risk factors, such as existing health conditions, maternal age, lifestyle, and complications during pregnancy, can adversely influence pregnancy outcomes by increasing the likelihood of a premature or LBW delivery. Because of each patient's unique health record, one or more risk factors do not automatically result in a high-risk pregnancy designation. Instead, a holistic evaluation by a trained health care provider is necessary for classification and, in turn, the delivery of effective prenatal care.

Further, high-risk factors can emerge even in healthy mothers. For example, multiple gestations increase the risk of infants born prematurely and are not a chronic health factor that is controlled for before pregnancy.[14] As a result, some high-risk conditions are not preventable. This study does not seek to evaluate CenteringPregnancy as a model of health care delivery capable of preventing these health conditions, but rather as a model capable of mitigating the adverse health outcomes associated with a high-risk designation.[15] Below is a brief review of the literature regarding high-risk conditions evaluated in this study.

Firstly, demographic and socioeconomic factors are associated with adverse health outcomes. For example, low and high maternal age (mothers younger than age 18 or older than age 35) are commonly considered covariates predictive of poor health outcomes—especially among first-time mothers.[16] Discrepancies exist in the literature concerning the correlation between teenage pregnancy and adverse health outcomes, with some studies finding a biological explanation, while other studies determine that cofounding variables are likely the cause. However,

the incidence of adverse perinatal outcomes does increase for patients over age 35 and is evaluated by the provider.[17]

Additionally, the incidence of preterm and LBW infants is higher among impoverished households. Studies indicate that women classified as being of a lower socioeconomic status tend to have an increased risk of adverse perinatal outcomes such as preterm birth and LBW.[18] Further, an analysis of ethnicity and racial differences in infant health outcomes reveals discrepancies. In 2006, non-Hispanic African American newborns were about twice as likely as non-Hispanic white and Hispanic infants were to have LBW or VLBW at delivery.[19]

The risk of infant death was similarly twice as high among these demographics, as indicated in data from 2004.[20] The *National Vital Statistics Report* from 2018 identifies a continual persistence of the disparity with non-Hispanic black infants experiencing adverse health outcomes at a similarly greater rate compared to non-Hispanic white infants.[21] This study does not have the depth to address the cause of this disparity, but my analysis may provide further insight on CenteringPregnancy's ability to improve health outcomes among non-Hispanic African American infants. Lastly, other demographic and economic variables included in this study include marital status and insurance coverage.

Social factors such as tobacco and drug use and alcohol consumption during pregnancy can contribute to fetal defects, premature birth, and LBW. One study found smoking tripled the risk of stillbirth or fetal death after 20 weeks of pregnancy.[22] Regarding alcohol consumption, the literature indicates minimal fetal exposure is associated with long-term developmental complications.[23]

Further, various chronic and acute health conditions can harm pregnancy outcomes and are considered when assigning a high-risk designation. (A reference chart used at the health center in this study is included in Table A1.) Chronic conditions such as diabetes heighten pregnancy risks in several ways. For example, the development of severe preeclampsia, an acute condition that leads to early preterm delivery, is common among women with diabetes.[24] Obesity because of complications that arise with severe preeclampsia also correlates with adverse health outcomes.[25] Furthermore, acute factors that arise can also designate a high-risk pregnancy and harm an infant's health. For example, physical abnormalities or conditions such as fetal anomalies, bacteriuria, gestational hypertension, gestational diabetes, and sexually transmitted infections (STIs) are listed as high-risk qualifiers.[26]

Moreover, psychological conditions such as depression and anxiety contribute to pregnancy complications and adverse health outcomes.[27] Additional health characteristics analyzed include a history of preterm or LBW deliveries and multiple gestation. Altogether, this study uses these covariates in the analysis comparing outcomes between individuals receiving CenteringPregnancy and those receiving traditional prenatal care.

CenteringPregnancy Background

The following section discusses relevant background information regarding CenteringPregnancy, including its adoption, its relation to low-risk patients, and policies affecting its application.

CenteringPregnancy Formation and Expansion. Prenatal care in the US has remained largely unchanged over the past century. This is despite the expanding goals of prenatal care, from solely preventing maternal and neonatal mortality to also including a more comprehensive concern for these morbidities.

In light of these expanded objectives, in 1989, the US Public Health Service Expert Panel on the Content of Prenatal Care summarized and formally outlined the goals of prenatal care.[28] It was traditional prenatal care's failure to meet these objectives that inspired the development of the CenteringPregnancy model of group prenatal care. Most notably, CenteringPregnancy allows for approximately 20 hours of prenatal care throughout the pregnancy, compared to the two hours total that is typical with the individual visit model. The idea was to create an economy of scale that allows more instructional time

for a broader range of pregnancy-related topics without affecting provider productivity during a typical prenatal appointment.

In practice, obstetrically low-risk women are grouped into cohorts of eight to 12 participants with a similar GA. These cohorts meet 10 times in place of traditional individual visits. During these meetings, women receive the usual physical assessment and then participate in discussions about a range of health-education topics as outlined by the Centering Healthcare Institute.

The 10 educational components developed throughout the program include early pregnancy concerns, adjustment to pregnancy, and fetal development; nutrition, lactation, and early infant care; exercise; substance abuse concerns; preparation for childbirth; infant feeding with an emphasis on breastfeeding; infant care; parenting techniques and self-esteem building; postpartum issues, including contraceptive methods and postpartum depression; and relationship issues, physical or sexual abuse, and communication.[29] The accredited provider is responsible for adhering to the educational guidelines outlined by the Centering Healthcare Institute, and the discussions are uniform nationwide where the program is implemented.

Each cohort is required to meet for 90 to 120 minutes, with the first 30 minutes reserved for physical assessments and the remainder spent in guided conversation. Conversation is ideally led by a provider and co-leader, often a nurse or certified midwife.

At the Waco Family Health Center, patients classified as both low- and high-risk are placed into CenteringPregnancy cohorts. Therefore, the distribution of patients is heterogeneous with ample numbers of low- and high-risk patients provided with the treatment. This allocation allows for further study into this treatment's efficacy for low- and high-risk patients, using patients receiving traditional prenatal care as a control. For high-risk patients, the literature has yet to reach an evidence-based conclusion, necessitating this inquiry.

CenteringPregnancy and Low-Risk Patients. When CenteringPregnancy was originally developed, the thought was to provide an alternative means of treatment for low-risk women.[30] The program's initial iterations sought to allocate resources in a cost-effective, economically productive manner. This model of care was thought to improve birthing outcomes for low-risk women, especially those coming from low socioeconomic backgrounds, by facilitating a conversation about essential prenatal educational objectives. Additionally, proponents of CenteringPregnancy stated that patient and provider satisfaction improved following CenteringPregnancy's implementation. Researchers have since presented evidence to substantiate these claims; however, a few studies found inconclusive results that necessitate further refined analysis.[31]

The literature generally agrees that CenteringPregnancy improves outcomes for low-risk women or, at minimum, has similar outcomes to traditional care models. Similar studies provide scarce evidence to indicate that high-risk women benefit from the treatment, but the scarcity of research warrants further analysis.[32] This study seeks to determine if implementing CenteringPregnancy treatment for high-risk patients will yield similar results and to affirm previous studies for low-risk patients.

The objective for implementing levels of maternal care is to reduce maternal morbidity and mortality by encouraging the provision of risk-appropriate care specific to maternal health needs.[33] Nonetheless, risk levels are not clearly defined. Due to lack of uniformity at the national level, risk assessment varies by provider, clinic, and state. This variation can result in difficulty distinguishing the two groups when implemented in practice. However, a good summary that is commonly used in the literature and practice is to define low-risk pregnancies as meeting the following criteria: singleton, term, and vertex, without other medical or surgical conditions.[34]

I include the recommended criteria used at the Waco Family Health Center to identify high-risk pregnancies in Table A1. Risk assessment is a time variable and subject to change throughout the pregnancy due to acute and unexpected factors. A failure to meet one of the aforementioned objectives could result in a current pregnancy being termed high-risk.

This study defines low- and high-risk as labeled by the provider: an exogenous decision made by the clinician independent of individual patient preference. I conduct this study in a single clinic system, which I predict will limit variability with provider designation.

Current Policy and Investment in CenteringPregnancy. Medicaid is the largest payer of maternity health benefits in the US, and inpatient costs associated with preterm births exceed $6 billion annually—representing half of all costs associated with infant births. Approximately one out of every 10 pregnancies results in a premature birth, placing the newborn at increased risk of death, medical complications, and lifelong health challenges.[35]

In this environment, the link between effective prenatal care and health care expenditures paid by Medicaid can be substantial. A better quality of care is easily associated with cost savings. Private insurers can also reap these savings. Despite the research indicating CenteringPregnancy has improved health outcomes and is ultimately a long-term positive investment (47 states have a group care code for billing purposes indicating, at minimum, the model's widespread acknowledgment), the upfront costs of implementing the program pose barriers to model adoption. These costs include increased investment in human capital required to staff the groups and costs associated with purchasing the necessary equipment, ensuring an appropriate meeting space, and obtaining accreditation from the Centering Healthcare Institute. As a result, incentives to invest in CenteringPregnancy, the upfront costs of which the health care facility incurs, are not directly connected with potential savings, which the insurer incurs.

A recent study, however, indicates that enhanced reimbursement, which increases expenditures in the short term, could decrease overall expenditures by improving health outcomes and thus reducing the prevalence of secondary interventions to treat more serious health concerns.[36] Further, such a policy would incentivize clinics to adopt this model by providing additional funds to cover the implementation cost. In August 2019, New Jersey became the first state to approve legislation allowing federally qualified health centers to bill Medicaid for group prenatal care services and receive an enhanced rate of an additional $30 for a CenteringPregnancy appointment.[37] While support for the treatment is growing—with some private insurers providing various levels of enhanced reimbursement and private organizations such as the March of Dimes providing startup grants—a lack of widespread recognition of the potential cost savings has hampered CenteringPregnancy's ability to propagate and become a common model of prenatal treatment.

The University of South Carolina completed an influential study in 2016 on the efficacy of CenteringPregnancy's cost savings. The study determined there was an average savings of $22,667 for each premature birth prevented by applying CenteringPregnancy treatment. In total, the state invested $1.7 million in the CenteringPregnancy program and estimated a net return of about $2.3 million. The study concluded that cost savings were achieved with better outcomes due to low-risk Medicaid beneficiaries participating in CenteringPregnancy.[38] However, this study reviewed costs only one year after delivery, which likely underestimated the costs, so the savings realized are likely larger than in the long term.

While this study will suffer from similar limitations, I seek to add to the literature regarding the cost savings of a similar investment in a high-risk patient population and hope to contribute to the growing conversation surrounding CenteringPregnancy's wider implementation.

Challenges. Specific challenges related to high-risk patients, such as an increased number of cofounding variables originating from health complications and additional treatments, make identifying the casual effect for the high-risk population more difficult. Nonetheless, applying econometric techniques can tease out the coefficient by employing matching methods to help eliminate bias. This will be the primary objective of the analysis.

Data and Methods

The following section describes and presents the methodology used in this study.

Data Collection. I gather data from the Waco Family Health Center—a community health clinic serving the central Texas region. I identify patients who participated in CenteringPregnancy using the center's physical medical records. I then manually extract relevant socioeconomic and health covariates from the electronic medical record system the clinic uses. I collect records for groups with expected delivery dates starting in 2014 through 2018, spanning the program's inception at the clinic through the most recent completed year when this study began.

I format a matched cohort of patients by retrospectively gathering a random sample of patients who received traditional prenatal care with expected deliveries between 2014 and 2018. I exclude patients who attended traditional prenatal-care appointments with CenteringPregnancy from the control group and place them in the treatment group with an additional control variable. This includes accounting for additional treatment. I then identify birthing outcomes, GA, and birth weight for each pregnancy recorded in days (GA) and ounces (birth weight) and include these variables in the dataset for further analysis.

Propensity Score Matching: Concept and Application. Donald Rubin developed propensity score matching in the mid-1970s to early 1980s, and it is commonly used in medical sciences and economic studies.[39] I use this method of analysis as the basis for my argument that assignment to a CenteringPregnancy group is not random but made on a collection of observable characteristics. These are used to calculate the propensity score—the probability of receiving treatment rather than assignment to the control. I denote $A = 1$ for assignment to the treatment group and $A = 0$ for assignment to the control. I then denote the propensity score for subject i by π_i as represented in the following equation:

$$\pi_i = P(A = 1|X_i)$$

The propensity score is a balancing score. Conditioning on the propensity score is conditioning on an allocation probability. Thus, if one looked only at the same propensity score, treatment and control distributions of covariates should be equal where:

$$P(X = x|\pi(X) = p, A = 1) = P(X = x|\pi(X) = p, A = 0)$$

If one matches on the propensity score, there should be balance between the treatment and control groups.

The propensity score method includes two assumptions: (1) the conditional independence assumption and (2) the common support assumption. The conditional independence assumption is also referred to as selection on observables. The assumption requires that all participants have a nonzero probability of assignment to either the treatment or control, that outcomes for each participant be independent of outcomes for any other participant, and that every initial difference between the treatment and control group (absent treatment effects) that might result in differences in the outcomes be accounted for—this being the key implication.[40] Common support simply requires that a positive probability of being both treated and untreated exists for each value of X. The common support assumption requires that sufficient overlap exists between the treatment and control groups to identify adequate matches. Both assumptions must be satisfied; however, only the common support assumption is testable through the review of histograms or summary statistics.

The propensity score method matches individuals who, based on observable factors, are predicted to have similar probabilities of being placed in the treatment group, even though those individuals differ with actual treatment assignment. If, conditional on covariates, two units have the same or similar probability of being treated, then they have similar propensity scores. I can then condition on this propensity score for further analysis. Because I argue that clinicians make CenteringPregnancy assignments mainly on observables, I assume that, when two units have the same or similar propensity score but differ in nonrandom assignment to the treatment and control

group, the difference in outcome is attributed to the treatment.

To implement propensity score matching, I must first fit a logistic regression to a list of covariates (X_i) and then determine the fitted value for each subject—that subject's specific propensity score. I use trimming to effectively remove units with propensity score values that do not overlap, to impose common support. This satisfies the balancing property, which seeks to make the control and treatment groups observationally similar on covariates. Thereafter, I employ a maximum likelihood model to estimate the conditional probability of treatment, and lastly, I estimate the standard errors.[41]

Correlates of CenteringPregnancy. I begin by examining the factors correlated with CenteringPregnancy assignment among all women included in the sample as described in the following equation:

$$(1)\ CenteringPregnancy_i = \beta_0 + \beta_1 X_i + \varepsilon_i$$

where i indexes the individual mother. The vector X_i contains covariates as suggested by prior literature and physician recommendation, including language, entry GA, maternal age, insurance status, marital status, gravidity, parity, median household income, and total number of high-risk qualifying conditions, along with dummy variables for African American race, anxiety, depression, multiple gestation, uterine anomaly, STI, bacteriuria, previous spontaneous abortion (SAB), previous LBW, previous preterm, obesity, maternal age, hypertension, diabetes, gestational diabetes, preeclampsia, insufficient prenatal care, previous or current maternal drug use (MDU), and previous or current smoking status.

Infant Health Outcomes. I then consider the effects of CenteringPregnancy on infant health outcomes, including GA and birth weight, using the data collected from electronic medical records at the Waco Family Health Center. I do not condition or limit the sample, but rather analyze the full sample, classifying by risk during the propensity score matching analysis.

I begin by performing a standard regression of CenteringPregnancy on infant health. I understand that selection bias could affect the outcome, as maternal health may correlate with treatment assignment and poorer infant health outcomes. However, a large sample of covariates serving as a proxy for maternal health may limit or exclude this concern, meaning standard regression analysis may provide reasonable estimates of CenteringPregnancy's effect on infant health. In this analysis, I include a broad set of covariates to minimize or eliminate this bias.

I first estimate the effect of CenteringPregnancy on infant health using a standard ordinary least squares regression of the following form:

$$(2)\ Y_{ilt} = \beta_0 + \beta_1\, CenteringPregnancy_{ilt} + \beta_2 X_{ilt} + \theta_l + \tau_t + \varepsilon_i$$

where i indexes the individual mother, l indexes the specific location (clinic) where treatment was administered, and t indexes the delivery year. The outcome variable, Y_{ilt}, represents one of four binary outcomes: very premature (less than 33 weeks), premature (less than 37 weeks), VLBW (less than 1,500 grams), and LBW (less than 2,500 grams). $CenteringPregnancy_{ilt}$ represents assignment to the treatment, which is determined with the intent-to-treat principle with no conditions imposed. The vector X_{ilt} contains covariates as described in Equation 1 and includes location and year fixed effects. Further, three regressions are performed, including only location and year fixed effects; maternal characteristics, location, and year fixed effects; and health conditions, maternal characteristics, location, and year fixed effects.

I then estimate CenteringPregnancy's effect on infant health using propensity score matching. I begin by predicting the likelihood of CenteringPregnancy assignment as a function of observable maternal characteristics according to a logit regression of the following form:

$$(3)\ Pr(CenteringPregnancy_i = 1 | X_i) = F(\beta_0 + \beta_1 X_i)$$

where the vector of covariates, (X_i), are those characteristics that are particularly important in treatment assignment and remain identical to those

in Equation 1. I then use estimates of this equation to develop propensity scores, which predict the probability of assignment to the treatment group. Further, assuming the conditional-independence assumption holds, conditioning on the propensity score allows treatment assignment to essentially be as effective as random assignment. This, in turn, theoretically secures an unbiased estimate of the treatment effect, by conditioning on the propensity score when considering the average treatment effect on the treated.

I then match individuals with similar treatment probabilities. I estimate the treatment effect using a regression similar to Equation 2, but in which the score computed in Equation 3 weights the observations. In the analysis, I use nearest-neighbor propensity score matching (with three nearest neighbors). Using Stata 16 software and the *teffects psmatch nneighbor(3)* command, I can calculate corrected standard errors via Alberto Abadie and Guido W. Imbens' adjustments.[42] This model yields an estimate of the average treatment effect on the treated, which is the expected causal effect of the treatment for individuals in the treatment group. This differs from the average treatment effect, which is the treatment effect for all individuals in a population. I determine the average treatment effect on the treated for the full sample and low- and high-risk populations. In addition to the estimated treatment effect, I also provide details on the propensity score estimation, establishment of common support, and bias reduction.

Results

The following section presents this study's findings, including ordinary least squares regression and propensity score matching results.

Descriptive Statistics. Table 1 depicts the summary statistics for the relevant covariates collected from the Waco Family Health Center's electronic medical records for the full sample and analyzed subpopulations. Columns 1–3 represent the full sample and traditional low- and high-risk groups. Columns 4 and 5 represent the CenteringPregnancy low- and high-risk groups, respectively. A few cells contain a value of zero, indicating no patients in that subpopulation presented with the condition or the outcome was not present. Given the low frequency of some of the conditions in the general population and the size of the sample, these missing values are logical.

Spanish-speaking individuals represented 33 percent and 37 percent of low- and high-risk CenteringPregnancy groups, respectively, versus 13 percent and 17 percent of low- and high-risk traditional prenatal care groups, respectively. This represents a twofold to threefold increase in representation in the treatment group versus the control.

The average CenteringPregnancy patient attended six sessions, with a control variable—accounting for any prenatal visits attended in addition to CenteringPregnancy sessions—indicating an average of four additional traditional visits per individual in the conditional columns.

Empirical Findings. Table B1 presents the correlates of CenteringPregnancy. The sample included in the table represents the full sample of patients, accounting for both low- and high-risk patients. The correlates of CenteringPregnancy indicate that Spanish-speaking mothers and entry GA significantly predict assignment to the treatment group. Additionally, current MDU positively correlates and is significantly predictive of assignment to the treatment group. The remaining variables do not appear to have any statistically significant predictive value regarding treatment assignment.

Ordinary Least Squares Regression. I estimate CenteringPregnancy's effects on infant health outcomes using ordinary least squares in Table 2.

I first estimate CenteringPregnancy's effect using an equation similar to Equation 2, but I control for only year and state fixed effects (Table 2, Panel A). The only statistically significant coefficient reveals a large, negative relationship between CenteringPregnancy and the probability of the LBW outcome. This indicates CenteringPregnancy correlates with a reduced probability of LBW. The remaining outcome variables have similar conclusions, including the rest of the

Table 1. Descriptive Statistics

	Unconditional on CenteringPregnancy			Conditional on CenteringPregnancy	
Variable	[1] Full Sample Mean	[2] Traditional Low-Risk Mean	[3] Traditional High-Risk Mean	[4] Centering-Pregnancy Low-Risk Mean	[5] Centering-Pregancy High-Risk Mean
N	814	145	69	388	212
Delivery GA	271.3	271.6	265.5	274.1	267.7
Delivery Weight	113.0	111.8	110.4	115.2	110.4
Healthy Delivery	0.8317	0.8414	0.6957	0.8814	0.7783
Very Preterm	0.0307	0.0414	0.0290	0.0206	0.0425
Preterm	0.0860	0.0414	0.2173	0.0541	0.1321
VLBW	0.0209	0.0276	0	0.0103	0.0425
LBW	0.0799	0.0483	0.2174	0.0515	0.1085
SAB	0.0246	0.0552	0.0435	0.0180	0.0094
Spanish Speaking	0.2900	0.1310	0.1739	0.3273	0.3679
Entry GA	94.10	103.6	97.93	93.55	87.41
Mother's Age	25.07	23.99	27.39	23.77	27.43
Insurance Status	0.7432	0.8276	0.7826	0.6985	0.7547
Marital Status	0.3636	0.2966	0.4638	0.3376	0.4245
Gravidity	2.850	2.807	3.913	2.397	3.363
Parity	1.373	1.386	2.014	1.046	1.755
Household Income	39,380	39,770	40,600	39,610	38,370
African American	0.2604	0.3034	0.2609	0.2448	0.2594
Anxiety	0.0897	0.0828	0.1884	0.0644	0.1085
Depression	0.1388	0.1172	0.1739	0.1186	0.1792
Multiple Gestation	0.0184	0.0069	0.0725	0.0026	0.0377
Uterine Anomaly	0.0332	0.0414	0.0580	0.0180	0.0472
STI	0.1708	0.1724	0.1884	0.1701	0.1651
Bacteriuria	0.3317	0.2828	0.2753	0.3608	0.3302
Previous SAB	0.2297	0.2276	0.4202	0.1727	0.2736
Previous LBW	0.0799	0.0828	0.2174	0.0258	0.1321
Previous Preterm	0.1302	0.1172	0.2609	0.0490	0.2453
Obesity	0.3759	0.2828	0.5072	0.3247	0.4906
Maternal Age	0.1572	0.1103	0.1884	0.1082	0.2689
Hypertension	0.0504	0.0207	0.1739	0.0129	0.0991
Preexisting Diabetes	0.0356	0	0.1449	0.0052	0.0802
Gestational Diabetes	0.0565	0.0138	0.1014	0.0077	0.1604
Preeclampsia	0.0135	0.0138	0.0290	0.0052	0.0236
Insufficient Prenatal Care	0.0454	0.0621	0.0580	0.0464	0.0283
Total High-Risk Conditions	2.770	2.517	3.812	2.276	3.509
Previous MDU	0.0086	0.0138	0	0.0052	0.0142
Current MDU	0.0799	0.1586	0.1014	0.0464	0.0802
Previous Smoker	0.1511	0.1724	0.1884	0.1211	0.1792

Continued on next page

Table 1. Descriptive Statistics (Continued)

	Unconditional on CenteringPregnancy			Conditional on CenteringPregnancy	
Variable	[1] Full Sample Mean	[2] Traditional Low-Risk Mean	[3] Traditional High-Risk Mean	[4] Centering-Pregnancy Low-Risk Mean	[5] Centering-Pregancy High-Risk Mean
Current Smoker	0.0921	0.0828	0.1884	0.0593	0.1274
Provider Designated High-Risk	0.3452	0	1	0	1

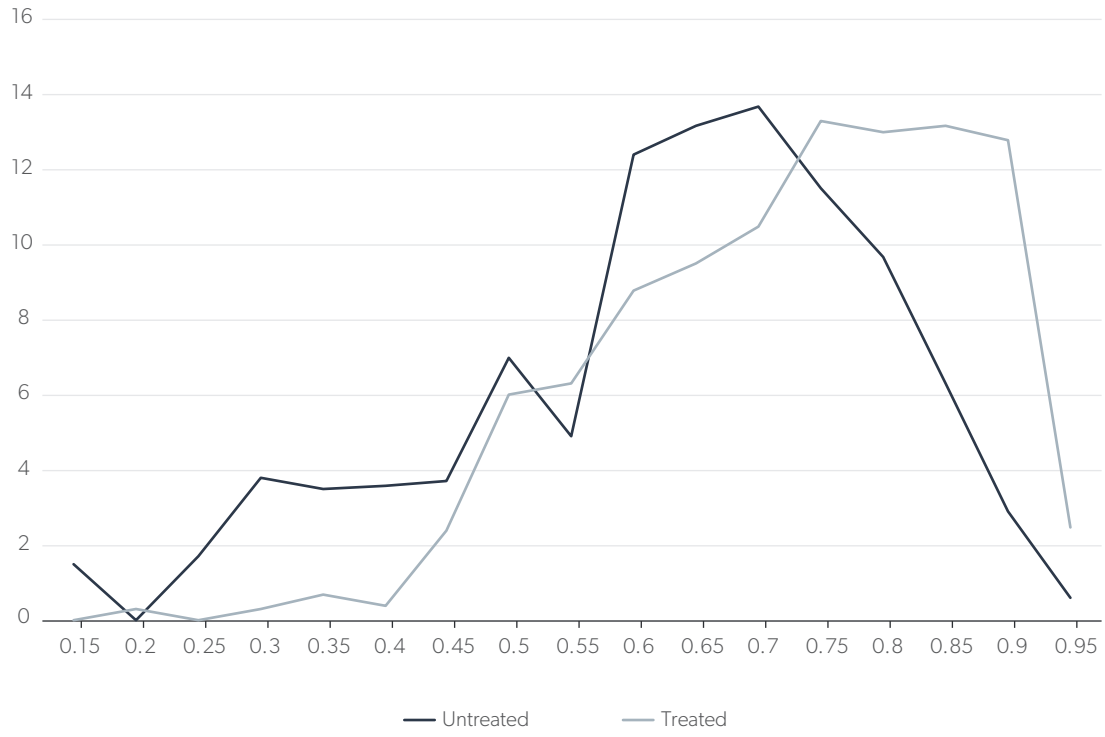
Note: This table includes observations from multiple clinics in the Waco Family Health Center system in Waco, Texas, spanning 2014 through 2018. Columns 1–3 represent the unconditional sample of all patients, low-risk, and high-risk, respectively. Columns 4 and 5 are conditional on CenteringPregnancy for low- and high-risk patients, respectively. Delivery GA is measured in days, and delivery weight is measured in ounces. A very preterm birth and a preterm birth are defined as delivery before 33 and 37 weeks, respectively. VLBW and LBW refer to a delivery weight below 53 and 88 ounces, respectively. SAB is spontaneous abortions. Deliveries that do not meet one of these criteria are classified as a healthy delivery—SAB excluded. Median household income is an estimated value in US dollars derived from the patient's ZIP code on record. MDU is maternal drug use. I calculate the total number of high-risk conditions by summing dummy variables for African American race, anxiety, depression, multiple gestation, uterine anomaly, STI, bacteriuria, previous SAB, previous LBW, previous preterm birth, obesity, maternal age (specifically younger than age 18 or older than age 35), hypertension, preexisting diabetes, gestational diabetes, preeclampsia, insufficient prenatal care, and low socioeconomic status (a dummy variable assigned to patients residing in the following ZIP codes: 76704, 76705, 76706, and 76707 by the Waco Family Health Center). For categories assigned a dummy variable, the number presented in the table represents the mean for each sample.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

Table 2. CenteringPregnancy's Effect on Infant Health Outcomes, by Ordinary Least Squares

	[1] Very Preterm	[2] Preterm	[3] VLBW	[4] LBW
Panel A. Location and Year Fixed Effects Only				
CenteringPregnancy	–0.0144	–0.0415	0.00962	–0.0607*
	(0.0175)	(0.0291)	(0.0148)	(0.0278)
Panel B. Demographic Variables, Location, and Year Fixed Effects				
CenteringPregnancy	–0.0182	–0.0215	0.0102	–0.0465
	(0.0178)	(0.0296)	(0.0151)	(0.0283)
Panel C. Demographic Variables, Pregnancy Problems, Location, and Year Fixed Effects				
CenteringPregnancy	–0.0117	–0.00777	0.0171	–0.0345
	(0.0177)	(0.0282)	(0.0148)	(0.0269)
N	814	814	814	814

Note: Standard errors are in parentheses. Coefficients are derived from an ordinary least squares model. Panel A includes location and year fixed effects only. Locations include 10 clinics in the Waco Family Health Center system, and year fixed effects range from 2014 through 2018. Panel B includes demographic variables including language, entry GA, mother's age, insurance status, marital status, gravidity, parity, median household income, and African American race. Panel C includes pregnancy problems including anxiety, depression, multiple gestation, uterine anomaly, STI, bacteriuria, previous SAB, previous LBW, previous preterm birth, obesity, maternal age, hypertension, diabetes, gestational diabetes, preeclampsia, insufficient prenatal care, number of high-risk qualifying conditions, previous MDU, current MDU, previous smoker, and current smoker. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

Figure 1. Propensity Score Distribution



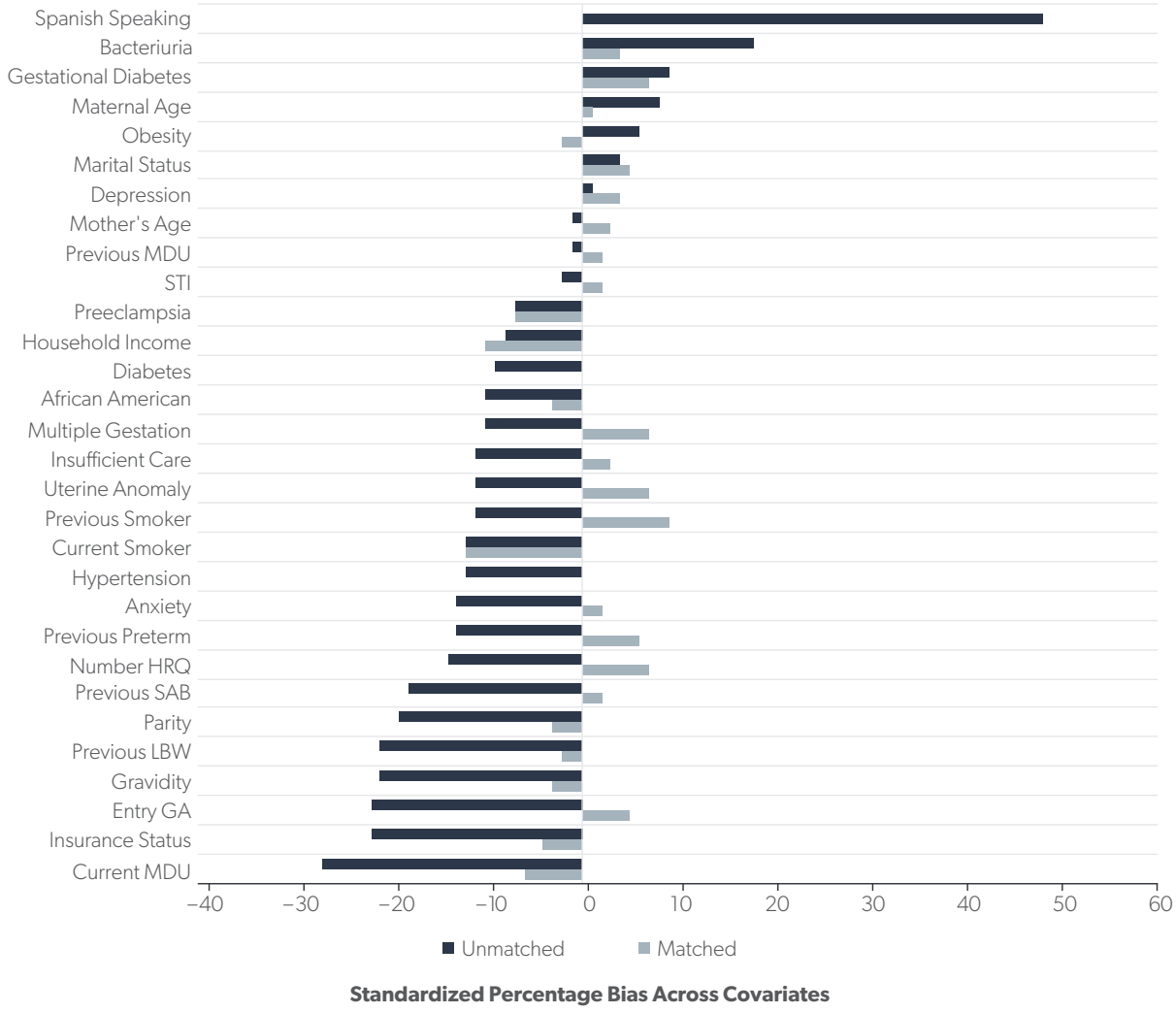
Note: Propensity scores are calculated using the Stata 16 *pscore* function.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

LBW, very preterm, and preterm columns, although the analysis does not yield sufficiently significant coefficients for these columns. Conversely, the coefficients for VLBW are smaller and positive, although these are also not statistically significant. The addition of demographic and pregnancy problems does not appear to reduce bias as theory might suggest, and the ability of these variables to control for bias in practice remains unclear in the sample. Notably, a lack of VLBW infants born to high-risk mothers in the control group also likely influences the statistical outcomes for the VLBW column.

Matching. In this section, I use propensity score nearest-neighbor matching to attempt to construct a causal estimate of CenteringPregnancy's effect on birthing outcomes. Table B2 shows the results of the logit model predicting CenteringPregnancy, which is the foundational step for the propensity score estimation. The variables included are identical to the ones analyzed in the correlates of CenteringPregnancy analysis. Similar to the correlates of CenteringPregnancy, the variables for Spanish speaking, entry GA, and current MDU are significantly predictive of treatment assignment. The dummy variable for Spanish speaking is substantial and positive, indicating a high probability of selection into a CenteringPregnancy group. The variable for entry GA is small and negative, but since the units are in days, a sizable increase in the entry GA predicts a sizable decreased probability of CenteringPregnancy group assignment. The dummy variable for current MDU has a similar trend; however, the coefficient is much larger.

Figure 1 displays the values of the estimated propensity scores for the treatment and control groups, indicating a high degree of common support. To remove scores that did not match and fully impose

Figure 2. Bias Reduction from Propensity Score Matching



Note: Bias reduction via propensity score matching is calculated using the Stata 16 *pstest* function. Propensity scores are calculated for analysis using the Stata 16 *teffects psmatch* due to the enhanced standard error calculation (Abadie-Imbens adjusted standard errors). HRQ is high-risk qualifying conditions.

Source: Author's calculations generated in Stata 16 software from the study's dataset.

common support, I trimmed the data and dropped propensity scores of less than 0.3 from the analysis. Figure 2 shows the reduction in bias via propensity score matching by comparing the matched and unmatched samples. Matching greatly reduces selection bias—although it is not entirely eliminated from the sample. Nonetheless, the vast reduction in bias improves confidence in my interpretation of the results.

Table 3, Panel A displays the results for infant health outcomes using nearest-neighbor propensity score matching. Data trimming removes five patients, leaving a full sample of 809 patients. The coefficients measure the average treatment effect on the treated for all three panels. The low- and high-risk subgroups are subsets of the full sample and determined by provider classification. For Panels A and B—the full and low-risk sample—no statistically

Table 3. CenteringPregnancy's Effect on Infant Health Outcomes by Risk

	[1] Very Preterm	[2] Preterm	[3] VLBW	[4] LBW
Panel A. Full Sample				
CenteringPregnancy	0.00779	0.0134	0.0100	0.0100
	(0.00927)	(0.0202)	(0.00846)	(0.00846)
N	809	809	809	809
Panel B. Low-Risk Sample				
CenteringPregnancy	0.00601	0.0137	0.00344	0.00344
	(0.0109)	(0.0176)	(0.00631)	(0.00631)
N	532	532	532	532
Panel C. High-Risk Sample				
CenteringPregnancy	0.0269	–0.0474	0.0427**	–0.0585
	(0.0166)	(0.0534)	(0.0136)	(0.0428)
N	277	277	277	277

Note: Abadie-Imbens adjusted standard errors are in parentheses. This sample uses all patients except five, whose predicted propensity scores were trimmed from the sample before matching analysis; in Panels B and C, the remaining full sample is divided by risk classification. The coefficients represent the average treatment effect for very preterm, preterm, VLBW, and LBW infant health outcomes. The *X* vector includes the same list of covariates used in Equation 1. Panel A represents the full sample, Panel B represents the low-risk proportion of the full sample, and Panel C represents the high-risk proportion of the full sample. I use Stata 16 and the *teffects psmatch* command for nearest-neighbor matching, employing three nearest neighbors. The treatment model uses a logit model. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

significant coefficients can be identified. For Panel C—the high-risk sample—the VLBW coefficient is large and positive, indicating an increase in adverse health outcomes following treatment. The remaining outcome variables fail to present statistically significant coefficients. Comparing these results with the ordinary least squares regressions in Table 2, I fail to identify a result that is consistent with a reduction in bias. The majority of the estimated coefficients are not statistically significant, and I fail to identify a common trend regarding the treatment's effect.

Back-of-the-Envelope Calculations

In the following section, I employ readily available information regarding expenditures to develop back-of-the-envelope calculations to measure the potential cost savings of implementing CenteringPregnancy to the extent that can be determined by this study and from the literature. Cost savings are defined in terms of decreased insurance expenditures, but costs may be incurred by both the health care facility and third-party payers. These calculations rely on a series of assumptions, elaborated below, and should be reviewed with these limitations in mind.

I analyze the cost-saving potential for low-risk and then high-risk obstetric patients under two conditions: (1) a marked increase in VLBW deliveries and (2) no significant change in birthing outcomes. The first calculation for high-risk patients appropriately matches the results in this report; however, concerns regarding the internal validity given the limited control sample warrant the second calculation, which would align with the hypothesis. I then elaborate on the costs—notably, the initial investment in the human capital necessary to operate a CenteringPregnancy program and the additional health care expenditures from mothers seeking additional traditional care on top of group prenatal treatment. All prices are converted to their 2020 dollar

value using the consumer price index provided by the US Bureau of Labor Statistics.

This study assumes immediate expenditures of $77,052.45 for preterm infants less than 1,500 grams and $38,305.23 for preterm infants between 1,500 and 2,500 grams.[43] I analyze these outcomes together because of the direct correlation between preterm birth and LBW. Further, Danielle T. Barradas et al. indicate no significant difference exists between Medicaid and commercial insurance in length of hospital stay or hospital costs. I use the results of this analysis to examine health care expenditures generally.[44] Rudimentary cost-savings analysis are performed in nominal terms, taking into account sample size and estimated improvements in delivery GA and birth weight.

This study identifies no significant difference in outcome measures for low-risk patients who participate in CenteringPregnancy. However, CenteringPregnancy implementation could reduce expenditures in a group setting. A recent study by Mika Ohno et al. identified a margin of $1,514.83 saved per patient receiving CenteringPregnancy treatment on average.[45] Further, the CenteringPregnancy model remains cost-effective as long as the prenatal care received does not exceed $6,908.36. If these numbers hold for my sample, the Waco Family Health Center would save $587,754.04 (without considering the initial capital investments), assuming no increase in adverse health outcomes for low-risk patients. Notably, the number of CenteringPregnancy patients in a particular group would affect total expenditures.

Regarding the high-risk patient population, a similar analysis using the numbers described above would result in $321,143.96 in savings, assuming no significant outcome in infant health characteristics. However, my analysis identified an uptick in the percentage of VLBW infants in the treatment group, indicating an adverse outcome may correlate with treatment reception. More studies are necessary to validate this claim, given the largely inconclusive nature of this study. Health care costs significantly increase among infants in the VLBW category. In turn, insurers would lose $697,509.60—nearly double CenteringPregnancy's potential savings for high-risk patients receiving the treatment. This might indicate CenteringPregnancy is not an effective model of care for high-risk patients regarding health outcomes or financial investment.

While the above analysis focuses on discrete birthing outcomes and their corresponding economic impact, a wide range of other benefits that might result in long-term gains are unrealized in this inquiry. For example, some studies indicate that CenteringPregnancy correlates with increased patient and provider satisfaction and patients' improved understanding of key infant care objectives such as family planning, postpartum depression, and early childrearing.[46] This increased knowledge can potentially correlate with a decrease in hospital attendance during pregnancy, contributing to even greater cost savings.

Further, breastfeeding increased among CenteringPregnancy participants, which provides short- and long-term health, economic, and environmental advantages to children, women, and society.[47] Additionally, group care helps the adolescent population via adolescent-specific groups. In conjunction, group care models benefit women with diabetes, and it is hypothesized that women with diabetes in group prenatal care benefit similarly. Anecdotal evidence from observational studies identifies improved hemoglobin A1c levels and notes mothers less often progressed to a stage in their pregnancy that required insulin, although further research is warranted.[48] The positive externalities for implementing CenteringPregnancy are numerous, warrant further study, and should be considered in a more thorough cost analysis.

In evaluating CenteringPregnancy's cost-effectiveness, the initial investments in human capital should be included in any rough estimation. This includes investments in provider training, securing a meeting location, and acquiring the appropriate materials and licensing from the Centering Healthcare Institute. The Centering Healthcare Institute website indicates an $8,000 annual CenteringPregnancy licensing fee and a $2,000 training course. Securing a meeting space can be difficult for some clinics, and continued financial support for meeting supplies and investments in data collection are difficult to provide without enhanced reimbursement.[49]

Further, many patients in the treatment group in this analysis were receiving additional prenatal care in a traditional format. For insurers, this carries an additional cost. Participants receiving CenteringPregnancy attended, on average, four additional traditional prenatal appointments, which would reduce the cost-savings margin or potentially eliminate it altogether. This analysis uses an intent-to-treat principle: Some patients may have begun CenteringPregnancy treatment and then transitioned to traditional care. Thus, the description of four additional appointments represents an upper bound, with the true value likely lower.

Overall, this analysis indicates that CenteringPregnancy may be a cost-effective prenatal care model for low-risk patients regardless of any significant difference in infant health outcomes. However, the treatment's cost-effective nature for high-risk patients is unclear. Further studies are needed to analyze this aspect accurately.

Conclusion

Infant health is crucial to a lifetime of human capital production and is associated with adequate prenatal care. Further, inadequate prenatal care can harm an individual's health and well-being in the short- and long-term. Two outcome variables used in this study to analyze immediate infant health outcomes following pregnancy include birth weight and GA, which are associated with various adverse health outcomes if they do not meet normal standards. While interventions can mitigate these effects during childhood, preventive interventions given before birth can improve health outcomes and reduce health care expenditures. In this report, I analyze a relatively novel preventive intervention implemented before birth: group prenatal care, specifically CenteringPregnancy.

CenteringPregnancy is the most widely studied and employed version of prenatal care. It provides prenatal care in a group setting for a small cohort of women to improve health outcomes and reduce health care expenditures. While most of the literature identifies some benefit from CenteringPregnancy for low-risk women—for whom the treatment was initially designed—some studies have identified inconclusive outcomes. Few studies have expanded this analysis to investigate CenteringPregnancy's efficacy for high-risk patients with promising results. This study uses patient electronic medical records from the Waco Family Health Center and a wide range of covariates to identify if CenteringPregnancy is an effective form of treatment for both low- and high-risk patients.

My estimates depend on the ability to control for the types of observable characteristics that physicians use to assign a patient to CenteringPregnancy. This study includes a wide range of individual-level characteristics and health problems. Notably, a similar study analyzing infant health shows that the inclusion of health problems controls for the majority of bias.[50] However, in my analysis, ordinary least squares regressions and propensity score matching failed to demonstrate a similar outcome regarding the treatment's effect. This result indicates that no apparent causal effect can be shown from this study.

The one statistically significant correlation regarding the high-risk patient population is in the VLBW outcome variable (less than 1,500 grams). The coefficient is large and positive, indicating increases in this adverse outcome. However, I cannot identify a causal effect because of the analysis' inconclusive nature in this study.

Notably, one of this study's greatest challenges is its sample size. With data indicating only 1.41 percent of infants born in the United States were VLBW in 2017 and my sample consisting of only 814 patients, significant variability regarding the distribution of these patients could significantly alter the matching outcomes.[51] The unconditional high-risk control group consists of only 69 patients, and no infant outcomes with VLBW are identified. This group is matched to the conditional high-risk group, which likely results in the positive figures and thus lacks validity.

The ordinary least squares regressions indicate CenteringPregnancy might reduce LBW outcomes but are significant accounting for only location and

year fixed effects, not demographic and health characteristics, which should theoretically reduce bias. Further, the most significant covariable predictive of CenteringPregnancy is the dummy variable for Spanish-speaking individuals. The Waco Family Health Center conducts CenteringPregnancy groups for Spanish-speaking individuals specifically, who compose a significant proportion of the local population, and this may bias the result upward.

Despite this study's inconclusive results, this report does support other studies that indicate CenteringPregnancy results in no harm for its intended low-risk patient population.[52] The lack of significant adverse findings illustrates that no glaring adverse outcome is associated with the treatment among this population. Further, the American College of Obstetricians and Gynecologists' review of the literature indicates higher patient and provider satisfaction, enhanced patient education, and that patients in a CenteringPregnancy group feel more ready for labor and delivery.[53]

Altogether, CenteringPregnancy's implementation is warranted and may have numerous benefits beyond what this study analyzes. Implementing economies of scale for low-risk patients decreases health care expenditures while not statistically decreasing outcomes. Regarding high-risk patients, further studies are necessary to identify CenteringPregnancy's causal effect, as the results of this study are inconclusive—despite the statistically significant finding—due to concerns regarding the control group's inability to effectively control for bias. Further studies might expand the sample size, especially regarding the control, to reduce bias, properly analyze relatively rare birthing outcomes, and determine the causal effect.

Acknowledgments

A special thank you to James Henderson, who was a great support throughout this project. Additionally, I would like to thank all those who read this report and offered their feedback and the Waco Family Health Center for generously welcoming me. Any remaining errors are my own.

Appendix A

Table A1. High-Risk Obstetrics Referral Guidelines

Category 2 Refer to high-risk obstetrician for consultation and to assume care if appropriate.	**Category 3** Consult with available high-risk obstetrician if desired by provider or patient.
Consult at time of diagnosis • All twins (mono-mono, mono-di, and di-di) • Chronic hypertension—with poor control • Preexisting diabetes—type 1 diabetes or type 2 AODM • Gestational diabetes—A2 with poor control • Seizure disorder • HIV • Asthma—poorly controlled • History of cerebrovascular accident • Systemic lupus erythematosus • History of third-trimester IUFD • History suggestive of incompetent cervix • Prior CHF history or cardiomyopathy with current normal EF • History of cancer less than five years • Placenta previa—diagnosed or persisting after 28+0 • History of thrombophilia or thromboembolic event • Breech at more than 34 weeks • Sickle cell disease	History of prior C-section. Patient desires TOLAC and is determined to be an appropriate candidate, and STFM VBAC calculator is greater than 60 percent. • Chronic hypertension—with satisfactory control • Gestational diabetes—with satisfactory control • Advanced maternal age • History of preterm labor • History of premature rupture of membranes • Thyroid disease • Asthma—well controlled • History of cancer greater than five years
Consult may be obtained by telephone with WFHC attending to expedite appropriate care a. IUGR b. Oligohydramnios c. Macrosomia	
History of previous C-section (refer at 34 weeks) • Desires repeat C/S • Desires TOLAC (STFM VBAC calculator less than 60 percent)	

Note: Category 1—maternal fetal medicine referral guidelines—is excluded. Further, the Waco Family Health Center states, "The following is presented to provide guidance in the management of high-risk OB patients and is not intended to constitute Waco Family Health Center policy. For each patient and condition, varying degrees of morbidity and medical complexity may result in an individual patient appropriately receiving care in a lower or higher level than outlined below. Likewise, provider training and experience vary and may appropriately result in an individual patient receiving care in lower or higher level of care than outlined below. Residents are encouraged to follow the guidelines as presented unless there is attending approval documented in the chart." Waco Family Health

Continued on next page

Table A1. High-Risk Obstetrics Referral Guidelines (Continued)

Center, "High-Risk Obstetrics Referral Guidelines." "Mono-mono" is an abbreviation for a monochorionic, monoamniotic pregnancy; "mono-di" is an abbreviation for a monochorionic, diamniotic pregnancy; "di-di" is an abbreviation for a dichorionic, diamniotic pregnancy. The numbers 28+0 refer to a pregnancy at 28 weeks and zero days gestational age. AODM is adult-onset diabetes mellitus. IUFD is intrauterine fetal death. CHF is congestive heart failure. EF is ejection fraction. WFHC is Waco Family Health Center. IUGR is intrauterine growth restriction. C/S is cesarean section. TOLAC is trial of labor after cesarean section. STFM VBAC is Society for Maternal-Fetal Medicine vaginal birth after cesarean.
Source: Waco Family Health Center, "High-Risk Obstetrics Referral Guidelines."

Appendix B

Table B1. Correlates of CenteringPregnancy

	Treatment
Spanish Speaking	0.213***
	(0.0423)
Entry GA	–0.00112**
	(0.000365)
Mother's Age	–0.00297
	(0.00366)
Insurance Status	–0.0587
	(0.0350)
Marital Status	–0.0595
	(0.0364)
Gravidity	0.0174
	(0.0243)
Parity	–0.0398
	(0.0274)
Household Income	–0.00000167
	(0.00000160)
African American	0.0518
	(0.0523)
Anxiety	–0.0960
	(0.0663)
Depression	0.0828
	(0.0592)
Multiple Gestation	–0.128
	(0.118)
Uterine Anomaly	–0.0381
	(0.0902)
STI	–0.0214
	(0.0545)
Bacteriuria	0.0491
	(0.0470)
Previous SAB	–0.0673
	(0.0574)
Previous LBW	–0.131
	(0.0746)
Previous Preterm	0.0678
	(0.0649)
Obesity	0.0628
	(0.0455)
Maternal Age	0.0517
	(0.0554)
Hypertension	–0.0596
	(0.0797)
Diabetes	–0.0609
	(0.0919)
Gestational Diabetes	0.0706
	(0.0759)
Preeclampsia	0.00880
	(0.135)
Insufficient Care	–0.0126
	(0.0825)
Number HRQ	–0.0129
	(0.0338)
Previous MDU	0.0577
	(0.166)
Current MDU	–0.170**
	(0.0583)
Previous Smoker	0.0116
	(0.0444)
Current Smoker	0.00565
	(0.0567)
Constant	0.999***
	(0.119)
N	814

Note: Standard errors are in parentheses. HRQ is high-risk qualifying conditions. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

Table B2. Propensity Score Logit Model

	Treatment
Spanish Speaking	1.351***
	(0.267)
Entry GA	–0.00604**
	(0.00199)
Mother's Age	–0.0172
	(0.0208)
Insurance Status	–0.380
	(0.213)
Marital Status	–0.352
	(0.209)
Gravidity	0.0801
	(0.132)
Parity	–0.199
	(0.148)
Household Income	–0.00000825
	(0.00000870)
African American	0.256
	(0.287)
Anxiety	–0.538
	(0.361)
Depression	0.486
	(0.340)
Multiple Gestation	–0.608
	(0.621)
Uterine Anomaly	–0.160
	(0.478)
STI	–0.123
	(0.305)
Bacteriuria	0.259
	(0.270)
Previous SAB	–0.348
	(0.317)
Previous LBW	–0.684
	(0.404)
Previous Preterm	0.388
	(0.364)
Obesity	0.376
	(0.261)
Maternal Age	0.266
	(0.321)
Hypertension	–0.297
	(0.426)
Diabetes	–0.372
	(0.489)
Gestational Diabetes	0.428
	(0.464)
Preeclampsia	0.0646
	(0.709)
Insufficient Care	–0.0475
	(0.441)
Number HRQ	–0.0659
	(0.190)
Previous MDU	0.324
	(0.913)
Current MDU	–0.792**
	(0.294)
Previous Smoker	0.0782
	(0.246)
Current Smoker	0.0408
	(0.305)
Constant	2.560***
	(0.673)
N	814

Note: Standard errors are in parentheses. HRQ is high-risk qualifying conditions. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
Source: Author's calculations generated in Stata 16 software from the study's dataset.

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