ABSTRACT

The Effect of Family Functioning on Birthweight:
A Prospective Cohort Study

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A variety of factors influence how the infant grows while in the womb. This NIH-funded prospective cohort study followed 1,206 mother-infant pairs from their first prenatal care visit to delivery. The focus was on the impact of one psychosocial factor, family functioning, on infant birthweight. The hypothesis was that family dysfunction would lead to infants that weighed less, on average, at delivery, than infants born to women from functional families. After a basic linear regression model was built that included the major known determinants of infant birthweight – length of gestation, sex of the infant, parity, maternal height, maternal weight, ethnicity, smoking status, and gestational weight gain – with an adjusted $r^2 = 0.5562$, the family functioning variable was added. The study found that family functioning was not associated with infant birthweight, with the incremental adjusted $r^2 = -0.0071$ (p-value = 0.6870) for the family functioning variable.

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THE EFFECT OF FAMILY FUNCTIONING ON BIRTHWEIGHT: A PROSPECTIVE COHORT STUDY

A Thesis Submitted to the Faculty of
Baylor University
In Partial Fulfillment of the Requirements for the
Honors Program

By

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CHAPTER ONE

Introduction

Bringing a child into the world is a difficult and complex process. Not only do maternal characteristics affect the growth of a fetus, but also the environment plays an important role in the growth of a fetus in the mother's womb. For over 40 years, attempts to quantify how much certain factors impact fetal growth have taken place. This study is an attempt to contribute further to the scientific understanding of fetal growth by specifically looking at ways that family dysfunction negatively impacts infant birthweight.

Maternal Factors

Many characteristics of the expecting mother have been identified as having an impact on the outcome of her pregnancy. The maternal factors that have been ascertained can fall into three general categories: biochemical factors, anthropometric issues, and the social environment.

Biochemical factors range from the hormonal make up of the mother at any given time to the additional nutritional supplements taken during pregnancy. Extreme values of these determinants have been shown to harm the growing fetus - which is itself a sensitive chemical system. An example is the increased chance of neural tube defects in infants whose mother lacked proper levels of folic acid at the beginning of pregnancy (Honein 2001). This underscores the sensitivity of the fetus during pregnancy, since an increase of 400 μg of folic acid has been shown to reduce neural tube defects (Honein 2001).

Maternal anthropometric factors include maternal height, weight, and fat distribution. A shorter mother is more likely to have a smaller pelvic girdle, which may impact how large the fetus is able to grow during pregnancy. A mother's pre-pregnancy weight can also impact the growth of the infant; for example, women who are underweight have an increased risk for delivering low birth weight infants (Han 2011).

The social environment plays an important role in pregnancy and its outcome; such factors include maternal stress in the workplace and in the family, and ways the family members interact as a social unit. Socioeconomic status has been demonstrated to impact pregnancy via utilization of prenatal care (Daniels 2006). In this way, the social environment plays a pivotal role in the whole process of pregnancy beyond just the biological processes taking place within the mother.

In this study, a close look at family functioning, a measurement of how the family operates as a unit, will provide potential insight into ways the family environment impacts the development of the fetus during pregnancy. Previous studies (Ramsey 1986, Abell 1991) have shown the negative impact of family dysfunction on infant birthweight; however, there are many types of family dysfunction (Olson 1976), and a study comparing these different types has not been performed.

Infant Outcomes

Three outcomes pertinent to the field of fetal growth are gestational age, prematurity, and low birthweight. These are all concepts that deal with pregnancy outcome, and are measured (or estimated, in the case of gestational age) after the infant is born.

Gestational age is the length of time (usually presented in weeks) of the pregnancy. Though commonly thought of as 9 months, a more accurate estimate of an average gestational time is 39 weeks (Mittendorf et al. 1990). It is very difficult, however, to determine the precise gestational age of a newborn infant. Estimates are made using several approaches to measurement. These estimates include counting from the last menstrual cycle before becoming pregnant and testing the newborn for a variety of neurological signs that correlate with gestational age (Dubowitz 1970). Gestational age ultimately provides a benchmark by which to ascertain if the infant is large or small for its time since conception. A fetus, on average, will continue to grow until approximately 39 weeks (3 trimesters of 13 weeks each). A plateau, and even a slight decrease, in fetal size tends to occur if it stays in the womb after 39 weeks.

An infant is designated premature if it is born before 37 weeks of gestation (CDC Vital Statistics 2010). It is important to stress that prematurity is very difficult to predict and is reflected in the degree of success previous studies have had when attributing various factors to the onset of premature labor. In 2010, the percentage of infants born before 37 weeks was 11.99% (CDC Vital Statistics 2010). Prematurity has been linked to numerous negative health outcomes later in life including high blood pressure and coronary artery disease (Barker 1999), so the importance of reducing the percentage of prematurity is a high priority.

Birthweight is the amount an infant weighs (usually expressed in grams) at birth. Typically, this measurement is made immediately following delivery. The average birthweight in the U.S. for deliveries at 37 – 41 weeks was 3,441g in 1990 and 3,389g in 2005 (Donahue et al. 2010). The term "low birthweight" is reserved for infants that weigh less than or equal to 2500g at birth. The percentage of low birthweight (LBW) infants born in 2010 was 8.15% (CDC Vital Statistics 2010). LBW has been linked to future negative health outcomes such as diabetes, obesity, asthma, as well as cognitive problems (Barker 1998).

Relevance

The cumulative incidence of LBW infants in the United States in 2010 of 8.15% was an increase from the percentage of LBW infants born in 1990 of 6.96% (CDC Vital Statistics 2010). There was a similar increase in the percentage of premature deliveries in the US (11.99% in 2010 versus 10.5% in 1990). The increase in LBW infants can be explained in part by the increase in prematurity, since premature babies are smaller, on average, than full term infants. Yet an increase in both prematurity and low birth weight only adds immediacy to fetal growth studies, given that poor fetal growth and development have strong negative repercussions later in life. This study's goal is to contribute to the body of knowledge in the field by investigating the potential impact of family functioning on infant birthweight.

CHAPTER TWO

Review of the Literature

Infant low birthweight (LBW) is one of the main determinants of neonate morbidity and mortality during the first year of life (McIntire 1999). LBW is also linked to developmental problems ranging from behavioral problems to cardiovascular disease (Barker 1998). The cumulative incidence of LBW in the United States in 1990 was 6.960% and in 2010 was 8.15% (CDC Vital Statistics 2010).

A comprehensive review of the literature shows pregnancy to be a complex biopsychosocial undertaking for the expecting mother, with an impressive array of variables that impact the growing fetus. Kramer (1987), in a systematic review of what might be impacting birth weight, arrived at 43 factors that needed to be assessed. These variables can be divided into seven main divisions: genetic and constitutional factors, demographic and psychosocial factors, obstetric factors, nutritional factors, maternal morbidity during pregnancy, toxic exposures, and prenatal care (Kramer 1987). Kramer provides a good frame of possible measureable factors that impact fetal development, but the list is by no means exhaustive.

The first factor that needs to be addressed is the impact of gestational age on birthweight. The longer the fetus stays in the womb, the more it will tend to grow. Alexander et al. (1996) stressed the importance of the latter weeks of gestation (33 to 38 weeks) in fetal development.

Constitutional factors, studies have routinely shown, impact the growth of the fetus. Constitutional factors include the sex of the infant (Ingemarsson 2003), ethnicity (Zhang 1995, Bryant et al. 2010), maternal height, and maternal prepregnancy weight (Han et al. 2011).

The sex of the fetus is an important genetic component in the development of the fetus. Ingemarsson (2003) showed that the male fetus must grow at a rate faster than females. Thus, the sex of the infant must be considered when performing a large cohort study, as seen in Zhang (1995). Males have been more likely to spontaneously abort than females, yet the incidence of preterm deliveries between the sexes has been similar. However, males have a higher incidence of neonate mortality and mortality within the first year of life than females (Zhang 1995). The males have to grow more than females (as seen in their higher birthweights) in the same amount of time.

Demographic factors also play a role. Maternal age is a factor associated with pregnancy outcome. Although Bianco et al. (1996) found an increase in maternal morbidity associated with age, pregnancy outcome was not affected specifically by maternal age. Socioeconomic status (SES) is an important variable in fetal growth studies because it can encapsulate many modifiers and confounders that each impact pregnancy outcome (Orr et al.

1996, Luo et al. 2006, Lobel et al. 1992). More often than not, the effect of lower SES is one of a barrier to prenatal health care (Kugler 1993, Daniels et al. 2006, Gonzalez-Calvo et al. 1998). Parity is also an important known determinant in low birthweight, particularly in the issue of pregnancy interval (Zhang and Bowes 1995, Shults et al. 1999). Zhang and Bowes 1995 found that primiparous women had infants that weighed on average 80g less than the infants delivered by multiparous women. Shults et al. 1999 found that women who spaced their pregnancies 0-3 months after their previous delivery were more likely to deliver LBW infants than women who waited 13-24 months (OR=1.6, CI:1.4-1.8).

Smoking is a known determinant of neonatal morbidity and mortality (Butler et al. 1972). Not only is there a dose-response relationship between number of cigarettes smoked and lower birthweight (Ekard et al. 1996), but also smoking during pregnancy has been shown to increase maternal morbidity (Cnattiingius et al. 1993). Smoking also impacts what nutrients reach the fetus (Haste et al. 1991). Although smoking is linked with other known determinants of adverse pregnancy outcome, smoking is largely preventable (Paarlsberg et al. 1999, Sheehan 1998).

Psychosocial factors have been shown to impact the process of pregnancy. Psychosocial factors include: job stressors, “intention” of the pregnancy, “stressful life events,” and family functioning. For example, psychosocial job stressors might explain earlier reports of an increased risk of pregnancy-induced hypertension among pregnant workers (Landsbergis and Hatch 1996). Psychosocial stressors are also known determinants of premature delivery (Dole et al. 2003). Unintended pregnancies, stressful life events, and overall "life stress" are associated with prematurity (Orr et al. 2000, Wadhwa et al. 1993, Tegethoff et al. 2010, Khashan et al. 2008, Beijers et al. 2010). Wadhwa et al. (1993) showed a dose-response relationship between number of stressful life events and reduced birthweight and reduced gestational age.

Chronic psychosocial stress has been shown to be associated with LBW deliveries (Bryant Borders et al. 2007, Lee et al. 2011). Paarlberg et al. (1999) found that psychosocial factors in the first trimester of pregnancy increased the odds of delivering a LBW infant. Sheehan (1998) found that several types of psychosomatic stressors did not directly result in LBW infants; rather, psychosocial stress led to addictive behaviors that subsequently had a negative impact on infant birthweight. Both Paarlberg et al. (1999) and Sheehan (1998) called attention to the fact that studies need to be careful in designing their observations to see if psychosocial stressors directly impact fetal growth.

Out of the many types of psychosocial stressors, several studies have focused on family functioning. Reeb et al. (1987) showed that family dysfunction was associated with both LBW infants and intrapartum complications; family dysfunction was the only predictor strongly associated with both outcomes. Ramsey et al. (1986) and Abell et al. (1991) both showed that the psychosocial stress of a dysfunctional family negatively impacted infant birthweight. One of the psychosocial stressors Sheehan (1998) specified in the increase of addictive behavior was family dysfunction. In Reeb et al. (1987), Ramsey et al. (1986), and Abell et al. (1991), the Family Adaptability and Cohesion Scales (FACES) were used to assess family functioning.

FACES — the Family Adaptability and Cohesion Scales

The Family Adaptability and Cohesion Scales (FACES) is a self-reported measurement developed by Olson (1982). FACES is used to collect data in support of the Circumplex Model of Marital and Family Systems, also developed by Olson (1979). The main hypothesis of the Circumplex Model is that "balanced" couples and family systems tend to be more functional than unbalanced systems (Olson 2000).

Family cohesion and adaptability are the two dimensions in the Circumplex Model of Marital and Family Systems, and FACES independently measure these two dimensions. Family cohesion is defined by Olson as "the emotional bonding that family members have towards one another" (Olson 2000). Cohesion levels, as determined by FACES, range from disengaged (low scores on the cohesion dimension) to enmeshed (high scores on the cohesion dimension). A disengaged relationship is characterized by little involvement of the family members in each other's lives. Separateness and independence for each of the members is also observed. On the other end of the cohesion dimension, an enmeshed family is characterized by an over-involvement of family members in each other's lives. Family members are also very dependent on each other, and members devote a great amount of their energy to the family. Both disengaged and enmeshed families are known as extremes on the cohesion dimension.

Family adaptability is defined by Olson as "the amount of change in its leadership, role relationships and relationship rules" (Olson 2000). Adaptability levels, as determined by FACES, range from rigid (low scores) to chaotic (very high scores). A rigid relationship is evidenced when *one* individual is in charge and is highly controlling. Rules do not change in these systems. A high score on the adaptability dimension is known as "chaotic." Erratic or limited leadership characterizes chaotic systems. Decisions are hastily made. Both rigid families as well as chaotic families are considered by FACES to be dysfunctional.

To be considered dysfunctional by FACES, a family must score in a dysfunctional rage for *both* dimensions. Therefore, there are four types of family dysfunction: chaotically disengaged, chaotically enmeshed, rigidly disengaged, and rigidly enmeshed (Olson 2000). A family is *not* considered to be dysfunctional if they score, for example, high on cohesion yet balanced on adaptability. A family can change their functioning type to adapt to a sudden struggle, but it has been reported that dysfunctional families lack the abilities to change effectively (Olson 2000).

Family functioning is seen as a psychosocial factor in pregnancy. The Circumplex Model assumes that "current family system dynamics are helping to maintain symptomatic behaviors," and the family is a crucial support system for the expecting mother (Olson 2000). By studying the effects of family dysfunction on pregnancy outcome, it is possible to learn ways that the social environment affects the growing fetus.

The effect of family functioning on pregnancy outcome has been studied previously (Ramsey et al. 1986; Reeb et al. 1987; Abell et al. 1991) specifically using the Circumplex Model, yet a missing gap in the literature would be a natural extension of these studies. Given the relationship between family dysfunction and its negative impact on birth weight, the next step would be to ask what *type* (or types) of family dysfunction is more associated with a negative impact on birth weight.

The FACES scale distinguishes four different types of family dysfunction: chaotically enmeshed, chaotically disengaged, rigidly enmeshed, and rigidly disengaged. Though it is easy to lump these different types together as "dysfunctional," it would not make sense to continue this agnosticism. These extremes are operational opposites of each other (a rigid family operates differently than a chaotic family).

In the previous work completed by Ramsey et al. (1986) and Abell et al. (1991), the sample sizes of the studies were unable to "tease out" the different types of family dysfunction. The Ramsey et al. (1986) article specifically did look at the "enmeshed" families in its study as a predictor for low birth weight, but did not have the statistical power to address the other types of family dysfunction. The Abell et al. (1991) study did not extend beyond observing that "family dysfunction" negatively impacts birth weight. The current study provides a larger sample with the statistical power to explore the different family types' impact on infant birthweight.

Previous studies have suggested that several of the extreme functional types might play a role in negatively impacting infant birthweight. These previous studies inform this study's hypotheses. Griffin-Carlson and Schwanenflugel (1998) used FACES to determine quality parental reactions to adolescent abortions stratified across the dimensions of FACES: cohesion and adaptability. Adaptability was the most significant variable in the study and indicative of a supportive parental reaction to adolescent abortion. Extremes in the adaptability dimension were not studied; rather, the "functional" range of adaptability scores was associated with a supportive parental reaction. Kugler, Yeash, and Rumbaugh (1993) studied the impact of family function variables on medical prenatal care; there was a negative association of family functioning scores with the level of medical prenatal care. The study showed that extremes on the cohesion dimension were associated with a decreased use of medical prenatal care. Clover et al.'s (1989) study on the relationship between family dysfunction and the incidence of influenza identified that extremes in either the adaptability or cohesion dimension increased one's risk of developing an influenza infection. These studies have influenced this study's secondary hypotheses on how the different family dimensions impact infant birthweight. To identify sub-groups of family functioning characteristics that have differing impacts on infant birthweight is to identify an "at risk" sub-cohort of pregnant women not previously known.

CHAPTER THREE

Hypotheses

With the general objective of investigating the effects of psychosocial stressors on infant birthweight, this study proposes to test on a prospective cohort of Oklahoma women the hypothesis that certain kinds of family functioning during pregnancy, as determined by the FACES II model of family functioning, will impact the outcome of infant birthweight.

Primary Hypothesis:

- Women from dysfunctional families will deliver infants with lower birthweights (in grams) than infants from women with functional families, while adjusting for gestational age, the mothers' constitutional factors (specifically height, weight, weight gain, ethnicity), maternal medical histories, maternal obstetrical histories, the sex of the fetus, and smoking status.

Corresponding Null Hypothesis:

- There will be no difference between the infant birthweights (in grams) of infants delivered by women from dysfunctional families and women from functional families.

Secondary Hypotheses:

1. Women with extreme values on the adaptability scale (either high or low values) will deliver, on average, lower birthweight infants than women within the normal range on the adaptability scale.
2. Women with extreme values on the cohesion scale (either high or low values) will deliver, on average, lower birthweight infants than women within the normal range on the cohesion scale.

Corresponding Null Hypotheses:

1. There will be no difference in birthweight of infants delivered by women from either extreme-ranged or normal-ranged values on the adaptability scale.
2. There will be no difference in birthweight of infants delivered by women from either extreme-ranged or normal-ranged values on the cohesion scale.

CHAPTER FOUR

Methods

Participants

Participants in this prospective cohort study were obstetrical patients at three clinics at the University of Oklahoma Health Sciences Center in Oklahoma City, Oklahoma — two clinics affiliated with the Department of Family Medicine and one clinic of the Department of Obstetrics and Gynecology. These clinics served mostly indigent and lower income families. This convenience sample consisted of obstetrical patients who were offered the opportunity to participate in the study at their initial prenatal visit at one of the three clinics. Informed consent was obtained at the time of enrollment. Exclusions included women who were multiparous (twins, triplets, etc.), who were in prison at the time of the initial interview, and who had a spontaneous or elective abortion. Loss to follow-up included women who moved and women who died before delivery.

Funding and Institutional Review Board

This study was funded by the National Institute of Child Health and Human Development (NICHD), an institute of the National Institutes of Health (NIH) of the United States (NICHD # R01 HD20511-01A3). All procedures and assessments, including the method of obtaining informed consent, were approved by the Institutional Review Board (IRB) of the University of Oklahoma Health Sciences Center. The project was led by principal investigators Troy Abell, PhD MPH and Lisa Baker, MD PhD.

Time Frame

The data collection portion of the study occurred from 1990-1993. The measurements were collected at four different times during each woman's pregnancy. Data were collected at a participant's first clinic visit (an initial extensive interview between 4-24 weeks of gestation), a second extensive interview (usually between 36-40 weeks of gestation), at delivery (within 12-48 hours following birth), and at a postpartum review of the pregnancy's course using medical records. At these collection times, some of the same measurements were collected.

At the first obstetrical visit, the participants were asked, in a personal interview, about their sociodemographic background, their family structure, previous medical history, last normal menstrual period, their contraceptive history, their attitudes towards the pregnancy, health behaviors (including smoking), and life events.

During the first visit, the participants completed The Family Adaptability and Cohesion Evaluation Scale (FACES), developed by Olson (1979). This scale assessed family functioning. It measured two dimensions of family functioning: adaptability and cohesion. From the composite scores of adaptability and cohesion from the scale, the family was categorized to be either “functional” or “dysfunctional.” The family assessment was ascertained during the first interview so that it might be used as a potential predictor of pregnancy outcome.

Also collected in the first clinic visit were a number of anthropometric measurements. The following measurements of circumference were recorded: upper arm, thigh, head, chest, and buttocks. Skin fold measurements using Lange calipers (Cambridge Industry Co. Cambridge, Maryland) were collected on the following sites: biceps, triceps, suprailiac, and thigh (anterior and posterior). For a few women, the calipers would not fit due to an extraordinary amount of adipose tissue. The height of the mother was ascertained in centimeters. The woman’s weight was recorded in kilograms. All of the measurements were taken by trained personnel. These anthropometric measurements were taken whenever other major components of the study were also completed (second prenatal interview and delivery).

The second major data-collecting component in the study was at the prenatal clinic visit during the woman’s 36^{th} to 40^{th} week of gestation. This second prenatal interview was conducted in a similar manner as the first prenatal interview. Questions concerned sociodemographic updates, future contraceptive planning, social support, and family functioning. These questions not only were used to track changes that could have been made during the interim, but also collected data about possible future pregnancies.

Within 12 to 48 hours after delivery, the newborns were assessed to determine: (1) gestational age (by Dubowitz assessment); (2) anthropometric measurements of crown-heel and crown-rump length (Holtrain tool especially built for newborns); (3) circumferences of head, arm, chest, and thigh; and (4) skin folds from triceps, thigh, and subscapular locations. The length of time in hours and minutes since delivery was ascertained from the medical chart. The skin fold assessments were made at 15 and 60 seconds. Infant birth weight (in grams) was taken from two sources: (1) the hospital birthbook and (2) the newborn nursery nurse's notes.

Dubowitz assessments were performed to help more precisely determine gestational age of a newborn (Dubowitz and Dubowitz 1970). In a Dubowitz assessment, a series of measurements are made to determine neurological maturity of the infant: the baby's posture while laying flat on its back; how the arm rests in relation to its body (a "square window"); to what degree the ankle flexes towards the body ("ankle dorsiflexion"); arm recoil; leg recoil; to what degree the knees bend while the baby is resting on its back ("popliteal angle"); the extent that the infant's heels can touch its ears; to what extent a baby's arm can cross its middle ("scarf sign"); to what degree a baby's head lags if picked up by its arms ("head lag"); and the infant's position when rested on one hand ("ventral suspension") [See Appendix D]. Each of the various checkpoints is summed into a composite score, and is used to predict gestational age. Gestational age was also estimated using last normal menstrual period.

Maternal anthropometric measurements were taken a third time within 18 to 24 hours post partum, following the same protocol established in the previous two data collection times.

Once the medical record was complete (usually within two weeks of delivery), a fourth data collection effort took place. The medical record was abstracted to summarize, for each participant, the course of the pregnancy. Variables abstracted were: the delivery date of the baby, the estimated gestational age at the first prenatal visit, the estimated gestational age of the infant at delivery, number of prenatal visits, the height of the mother in centimeters, and maternal weight in kilograms.

A summary of the infant's stay at the hospital included information on various therapies —use of respirator, extra oxygen, ventilation, phototherapy— and infant injury. Length of hospital stay, discharge weight of infant in grams, discharge length in centimeters, and discharge head circumference in centimeters were recorded.

Delivery data included the date of delivery, the sex of the infant, one minute and five minute APGAR scores, and type of delivery (vaginal delivery, elective C-Section, or emergency C-Section).

Statistical Analysis

Analyses will include univariate, bivariate, and multivariate analysis of the study data. Statistical computing will use the SAS Statistical Package Version 9.2 for Windows (Cary, North Carolina).

Hypothesis Testing

The primary null hypothesis is that family functioning does not have an effect on infant birthweight after adjusting for other known determinants. Alpha is set at 0.05 for this primary hypothesis. (Power is dependant on the sample size.)

The secondary null hypotheses state that there is no difference between the types of family dysfunction in their effect on infant birthweight. The distinct dysfunctional types result from the two dimensions of the FACES scale (Olson 1979). There are two secondary hypotheses (listed in null form):

1. There will be no difference in birthweight of infants delivered by women from either extreme compared to normal-ranged values on the adaptability scale.
2. There will be no difference in birthweight of infants delivered by women from either extreme compared to normal-ranged values on the cohesion scale.

Using the Bonferroni (1936) method of multiple hypotheses testing, the initial alpha, divided by the number of hypotheses, results in the alpha of these hypotheses. Therefore, alpha for the study's second and third hypotheses will be: (0.05/3) = 0.017.

Univariate Analyses

This first stage of data analysis is univariate analysis. Univariate analyses describe the sample. In this particular study, univariate analyses will be performed on each of the variables in the analysis: infant birthweight, infant gestational age, sex of the infant, maternal parity, maternal height, maternal (height-free) weight, maternal ethnicity, maternal smoking, and maternal weight gain during pregnancy. Univariate analyses also will provide measures of central tendency and dispersion for the continuous variables (such as height and weight) and proportional distribution for categorical variables (such as gender) will be presented.

Univariate analyses also will be performed on the FACES scale of family functioning, placing each participant into either a "functional" or "dysfunctional" category of family functioning. This process is performed because both high and low scores are considered to fall into the "dysfunctional" category, due to the curvilinear relationship of the measured dimensions established by FACES. This curvilinear relationship is illustrated in Figure 1:

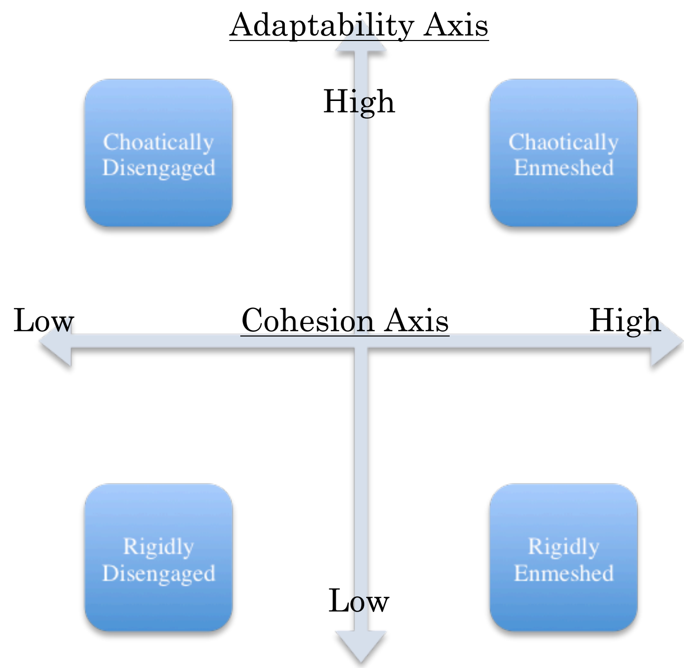

Figure 1: The Circumplex Model. Extremes labeled denote the various types of family dysfunction. (Modeled after Olson 1979.)

Therefore, it will be possible to determine what percentage of the sample comes from a "functional" family and what percentage of the sample comes from a "dysfunctional" family. In addition, FACES calculates family functioning by assessing two different dimensions that have impact on family functioning — cohesion and adaptability. It also will be possible to calculate the percentage of women who scored in the extreme values on the cohesion dimension of the FACES assessment. Extremes in the adaptability dimension can be measured in this way as well. Univariate analyses on the various family functioning variables will provide a description of family functioning and identify a crucial subset of the sample for the study's hypothesis: the women who come from "dysfunctional" family situations.

The main outcome variables of the study –infant birth weight and gestational age— are continuous in nature; the resultant univariate analyses performed will focus on arithmetic means, standard deviations, and standard errors of the mean. Additionally, given the accepted definition of low birth weight as <2500 grams, the percentage of the infants who fall under this nominal category will also be provided. This categorical method will also be performed with the outcome variable of gestational age. If an infant is born before 37 weeks, a standard definition of preterm birth, the percentage of the infants that were born before that time will be provided. Ultimately, these univariate analyses will provide a clear description of both the mothers and the infants delivered.

Bivariate Analyses

A bivariate analysis is the comparison between two variables. In this study, the main outcome variable is birthweight in grams.

The initial bivariate analysis is the linear regression of birth weight on gestational age. Birth-weight-adjusted-for-gestational-age will be the foundation on which additional relationships will be estimated. Gestational age is the largest determinant of infant birth weight, and has been shown to account for up to 30% of the variance in infant birth weight (Abell et al. 1991). This analysis will result in a linear regression coefficient, a standard error from which confidence intervals for the regression coefficient can be calculated, and a corresponding p-value.

Multivariate Analyses

In the linear regression models used in this study, birth weight is regressed on a number of variables. The models will be of the form:

$Bwt = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \ldots + b_kx_k$, k = number of factors for which the model is adjusting.

These models will result in regression coefficients, standard errors (for these regression coefficients), and p-values. These models will quantify the contribution of the predicting variable on infant birthweight, while adjusting for the other variables in the model.

Multiple regression analysis will provide an estimate of how each variable contributes to our understanding of infant birth weight. A key result is r^2, which is known as the "explained variance." Explained variance is the amount that a mathematical model accounts for the variance in the data. Researchers use explained variance to quantify the accuracy of their mathematical models.

For the study's primary hypothesis, infant birth weight will be regressed on family functioning, while adjusting for other known determinants: gestational age, sex of the infant, maternal parity, maternal height, maternal (height-free) weight at the beginning of her pregnancy, maternal ethnicity, maternal smoking status, and maternal weight gain during pregnancy. The family functioning variable will be dichotomized into "functional" and "dysfunctional" based on FACES (Olson 1979). The model will estimate the contribution of family functioning on the outcome of birth weight.

For the study's secondary hypotheses, a similar method will be employed in the creation of a linear model. When modeling the impact of extremes in the adaptability or the cohesion scale, it is not possible simply to input the scale in its initial form, given its curvilinear nature. One must transform the curvilinear data into either dichotomous variables or into a usable continuous scale. (See Figure 2 below.)

Figure 2: The Adaptability Dimension

In this way, the effects of the different types of family functioning can be successfully incorporated into the linear regression model. The models will be able to estimate the impact of different types of dysfunction on infant birthweight, after adjusting for other known determinants.

CHAPTER FIVE

Results

Three results of this prospective cohort study are reported here. First, the sample in the study is typical of the population of women in the U.S. considered at risk for poor pregnancy outcomes. The women in the sample come from a variety of familial situations. The second result of the study was that no relationship between family dysfunction (as measured by the FACES II Scale) and infant birthweight was found. Thirdly, no association was detected between family dysfunction and the cumulative incidence of low birthweight infants. A detailed presentation of the results follows.

Sample

Data were recorded for 1,533 mother-infant pairs. If the mother was missing data on any one variable or failed to meet the inclusion criteria, she was excluded from analysis. Our resulting sample size was 1,206 mother-infant pairs. Table 1 reports the characteristics of the 1,206 mother-infant pairs in this study.

Important features of Table 1 include its information on maternal characteristics: maternal age, ethnicity, marital status, and smoking status. The average age of a mother in this study was 23.85 years. The study was comprised of 31.34% African Americans and 68.66% European Americans. 34.46% of the women were married; 13.78% were living with a partner. So, roughly half (48.24%) of the women were living with someone during their pregnancy. "Other" living arrangements included the pregnant

Table 1:		
Maternal Characteristics:	Mean	Standard Deviation
Maternal Age (yrs)	23.85	5.11
Education (yrs)	11.41	1.81
Maternal Height (cm)	162.53	6.80
Pre-pregnancy Weight (lb)	139.35	34.17
Height-Free Weight (percent)	99.99	23.57
Gestational Weight Gain (lb)	16.05	7.67
Ethnicity:	*Proportion*	
African American	31.34%	
European American	68.66%	
Marital Status:		
Married	34.46%	
Single	36.43%	
Living with Partner	13.78%	
Other	15.33%	
Primiparous	33.11%	
Smokers	38.35%	
Infant Characteristics:	Mean	Standard Deviation
Birthweight (g)	3319.56	620.07
Gestational Age (wk)	38.83	2.02
	Proportion	
Female	48.76%	
Preterm	7.40%	
Low Birth Weight (LBW)	7.05%	

woman living with her immediate or extended family, her partner's immediate or extended family, or some other living arrangement. Nearly 40% of the women in this study were smokers at some point in their pregnancy.

Table 1 also includes information on infant outcomes in this study. Average birthweights and gestational ages are reported. Also, birth outcomes important to the study are shown. 48.76% of the infants were female. Most importantly, 7.05% of infants were considered low birthweight (LBW).

Table 2 details how the mothers scored on the FACES II Scale. On the adaptability scale, roughly half (50.27%) scored in the normal range; the other half scored on some extreme on the scale. On the cohesion scale, about a third of the women had a normal range score, while two-thirds had an extreme range score. In particular, over half of the women had an enmeshed score. Extreme scores in both the adaptability and the cohesion scales are considered dysfunctional. These results help to provide insight into the family dynamics of the women in this study according to the FACES II Scale.

Table 2:
Adaptability and Cohesion Scales

Characteristic	Proportion
Adaptability Scale (n=1104)	
Rigid	34.42%
Normal Range	50.27%
Chaotic	15.31%
Cohesion Scale (n=1117)	
Disengaged	13.88%
Normal Range	33.75%
Enmeshed	52.37%

Table 3 shows how many women were in a dysfunctional family situation. According to the results of the FACES II Scale, 321 mothers were in some type of dysfunctional family. Approximately 20% of those that completed a FACES II assessment (n=1104 of our 1206 sample) were in an enmeshed family situation. About 15% of the families in this study were assessed as rigid. Chaotically disengaged families were not found in our study.

Table 3: Dysfunctional Family Types		
Dysfunctional Family Type	Number	Proportion of Total Families (n=1083)
Chaotically Enmeshed	152	14%
Rigidly Enmeshed	65	6%
Chaotically Disengaged	0	0.00%
Rigidly Disengaged	104	11.2%

Preliminary Analysis

One of the important variables in our study is maternal weight. The development of this variable was the first preliminary analysis performed. There is a need to distinguish between the impact of height on fetal growth and the impact of maternal weight on fetal growth. It is challenging to measure maternal weight in a way that does not include the impact of height. Multiple models were built to eliminate height from maternal weight. These models are summarized in Table 4. The model that estimates height-free maternal weight most effectively is defined as the one that has the smallest association with maternal height. The model that did this used residuals derived from regressing maternal weight on height among the women in this study (as opposed using national data). Thus, we were able to model how maternal weight—that is independent of height—impacts fetal growth.

Table 4: Models for Height-Free Weight

Maternal Height Regressed on:					
Adiposity Measurement	Adiposity Equations*	Regression Coefficient	S.E.	r^2	P-Value
BMI^2	$height/weight^2$	-805.61	350.6	0.0037	0.0218
BMI^3	$height/weight^3$	-442938	53577	0.0551	0.0001
National Insurance Residuals	(weight/(0.53*height – 25.55))*100	0.00949	0.00809	0.0033	0.2407
Residuals Derived from This Study	(weight/(0.63*height – 38.67))*100	0.00012648	0.00843	-0.0009	0.9880

*For all equations, height is in centimeters and weight is in kilograms.

Bivariate Analysis

Table 5 summarizes the bivariate analysis performed between the known determinants of infant birthweight in our study. It shows the Pearson correlation coefficients for the eight variables in our basic regression models, matched pair-wise. Highlighted values are statistically significant.

Table 5: Bivariate Correlation between Known Determinants of Birthweight

	Birth Weight	Gestational Age (weeks)	Sex of Infant	Parity	Maternal Height	Maternal Weight	Ethnicity	Smoking Status	Weight Gain (lbs)
Birth Weight		0.66725 <.0001 1206	-.14850 <.0001 1206	-.1139 .6932 1202	.14346 <.0001 1191	.19670 <.0001 1156	.18174 <.0001 1206	.13244 <.0001 1202	.33147 <.0001 1154
Gestational Age (weeks)			-.08455 .0033 1206	.03158 .2739 1202	.01801 .5347 1191	.08051 .0062 1156	-.04450 .1125 1206	-.08395 .0036 1202	.21761 <.0001 1154
Sex of Infant				-.04609 .1102 1202	-.00867 .7651 1191	.00170 .9540 1156	.00608 .8328 1206	-.01756 .5430 1202	.03920 .1833 1154
Parity					.03312 .2542 1187	-.07790 .0082 1152	-.07816 .0067 1202	-.15853 <.0001 1198	.14115 <.0001 1150
Maternal Height (cm)						.00044 .9880 1156	.02678 .3559 1191	-.00212 .9418 1188	.17737 <.0001 1140
Maternal Weight (%)							.07481 .0109 1156	-.11811 <.0001 1153	-.08165 .0058 1140
Ethnicity								-.19138 <.0001 1202	-.04916 .0951 1154
Smoking Status									-.01757 .5517 1150
Weight Gain (in lbs)									
	Line 1: Pearson Correlation Coefficient [-1.00 – 1.00] Line 2: P-Value (Highlighted values reached statistical significance) Line 3: n (Number of observations)								

Two associations are noted. The strongest positive relationship exists between birthweight (in grams) and gestational age (in weeks) (r=0.66725). This supports the idea that the largest determinant of birthweight is the length of time spent in the womb. The largest negative relationship is found between ethnicity and smoking status. Based on the operationalization of the ethnicity and smoking variables (1=African American, 0=European American; 1=Smoker, 0=Non-Smoker), this negative correlation shows that European American women smoked more during pregnancy than their African American counterparts. Overall, Table 5 helps to show how the major known associates of infant birthweight related to each other in this study.

Multivariate Analysis

Basic Regression Model

The first step in the multivariate assessment was the creation of a basic regression model that incorporated known determinants of infant birthweight other than family functioning (see Table 6). In this way, additional hypothesis testing could be based off of this basic regression model. Infant birthweight (in grams) was regressed on the following eight variables: gestational age (in weeks), sex of the infant, parity, maternal height (in centimeters), maternal weight (percentage of ideal weight for height), ethnicity, smoking status, and weight gain (in pounds) (Table 6).

Table 6: Basic Regression Model
Infant Birthweight (g) Regressed on: (n=1,206)

Variable	Regression Coefficient	S.E.	t	P-value	Incremental r^2	Cumulative r^2
Intercept	-5647.17	383.03	-14.74	0.0001	-	-
Gestational Age (in weeks)	204.40	6.58	31.08	0.0001	0.4448	0.4448
Sex of the Infant*	-115.01	26.52	-4.34	0.0001	0.0081	0.4529
Parity	-48.16	28.14	-1.71	0.0873	0.0009	0.4538
Maternal Height (cm)	12.18	1.93	6.31	0.0001	0.0149	0.4687
Maternal Weight (%)	3.74	0.55	6.79	0.0001	0.0249	0.4936
Ethnicity*	-220.16	27.57	-7.98	0.0001	0.0263	0.5119
Smoking Status*	-135.91	26.80	-5.07	0.0001	0.0102	0.5301
Weight Gain (in lbs)	15.74	1.66	9.48	0.0001	0.0261	0.5562

*Sex of Infant: 1=Female, 0=Male; Parity: 1=Primiparous, 0=Multiparous; Ethnicity: 1=African American, 0=European American; Smoking status: 1=Smoker, 0=Non-smoker

Note that, on average, an infant grows approximately 204g per week of gestation. Female infants are born weighing, on average, 115g less than males after adjusting for length of gestation. Primiparous women deliver infants that weigh, on average, 48g less than women who are multiparous – after adjusting for length of gestation and sex of the infant. Taller women deliver, on average, heavier infants, after adjusting for the impacts of length of gestation, sex of the infant, and parity. Each centimeter in maternal height translated into 12g of increased infant birthweight. Height-free pre-pregnancy weight was a positive determinant of infant birthweight, with heavier women delivering larger infants; each percentile of height-free weight was worth 3.7g in infant birthweight – after adjusting for the variables already entered into the model. Infants from African-American women weighed approximately 220g less, on average, than infants born to European-American women – after adjusting for other determinants.

Smoking women delivered infants that weighed approximately 136g less than infants of non-smoking women, after adjusting for other known determinants. Finally, maternal weight gain during pregnancy resulted in infants, on average, weighing 16g more per pound of maternal weight gain, while adjusting for the other determinants.

The coefficient of determination, or r^2 adjusted for degrees of freedom, was 0.5562. That is, this initial regression model could explain a little over 55% of the variation in infant birthweight.

The Potential Impact of Family Functioning

By using the FACES II scale, it was possible to test the potential impact of the various family functioning variables on infant birthweight. The results are summarized in Table 7. In building the model, each family functioning variable was added to the basic regression model (Table 6). Changes in the adjusted r^2 were noted, as well as the regression coefficients and accompanying p-values. None of the family functioning variables improved our model (as seen by an increased adjusted r^2), nor did any of the variables reach statistical significance. The regression model shows the minor and statistically insignificant impact family dysfunction had on infant birthweight.

The first variable tested was the dysfunction variable (1=dysfunctional, 0=functional). This variable tested our first hypothesis about the impact of family dysfunction on infant birthweight. The regression model did not support this hypothesis.

Next, we added to our basic regression model the enmeshment, disengagement, chaotic, and rigid variables. These variables were "dummy" variables that were defined as the presence or absence of a particular trait. The enmeshment and disengagement variables are mutually exclusive, as are the chaotic and rigid variables. These two pairs of variables, however, are independent of each other. Assessed separately in our regression model, none of the variables impacted birthweight. One variable, disengagement, did provide a negative regression coefficient (-14.99, p-value=0.6796). However, none of the family functioning variables reached statistical significance.

Table 7: The Contribution of Family Functioning to the Basic Regression Model						
Family Functioning Variables	Adjusted r^2 of Basic Regression Model (Refer to Table 4)	Adjusted r^2 After Family Functioning Variable Added	r^2 Difference	P-Value of Added Family Functioning Variable	Regression Coefficient	Standard Error
Dysfunction	0.5562	0.5491	-0.0071	0.6870	11.20	27.79
Enmeshed	0.5562	0.5513	-0.0049	0.3342	24.55	25.41
Disengaged	0.5562	0.5509	-0.0053	0.6796	-14.99	36.28
Chaotic	0.5562	0.5505	-0.0057	0.5923	18.88	35.24
Rigid	0.5562	0.5504	-0.0058	0.8239	6.00	26.96
Modeling Family Types: (Described in text) (n=1,083)						
Chaotically Enmeshed	0.5562	0.5491	-0.0071	0.6977	14.28	36.75
Rigidly Enmeshed	0.5562	0.5493	-0.0069	0.4371	42.77	55.01
Rigidly Disengaged	0.5562	0.5491	-0.0071	0.6798	-16.71	40.48
Key: Dysfunction: 1=Dysfunctional, 0=Normal range; Enmeshed: 1=Enmeshed-scoring, 0=Not; Disengaged: 1=Disengaged-scoring, 0=Not; Chaotic: 1= Chaotic-scoring, 0=Not; Rigid: 1=Rigid-scoring, 0=Not; Chaotically Enmeshed: 1=Both chaotic and enmeshed, 2=Not; Rigidly Enmeshed: 1=Both rigid and enmeshed, 0=Not; Rigidly Disengaged: 1=Both rigid and disengaged, 0=Not. Highlighted values are discussed.						

To test the potential impact of the different types of dysfunctional families, dummy variables were constructed for those chaotically enmeshed, rigidly enmeshed, and rigidly disengaged. Since no women scored as chaotically disengaged, that analysis is not reported. These variables were then added to the basic regression model. The analyses of these variables were conducted separately. After addition of the variables, the model did not provide a better picture of family functioning's impact on birthweight. Rigid disengagement did provide a negative regression coefficient, suggesting its negative impact, yet failed to achieve statistical significance.

Family Functioning and Low Birthweight

The next step was to look at the contingency of the various family functioning variables with the proportion of low birthweight infants (LBW). To do these analyses, contingency tables were constructed and analyzed for the family functioning variables listed in Table 7 (See Table 8, Table 9, and Table 10). LBW is defined as weighing less than 2500g at the time of delivery. Table 8 details the presence or absence of family dysfunction and the proportion of LBW deliveries. Of the 1,083 women with family functioning information, there were 72 LBW deliveries (6.65% of all deliveries.). Those women from dysfunctional families were slightly less likely (5%) to deliver LBW infants than women from functional families (7%), OR=0.66 (p-value=0.1498).

Table 8: Family Dysfunction and LBW

Family Dysfunction (n=1083, df=1)			
	Present	Absent	Total
Birthweight <2500g	17 0.0503	55 0.0738	72 0.0665
Birthweight ≥2500g	321 0.9497	690 0.9262	1011 0.9335
	338	745	1083
		OR=0.66 χ^2: 2.0742 p-value=0.1498	

Table 9 is an aggregate of the four contingency tables analyzing the four characteristics assessed by the FACES II Scale. None of the four χ^2-values were statistically significant. Women from enmeshed, chaotic, and rigid families were slightly less likely to deliver LBW infants than their functional counterparts, although the results were not statistically significant. These results run counter to the study's hypotheses. Women from disengaged families did have slightly more LBW infants; the results were not statistically significant.

Table 9: LBW and Family Dysfunctional Characteristics												
	Dysfunctional Characteristics											
	Enmeshed (n=1117, df=1)			Disengaged (n=1117, df=1)			Chaotic (n=1104, df=1)			Rigid (n=1104, df=1)		
	+	–	Total	+	–	Total	+	–	Total	+	–	Total
Birthweight <2500g	37 0.063	38 0.071	75 0.067	11 0.071	64 0.067	75 0.067	8 0.047	67 0.072	75 0.068	23 0.061	52 0.072	75 0.068
Birthweight ≥2500g	548 0.937	494 0.929	1042 0.933	144 0.929	898 0.933	1042 0.933	161 0.953	868 0.928	1029 0.932	357 0.939	672 0.928	1029 0.932
	585	532	1117	155	962	1117	169	935	1104	380	724	1104
	OR=0.88 χ^2=0.2977 p-value=0.5853			OR=1.07 χ^2=0.0420 p-value=0.8376			OR=0.64 χ^2=1.3370 p-value=0.2476			OR=0.83 χ^2=0.5023 p-value=0.4785		

Finally, we tested associations between the different dysfunctional family types and LBW outcomes (Table 10). Again, none of the different dysfunctional family types resulted in statistically significant relationships.

Table 10: LBW and Dysfunctional Family Types									
	Dysfunctional Family Types								
	Chaotically Enmeshed (n=1083, df=1)			Rigidly Enmeshed (n=1083, df=1)			Rigidly Disengaged (n=1083, df=1)		
	+	–	Total	+	–	Total	+	–	Total
Birthweight <2500g	7 0.046	65 0.70	72 0.066	3 0.046	69 0.068	72 0.066	7 0.058	65 0.068	72 0.066
Birthweight ≥2500g	145 0.954	866 0.930	1011 0.934	62 0.954	949 0.932	1011 0.934	114 0.942	897 0.932	1011 0.934
	152	931	1083	65	1018	1083	121	962	1083
	OR=0.64 χ^2=1.1891 p-value=0.2755			OR=0.67 χ^2=0.4604 p-value=0.4974			OR=0.85 χ^2=0.1635 p-value=0.6860		

CHAPTER SIX

Discussion

Strengths

Design

One of the major strengths of this study was its design. Prospective cohort studies allow for the measurement of exposure before the cumulative incidence of a health outcome is measured. In this study, family functioning was measured at the first clinic visit. This step occurred before the delivery of the infant. In this way, there was less opportunity for systematic error to impact the study. Stated in another way, we avoided a theory-laden observation of infant delivery by separating temporally the observation of the exposure and the observation of the outcome. Taking observations of the exposure before observing the outcome is a definitive characteristic of a prospective cohort study. The design of our study, thus, helps to eliminate systematic error.

In addition to our interest in family functioning, measurements were taken of other major known determinants of infant birthweight. It was agreed upon before the study began what major determinants were to be measured, based on the scientific literature. Again, these measurements were taken prospectively. Some measurements were taken several times throughout the pregnancy to track possible changes. These measurements helped to construct the basic regression model described in Table 6. This regression model served as the background from which testing about the potential impact of family functioning on infant birthweight could take place. The measurements of these known major determinants of infant birthweight were crucial to the study; they provided a control from which hypothesis testing occurred. A fetal growth study that does not account for the known major determinants of birthweight can introduce significant distortion in its estimates. Failure to include these measurements could lead to a misrepresentation of the impact of the variable of interest on infant birthweight.

Another contributing factor to the success of our study was its location in a typical university clinic setting. The University of Oklahoma's Health Sciences Center Obstetrical Clinic serves a variety of women, and this variety increases the study's generalizability across persons (see Table 1). The setting provided the necessary context in which to measure accurately the study's participants, and assist women in need of care. The women that used the Health Clinic's services can be considered similar to other American women that utilize a major university's health clinic's services.

Sample Size

The large sample size of the study (n=1206) is a major strength of the study. A study that follows such a large number of mother-infant pairs confers with it statistical power. High statistical power helps prevent Type II errors. A large sample size also allows researchers to study outcomes that are relatively rare. In this study, 7.05% of our sample had infants that were low birthweight (LBW). This study was able to determine if family dysfunction impacted LBW deliveries (see Table 8). A large sample size also allows researchers to consider the clinical impact of small differences in exposure on health outcomes. Due to the fact that data on major known determinants of infant birthweight were collected on such a large sample of pregnant women, our study had the statistical power to test our hypothesis about family functioning's potential impact on infant birthweight. In this way, the large sample size of our study, coupled with the thorough data collected on major known determinants of infant birthweight for each mother-infant pair, helped us limit the impact of random error.

Explained Variance

An important strength of the study is the adjusted r^2 value of the basic regression model, 0.5562 (see Table 6). To our knowledge, this adjusted r^2 value is one of the highest levels of explained variance in the literature. Over half of the variance in infant birthweight in our study was explained by eight variables that are measurable and can be repeated in other studies. The single largest contributor to this value was the length of gestation (incremental r^2 value = 0.4448). The issue remains that about 45% of the variance in infant birthweight is unaccounted for, and that family functioning was not seen as an explanatory factor.

Limitations

Issues impacting epidemiological studies fall into four main categories: systematic error, random error, construct validity, and generalizability. These issues can potentially limit the usefulness of the results of any study. A discussion of these four issues in this study follows.

Systematic Error

Systematic error is the bias that exists in a study that is the result of methodological failures. Systematic error distorts study estimates; this can come about by failing to name all potential confounders or by failing to adjust properly for the contributions of these potential confounders. In this study, systematic error would have manifested itself by the misrepresentation of the family functioning variable's impact on infant birthweight. Measuring all major known determinants of infant birthweight in our sample limited this systematic error. Systematic error was also limited by the choice of using a prospective cohort study design.

Random Error

Random error leads to a lack of precision in a study. Two main sources of random error are measurement error and sampling error. In our study, we minimized random error through our large sample size, careful measurements and calculations, and acknowledging possible limitations in our sample. Taken together, these strategies help provide credibility to our obtained results by reducing the role chance played in our study.

One issue with the results of the study is the high p-values for the family functioning variables when added to the regression model. High p-values mean that if the null hypothesis is true there is a high probability that the results obtained were due to random fluctuation. Therefore, the results are considered statistically insignificant. Given the sample size, it can be inferred that family functioning as operationalized in the study was not a determinant of infant birthweight after adjusting for other known determinants.

Construct Validity

Construct validity was a major concern in this study. The focus of construct validity is the issue of whether the measurements used are useful surrogate measures for the phenomena studied. The measurements for the major known determinants of infant birthweight in the basic regression model (infant birthweight, gestational age, sex of the infant, etc.) are on sure footing concerning construct validity. The construct validity of the measurement of family functioning can be called into question. Specifically, a pen and paper measure may not be the best assessment for the social dynamics that happen within a family.

Generally, a questionnaire developed to measure behavior is an ideal example of a surrogate measure. Also, questionnaires only capture the behavior of the responder in one particular moment, and this moment may have been influenced by events that occurred just prior to the test. Although an extensive seventy-six itemed tool, FACES II has its own limitations.

Generalizability

The results of the study are generalizable to African Americans and European Americans in the U.S. of working class or indigent background. The study did not enroll enough women of other ethnic groups to perform adequate data analysis for these groups.

The setting of the study in a major university clinic allows generalizablity of the results obtained to pregnant women in working class and indigent settings. There are not data to suggest that pregnant women in Oklahoma are markedly different from women in other regions of the country.

One possible limitation in the study was the time the data was collected. Americans have increased in adiposity since the time of this study (El-Chaar et al. 2013). This change in the American population could have a slight impact on the basic regression model used in this analysis. Family functioning, however, is still a dynamic social phenomenon.

Conclusion

In this prospective cohort study of 1206 mother-infant pairs, we observed no relationship between family dysfunction and infant birthweight. Although multiple linear regression models were created, no significant contributions to infant birthweight were made by any of the family functioning variables.

The results of this study form two main conclusions. The first is that a significant (adjusted r^2=0.5562) part of fetal growth is based primarily on two things: length of gestation, and the anthropometric characteristics of the mother. These basic aspects of pregnancy contribute a large portion to our understanding of infant birthweight. The second main conclusion stresses the limitations of pen and paper assessment tools for modeling social and family interactions. In turn, limitations exist in using these tools in predicting the physiological impact of psychosocial stressors.

Ultimately, attempts to study fetal growth are messy endeavors. Moreover, attempts to model family interactions are subject to be called into question over their construct validity. In this study, not seeing a relationship between family dysfunction and infant birthweight does not mean that family interactions do not play a role in an individual's health. Rather, family interactions as measured in this study did not impact the physiological outcome of infant birthweight.

REFERENCES

Abell, T D, L C Baker, R D Clover, and C N Ramsey Jr. 1991. “The Effects of Family Functioning on Infant Birthweight.” *The Journal of Family Practice* 32 (1) (January): 37–44.

Alexander, G R, J H Himes, R B Kaufman, J Mor, and M Kogan. 1996. “A United States National Reference for Fetal Growth.” *Obstetrics and Gynecology* 87 (2) (February): 163–168. doi:10.1016/0029-7844(95)00386-X.

Barker, D J. 1999. “Fetal Origins of Cardiovascular Disease.” *Annals of Medicine* 31 Suppl 1 (April): 3–6.

Barker, D. J. P. 1998. *Mothers, Babies, and Health in Later Life*. 2nd ed. Edinburgh ; New York: Churchill Livingstone.

Beijers, Roseriet, Jarno Jansen, Marianne Riksen-Walraven, and Carolina de Weerth. 2010. “Maternal Prenatal Anxiety and Stress Predict Infant Illnesses and Health Complaints.” *Pediatrics* 126 (2) (August): e401–409. doi:10.1542/peds.2009-3226.

Bianco, A, J Stone, L Lynch, R Lapinski, G Berkowitz, and R L Berkowitz. 1996. “Pregnancy Outcome at Age 40 and Older.” *Obstetrics and Gynecology* 87 (6) (June): 917–922.

Bonferroni, C. E. "Teoria statistica delle classi e calcolo delle probabilità." *Pubblicazioni del R Istituto Superiore di Scienze Economiche e Commerciali di Firenze* **8**, 3-62, 1936.

Bryant, Allison S, Ayaba Worjoloh, Aaron B Caughey, and A Eugene Washington. 2010. “Racial/ethnic Disparities in Obstetric Outcomes and Care: Prevalence and Determinants.” *American Journal of Obstetrics and Gynecology* 202 (4) (April): 335–343. doi:10.1016/j.ajog.2009.10.864.

Butler, N R, H Goldstein, and E M Ross. 1972. “Cigarette Smoking in Pregnancy: Its Influence on Birth Weight and Perinatal Mortality.” *British Medical Journal* 2 (5806) (April 15): 127–130.

Clover, R D, T Abell, L A Becker, S Crawford, and C N Ramsey Jr. 1989. “Family Functioning and Stress as Predictors of Influenza B Infection.” *The Journal of Family Practice* 28 (5) (May): 535–539.

Daniels, Pamela, Godfrey Fuji Noe, and Robert Mayberry. 2006. “Barriers to Prenatal Care Among Black Women of Low Socioeconomic Status.” *American Journal of Health Behavior* 30 (2) (April): 188–198. doi:10.5555/ajhb.2006.30.2.188.

Dole, N, D A Savitz, I Hertz-Picciotto, A M Siega-Riz, M J McMahon, and P Buekens. 2003. “Maternal Stress and Preterm Birth.” *American Journal of Epidemiology* 157 (1) (January 1): 14–24.

Donahue, Sara M. A., Ken P. Kleinman, Matthew W. Gillman, and Emily Oken. 2010. “Trends in Birth Weight and Gestational Length Among Singleton Term Births in the United States.” *Obstetrics and Gynecology* 115 (2 Pt 1) (February): 357–364.

Dubowitz, L M, V Dubowitz, and C Goldberg. 1970. “Clinical Assessment of Gestational Age in the Newborn Infant.” *The Journal of Pediatrics* 77 (1) (July): 1–10.

El-Chaar, Darine, Sara A Finkelstein, Xiaowen Tu, Deshayne B Fell, Laura Gaudet, Jacques Sylvain, George Tawagi, Shi Wu Wen, and Mark Walker. 2013. “The Impact of Increasing Obesity Class on Obstetrical Outcomes.” *Journal of Obstetrics and Gynaecology Canada: JOGC = Journal D’obstétrique Et Gynécologie Du Canada: JOGC* 35 (3) (March): 224–233.

Griffin-Carlson, M S, and P J Schwanenflugel. 1998. “Adolescent Abortion and Parental Notification: Evidence for the Importance of Family Functioning on the Perceived Quality of Parental Involvement in U.S. Families.” *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 39 (4) (May): 543–553.

Han, Zhen, Sohail Mulla, Joseph Beyene, Grace Liao, and Sarah D McDonald. 2011. “Maternal Underweight and the Risk of Preterm Birth and Low Birth Weight: a Systematic Review and Meta-analyses.” *International Journal of Epidemiology* 40 (1) (February): 65–101. doi:10.1093/ije/dyq195.

Haste, F M, O G Brooke, H R Anderson, and J M Bland. 1991. “The Effect of Nutritional Intake on Outcome of Pregnancy in Smokers and Non-smokers.” *The British Journal of Nutrition* 65 (3) (May): 347–354.

Honein, M A, L J Paulozzi, T J Mathews, J D Erickson, and L Y Wong. 2001. "Impact of Folic Acid Fortification of the US Food Supply on the Occurrence of Neural Tube Defects." *JAMA: The Journal of the American Medical Association* 285 (23) (June 20): 2981–2986.

Ingemarsson, Ingemar. 2003. "Gender Aspects of Preterm Birth." *BJOG: An International Journal of Obstetrics and Gynaecology* 110 Suppl 20 (April): 34–38.

Khashan, Ali S, Roseanne McNamee, Kathryn M Abel, Marianne G Pedersen, Roger T Webb, Louise C Kenny, Preben Bo Mortensen, and Philip N Baker. 2008. "Reduced Infant Birthweight Consequent Upon Maternal Exposure to Severe Life Events." *Psychosomatic Medicine* 70 (6) (July): 688–694. doi:10.1097/PSY.0b013e318177940d.

Kramer, M S. 1987. "Intrauterine Growth and Gestational Duration Determinants." *Pediatrics* 80 (4) (October): 502–511.

Kugler, J P, J Yeash, and P C Rumbaugh. 1993. "The Impact of Sociodemographic, Health Care System, and Family Function Variables on Prenatal Care Utilization in a Military Setting." *The Journal of Family Practice* 37 (2) (August): 143–147.

Landsbergis, P A, and M C Hatch. 1996. "Psychosocial Work Stress and Pregnancy-induced Hypertension." *Epidemiology (Cambridge, Mass.)* 7 (4) (July): 346–351.

Lee, Bo-Eun, Mina Ha, Hyesook Park, Yun-Chul Hong, Yangho Kim, Young Ju Kim, and Eun-Hee Ha. 2011. "Psychosocial Work Stress During Pregnancy and Birthweight." *Paediatric and Perinatal Epidemiology* 25 (3) (May): 246–254. doi:10.1111/j.1365-3016.2010.01177.x.

Lobel, M, C Dunkel-Schetter, and S C Scrimshaw. 1992. "Prenatal Maternal Stress and Prematurity: a Prospective Study of Socioeconomically Disadvantaged Women." *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association* 11 (1): 32–40.

Luo, Zhong-Cheng, Russell Wilkins, and Michael S Kramer. 2006. "Effect of Neighbourhood Income and Maternal Education on Birth Outcomes: a Population-based Study." *CMAJ: Canadian Medical Association Journal = Journal De l'Association Medicale Canadienne* 174 (10) (May 9): 1415–1420. doi:10.1503/cmaj.051096.

McIntire, D D, S L Bloom, B M Casey, and K J Leveno. 1999. "Birth Weight in Relation to Morbidity and Mortality Among Newborn Infants." *The New England Journal of Medicine* 340 (16) (April 22): 1234–1238. doi:10.1056/NEJM199904223401603.

Orr, S T, S A James, C A Miller, B Barakat, N Daikoku, M Pupkin, K Engstrom, and G Huggins. 1996. "Psychosocial Stressors and Low Birthweight in an Urban Population." *American Journal of Preventive Medicine* 12 (6) (December): 459–466.

Orr, S T, C A Miller, S A James, and S Babones. 2000. "Unintended Pregnancy and Preterm Birth." *Paediatric and Perinatal Epidemiology* 14 (4) (October): 309–313.

Ramsey, C N, Jr, T D Abell, and L C Baker. 1986. "The Relationship Between Family Functioning, Life Events, Family Structure, and the Outcome of Pregnancy." *The Journal of Family Practice* 22 (6) (June): 521–527.

Reeb, K G, A V Graham, S J Zyzanski, and G C Kitson. 1987. "Predicting Low Birthweight and Complicated Labor in Urban Black Women: a Biopsychosocial Perspective." *Social Science & Medicine (1982)* 25 (12): 1321–1327.

Shults, R A, V Arndt, A F Olshan, C F Martin, and R A Royce. 1999. "Effects of Short Interpregnancy Intervals on Small-for-gestational Age and Preterm Births." *Epidemiology (Cambridge, Mass.)* 10 (3) (May): 250–254.

Tegethoff, Marion, Naomi Greene, Jørn Olsen, Andrea H Meyer, and Gunther Meinlschmidt. 2010. "Maternal Psychosocial Stress During Pregnancy and Placenta Weight: Evidence from a National Cohort Study." *PloS One* 5 (12): e14478. doi:10.1371/journal.pone.0014478.

Wadhwa, P D, C A Sandman, M Porto, C Dunkel-Schetter, and T J Garite. 1993. "The Association Between Prenatal Stress and Infant Birth Weight and Gestational Age at Birth: a Prospective Investigation." *American Journal of Obstetrics and Gynecology* 169 (4) (October): 858–865.

Zhang, J, and W A Bowes Jr. 1995. "Birth-weight-for-gestational-age Patterns by Race, Sex, and Parity in the United States Population." *Obstetrics and Gynecology* 86 (2) (August): 200–208.