ASSOCIATIONS BETWEEN PREGNANCY-RELATED WEIGHT VARIATIONS, PRENATAL CARE FACTORS, AND INFANT BIRTH WEIGHT

by

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ABSTRACT

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Background: Variations in maternal weight before and during pregnancy are intricately connected to infant birth weight (IBW). More than 50% of women enter pregnancy at a higher-than-normal body mass index (BMI) and gain outside of the recommended weight during pregnancy based on the 2009 IOM gestational weight gain (GWG) guidelines, impacting IBW. This is a concern because infants born too small or large are at risk for perinatal complications and future health problems. The study explored women's characteristics and prenatal care factors linked to pregnancy-related weight variations such as BMI, GWG, and IBW and the relationships between these three factors within the IOM GWG guidelines.

Methods: This study employed a retrospective descriptive-correlational design utilizing PeriData.Net®. This-dataset includes clinical data on each delivery at one of the Midwest urban hospitals. The PeriData.Net® data has maternal demographics, medical history, and maternal and infant information on delivery. A generalized multinomial model was used to identify how women's characteristics, prenatal care factors, and BMI were associated with the odds of inadequate or excessive GWG according to the 2009 IOM guidelines.

Results: A total of 8,699 women (>18 years) with a live singleton birth were included in the study. Regardless of pre-pregnancy BMI, nearly half (48.4%) of all women gained excessive weight during pregnancy. Notably, white (52%) and Black (43.5%) women in the overweight or

obese BMI categories were more likely to have inadequate or excessive GWG and deliver an SGA or an LGA infant, Race, parity, education, BMI, parity, health insurance, nativity, and prenatal care visits had a significant effect on the odds of observing inadequate or excessive GWG compared with recommended GWG. Overall, 27.8% of this sample met the IOM-recommended GWG guidelines, regardless of BMI. Nearly a quarter (23.8%) of the women did not meet adequate gestational weight gain. Race, parity, education, BMI, age, and marital status significantly increased the odds of delivering small-for-gestational-age (SGA) or large-for-gestational-age (LGA) infants compared to an appropriate-for-gestational-age (AGA) infant. Black or African American, unmarried, and inadequate GWG significantly increased the odds of SGA infants. Increased woman's age, number of prenatal visits, overweight and obesity prior to pregnancy, high gestational weight gain, and multiple pregnancies significantly increased the odds of having an LGA infant.

Conclusions: This study shows that despite 2009 IOM national guidelines, much variation exists in the weight gain by women with normal and high BMI prior to pregnancy, as only 28% met the recommended weight gain. Findings from this study indicate that (a) population diversity, both in BMI and GWG, needs specific guidelines; (b) implementation of the guidelines needs to be evaluated to reflect current women's characteristics and prenatal care factors that impact adherence to IOM guidelines, and (c) guidelines must address specific weigh gain ranges for each obesity class. Future guidelines should reflect the diversity of the population and ways to optimize GWG and likely call for further research to provide insights into recommended GWG during pregnancy.

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To

my parents,

my husband,

and especially my daughters

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LIST OF ABBREVIATIONS

AGA	Average for Gestational Age
BMI	Body Mass Index
GA	Gestational Age
GWG	Gestational Weight Gain
IBW	Infant Birth Weight
IBW-FOR-GAP	IBW for GA Percentiles
IOM	Institute of Medicine
IUGR	Intra-Uterine Growth Restriction
LCT	Life Course Theory
LGA	Large for Gestational Age
PNC	Prenatal Care
PrePBMI	Pre-Pregnancy BMI
SGA	Small for Gestational Age

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Chapter 1

Chapter 1 introduces the problem of pre-pregnancy body mass index (PrePBMI); prenatal care factors such as prenatal care, health insurance, and supplemental nutrition programs; and their impact on gestational weight gain (GWG) and IBW-FOR-GAP. The terms *pre-pregnancy weight*, *pre-pregnancy body mass index* (PrePBMI), and *body mass index* (BMI) will be used interchangeably. *Pregnancy-related weight variation* refers to the ranges outside the reference ranges accepted as normal for PrePBMI and GWG per recommended guidelines and IBW that is either small or large for gestational age.

This study will contribute to nursing knowledge by describing a) characteristics of women who experience inadequate weight gain during their pregnancy, b) characteristics of women who give birth to infants who are small-for-gestational-age (SGA) and large-for-gestational-age (LGA), c) how prenatal care factors predict relationships between PrePBMI, GWG, and IBW and d) whether current weight gain guidelines optimize the health of diverse populations. This first chapter describes the prevalence and significance of PrePBMI, GWG, and IBW in women of childbearing age, as well as potential prenatal care factors such as (a) type of health insurance, (b) frequency of prenatal care visits,(c) group prenatal care and (d) Women, Infants, and Children (WIC) nutritional supplemental program enrollment and women's characteristics, such as (a) age, (b) education, (c) race, (d) ethnicity, (e) nativity, (f) education, (g) parity and (h) marital status. The principles and temporal concepts of Life Course Theory (LCT) will be described, as well as how they can be applied to pregnancy-related weight variations and associated factors.

People's first language recognizes people as individuals with rights to dignity and care and puts the person rather than their condition, disability, and other deviating factors first. Terms

related to overweight, and obesity will use a person's first language. The terms *women of childbearing ag*e and *maternal* will be used to describe pregnant individuals. However, the author recognizes that people of various gender identities, including transgender, nonbinary, and cisgender individuals, give birth and receive perinatal/maternity care.

Background

Obesity is a significant global public health concern and challenge, and maternal obesity is one of its most alarming consequences. Obesity in women of childbearing age has been linked to several adverse maternal outcomes, including gestational diabetes, hypertension, preeclampsia, and excessive weight gain during pregnancy. In 2009, the Institute of Medicine (IOM) released guidelines on weight gain during pregnancy to mitigate these risks. However, there is limited research on how adherence to these guidelines affects IBW, specifically in the context of prenatal care factors and women's characteristics. Therefore, this literature review explores the relationships between women's characteristics, prenatal care factors, variations in weight before and during pregnancy, and IBW in the context of perinatal obesity and the 2009 IOM guidelines.

Obesity has been challenging to combat worldwide. Obesity rates, and the risks associated with being overweight and obese, have been rising for the last three decades across all populations (The GBD Obesity Collaborators, 2017). The estimated direct and indirect cost of obesity in the United States was $147 billion (about $450 per person in the U.S.) in 2008. It could rise by an estimated $66 billion (about $200 per person in the U.S.) annually by 2030 (Finkelstein et al., 2009; Wang et al., 2011). Consequently, maternal obesity, a complex global health concern, is associated with common pregnancy complications and a higher risk of

perinatal morbidity and mortality (Aune et al., 2014; Poston et al., 2016; Lisonkova et al., 2017; Wang et al. 2021).

According to the U.S. vital statistics between 2012 and 2017, 45% of all infants born alive to women with low-risk pregnancies, 9.9% fell into the SGA, 9.2% into the LGA, and 80% into the AGA categories, 39 to 41 weeks, stratified by birth weight percentile (Mendez, Chen & Chauhan, 2021). The number of LGA infants has increased over time. In Wisconsin, the births between 1996 to 2007, showed that the likelihood of SGA was 57% higher than LGA (11% vs. 7% respectively) (Chen et al., 2011).

Despite the Institute of Medicine (IOM), now called the National Academy of Medicine (NAM), GWG recommendations updated in 2009, and the increased tracking of weight changes after 2010, the guidelines had limited impact on improving perinatal outcomes in the last decade (Tennekoon, 2022). Pre-pregnancy body mass index (PrePBMI) and GWG continue to trend upward. Over half of the women enter their pregnancy with a PrePBMI in the overweight or obese category and continue to gain outside the 2009 IOM GWG recommendations (Goldstein et al., 2018). To address the gap in population-specific weight-related guidelines, the first step is to determine existing weight patterns among various subpopulations and explore their association with infant weight. IBW is an indicator of the mother's intrauterine condition. The intrauterine environment affects pregnancy and neonatal outcomes and subsequent long-term health (Calkins & Devaskar, 2011; Chen et al., 2011; Stephenson et al., 2018). Therefore, this study explores associations between pregnancy-related weight variations, such as PrePBMI and GWG, maternal characteristics, prenatal care factors, and IBW among a cohort of Wisconsin women delivering at one urban hospital. The findings will further delineate whether weight changes are following the recommendations of the IOM 2009 guidelines.

This Study matters in the improvement of maternal and infant outcomes to guide future pregnancies in optimum GWG. Higher than normal PrePBMI and excessive GWG are some of the important determinants of IBW and can lead to adverse short- and long-term perinatal outcomes for both the women and their children (Josefson, Hoffmann & Metzger, 2013; Woo Baidal et al., 2016; Lisonkova et al., 2017; Leonard et al., 2020). Low and high PrePBMI is a moderate risk factor for severe maternal mortality (SMM); (Lisonkova et al., 2017; Leonard et al., 2020). Low PrePBMI, while less common in the United States in the last decades, also increases the risk of SMM for not well-understood reasons (Trong et al., 2015; Leonard et al., 2020). High PrePBMI is relevant and increases the risk for comorbidities and instrumental delivery. However, independent of PrePBMI, the amount and the rate of weight gain during pregnancy might have an additive effect on the maternal and infant mortality risk (Chinn et al., 2020; Lawrence et al., 2014; Wang et al., 2021a, 2021b).

The 2009 IOM GWG guidelines recommend appropriate weight gain during pregnancy based on PrePBMI categories to account for the risk and benefits to the mother and fetus dyad. However, only 32% of women can stay within the recommended weight range (CDC, 2015). All women of childbearing age are at risk for variations in GWG, irrespective of culture (Denize et al., 2018). Overall, 69% of women experience discordant GWG outside of IOM 2009 guidelines, meaning they gain outside the recommended ranges, with most exceeding the recommendations (Denize et al., 2018; Fakhraei et al., 2022). Risk factors include maternal age, parity, smoking, alcohol or drug use, stress, low socio-economic status, and access to healthcare and healthy foods. Women with multiple gestations, such as twins or triplets, are also at increased risk for variations in GWG and IBW-FOR-GAP. Healthcare providers must identify women at risk early in pregnancy and provide appropriate monitoring and interventions to reduce adverse outcomes.

The relationships between PrePBMI, GWG, and perinatal outcomes are also non-linear (Hutcheon et al., 2018). Additionally, other determinants of GWG, such as maternal, psycho-social, biological, and environmental factors, interact on multiple levels and influence maternal and infant health outcomes. Therefore, this study aims to evaluate women's factors associated with prenatal care and their role in PrePBMI, GWG, and IBW-FOR-GAP.

Background to the Problem

Given the current obesity epidemic, identifying, and quantifying modifiable risk factors for obesity are a public health concern. Body mass index (BMI) and gestational weight gain (GWG) are key risk factors for IBW and are associated with future overweight and obesity in childhood and adulthood. The health and well-being of women of childbearing age play a pivotal role in the health of future generations. High PrePBMI and inappropriate weight gain during pregnancy are significant precursors to most non-communicable diseases (Deputy et al., 2015).

More women enter their pregnancy with a higher-than-normal BMI and a diagnosis of a chronic illness than ever before (Johnson et al., 2015; Deputy et al., 2018). Across developed nations, one in two women enters pregnancy overweight (25.3%) or obese (29.8%), with only 41% entering pregnancy at a normal weight (BMI 18.5 - 24.9 kg/m2kg/m2) (Driscoll & Gregory, 2020).

High PrePBMI increases the risk for excessive GWG. Excessive GWG is associated with postpartum weight retention (PPWR) that further impacts women's and their children's weight later in life (Archuleta & Chao, 2021; Ashley-Martin & Woolcott, 2014; Eriksson et al., 2001; Wadhwa et al., 2009). Women who are obese during pregnancy face a higher risk of cancer, cardiovascular disease, and other chronic diseases later in life ref. Children born to women with a higher-than-normal PrePBMI are at increased risk of poor outcomes over a lifetime,

perpetuating a vicious cycle of transgenerational obesity (Mamun et al., 2014; Pullar et al., 2019). Surprisingly, even women underweight or normal weight before pregnancy are not exempt from the risks of future diseases if they experience variations in GWG outside of the 2009 IOM recommended ranges (Jeric et al., 2013; Josefson et al., 2013; Mendez-Figueroa et al., 2021).

Despite the efforts during the last decade to improve weight gain during pregnancy, 48% of women gained above the recommended weight during pregnancy, and 21% of women gained under the 2009 IOM recommendations for weight gain during pregnancy in the United States (Fisher et al., 2013; Flegal et al., 2012; Hamad et al., 2016; Tennekoon, 2022). One area that warrants further investigation is the associations between PrePBMI, GWG, and perinatal outcomes. Research since the publication of the 2009 IOM GWG guidelines shows that a few of the most significant challenges women face are (a) entering pregnancy with a normal BMI and (b) gaining adequate weight during pregnancy (Deputy, Sharma, & Kim, 2015; Deputy, 2018; Johnson et al., 2015). Therefore, this study aims to explore the patterns of pregnancy-related weight variations in a cohort of women to understand what women's characteristics and prenatal care factors play a role in these variations.

Pregnancy is a sensitive period during which women naturally gain weight to support the increased metabolic demands due to fetal growth (Donangelo & Bezerra, 2016; Parrettini et al., 2020). As more women enter pregnancy at a higher-than-normal BMI, the risk for postpartum complications and the development of future chronic illnesses are increased (Farpour-Lambert et al., 2018). Women who are overweight or obese are at higher risk of gaining more than the recommended weight during pregnancy (Rong et al., 2015). GWG is a determinant of maternal obesity and risk for obesity later in life, not only in women but also in their children (Ashley-

Martin & Woolcott, 2014; Mamun et al., 2014). Excessive GWG is associated with post-partum weight retention and further impacts weight in later adult life, even 15 to 20 years postpartum (Makama et al., 2021; Rong et al., 2015).

PrePBMI is an effect modifier between GWG and IBW, regardless of the BMI category, if weight gain exceeds 20 lbs. above the IOM guidelines (Zhao et al., 2018; Hutcheon & Bodnar, 2018; Troung et al., 2015; McDonald et al., 2018; Pölzlberger et al., 2017; Jeric et al., 2013). High PrePBMI increases the risk of pregnancy and birth complications, such as gestational diabetes, hypertension, premature birth, increased length of hospital stays, risk of delivering a large-for-gestational-age (LGA) or small-for-gestational-age (SGA) infant, metabolic complications, induction of labor, and Caesarean section (Baugh et al., 2016; Mamun et al., 2014; Pullar et al., 2019). IBW frequently indicates intrauterine conditions (Falluca et al., 2009). The mother's intrauterine environment affects pregnancy and neonatal outcomes and subsequent long-term health (Rinaudo & Lamb, 2008; Fakhraei et al., 2022).

While the importance of adherence to the IOM weight gain guidelines is evident, women struggle to meet them. Abnormal PrePBMI and GWG increase the risk of adverse birth weight outcomes, with GWG exerting a differential effect on the rates of or severity of adverse birth outcomes across all PrePBMI categories. Troung et al. (2015) suggest that the direction and the magnitude of associations between weight gain during pregnancy and perinatal morbidity are defined on a continuum rather than a stepwise threshold. For example, women who gained over 20 lbs. above the recommended 2009 IOM guidelines had a higher risk of perinatal morbidity, regardless of their PrePBMI, suggesting that BMI is not an effect modifier in the association between GWG and perinatal morbidity. In summary, to reduce the risk of adverse maternal and infant outcomes after pregnancy, it is vital to guide women and clinicians with pregnancy-related

weight recommendations based on evidence considering contributing factors to PrePBMI, GWG, and IBW-FOR-GAP.

Problem Statement

Variations in maternal and infant weight are intricately connected and associated with pregnancy outcomes. More than 50% of women enter pregnancy at a higher-than-normal body mass index (BMI) and gain more than the recommended weight during pregnancy based on the 2009 IOM Gestational Weight Gain (GWG) guidelines (Johnson et al., 2015; Deputy et al., 2018; Driscoll & Gregory, 2020). Only 32% of all women gain the recommended weight based on the recent Center for Disease Control (CDC) report, with 48% of women gaining above and 21% of women gaining below the recommended ranges (CDC, 2016; Fisher et al., 2013; Flegal et al., 2012).

Pregnancy-related weight variations are significant determinants of future health. The 2009 IOM GWG recommendations include weight gain ranges in four BMI categories, specifically for (a) underweight (<18.5 kg/m$^{2)}$, (b) normal weight (18.5-24.9 kg/m^2), (c) overweight (25-29.9 kg/m^2), and (d) obese (≥ 30 kg/m^2). The recommended ranges are 12.5-18 kg, 11.6-16 kg, 7-11.5 kg, and 5-9 kg, respectively (IOM, 2009). However, these guidelines lack specific recommendations for women with different classes of obesity and do not consider age, parity, race/ethnicity, and infant sex. Gaps must address crucial determinants such as women's characteristics and prenatal care factors. In summary, the current recommendations may be suitable for less diverse populations of women, but they do not serve all women. Despite the recommendations, higher-than-normal PrePBMI and poor pregnancy outcomes are rising. Every woman is at risk regardless of their PrePBMI, throwing into question whether the guidelines meet the needs of today's population with changing and diverse demographics.

While the 2009 IOM GWG guidelines consider women's welfare, they are not much different from those published in 1990. The two guidelines differ in two ways. First, the 2009 GWG guidelines use the World Health Organization (WHO) BMI categories. Second, the new guidelines also include a specific range of recommended weight gain for women with a PrePBMI in the obese category (IOM/NRC, 2009; Rasmussen & Yaktine, 2009).

Adopting the revised version of the birth certificate in 2003 aided in the increased tracking of maternal weight and height and the last recorded weight in clinical settings. The committee's recommendations were to conduct routine surveillance of weight gain during pregnancy and postpartum and report findings stratified by age, race, ethnicity, and socioeconomic status. PNC visits are great nutrition and physical activity education opportunities based on women's needs while assessing PrePBMI. In addition, every entity and health care provider who provides care and services to women of childbearing age should include pre-conceptional counseling and inform all women of the importance of conceiving at a healthy PrePBMI.

Mean PrePBMI has risen for women of all ages and most racial groups and population sub-groups in recent decades (Fryar et al., 2018; Liu et al., 2021). Pre-pregnancy weight is considered a poor predictor for the size of perinatal weight changes. However, it is an independent risk factor for adverse maternal and child health outcomes (Chiavaroli et al., 2021; Weiss et al., 2019). Most U.S. women do not meet GWG recommendations (IOM/NCR, 2009; Blencowe et al., 2013; Woo Baidal et al., 2016). Only 32% of women with full-term singleton deliveries gained weight within the recommended range in 2015, with 48% gaining in excess and 21% gaining less than recommended (MMMR, 2016). Additionally, an estimated 50% of women will retain more than 10 pounds, and 24% will retain more than 20 pounds 1 year postpartum

(IOM/CCR, 2009, Endres et al., 2015). In combination, the continuous increase in pre-pregnancy, maternal and postpartum obesity across all major racial/ethnic groups in the United States and the concurrent increase in the obesity-associated burden of poor pregnancy outcomes in the last decades evoke urgency to reverse these negative trends to prevent short- and long-term consequences of obesity and pregnancy-outcomes both in women and their children. This study explores the relationships between pregnancy-related weight variations in a diverse cohort of women considering race, ethnicity, nativity, age, education, and marital status.

A growing body of literature recognizes the risk of adverse pregnancy outcomes with inadequate or excessive weight gain. Studies over the last decade have provided evidence. However, it is still unclear whether and how much pregnancy-related weight variations (particularly in BMI and GWG) are related to adverse perinatal outcomes (Yu et al., 2013; Poston et al., 2016; Joaquino et al., 2018). One challenge in most studies has been measuring and evaluating GWG and its associations with IBW-FOR-GAP.

The problem concerns the need for insight into the factors that impact outcomes. The relationship between maternal race/ethnicity (Steinfield et al., 2000; Ramos & Caughey, 2009; Bryant et al., 2010; Marshall et al., 2014; Snowden et al., 2016) and other maternal characteristics, PrePBMI, and pregnancy complications are not clear. Race and maternal age contribute to birth weight disparities (CDC, 2016). Race is a modifier between maternal age and low birth weight (LBW). Given the controversy in evidence, the relationship between race, maternal age, parity, and maternal and IBW outcomes remains unclear. Other variables such as paternal factors, access to healthcare, exercise, food insecurity, nutritional status, social network, and stress play a role. This study will focus on maternal age, parity, and nativity, as research has indicated their association with the outcomes of interest (Bililign Yimer et al., 2019; Birthweight

et al., 1985; Boudet-Berquier et al., 2017; Clapp et al., 2019; Hinkle et al., 2014; Iversen et al., 2018).

Purpose Statement

This study aims to explore women's characteristics and prenatal care factors associated with pregnancy-related weight variations and IBW. The study will generate insights into (a) women's pregnancy-related weight variations defined as PrePBMI and GWG, (b) women's characteristics and prenatal care factors, (c) IBW-FOR-GAP and explore relationships between these three factors.

Research Questions

Objective 1

Explore and describe the role of women's characteristics related to PrePBMI, GWG, and IBW-FOR-GAP (SGA, LGA, AGA).

Research Question 1

What are the characteristics of women (age, parity, race/ethnicity, nativity, zip code, and marital status) who gave birth to SGA and LGA infants compared to women who gave birth to AGA infants, stratified by PrePBMI and GWG categories?

Objective 2

Evaluate the relationships between prenatal care factors (number of prenatal care visits: group prenatal care; Women, Infants, and Children (WIC) program enrollment; type of health insurance) with total GWG (inadequate, adequate, excessive).

Research Question 2

Do prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, and type of health insurance) predict IOM recommended GWG while controlling for women's characteristics and PrePBMI?

Objective 3

Evaluate the relationships between prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, type of health insurance) and IBW-FOR-GAP (SGA, LGA).

Research Question 3

Do prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, or type of health insurance) predict IBW-FOR-GAP (LGA, AGA, SGA) while controlling for women's characteristics and PrePBMI?

Life Course Theory: A Theoretical Framework

Maternal health is affected by an intricate web of environmental, biological, and psychosocial factors (Kuh et al., 2003). Links between maternal health and infant health are relevant, especially during a critical and sensitive period such as pregnancy when the growth of the fetus depends on factors that affect a woman’s health. The tenants of life course theory best describe the relationship between the mother's and fetus's health. Life-course considers the temporal events, impending and protecting factors throughout a woman's life, especially during a critical and sensitive period, such as pregnancy, to evaluate the links and predictors of the health of future generations. Intrauterine malnutrition (under or overnutrition) at various stages of gestation is linked to early growth patterns in children and adult diseases later in life (Kuh et al., 2003; White et al., 2012). The LCT is appropriate for this study as it incorporates how health

insurance, prenatal care visits, nutritional status, and other individual characteristics influence PrePBMI, GWG, and IBW-FOR-GAP.

Maternal malnutrition and intrauterine undernutrition are linked to early growth patterns in childhood and adult diseases later in life. These infants are mostly born small for their gestational age but not necessarily premature (Lynch & Smith, 2005; Wadhwa et al., 2009). Barker hypothesizes that undernutrition during gestation could permanently change the body's structure, function, and metabolism (Barker et al., 1993). "Baker's hypothesis" or Fetal Origins of Disease Hypothesis (FoAD) evolved into the field of Developmental Origins of Health and Disease (DOHaD) (Calkins & Dvaskar, 2011; Wadha et al., 2009), a precursor to LCT.

The LCT theory is based on the concept of the fetus' predictive adaptive or maladaptive responses to various exposures and the consequences resulting from a mismatch between prenatal and postnatal environments. The theory of fetal origins of transgenerational obesity due to maternal malnutrition (over- and undernutrition) during the perinatal period explains potential pathways into obesity in childhood and later adult life. Adaptations are linked to changes in concentrations of placental and fetal hormones and metabolic abnormalities later in adulthood. Infants born to mothers with high BMI in pregnancy had more rapid growth during childhood and an increased risk of adult obesity. Infant birthweight and growth rate during gestation, infancy, and childhood moderated the risk of coronary events in adulthood (Eriksson et al., 2001).

In summary, pregnancy is a critical and sensitive period in human development, considered a period of plasticity, when fetuses are exposed to the intrauterine environment. Hence, the health of the mother and her child are inseparably intertwined. LCT goes beyond the

theories of developmental origins by providing a conceptual framework to explain health and disease patterns across populations and over time.

LCT postulates many pathways linking exposures that may influence disease risk across the life course and health outcomes. These pathways or trajectories differ for each population. These pathways are influenced by biological, physical, social, and environmental risk and protective factors during critical or sensitive periods in individuals' lives. LCT lands a natural choice for studying and evaluating pathways and weight variations affecting women's and infants' health. The LCT (a) recognizes that all stages of a woman's life are intricately intertwined with others in society across time, (b) health and well-being depend on the interactions between risk and protective factors throughout women's lives, and (c) recognizes that it is everyone's responsibility to prevent and promote health and well-being. Finally, the LCT recognizes the importance of health and disease risk inequalities beyond personal choice and genetics (Giele & Elder Jr., 1998).

Significance of the Study

The study will generate important insights about how individual characteristics of women of childbearing age, weight variation before and during pregnancy, and prenatal care factors and or services are associated with GWG and IBW-FOR-GAP, respectively. This study will contribute to a deeper understanding of the magnitude of how these three components individually and jointly affect GWG and IBW-FOR-GAP, so tailored interventions can be developed in the future to target high-risk subgroups of women of childbearing age in weight management before and during and in between pregnancies.

Chapter Summary

This chapter introduced the issue of weight variations before and during pregnancy and their potential relationships with perinatal outcomes. Pregnancy-related weight variations are associated with poor IBW outcomes and risk for developing future and chronic diseases related to body weight variations, such as heart disease, diabetes, and some cancers. The 2009 IOM GWG recommendations have been inadequate to address the issue of weight gain during pregnancy and its associated factors. Therefore, this study explores the associations between pregnancy-related weight variations, individual characteristics, prenatal care factors, and IBW.

Chapter 2: Literature Review

This literature review explores the relationships between women's characteristics, prenatal care factors, weight variation before and during pregnancy, and IBW. LCT explores the complex interplay between these factors and the potential role of women's characteristics, prenatal care factors, and pregnancy-related weight variations in shaping obesity risk across generations. The application of LCT to this topic focuses on how various social and environmental factors, including individual (women's characteristics) and structural factors (prenatal care), may shape perinatal outcomes and contribute to the health disparities among diverse groups of women and their infants. This chapter aims to provide an overview of the LCT and how it applies to this study. The chapter first describes LCT and then women's characteristics and is completed with a discussion of how LCT supports this study.

Life Course Theory

Maternal health is affected by an intricate web of environmental, biological, and psychosocial factors. Consequently, fetal growth is influenced by maternal health. Links between maternal health and infant health are relevant, especially during a critical and sensitive period such as pregnancy when the fetus's growth depends strictly on the health of the womb. Prenatal care factors, such as health insurance, nutrition, prenatal care visits, and the type and quality of prenatal care, are crucial in supporting maternal and fetal health. Life Course Theory (LCT) allows for examining the intricate relationships between social, economic, and environmental factors and their effects on an individual's health and well-being throughout their lifespan. The theory proposes that health outcomes are not only determined by individual-level factors but are also influenced by the social and historical contexts in which individuals live. The LCT encompasses several key concepts, including timing, duration, and social context, all shaping

health outcomes. The terms *life course theory*, *life course approach*, *life course model*, *life course perspective*, and *life course framework* are used interchangeably in the literature. For this study, *life course theory* will refer to all concepts and principles associated with the above terms (Giele & Elder Jr., 1998).

Sociologist Glen Elder, Jr. is recognized as one of the leading pioneers and founders of the life course theory (Elder, 1975, 1979). Elder (1998) referred to the "Life Course" in his seminal work Life Course Theory (LCT), which emerged in sociology and developmental psychology in the early 1900s. As a concept, it refers to the series of life events and roles that form individuals' biographies. As a theoretical orientation, a "life course" provides an organizing framework for scientific inquiry, study design, variable selection, and data analysis (Richardson, Hussey & Strutz, 2013).

This broad view of the theory describes the complexity and multi-modal nature transgenerational of obesity. Elder and Shanahan (2006) proposed five principles (life span development, human agency, timing, linked lives, and historical time and place) and three critical temporal concepts (trajectories, transition, and turning points) in LCT (Richardson et al., 2013). LCT focuses on the long-term health impacts of experiences, exposures, events, and behaviors on an individual's life span. This approach also recognizes the opportunity to prevent and control diseases at critical stages, from preconception to pregnancy, infancy, childhood, adolescence, and adulthood. The LCT assumes that the trajectory that determines early in life with influencing factors such as maternal diet exposure in utero, body composition before and during pregnancy, and childhood experiences are all influencing factors of increased disease risk later in life. LCT helps us understand the development and factors that impact health and outcomes. Studies based on the developmental origin of health and disease have shown the

transgenerational nature of chronic disease risk. There is a need to obtain optimum health in the preconception. Hence, the focus on the health of childbearing-age women in this study will contribute to the body of knowledge in guiding women before, during, and after pregnancy on managing their weight and health.

One of the strengths of the LCT is that it encompasses biological, behavioral, and psychosocial influences on the development of chronic diseases operating across an individual's life course or generations. It applies within the context of reproductive health and women's general health and well-being. It also highlights a temporal and social perspective looking back across individuals and exploring their experiences to understand current health patterns while recognizing that the broader social, economic, and cultural context shapes past and present experiences.

Five Principles of LCT

LCT has five guiding principles: lifespan development, human agency, the timing of events, linked lives, and historical context. The five principles of the LCT offer conceptual approaches to understanding the role of an individual's life course in their health. The principles should not be seen as definite or mutually exclusive since their applicability depends on the problem being examined and the purpose for which the life course approach is intended. By considering these principles of LCT, researchers, and practitioners can gain a more nuanced understanding of how health outcomes develop and are influenced by various factors across a lifespan. It can inform the development of interventions and policies to improve health outcomes in the prenatal period for both women and their infants (Black et al., 2009).

The first principle of lifespan development assumes that health and well-being, our dynamic and lifelong processes, cannot be fully understood without the context of personal, cultural, and social life experiences. The second principle, the principle of human agency,

focuses on the impact of individuals' decisions and actions regarding their health and well-being. The second principle highlights individual responsibility in personal control and health behavior embedded in the social context. According to Elder and Shanahan (2006), individual decisions are made “within the opportunities and constraints of history and circumstances” (p. 2635). The third principle is concerned with the timing of life course events with regards to when, how long (duration), and in what order (sequencing) they occur (Elder & Shananhan, 2006). The fourth principle of linked lives suggests that individuals’ health is shaped by the interdependency of the social network to which they belong. The last principle of historical time and place considers the period, cohort, and contextual factors that might influence the life course.

Three Key Temporal Concepts of Life Course Theory

LCT’s three key temporal concepts are trajectory, transition, and turning point, commonly used in life course research to describe human development. *Trajectories* are pathways packed with changes in the developmental processes such as work-life, education, parenting, and marriage are often described in terms of trajectories. Trajectories can be shaped by biological, psychological, and social factors impacting health outcomes. *Transitions* are entry points for new states and refer to significant life events of changes. The onset of parenthood is a transition that could also initiate a turning point in one’s life, such as less alcohol consumption. LCT suggests that transitions can have a lasting impact on health outcomes, depending on the timing, context, and individual experience during the transition. Transitions have a liminal quality, being on the threshold or edge of a physical or psychological state (Turner, 1974). Liminality is “neither here nor there,” and “betwixt and between all fixed points of classification” (Turner, 1969, p. 232, Black, Holditch-Davis & Miles, 2009). Liminal phenomena evoke negative feelings, reflecting threatening ambiguity because they disturb a sense of order. Women’s transition between pregnancy and motherhood can be considered a liminal

phenomenon. *Turning points* are abrupt and substantial events that can change an individual's trajectory. For example, a severe illness or a significant event such as the birth of a child may cause an individual to reevaluate their life goals and priorities, leading them to make different choices that can impact their health outcomes. Temporal concepts are not delineated, and one can overspill into the other, but understanding the slight differences in definitions is beneficial (Richardson et al., 2013). LCT conceptual models aid in visualizing the discussed principles and temporal concepts. The most used approaches to study life course processes are defined in overlapping causal models (See Figure 1) adapted from (Kuh et al., 2003).

a) Critical period model biological programming or latency model

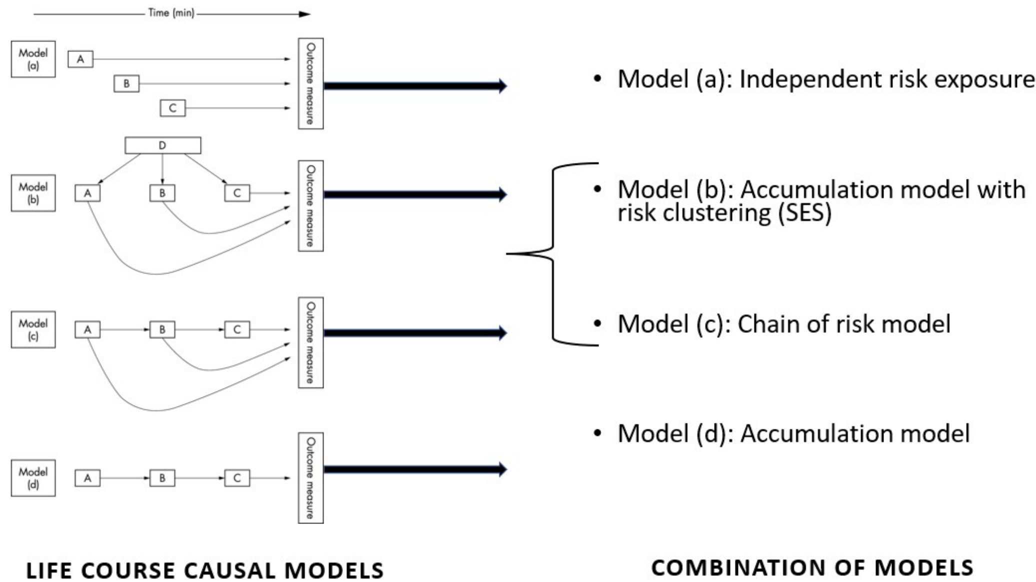
b) The critical period model with later effect modifiers

c) Accumulation of risk model or cumulative model

d) Pathway model or chain of risk model, or trigger model

Figure 1

Life Course Theory Causal Models



Note. The four models depict causal pathways about time (accumulation, chain of risk), timing and order of causal actions (A, B, C, D), and lastly, the different types of mechanisms and relationships between A, B, C, and D. From "Life Course Epidemiology," by D. Kuh, Y. Ben-Shlomo, J. Lynch, J, Hallqvist, and C. Power, 2003, *Journal of Epidemiology and Community Health*, 57, p. 778-783(http://dx.doi.org/10.1136/jech.57.10.778).

Application of Life Course Theory to Perinatal Health

Applying an LCT to health promotion and disease prevention requires a change in how public health is viewed. According to Mary Barker (2015), "the new public health" demands a developmental approach to better understand the role of social and physical environments in shaping health behaviors and how those behaviors are influenced by automatic processes and habits as much as reflective processes and rational decisions. Therefore, knowledge is insufficient to attain and sustain healthy behaviors that lead to positive health outcomes. Looking

through the lenses of LCT provides an opportunity to focus on (a) the role of preconception health and well-being on birth outcomes, (b) the long-term effects of adverse childhood experiences, and (c) the fetal origins of adult disease, and (d) the factors associated with maternal and infant health. According to the fetal origins of disease hypothesis (FoAD), the adult disease cannot be fully understood without considering early life exposures in the uterus or even before pre-conception that may increase the body's susceptibility to adult/chronic diseases (Barker et al., 2017; Godfrey et al., 2017; Barker et al., 2018).

The LCT can be tailored to specific populations or health concerns. Women of reproductive age have special needs for health promotion in the prenatal period, in childbirth, and during the infancy of their babies. PrePBMI and GWG strongly predict obesity and overweight later in life (Chiavaroli et al., 2021; Fakhraei et al., 2022; Gilmore et al., 2015; Hu et al., 2019; Ohlendorf et al., 2019; Soria-Contreras et al., 2020). LCT allows the exploration of multi-level factors associated with obesity in this population across the life course. For example, genetic inheritance, intrauterine environment, fetal development, fetal programming, maternal health and nutrition, infant/child health and nutrition, socioeconomic status, psychological conditions, and behavioral issues, as well as sociocultural, political, environmental, and historical context can be evaluated when applying LCT (Pratt & Frost, 2016).

Women's Characteristics and Pregnancy-Related Weight Variations

Women's age, parity, race/ethnicity, and PrePBMI are essential predictors of GWG. Increased maternal age is associated with increased BMI and infant weight. Some studies found that maternal height and BMI, rather than age and ethnicity, significantly predicted IBW (Spada et al., 2017). Structural racism is a fundamental cause of health inequities in women of

childbearing age. Disparities in maternal mortality are intricately linked with social, economic, and environmental disadvantages considering that non-Hispanic Black women at all levels of education and income are more likely to experience death around pregnancy than non-Hispanic White women (CDC, 2017). This is compounded by environmental effects, chronic diseases, poor treatment, and negative experiences within the healthcare system (Chinn et al., 2020). Many non-Hispanic and Hispanic women experience poor or disrespectful patient-provider communication, trauma, and difficulty obtaining quality perinatal care (Chinn et al., 2020).

There has been considerable progress in understanding the behavioral determinants of women's health (Cilar Budler & Budler, 2022; Seifu et al., 2021). However, less is known about how to change them and the broader determinants of women's health that involve the social community and societal factors. Determinants of women's health fall into four categories: biological, psychological, environmental, and social-cultural. The first two are considered downstream factors that are modifiable through complex pathways. The last two are considered upstream and can be impacted by social and economic policies (WHO, 2023).

Behavioral determinants are risk factors for most chronic conditions. Cultural, social, and societal contexts shape these behavioral factors and mark the differences in the prevalence of and mortality from various conditions in women who experience social disadvantage due to race and ethnicity, lack of education, and low income. The difference is seen from various social determinants, including differential exposure to stressors and violence, which are more common in disadvantaged communities (Koupil I & Toivanen P, 2008; WHO, 2023).

A wide range of natural, biological, social, environmental, cultural, and physical factors have been linked to maternal, infant, and child health outcomes (HealthyPeople 2030, n.d.). These are also defined as determinants of health. Understanding how these factors impact

women is crucial to finally improve obesity prevention measures and the health of future generations (WHO, 2005). Health-promotion efforts address the full range of potentially modifiable determinants of health, not only those related to individuals' health behavior and lifestyle choices but also factors such as income, education, working conditions, access to adequate health services and programs, and the environment (WHO, 1998).

Disparities in preconception health hurt both birth outcomes and women's health. Improving preconception health before and between pregnancies is critical in addressing maternal mortality and pregnancy-related complications (U.S. Department of Health and Human Services, 2017). Structural racism, implicit bias, disparities in different geographic and birth settings (Burgess et al., 2020), and the need for social support and respectful care are some of the social determinants of health that need to be addressed to decrease maternal morbidity and mortality in the United States (Main & Menard, 2013; Chinn et al., 2020).

Rates of maternal mortality vary at state and local levels in the United States. Some states have rates resembling those of developing countries (Louisiana, for example, has a mortality rate of 72 per 100,000 live births). Others are comparable with the rates of developed European countries (such as Alaska, with 12.4 per 100,000 live births) (America's Health Rankings, 2020). Wisconsin's maternal mortality rate was 19.9 per 100,000 live births in 2019. One of the proposed objectives of Healthy People 2030 is to reduce maternal death (MICH-04) from 17.4 maternal deaths per 100,000 live births in 2018 to 15.7 maternal deaths per 100,000 live births by 2030 (ODPHP, n.d.). According to Nelson et al. (2018), maternal obesity has been consistently reported to increase the risk of pregnancy complications such as thromboembolic disease, gestational diabetes mellitus, and hypertensive disorders of pregnancy, which are the

leading causes of maternal mortality in the United States. Hence, additional emphasis is warranted in promoting general pre-conception health of women of childbearing age.

Age

The prevalence of overweight and obesity increases in women of childbearing age (Akseer et al., 2022; Amyx et al., 2021; Archuleta & Chao, 2021; Ewing et al., 2017; Yakusheva et al., 2017). According to the National Center for Health Statistics (NCHS), the prevalence of obesity (BMI 30.0 or higher) in women aged 20-39 was 39.7% in 2017-2018 (Hales et al., 2020). While there was no difference between those aged 25-29 and 30-34, the percentage of overweight ranged from 22.6% among women under age 20 to 28.5% among those aged 40-54. Obesity before pregnancy ranged from 16.6% in women under age 20 to 27.0% in women 40-54 years old (Branum et al., 2016). Maternal risk factors have been tabulated for women of childbearing age based on defined age ranges. However, age-related factors might be overestimated by the values for the youngest and the oldest women in the age range since they are more commonly represented in the U.S. population of women (Parker et al., 2013).

Defining a population based on age ranges can influence the generalizability of findings across studies that use different age ranges. There is a risk of loss of information beyond the range (Parker et al., 2013). Consequently, high and low values at the beginning and end of the age range do not necessarily represent women more likely to give birth (between ages 30-35) (Parker et al., 2013). Interestingly, birth rates for women between ages 15 and 44 have been increasing steadily since 1985, and the mean age of mothers at first birth increased for all races in 2018 (Martin et al., 2019; Martin et al., 2021). Increased maternal age correlates with fetal death or loss, independent of the previous perinatal outcomes. Women 35 to 39 also have a

higher risk of spontaneous miscarriage and stillbirth; however, the increased risk is not fully understood (Fretts et al., 1995).

Perinatal mortality risk for preterm birth, SGA, and neonatal death follows a U-shaped trend, with the highest prevalence among females aged 10-14. It gradually reduced but increased again for females older than 40 (Akseer et al., 2022). Advanced maternal age increases the risk of SGA infants, miscarriage, pre-eclampsia, and Cesarean section (Khalil et al., 2013; Akseer et al., 2022).

Marital Status

Marital status can significantly influence women's access to prenatal care, health behaviors, and overall health outcomes. Studies have found that unmarried women have a higher risk of adverse pregnancy outcomes such as preterm birth, low birth weight, and neonatal mortality than married women. Unmarried women may also have limited access to healthcare and social support, impacting their ability to engage in healthy behaviors during pregnancy (Barr & Marugg, 2019). This is controversial, as a supportive partner was more important than marriage.

Research has also shown that marital status may be associated with differences in prenatal care utilization. For example, married women may be more likely to initiate prenatal care earlier in pregnancy and attend more prenatal visits than unmarried women. It may be due to the increased social support and resources available to married women. Marital status can affect the relationships between women's characteristics, prenatal care factors, and IBW. It is essential to consider marital status as a potential confounding variable in research studies examining these relationships reproductive (Fafard St-Germain et al., 2022).

Education

Research has shown that a woman's education can play a role in determining the quality and quantity of prenatal care received, which can, in turn, affect IBW (Cingil & Göger, 2020; Delgado, 2013; Kröger & Leopold, 2020; Mensch et al., 2019). Women with higher levels of education tend to have greater knowledge and awareness of healthy behaviors. They are more likely to engage in health-promoting behaviors during pregnancy, such as attending regular prenatal care visits, eating a balanced diet, and avoiding harmful substances such as tobacco and alcohol. As a result, they are more likely to have infants with healthy birth weights (Kröger & Leopold, 2020).

In contrast, women with a high school education or less may have limited access to healthcare services. They may lack the knowledge and resources to engage in health-promoting behaviors during pregnancy (Kröger & Leopold, 2020). This can put them at higher risk for poor pregnancy outcomes, including low birth weight and preterm birth. It is also important to note that education can be closely linked with other social determinants of health, such as income and employment status, which can further impact a woman's ability to access health care, such as prenatal care and have adequate health insurance, and engage in health-promoting behaviors during pregnancy (Mensch et al., 2019).

Race and Ethnicity if this is the order you put them here, I would begin discussing in this order.

Race and ethnicity are both social constructs to categorize and characterize distinct populations. Non-Hispanic Asian women had the lowest percentage of overweight and obesity before becoming pregnant among all age groups of women of childbearing age, 19.9% and 7.5%, respectively (Branum et al., 2016). Hispanic women, at 29.7%, had the highest prevalence of

overweight, followed by non-Hispanic American Indian and Alaska Native (AIAN) at 27.2% and non-Hispanic Black women at 26.9% (Branum et al., 2016). Obesity prevalence was highest among non-Hispanic AIAN women (36.4%), followed by non-Hispanic Black women (34.7%). The most notable disparity in mortality rates in the United States is defined by race. Black women's death rate ranges from three to four times the rate of their White counterparts (41/100,000 and 13/100000 as of 2010). American Indian and Alaskan Native woman women also fare worse than White women, with twice as many pregnancy-related deaths per 100,000 live births.

Racial disparities exist despite the significant improvement in neonatal morbidity and mortality over the last 25 years. Non-Hispanic black and American Indian/Alaska Native women have a three-fold higher maternal mortality rate compared to non-Hispanic White women (Creanga et al., 2017; Petersen et al., 2019). According to the CDC (2019), about 31% of deaths occurred during pregnancy, 36% at delivery or within one week after, and 33% between 1 week and one year postpartum. Every pregnancy-related death is tragic, especially because 60% are preventable. Ethnicity is a multi-dimensional concept, considered an expression of belonging based on one or more shared characteristics such as common ancestry, country of birth/origin or nativity, nationality, religion, culture, color, and language. The 1997 Office of Management and Budget (OMB) standards allow reporting more than one race, and individuals' response to race questions is based upon self-identification (see Table 3). The racial categories reflect the social definition of race recognized in the United States and are not an attempt to define race biologically, anthropologically, or genetically. It is also recognized that the categories of the race item include racial and national origin or social-cultural groups. People may report multiple races

to indicate their racial mixture, such as American Indian and White. We will use race/ethnicity as defined in the PeriData.Net®.

Many studies acknowledge racial and ethnic differences in obesity risk factors in women of childbearing age; however, the differences are not always well understood (*Correlates of Early Prenatal Care Access among U.S. Women: Data from the Pregnancy Risk Assessment Monitoring System (PRAMS) | SpringerLink*, n.d.; Oteng-Ntim et al., 2013).

Race and ethnicity have also been found to be associated with IBW. Studies have consistently shown that non-Hispanic Black and Hispanic women are more likely to deliver low birth weight infants compared to non-Hispanic White women (Misra et al., 2019; Rahman et al., 2019; Torloni et al., 2017). Studies have shown that race and ethnicity are associated with variations in IBW, with non-Hispanic Black and Hispanic women being more likely to have lower birth weight infants than non-Hispanic White women. This may be due to a range of factors, including differences in socioeconomic status, access to healthcare, and exposure to stressors (Bruce et al., 2007; Dominguez et al., 2008; Sackoff & Yunzal-Butler, 2015; Snowden et al., 2016; VanderWeele & Robinson, 2014).

Eliminating racial disparities in women of childbearing age can potentially reduce disparities in two leading causes of death in early and middle adulthood: heart disease and diabetes (CDC, 2017). Therefore, it is vital to continue evaluating birth weight outcomes based on race and ethnicity to tailor high-reach and low-cost intervention strategies to different ethnic groups of women. These strategies can have immense potential for promoting health promotion on a larger scale and reducing health disparities (Chasan-Taber, 2012)**.** Infants born to Black women have the highest frequency of adverse perinatal outcomes. However, the risk is no longer

observed after adjustment for sociodemographic factors. Disparities are highly correlated with insurance or payor status (Parchem et al., 2021) (data from 2008-2011).

Controversy exists in racial/ethnic differences between PrePBMI and fetal growth. Evidence suggests that PrePBMI and IBW are associated with European American women but not African American women (Gillespie & Christian, 2016; Jara et al., 2020). Serum leptin increases during pregnancy, but Black and White women's levels were significantly associated with GWG. In contrast, the combined effects of race and BMI resulted in a higher leptin-to-adiponectin ratio during pregnancy and postpartum in black women with obesity (Jara et al., 2020), suggesting racial disparities as a potential confounding factor in GWG and IBW outcomes.

Parity

Maternal parity is a well-recognized predictor of IBW. Nulliparous women are at increased risk of delivering low birth weight (LBW) and SGA infants (Skjaerven, Gjessing, & Bakketeig, 2000; Shah et al., 2010). The association between parity and IBW is also non-linear, meaning the impact of parity on IBW may vary depending on the level of parity. According to more recent studies, maternal age, residence, occupation, access to prenatal care, frequency of prenatal visits, and previous pregnancy complications are more significant in IBW outcomes than parity (Billing et al., 2019, Tadese, Desta & Tsegaw, 2021). It is debatable if parity should be considered when developing customized birthweight percentiles to identify SGA and LGA infants. However, it might be a valid argument not only for parity-specific birthweight references but also for the value it may serve in the update of the 2009 GWG guidelines (Nohr et al., 2009, Hutcheon, Walker & Platt, 2012). While multiparas may benefit from lower GWG than recommended to avoid post-partum weight retention, nulliparas are at substantial risk for gaining

in excess during pregnancy despite delivering smaller infants (Nohr et al., 2009; Hinkle et al., 2013).

Nativity

Nativity status has been identified as another potential factor that may influence IBW. Research has shown that immigrant women may have better birth outcomes than their counterparts born in the United States, which may be due to cultural or environmental factors (Misra et al., 2019; Rahman et al., 2019). Regarding nativity, research has found that foreign-born women may have better birth outcomes than women born in the United States, mainly if they have retained their home country's health practices and cultural norms (Daundasekara et al., 2020; Li et al., 2011). These findings are significant as this study explores the differences in individual characteristics and prenatal care factors in different groups of women based on their birthplace. However, this relationship is complex and may be influenced by factors such as length of time in the United States, acculturation, and access to healthcare. Further research is needed to understand these relationships better and to develop interventions that can help improve birth outcomes for all women and infants.

The factors contributing to these associations between maternal characteristics and IBW are complex and multifaceted. Biological factors such as genetics, maternal health conditions, and maternal nutrition have all been found to play a role (Misra et al., 2019; Rahman et al., 2019). Social and environmental factors such as poverty, access to healthcare, and exposure to environmental toxins have also been shown to impact IBW (Misra et al., 2019; Rahman et al., 2019). The literature suggests that maternal characteristics can significantly impact IBW. However, the mechanisms by which these factors influence birth weight are complex and not fully understood.

Women's Behaviors (Nutrition, Physical Activity, Alcohol, Substance, and Tobacco Use)

Behavioral lifestyle interventions, dietary and physical activity, or combinations of these factors generated mixed results over the last few decades (Lim et al., 2020). These interventions are only successful in the short-term, and are modest and unsustainable (Flynn et al., 2016; Lv et al., 2017, & Thangaratinam et al., 2012). It has been estimated that 20% of women of childbearing age will gain enough weight in 5 years to place them into a higher BMI category (Gunderson, 2009). A higher pre-pregnancy BMI will place women at an increased risk of adverse pregnancy outcomes, perpetuating a vicious cycle that causes long-term obesity (Cnattingius et al., 2012). Dodd et al. (2018) conducted a systematic review and meta-analysis to evaluate behavioral interventions that target diet and physical activity to promote weight loss and improve health in a subsequent pregnancy. The results indicate that diet or physical activity, alone or in combination, in the postpartum period can initiate more significant weight loss after the intervention and at 12 months post-partum. These effects must be evaluated carefully, given the challenges of a 25% attrition rate and the lack of longitudinal evaluation of outcomes (Dodd et al., 2018). In a more recent systematic review and meta-analysis of randomized controlled trials of lifestyle interventions in women up to 2 years postpartum and ages 23-36, Lim and colleagues (2020) concluded that behavioral strategies resulted in significant improvement in weight (mean difference −2.46 kg, 95%CI −3.65 to −1.27) and physical activity (standardized mean difference 0.61, 95%CI 0.20 to 1.02), but not in energy intake.

Chronic Diseases

Chronic diseases are more common in people whose living conditions place them at risk for poor health. These conditions are also diagnosed later in life, resulting in worse health outcomes in these populations (CDC, 2013). Disparities in preconception health hurt both birth

outcomes and women's health. Improving preconception health before and between pregnancies is critical in addressing maternal mortality and pregnancy-related complications (U.S. Department of Health and Human Services, 2017). A combination of higher BMI and gestational diabetes during pregnancy worsens the impact of complications, including the need for interventional and Caesarean deliveries and medical management of diabetes (Ijas et al., 2019; Alfadhli, 2021). Female adolescents with higher-than-normal BMI growth are more susceptible to the greater health risk of glucose dysregulation (Fong, 2019). Structural racism, implicit bias, disparities in different geographic and birth settings (Burgess et al., 2020), and the need for social support and respectful care are some of the social determinants of health that need to be addressed to decrease maternal morbidity and mortality in the United States (Main & Menard, 2013; Chinn et al., 2020).

Prenatal Care Factors

Prenatal care is a comprehensive care women may receive from their health care providers during pregnancy. The first visit usually occurs during the first trimester (between 1-3 months), and the frequency of the follow-up visits, ideally, is determined based on each woman's individual needs and risks. Women who receive early and frequent prenatal care tailored to their needs are more likely to have a pregnancy with fewer complications and more likely to deliver healthy infants (Fiscella, 1995; Krueger & Scholl, 2000; Petrou et al., 2003; Debiec et al., 2010). The American College of Obstetrics and Gynecologists (ACOG) recommends that women with uncomplicated/low-risk pregnancy should follow the following schedule: every 4 weeks for the first 28 weeks (approximately 6.5 months), then every 2 weeks until 36 weeks of gestations, and weekly after that until delivery. Again, women with risk factors, such as chronic diseases, extremes of reproductive age, and weight categories, will require closer surveillance. The timing

and the frequency of visits should allow the healthcare provider to assess the well-being of the woman and her fetus, provide timely and individualized education, complete recommended health screenings, detect any issues that might arise throughout the pregnancy, and reassure the woman (ACOG, 2017). Prenatal/Antepartum care is on the continuum of comprehensive perinatal care. As an integrative part of family-centered care, perinatal care should ideally begin before pregnancy and continue beyond the delivery, postpartum, and interpregnancy period (ACOG, 2017).

Starting prenatal care in the first trimester has shown to improve health outcomes for women of childbearing age (Martin et al., 2019). Most women, 77.5% of childbearing aged women, initiated prenatal care in the first trimester. Of women aged 20-24, 70.9%, and of women aged 35-39, 81.5%, were more likely to seek prenatal care in the first trimester in 2018 compared to women aged 25-29 and 40 (Martin et al., 2019). Women over the age of 40 have higher risk for complications in the perinatal period with increased risk of mortality (Chinn et al., 2020), so it is vital to start prenatal care early in the pregnancy especially considering the 4% increase in the first birth rates in this population in 2018 (Martin et al., 2019). By race and Hispanic origin, non-Hispanic Black (67.1%) and Hispanic women (72.7%) were less likely to start prenatal care in the first trimester compared to non-Hispanic White (82.5%) and non-Hispanic Asian women (81.8%).

Number of Prenatal Visits

The quantity and quality of prenatal care women receive during pregnancy can impact their weight gain patterns. Several studies have examined the relationship between prenatal care factors and GWG, including the number of prenatal care visits (Habibov et al., 2017); group prenatal care (Tanner-Smith et al., 2014); Women, Infants, and Children (WIC) enrollment

(Soneji & Beltrán-Sánchez, 2019); and type of health insurance (Greiner et al., 2020). A systematic review and meta-analysis of 14 studies found that women who attended more prenatal care visits were more likely to achieve the recommended GWG. However, the effect size was small (OR=1.09, 95% CI: 1.02-1.17) (Jafari et al., 2017).

Studies have shown that inadequate prenatal care is associated with excessive GWG, while adequate and consistent prenatal care is associated with appropriate weight gain during pregnancy (Andres et al., 2018; Roselló-Sastre et al., 2018). Women who receive group prenatal care have been found to have lower GWG and are more likely to meet the recommended guidelines for weight gain during pregnancy compared to those receiving individual care (McDonald et al., 2019; Suplee et al., 2014). Similarly, enrollment in WIC, a federal program that provides nutrition education and supplemental food to low-income pregnant women, has been associated with lower rates of excessive GWG (Shin et al., 2018).

While access to prenatal care is crucial for optimizing maternal and fetal outcomes, the number of prenatal care visits alone may not be sufficient to ensure optimal GWG. A study by Moore et al. (2019) found that among women with normal BMI, those with more prenatal care visits had a higher likelihood of meeting GWG guidelines than those with fewer visits. However, among women with overweight or obesity, the number of prenatal care visits was not significantly associated with meeting GWG guidelines.

Group Prenatal Care

Group prenatal care is an alternative option for low-risk pregnant women and has been associated with improved pregnancy outcomes. Group prenatal care models deliver prenatal health services and education to 8-12 women, usually with similar estimated delivery dates, during shared 1–2-hour visits. Each visit has a physical examination and informational group

session. Women's health practitioners usually facilitate these groups. Visits are billed as traditional prenatal visits. The results of group prenatal care are promising, and some studies show improved breastfeeding initiation rates and decreased incidence of preterm delivery. However, research is warranted to evaluate the benefits of prenatal group care to confirm its benefits to the mother and infant dyad (ACOG, 2017).

Group prenatal care has also been associated with improved GWG outcomes. A randomized controlled trial reported significantly lower rates of excessive GWG in women who received group prenatal care than those who received individual prenatal care (Chang et al., 2017). The mechanisms by which these factors influence GWG include improved access to healthcare, nutrition education, and social support. Group prenatal care and WIC enrollment also provide opportunities for social support and education, which can help women make healthier choices and adopt healthier lifestyles. Group prenatal care, which involves shared medical appointments and facilitated discussion among pregnant women, is associated with improved GWG outcomes, possibly through increased social support and access to nutrition education (Ickovics et al., 2016).

Women, Infants, and Children Program (WIC) Enrollment

The amount of nutrition assistance that women receive in Wisconsin depends on their income, household size, and other factors. A household's benefits are based on the Thrifty Food Plan, which estimates the cost of an essential, healthy diet. In Wisconsin, the Supplemental Nutrition Assistance Program (SNAP), also known as FoodShare, provides nutrition assistance to low-income individuals and families (Bureau, n.d.; Chiasson et al., 2016).

As of October 2021, the maximum monthly SNAP benefit amount for a household of one in Wisconsin is $75/month (more or less), depending on the income level (1855 of the U.S.

Department of Health and Human Services Nonfarm Income Poverty Guidelines for Gross Income) and household size. Women who are pregnant or have recently given birth may also be eligible for the Women, Infants, and Children (WIC) program, which provides supplemental food, nutrition education, and other services to low-income pregnant and postpartum women and their children until the children reach 5 years of age. The assistance WIC provides is based on the individual's needs and circumstances**.**

WIC, a national program, was established in 1969 during the White House Conference on Nutrition. It was first piloted in 1972 under a different name. Since then, it has grown to serve more than one-third of all pregnant women., half of all infants., and 30% of all children younger than 5 years of age in the United States. WIC intends to foster growth and development among U.S. women, infants, and children with the lowest incomes and most significant needs. Changes to the WIC program and the environment, including the expansion of other programs such as SCHIP, Head Start, Early Head Start, and Supplemental Nutrition Assistance Program (SNAP); new healthcare legislation; the economic recession that began in 2007; new technology; changes in the food supply; changes in health risks of the U.S. population; development of new growth charts; and changes in social norms relating to food, nutrition, and eating expedited the need to reevaluate the scientific evidence supporting the benefits of WIC.

WIC has been supporting women of childbearing age and their children since 1974. It is one of the nation's most successful and cost-effective federally-funded nutrition intervention programs. It specifically serves low-income pregnant women through pregnancy and up to 6 weeks (approximately 1.5 months) after birth or after pregnancy ends, breastfeeding women up to the infant's first birthday, non-breastfeeding women up to 6 months after the birth of an infant or after pregnancy ends, infants up to the first birthday, and children under the age of 5 who are

at nutritional risk, to promote optimal nutrition. Currently, the program serves half of the infants born in the United States; the eligibility requirement is having a family income of 186% or below the poverty level (Food and Nutrition Service, 2013). The program provides supplemental nutritious foods, nutrition education, counseling at WIC clinics, screening, and referrals to other health, welfare, and social services. The Food and Nutrition Service (FNS), a federal agency of the U.S. Department of Agriculture, is responsible for administering the WIC Program at national and regional levels. It is administered at the federal level by FNS and at the state level by state agencies. Income eligibility criteria must be used with nutritional risk criteria in determining a person's eligibility for participation in the program. WIC is not an entitlement program, which means not every eligible individual can participate in the program considering the set funds provided by Congress.

At the same time the 2009 IOM guidelines were updated, the USDA issued regulations that resulted in substantial revisions to the WIC. Around 2009-2010, Congress also appropriated $15 million for research related to WIC. Considering the changing demographics, public health services, and increasing prevalence of obesity in the general population and women of childbearing age, this allocation of money was timely. The research agenda focused on the impact of WIC on birth outcomes, overweight and obesity, breastfeeding, dietary intake, nutritional status, nutrition education, health care cost, food insecurity, and hunger.

Nutrition prior to conception is crucial in the critical stages of fetal development. The role of the placenta in fetal programming and future disease risk might be modifiable through healthy maternal nutrition before pregnancy by altering epigenetic processes (Sinclair et al., 2007; Steegers-Theunissen et al., 2009). Earlier studies, however, reported no effect of WIC or

nutritional supplementation during pregnancy on birth outcomes (Klerman et al., 2001; Metcoff et al., 1985; Rush et al., 1980(Soneji & Beltrán-Sánchez, 2019).

Health Insurance

Improved access to healthcare can also result in better management of health conditions that can impact GWG. One potential mechanism is access to healthcare, which can influence women's ability to receive regular prenatal care, monitor their weight gain, and receive nutrition education and support (Deputy et al., 2015). Evidence shows that women who receive public health insurance have poorer health outcomes and increased mortality rates compared to women who are covered by private insurance (Adams & Johnston, 2016). Although the percentage of births covered by Medicaid declined in 2018 (from 43% to 42.3%), there was a significant difference between the use of public insurance based on race/ethnicity. In 2018, the percentage of women of childbearing age with Medicaid coverage was 65.3% for non-Hispanic Black women compared to non-Hispanic White women at 30.0%. By age, Medicaid as the payment source declined in all ages except women over 40. The highest and the lowest percentage of Medicaid users were women under age 20, at 77.3%, and women aged 35-39, respectively (Martin et al., 2019).

Health insurance provides financial protection against healthcare expenses. It can cover medical expenses related to pregnancy and childbirth, such as prenatal care, delivery, and postpartum care. Private health insurance is typically obtained through an employer or purchased directly from a private insurance company. Medicaid is a public health insurance program for people with low income or disabilities, and BadgerCare Plus is Wisconsin's version of Medicaid. In terms of their relationship with WIC, both Medicaid, and BadgerCare Plus provide eligibility for WIC, which provides nutrition assistance to low-income pregnant women, new mothers, and

young children. However, some WIC services, such as nutrition education and counseling, may be covered by private health insurance (D'Angelo et al., 2012; Hawks et al., 2018).

Pregnancy-Related Weight Variations

Pre-Pregnancy Body Mass Index (PrePBMI)

Body mass index (BMI), the Quetelet's index, was first defined as body weight divided by height squared. BMI is calculated as the weight ratio in kilograms to the square of height in meters squared. See Table 1 for the description of different BMI categories and their nutritional status. While it does not measure body fat directly, BMI is moderately correlated with more direct measures of body fat obtained from skin full-thickness measurements, bioelectrical impedance, underwater weighing, dual-energy X-ray absorptiometry, and other methods (Komaroff, 2017). One major limitation of BMI in epidemiological studies is that it assumes an average person with average physical activity and average body composition. BMI is not a good proxy for fat distribution and cannot separate lean fat from body fat mass. The distribution of extra fat in the body can change the risk associated with obesity (Jensen, 2008, Booth, Magnuson & Foster, 2014). Upper body fat accumulation or visceral obesity is associated with adverse health outcomes. In contrast, lower body fat accumulation is associated with a reduced risk of obesity-induced metabolic dysregulation and is considered protective (Booth, Magnuson & Foster, 2014; Blundel et al., 2014).

Despite these facts, BMI is the most common index to measure weight status in adults, including women of childbearing age. Based on a study of the 2005-2012 National Health and Nutrition Examination Survey (NHANES), participants 18 and older and an estimated 74,936,678 adults could potentially be misclassified as cardiometabolically healthy or unhealthy when using only standard BMI categories as the primary proxy of health (Tomiyama et al.,

2016). Therefore, researchers must consider these measurement shortfalls when conducting studies since GWG 2009 IOM/NRC recommendations are based on PrePBMI categories defined by the World Health Organization (WHO; see Table 1). Other measures of body fat are available such as skinfold thickness, underwater weighing, dual-energy x-ray absorption, waist circumference, and waist-to-hip ratio. However, some can be intrusive and expensive and might not be widely available (CDC, n.d.). Scientific knowledge concerning obesity and related health issues is based on the association of BMI with health outcomes (Hubbard, 2000; CDC, n.d.). Obesity is one of the primary independent risk factors associated with non-communicable diseases.

Table 1

Body Mass Index (BMI) Categories

BMI	Nutritional Status
< 18.5	Underweight
18.5 – 24.9	Normal weight
25.0 – 29.9	Overweight
30.0 – 34.9	Obesity Class I
35.0 – 39.9	Obesity Class II
> 40.0	Obesity Class III

Note: Adapted from Body mass index- BMI. World Health Organization, n.d. *(Daundasekara et al., 2020; Li et al., 2011)*

BMI is widely used in chronic disease prediction. It is widely embedded in scientific knowledge and the ways in which health is evaluated, understood, and defined, but it is only a surrogate measure of fatness (Blundell et al., 2014). BMI is an easily obtained measure recommended for all age groups (CDC, n.d.; Hubbard, 2000). Its widespread use allows for comparison across populations in the United States from a public health perspective, although the established cutoff points might not be applicable across subpopulations. For example, health-related risks associated with obesity are commonly observed in Whites at a lower BMI compared

to Black Americans. Obesity-related comorbidities occur at a lower BMI in the Asian population and at a higher BMI in Pacific Islanders, due to their higher muscle mass; therefore, the cutoff points for overweight and obese were lowered for Asians and increased for Pacific Islanders (Hubbard, 2000). The difference in cutoff points may be explained by the fact that BMI does not measure body fat directly or body fat distribution and refers only to the actual sum of the mass rather than the distribution of mass. However, BMI is a reliable and valid measurement of population weight status and an excellent screening tool for identifying individual weight problems.

Consequently, BMI should be assessed along with other factors to guide clinical/practice recommendations related to an individual's health (DCD, n.d.) and not be the single outcome measure of success. The current GWG guidelines are ethnically blind. These ethnic differences should be accounted for when advising women on gestational weight.

Gestational Weight Gain (GWG)

Gestational weight gain, the total weight gained during pregnancy, can critically impact the short- and long-term health of women and their children. Placenta, fetus, and amniotic fluid comprise approximately 35% of the total gestational weight gain in a typical pregnancy, characterized by 27.56 pounds or 12.5-kilogram total GWG and delivery at 40 weeks. This amount at term includes all the following: fetus=3.40 kg/7.50 lbs. (2.5-5.0 kg [5.51-11.02 lbs.], placenta=0.65 kg/1.43 lbs., amniotic fluid=0.80 kg/1.76 lbs., maternal tissues (uterus, mammary glands) =1.38 kg/3/04 lbs., blood (plasma, red cell volume) =1.45 kg/3.20 lbs., maternal fat stores=3.35 kg/7.39 lbs., extracellular/extravascular fluid=1.48 kg/3.26 lbs. and edema=4.7 kg/10.36 lbs. (Hytten & Leitch, 1971; Hytten & Chamberlain, 1991, and IOM & NRC, 2009).

The recommendations for adequate weight gain during pregnancy have changed drastically and have been highly debated over the last 50 years in the United States.

According to the American College of Obstetricians and Gynecologists (ACOG), the American Institute of Ultrasound in Medicine (AIUM), and the Society for Maternal-Fetal Medicine (SMFM), the most precise method to estimate gestational age (GA) is an ultrasound measurement of the embryo or fetus in the first trimester (up to 13 6/7 weeks of gestation) (ACOG, 2017). The estimated delivery date (EDD) should be determined when data from the last menstrual period (LMP) and the first accurate ultrasound examination are obtained. EDD should be discussed with the woman and noted in the medical record. EDD is a crucial step since GA is the best estimate for clinical care. For research purposes, the best obstetric estimate, rather than LMP alone, should be used to measure GA (ACOG, 2017).

GWG Guidelines

In the 1950s, providers recommended that women limit their weight gain during pregnancy to 10-14 lbs. to avoid toxemia, difficult births, and obesity (Ferguson & Keaton, 1950; Schoendorf et al., 1992). Then in the 1960s, due to high neonatal and infant mortality rates in the United States and their positive association with GWG, experts increased the GWG goal to 20-25 lbs. for all women (Eastman & Helloman, 1966; Shank, 1970). As a result, in the following decades, there was an increase in high PrePBMI and IBW (Abrams, 1994). The updated 1990 IOM GWG guidelines considered the increase in maternal and infant weight and their impact on various maternal and fetal outcomes.

The guidelines provided specific recommendations according to PrePBMI with restrictions for women entering pregnancy with a higher BMI (IOM, 1990). While many studies support the idea that women who gain within the recommended weight range during pregnancy have better pregnancy outcomes than women who did not meet the guidelines, many women,

regardless of PrePBMI, have challenges meeting the IOM recommendations. Therefore, the 2009 IOM/NRC GWG guidelines focus on meeting and not exceeding the weight gain goals to avoid cesarean delivery and macrosomia (IOM/NRC 2009). The recommendations are based on pre-pregnancy BMI, independent of age, race, ethnicity, parity, and smoking history (IOM & NRC, 2009).

The recommended GWG is the lowest for the highest BMI. However, a GWG recommendation of 9 kg is the lowest published recommendation for the highest maternal BMI to prevent harm to the mother or baby. These recommendations were based on scarce evidence, as noted in the report's limitations (IOM & NRC, 2009; ACOG, 2013 [reaffirmed 2020]), and the estimates of weight gain ranges are based on data from a population of women with low obesity rates with an average total gain of 12.5 kg/27.56 lbs. Therefore, future research must consider factors such as age, race, ethnicity, parity, smoking history, comorbidities, and additional maternal characteristics to define optimal GWG across a range of maternal weight categories so groups at increased risk for adverse pregnancy-related outcomes can be identified.

Gestational weight is routinely measured during pregnancy in the US. It is inexpensive, widely available, and the first opportunity for providers to start the discussion of healthy behaviors and decisions around weight gain and their relation to pregnancy outcomes (IOM & NCR, 2009; ACOG, 2013 [reaffirmed 2020]). Consequently, maternal and infant risks during the perinatal period can be optimally balanced.

Table 2

Total and Rate of Weight Gain During Pregnancy, by Pre-Pregnancy BMI

Prepregnancy BMI (kg/m^2)	Total Weight gain		Rates of Weight Gain 2nd and 3rd Trimester	
	Range in kg	Range in lbs.	Mean (range) in kg/week	Mean (range) in lbs./week

Underweight (<18.5)	12.5-18.0	28.0-40.0	0.5 (0.4-0.6)	1.0 (1.0-1.3)
Normal weight (18.5-24.9)	11.5-16.0	25.0-35.0	0.4 (0.4-0.5)	1.0 (0.8-1.0)
Overweight (25.0-29.9)	7.0-11.5	15.0-25.0	0.3 (0.2-0.3)	0.6 (0.5-0.7)
Obese (≥30.0)	5.0-9.0	11.0-20.0	0.2 (0.2-0.3)	0.5 (0.4-0.6)

Note. Calculations assume a 0.5–2 kg (1.1–4.4 lbs.) weight gain in the first trimester.

From Weight Gain During Pregnancy: Reexamining the Guidelines, K.M. Rasmussen and A.L. Yaktine, Editors. 2009: Washington (DC).

Measurement of GWG

Associations between PrePBMI, GWG, and IBW-FOR-GAP have been challenging to evaluate due to data quality and integrity issues on maternal weight, GWG measurement concerns, and study methods to account for gestational age. Total GWG and incremental GWG are two methods used to assess GWG.

Measuring weight before conception and at the onset of labor is not standardized across practices, so BMI measures are not always accurate. Total GWG is calculated by extracting the pre-pregnancy weight from the final weight. These measures can be self-reported, extracted from medical records, or measured in clinics and hospitals. This process might appear simple, but the variances in measures and opportunities for error make this measurement difficult or even impossible to compare across studies, resulting in inconsistencies in evidence to support practice (Gilmore & Redman, 2015). To further accentuate the problem, 51% of pregnancies in the United States are unplanned (Finer & Zolna, 2014), making pre-pregnancy BMI measure unavailable or non-existent.

Incremental GWG is tracked as the pregnancy progresses and can be expressed as weight gain per week, month, or trimester. This approach is often used in research and clinical practice. According to Knabl et al. (2014), excessive weight gain during the first trimester predicts excessive weight gain throughout the pregnancy, which can be valuable in weight counseling.

Infant Birth Weight for Gestational Age Percentiles (IBW-FOR-GAP)

Birth weight (BW) is frequently used to indicate intrauterine conditions (Falluca et al., 2009). The intrauterine environment affects pregnancy and neonatal outcomes and subsequent long-term health (Rinaudo & Lamb; 008, Fakhraei et al., 2022). PrePBMI is an effect modifier between GWG and IBW, regardless of the BMI category, if weight gain exceeds 20 lbs. above

the IOM guidelines (Zhao et al., 2018; Hutcheon & Bodnar, 2018; Troung et al., 2015; McDonald et al., 2018; Pölzlberger et al., 2017; Jeric et al., 2013).

While the importance of adherence to the IOM weight gain guidelines is evident, women struggle to meet them. Abnormal BMI and GWG increase the risk of adverse birth weight outcomes, with GWG exerting a differential effect on the rates of or severity of adverse birth weight outcomes across all PPBMI categories. Therefore, this study aims to explore the relationships between pregnancy-related weight variations, prenatal care metrics/indices, and birth weight outcomes to understand why some women can gain within recommended weight ranges and why others experience challenges, regardless of PrePBMI. This study will evaluate the factors and risks of delivering a small-for-gestational-age (SGA) and a large-for-gestational-age (LGA) infant. Small-for-gestational-age (SGA) infants' birth weight is below the 10th percentile using gestational age- and sex-specific reference curves. Large-for-gestational-age (LGA) infants' weight is above the 90th percentile using gestational age- and sex-specific reference curves.

Small for Gestational Age (SGA)

SGA is based on gestational age (GA) and birth weight (BW). SGA definitions are based on constitutionally and pathologically small infant birth weight (Malin et al., 2014; Ananth & Vintzileos, 2009). While the importance of premature birth for neonatal morbidity and mortality is well-researched, the pathways underlying the influence of low BW independent of prematurity are less understood (Wilcox, 2001; Malin et al., 2014). The distribution of term births with SGA codes in the United States has steadily increased since 2002 (Ewing et al., 2017).

The evidence on the effects of SGA in infants born at term is contradictory. The distribution differs by income level, with lower socioeconomic status being a risk factor. However, rural versus urban geographical locations did not yield a significant variation in

distribution (Ewing et al., 2017; Thompson et al., 2005). The likelihood of pathologically small gestational-age infants decreases as GA increases while the number of constitutionally small infants increases (Ananth & Vintzileos, 2009).

Current research identified robust evidence of perinatal risks surrounding SGA infants at term (Mendez et al., 2016; Chauhan et al., 2017; Maden et al., 2018). SGA-coded infants at term have 20%-200% higher odds of in-hospital death compared to non-SGA infants (Kristensen et al., 2007; Ewing et al., 2017; Malin et al., 2014). SGA is also independently associated with perinatal death (Chavkin et al., 2019). Unfortunately, SGA infants are frequently not identified antenatally, particularly in low-risk women delivering at term, since routine ultrasound assessment of fetal growth is not performed in this population (Madden et al., 2018). On the other hand, some studies have shown that SGA infants born at term when using more restrictive cutoff points than the commonly used less than10th percentile, experience increased morbidity and mortality risks. In addition, SGA infants born to mothers with low-risk pregnancies have a significantly increased risk of mortality and morbidity compared to infants with appropriate gestational age (Madden, Flatley, & Kumar, 2018).

Other factors associated with SGA are maternal tobacco, substance, or alcohol use, chronic hypertension, diabetes mellitus, and poor maternal nutrition. The exclusion of women with known risk factors such as diabetes mellitus and hypertension and previous IUGR in studies might help to define the population of women at risk. It is crucial to investigate additional contributing factors associated with SGA among term infants, so interventions can be developed to target populations with a higher prevalence of the condition. The research is inconclusive in identifying women at risk for delivery of SGA-coded infants at term. Therefore, it is necessary to explore further additional contributing factors.

SGA is one of the leading causes of stillbirth, perinatal morbidity, and mortality (Francis, Hugh, & Gardosi, 2018). SGA is also associated with developing diabetes mellitus, obesity, and hyperlipidemia in childhood (Khashan et al., 2015; Kramer et al., 2017; Gohir et al., 2019; Souza et al., 2019). Additionally, SGA infants have a higher risk of cardio-metabolic diseases later in adulthood (Verkauskiene et al., 2005; Rueda-Clausen, Morton, & Davidge, 2009; Horikoshi et al., 2016). The associations between PrePBMI and the risk of SGA have been inconsistent. On the one hand, some studies argue that underweight PrePBMI increases the risk of SGA infants and overweight and obese PrePBMI categories decrease the risk of SGA infants (Tabet et al., 2015; Kim et al., 2016; Cosson et al., 2016). However, recent studies found no significant association between PrePBMI and the risk for SGA infants, and that even maternal obesity can stunt fetal growth, increasing the incidence of SGA infants (Xiao et al., 2017; Song et al., 2018). Thus, factors affecting the risk of SGA infants needs to be further explored.

Large for Gestational Age (LGA)

Large-for-Gestational Age (LGA) is commonly defined as a birth weight greater than the 90th percentile for gestational age (Alexander et al., 1996; Talge et al., 2014). LGA is not independently associated with perinatal mortality (Chavkin et al., 2019). Other researchers argue that the 97th percentile or greater (2 SD above the mean) should be considered LGA (Boulet et al., 2003, Xu; Simonet & Luo, 2010). In this study, LGA refers to a birth weight greater than the 90th percentile unless otherwise noted. According to eh National Center for Health Statistics, 7.8% of all live-born infants in the United States weighed 4000 g (about 8.82 lb) or more in 2019 (Martin et al., 2021).

LGA-coded infants are at risk for adverse short-term health outcomes, such as NICU admissions, respiratory distress, metabolic dysregulations, birth trauma, stillbirth, and even death. Birth weight above the 90th percentile subsequently increases the risk for childhood and

adult obesity, diabetes, cardiovascular disease, and even some cancers (Scifres et al., 2021). The majority of LGA-coded infants are born to women without diabetes.

Maternal nutrition before conception and during pregnancy significantly influences maternal weight gain, fetal growth, and neonatal outcomes. There is a paucity of data regarding optimal maternal nutrition, prenatal care, and the best ways to help women gain within the 2009 IOM GWG guidelines to improve perinatal health outcomes (Gresham et al., 2014; Muhlhausler et al., 2013). Therefore, identifying maternal and pregnancy factors associated with excess fetal growth is essential. One of the goals of this study is to explore prenatal care factors that can influence maternal nutrition during pregnancy and fetal growth.

Variations in PrePBMI, GWG, and IBW-FOR-GAP

Variations in prepregnancy BMI (PrePBMI) and GWG increase the risk of adverse birth outcomes; however, GWG exerts a differential effect on the rate of and severity of adverse birth weight outcomes across all BMI categories (Ukah et al., 2019). For example, inadequate or excessive weight gain during pregnancy is associated with an increased risk of severe adverse birth outcomes, except for women who are overweight before pregnancy and gain excess weight during pregnancy (Ukah et al., 2019). Troung et al. (2015) suggest that the direction and the magnitude of associations between weight gain during pregnancy and perinatal morbidity are based on a continuum rather than a stepwise threshold. For example, women who gained over 20 lbs. above the recommended 2009 IOM guidelines had a higher risk of perinatal morbidity, regardless of their PrePBMI, suggesting that BMI is not an effect modifier in the association between GWG and perinatal morbidity.

Women who are overweight or obese are at higher risk for gaining more than the recommended weight during pregnancy. Excessive GWG is associated with PPWR, which

further impacts the weight in later adult life, even at 15 to 20 years postpartum. High pre-pregnancy BMI increases the risk of several pregnancy and birth complications: gestational diabetes (Langer, 2016), hypertension, premature birth, increased length of hospital stays, the risk of delivering an LGA (Baugh, 2016) or SGA infant, metabolic complications, induction of labor, Caesarean section. A combination of higher PrePBMI and gestational diabetes mellitus worsens the impact of complications, including the need for interventional and Caesarean deliveries, medical management of diabetes mellitus, and risk of macrosomia (Nie et al., 2016; Shi et al., 2021).

Women's PrePBMI affects placental and fetal growth and development and, in turn, has been linked to increased obesity and other metabolic disturbances later in life, such as diabetes, cardiovascular disease, and potential immune and infectious disease-related outcomes (Bonye et al., 2005; Catalano et al., 2011; Godfrey et al., 2017). The increasing trends of obesity worldwide with perinatal programming of metabolic dysfunction in the offspring is an urgent concern for the health of women and their children, our future generations, and the health of economy and prosperity.

The changing demographics of women of childbearing age is an important consideration for developing new recommendations for GWG. For example, while race/ethnicity has been considered as a modifying factor between PrePBMI, GWG, and infant weight outcomes, today's landscape of women who claims multiethnicity might render consideration of race and ethnicity impractical due to the high degree of mixed races in the pregnant population (Garza & Onis, 2004). Most of the variances in SMM outcomes are related to SDoH factors. It is still unclear how much weight gained during pregnancy is adequate to equalize maternal and infant birth outcomes (dyad outcomes). The current GWG guidelines are over a decade old, and evidence has

not been conclusive on the adequacy of the recommendations for all groups of women. For example, women who gained over 20 lbs. above the recommended 2009 IOM guidelines had a higher risk of perinatal morbidity, regardless of their PrePBMI, suggesting that BMI is not an effect modifier in the association between GWG and perinatal morbidity.

Chapter Summary

Women's pregnancy-related weight variations impact IBW-FOR-GAP outcomes, thus influencing the mother's and infant's health not only during the perinatal period but long term. While higher than normal PrePBMI and excessive GWG are known predictors of poor pregnancy outcomes. The evidence is inconclusive on who the women at risk are. Women with a low or normal PrePBMI or inadequate GWG are also at risk for delivering SGA or LGA infants. Exploration of changing maternal and prenatal care factors is necessary to reevaluate the relationship between pregnancy-related weight variations, women's characteristics, prenatal care factors, and IBW-FOR-GAP outcomes. This study will serve as a foundation for future studies.

Chapter 3: Methods

This chapter presents the research methods; research design, setting, and sample; data collection; data management; data analysis; and conclusion. The analyses approach and results will address the research questions in this study framed under the life course theory.

Life Course Theory (LCT) Application to the Study

Life Course Theory (LCT) postulates pathways linking exposures during critical and sensitive periods across the life course to health outcomes. Pregnancy complications, childbirth, and infant birthweight are some markers used further to evaluate reproductive health (Rich-Edwards, 2002). Pregnancy is considered a critical period during which various maternal exposures can have harmful or protective effects on fetal development and pregnancy outcomes. Fetal development can also be viewed as a sensitive period during which exposure can substantially affect development and hence adverse outcomes, more so than at any other stage of life. The LCT assumes temporal ordering of exposure variables and their inter-relationships with the outcome measures directly and through an intermediary (modifying and mediating) variable (Kuh et al., 2003). This study aims to investigate the relationships between factors that influence pregnancy-related weight variations.

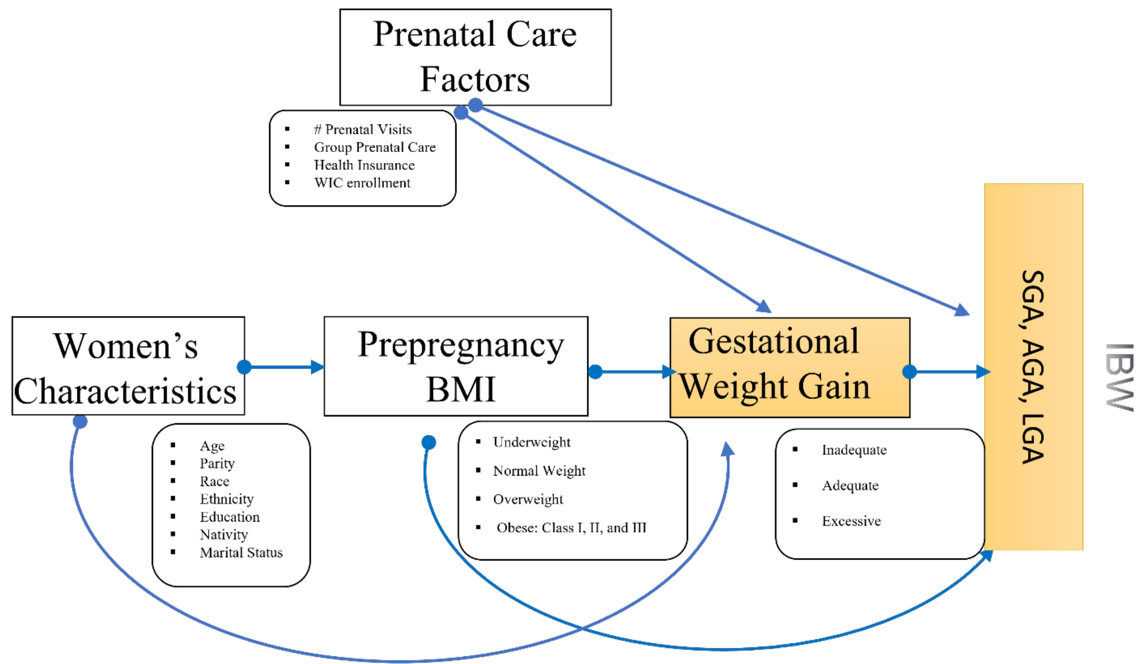
Hypotheses related to prenatal care factors, women's characteristics, and IBW are rooted in the theoretical framework of Life Course Theory (LCT). Weight gain during pregnancy and IBW based on GA are proxies for maternal and infant health. LCT connects health and disease risks to exposure in utero and the interconnections between women's and their children's health. Barker's initial hypothesis that undernutrition in utero can permanently alter body structure,

function, and metabolism, later called the Fetal Origins of Disease Hypothesis, links exposures during pregnancy to perinatal outcomes.

It is also important to note that women's reproductive health is linked to the reproductive characteristics of previous generations, which emphasizes the importance of linked lives and linked health (Stuebe & Rich-Edwards, 2009). Two different types of models have been proposed under the tenets of LCT. The critical period models focus on the critical and sensitive periods with or without later effect modifiers. For example, folic acid intake before and around conception prevents neural defects in offspring. The accumulation of risk models with a focus on independent and uncorrelated or correlated exposures and their effects on outcomes were combined and guided this study. See Models (b) and (c), as shown in Figure 1, will guide this study. The accumulation model with risk clustering assumes exposures are clustered in a socially patterned way. The chain of additive risk models proposes that a sequence of linked exposures, harmful or protective, tends to lead to another. The main idea is that each exposure in the chain probabilistically increases the risk of subsequent exposure and may have an independent additive effect on later health (Kuh et al., 2003) (Figure 1). Figure 2 explains the relationships between the proposed variables in this study.

Figure 2

Study Model



Note. The arrows represent the relationships between variables. The model is based on the combination of Life Course Theory Model (b), and Model (c), presented in Figure 1.

Research Questions

Objective 1: Explore and describe the role of women's characteristics related to PrePBMI, GWG, and IBW-FOR-GAP (SGA, LGA, AGA).

Research Question 1: RQ1: What are the characteristics of women (age, parity, race/ethnicity, nativity, zip code, and marital status) who gave birth to SGA and LGA infants compared to women who gave birth to AGA infants, stratified by PrePBMI and GWG categories?

Objective 2: Evaluate the relationships between prenatal care factors (number of prenatal care visits, group prenatal care, Women, Infants, and Children (WIC) program enrollment, type of health insurance) with total GWG (inadequate, adequate, excessive).

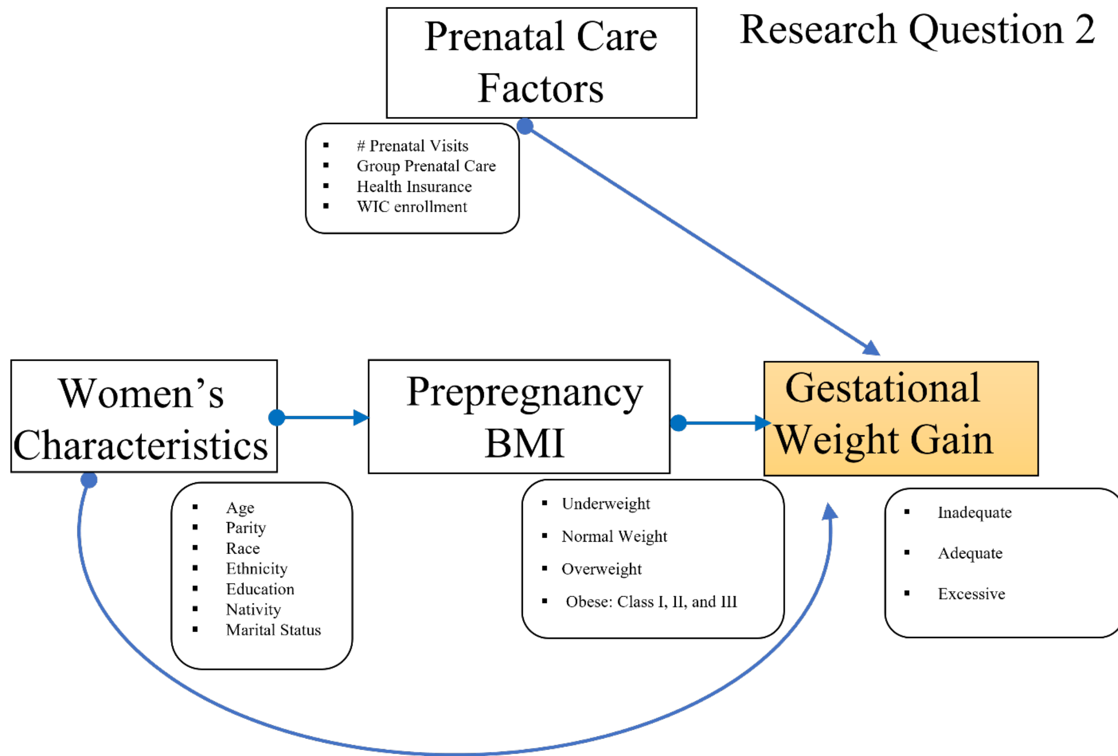
Research Question 2: Do prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, and type of health insurance) predict IOM recommended GWG while controlling for women's characteristics and PrePBMI?

H0: Prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, or health insurance) will not predict GWG while controlling for PrePBMI and women's characteristics.

H1: Prenatal care factors (number of prenatal care visits, group prenatal care, WIC enrollment, or health insurance) will predict GWG while controlling for PrePBMI and women's characteristics.

Figure 3

Evaluation of Prenatal Care Factors' Relationship with Gestational Weight Gain (RQ2)



Note. The arrows represent the relationships between variables. The model is based on the combination of Life Course Theory Model (b), and Model (c), presented in Figure 1.

Objective 3: Evaluate the relationships between prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, type of health insurance) and IBW-FOR-GAP (SGA, LGA).

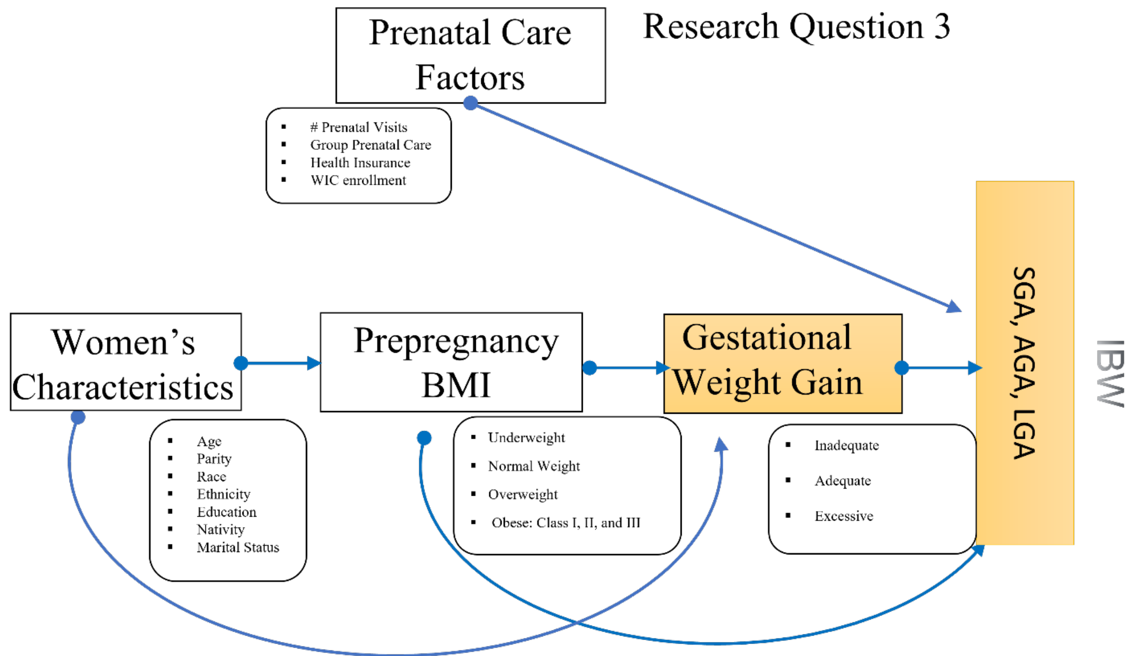
Research Question 3: Do prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, or type of health insurance) predict IBW-FOR-GAP (LGA, AGA, SGA) while controlling for women's characteristics and PrePBMI?

H0: Prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, or type of health insurance) will not predict infant birth weight by GA (LGA, AGA, SGA) while controlling for women's characteristics and PrePBMI.

H1: Prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, or type of health insurance) will predict infant birth weight by GA (LGA, AGA, SGA) while controlling for women's characteristics and PrePBMI.

Figure 4

Evaluation of Prenatal Care Factors' Relationship with Infant Birth Weight (RQ3)



Note. The arrows represent the relationships between variables. The model is based on the combination of Life Course Theory Model (b), and Model (c), presented in Figure 1.

Research Design

This study is a retrospective descriptive-correlational design. The goal is to describe the association between the independent and dependent variables (relationship between weight variations and infant weight outcomes) and provide a foundation for future research. Secondary data analysis is a practical approach for new researchers with limited resources to begin to answer important research questions (Polit & Beck, 2017). It is important to note that the data set

provides unique access to vulnerable populations, and mother-infant dyads, allowing researchers and clinicians to explore multiple variables and relationships.

Data Source

The study will use secondary data was collected using the PeriData.Net® worksheet (WAPC, 2021). Data will be de-identified prior to data release. PeriData.Net® is a web-based comprehensive perinatal clinical registry/database developed in partnership with the Wisconsin Association for Perinatal Care (WAPC) and the Urban Population Health at the University of Wisconsin-Milwaukee. It was created for Wisconsin hospitals to gather birth record data. PeriData.Net® is an enhancement of birth certificate data, and it was designed with healthcare systems in mind to promote quality improvement. The dataset houses many variables, including but not limited to maternal and paternal demographics, payor status, medications prior to and during the pregnancy, reproductive history, risk factors, prenatal testing, pre-existing maternal conditions, pregnancy, delivery complications, and perinatal outcomes. Psychometric properties are not known. Data abstractors receive training and guidance on completing the PeriData.Net® fields; however, inter-rater reliability indices are unknown.

Data Collection

Information for the PeriData.Net® worksheet is collected by hospital staff and entered into the registry by dedicated personnel responsible for registering the infants and other individuals. Information on measurement procedures, quality control, and management of missing data is not available. Once data collection is complete, the data is submitted to a third-party vendor, Ancilla, LLC. In summary, the PeriData.Net® has the potential to identify emerging reproductive health issues, detect women and infant groups at high risk for adverse outcomes, and provide ways to monitor and evaluate the progress of pregnancy-related

outcomes. This study will focus on the subset of 13 variables that will help answer the research questions. These variables include women's characteristics as confounders, so 10-30 cases are recommended per variable for each group. These variables were selected based on the literature review and the life course theory. An estimated 30x13=390 infants in each IBW-FOR-GAP (SGA, AGA, LGA) would provide enough participants for the analyses of IBW as an outcome.

Population and Setting

The population of interest is women of childbearing age in Wisconsin, 2012-2018. The sample for this study consists of women who delivered a live singleton birth at one of the participating Wisconsin (WI) hospitals where data was collected and recorded.

Sample and Sampling

Previous research in a group of women with low-risk full-term pregnancies (45%) showed that approximately 10% of infants are SGA, 9.2 % are LGA, and 80% are AGA. (Mendez, Chen & Chauhan, 2021). Out of the 9000 cases, 4050 would meet the low-risk pregnancies criteria.

Inclusion criteria

All singleton live births with complete and plausible values for GA, pregnancy height, weight, PrePBMI, and GWG were included in the study. The dataset was screened for outliers and missing values. If data was questionable and incomplete, cases were reviewed on individual bases and determined inclusion. All mother-infant dyads from 2012 – 2018 are included from a single community hospital in southeast Wisconsin that participate in the collection of PeriData.Net®.Net and shared data with UWM for research purposes. A selection of subset variables will be used to address the research questions in this study. Appendix A lists all PeriData.Net® worksheet variables.

Exclusion criteria

Women who delivered multiples will be excluded. Women with missing data on outcome measures, such as GWG and infant weight, will be excluded from the analyses. Other missing data will be evaluated for errors. An assessment will determine whether exclusion is random or reflects a systematic exclusion pattern.

Instrument

PeriData.Net® form was used to collect the primary data. See Appendix A for the form.

Human Subjects Considerations

In order to protect human subjects, approval of the research protocol will be obtained from the university's Institutional Review Board (IRB) before conducting this study. There is minimal risk to the participants, and risk will be minimized by removing all information containing patient identifiers such as first and last names and social security numbers. All participating women sign consent as part of the admission process to the hospital to be treated and that their data may be used for quality improvement purposes, retaining confidentiality.

Research Procedures

This study will investigate the association between pregnancy-related weight variation, prenatal care, and infant weight within one Wisconsin hospital in a cohort of women between 2012 and 2018. This section describes the data source and collection procedures for the PeriData.Net® dataset. Data collection and management method, purpose of the dataset, and number and type of variables will be described.

Data Management Plan

The data management plan for this study will take place using the data on a secure site through the University of Wisconsin-Milwaukee (UWM) system for use by students. The

database will be transferred from UWM's secure site to the student's workplace, the UWM's E-drive. A database copy will serve as the master file and be stored separately if original data is needed. A copy of the master database will be used for the study. The first steps focus on identifying the variables for the study and conducting descriptive analyses to determine missing data, outlying values, and other irregularities. Variables will be re-coded for the study using the available data dictionary for the PeriData.Net® and based on the number of cases available for each variable and category. Once all variables for the study have been verified, recorded, and assessed for complete/missing values, the analysis plan will be conducted.

This study investigates the association between pregnancy-related weight variation, prenatal care, and infant weight outcomes within one Wisconsin hospital in a cohort of women within a specific time frame. This section describes the data source and collection procedures for the PeriData.Net® dataset. Data collection and management method, the purpose of the dataset, number and type of variables will be described.

Data Integrity

After gaining access to the de-identified data, all data will be entered into a password-protected database. The dataset will be evaluated for missing data and other inconsistencies. Cases with any missing data will be evaluated and excluded from the analysis. Statistical analysis will be performed using the latest Statistical Package for Social Sciences software version (SPSS, Inc, Chicago, IL, USA).

Study Variables: Women's Characteristics

Characteristics include any factors that can distinguish individuals and groups of women from other individuals or groups. Women's characteristics are person-specific attributes such as socio-demographic factors, pregnancy, and outcome-related health risks. The maternal

characteristics of interest include age, race and ethnicity, nativity, parity, interpregnancy interval, marital status, education, and zip code.

Age

Age of woman in years at the time of their child's birth. The PeriData.Net® worksheet had multiple options for maternal age. The calculated age at the time of birth provided the most accurate information, calculated from the mother's and infant's date of birth. Maternal age was used as a continuous and categorical variable. Maternal age was categorized as 18-23, 24-27, 28-31, and 33-44.

Race and Ethnicity

Categories are defined based on the U.S. Office of Management and Budget's Revisions to the Standards for the Classification of Federal Dara on Race and Ethnicity. Women who identify as multiracial will also be reported. The PeriData.Net® worksheet provides an extensive list of races and ethnicity. Two different variables in the PeriData.Net® database, race, and Hispanic/Latino ethnicity, are used to create six mutually exclusive groups of race/ethnicity: Non-Hispanic White (NH-W), NH African American (NH-AA), Hispanic, NH Asian (NH-A), NH American Indian/Alaskan Native (NH-AI/AN), and NH Native-Hawaiian/Other Pacific Islander (NH-NHP).

Table 3

Classifying Race and Ethnicity

White	A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.
Black or African American	A person having origins in any of the Black racial groups of Africa.
American Indian or Alaska Native	A person having origins in any of the original peoples of North and South America, including Central America, and who maintains tribal affiliation or community attachment. ("Race and Ethnicity Classifications — State Data Center")
Asian	A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent, including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Native Hawaiian or Other Pacific Islander	A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific islands.

Note: Adopted based on 1997 Office of Management and Budget (OMB) standards*:* https://www.census.gov/topics/population/race/about.html

Nativity

Woman's country of birth. The PeriData.Net® worksheet includes the mother's birthplace information. The mother's country of birth will be used as a variable.

Parity

Parity or para indicates the number of times a woman had given birth to a fetus with a gestational age of 24 weeks or more, regardless of whether the child was born alive or was stillborn (Cunningham et al., 2022). Parity will be determined based on the number of

pregnancies, including current pregnancies. Parity will be categorized as none, one, two, three, or more.

Marital Status

Woman's state of being married/in a relationship or not married/in a relationship at the time of birth or between conception and birth. Participants were asked to select "yes," if they were married at birth or at any time between conception and birth, and to select "no," if the woman was not married at birth or between conception and birth. If the marital status is unknown, they were asked to select "unknown." Selecting "yes" will require additional information on the husband's screen.

Education

The fields in the PeriData.Net® worksheet provide information on the level of schooling completed by the mother. Categories for the school level (number of years of education) included "completed include 8th grade or less," "9th-12th grade (no diploma)," "high school degree or GED," "some college credit but not a degree," "associate degree," "bachelor's degree," "master's degree," "doctorate," "or professional degree." Some choices in this field require the specification of years of schooling completed in the following field.

Study variables: Pregnancy-Related Weight-Variations

Gestational Weight Gain (GWG)

Gestational weight gain is the total weight gained during pregnancy. Gestational weight is formed of water, protein, fat, placenta, uterus and amniotic fluid, maternal blood volume, memory glands, and maternal adipose tissue. Placenta, fetus, and amniotic fluid include 35% of the total gestational weight gain in a typical pregnancy characterized by 25 pounds or 11-

kilogram total weight gain and delivery at 40 weeks (about nine months). It is calculated in relation to pre-pregnancy BMI. Gestational weight is routinely measured during pregnancy in the United States. There are two ways to measure GWG.: (a) total GWG is maternal weight at delivery minus the pre-pregnancy weight in kilograms, and (b) GWG adequacy ratio is calculated from the total GWG divided by IOM-recommended GWG at the GA at delivery based on PrePBMI. For this study, the total GWG was calculated (Hutcheon & Bodnar, 2018)

GWG was an independent, dependent variable, and effect modifier in this study depending on the research question and the outcome of interest. (See the measurement description earlier in this chapter.) GWG will be categorized based on the 2009 Institute of Medicine (IOM) and National research council (NRC) guidelines. If the mother gained more than the recommended range for their PrePBMI weight category, weight gain would be categorized as excessive. If the mother gained within the recommended range for their PrePBMI weight category, weight gain would be categorized as adequate. Lastly, if the mother gained below the recommended range for their PrePBMI weight category, weight gain would be categorized as inadequate. For example, excessive gestational weight gain was defined as (a) women in the underweight PrePBMI category who gained more than 40 pounds, (b) women in the normal weight PrePBMI category who gained more than 35 pounds, (c) women in the overweight PrePBMI category who gained more than 25 pounds, and (d) women in the obese PrePBMI category (Class I, II and II) who gained more than 20 pounds (Table 1).

Total GWG and GWG adequacy ratio are two traditional methods to measure weight gain during pregnancy. They will be compared in this study for their ability to predict SGA and LGA outcomes. These methods have intrinsic limitations that may bias the results (Hutcheon & Bodnar, 2018). Total GWG is defined as maternal weight at delivery minus the pre-pregnancy

weight in kilograms. GWG adequacy ratio is calculated from the total GWG divided by IOM-recommended GWG at the gestational age (GA) at delivery based on PrePBMI.

Infant Birth Weight for GA Percentiles (IBW-FOR-GAP)

Size for gestational age was calculated into percentiles based on birth weight, infant's sex, and gestational age. Small for gestational age (SGA) means a birth weight below the 10th percentile for the infant's sex and gestational age. Large for gestational age (LGA) means a birth weight above the 90th percentile for the infant's sex and gestational age. An infant appropriate for gestational age (AGA) has a birth weight appropriate for the infant's gender and gestational age (between the 10th and 90th percentile) A growth chart was used as a reference against which growth was assesses and the percentile of size for a given GA was calculated (Battaglia & Lubchenco, 1967, 1967). Growth reference curves or growth charts vary based on institution and practitioner practice. Four types of growth reference charts are available depending on the institution and practitioner practice: 1) population-based chart where a population is used to estimate percentiles; 2) customized growth charts where percentiles are adjusted for a set of infant and maternal characteristics; 3) individualized growth charts where a fetal growth trajectory is calculated based on previous two measurements, and 4) conditional percentile assessment where fetal growth percentile is based on a previous measurement (Grantz, 2021). GA was assessed based on a direct physical assessment of the newborn after birth and measured in weeks. IBW was initially entered in pounds and ounces, then calculated automatically in grams. Size for GA is determined and categorized based on these initial measurements.

Pre-Pregnancy Body Mass Index (PrePBMI)

Body mass index is calculated from a person's mass or weight and height. It is defined as the body mass (weight) divided by the square of the body’s weight and expressed in kg/m

squared units. BMI is already calculated and reported in the PeriData.Net® dataset. However, calculations will be verified using SPSS (Version 28) to validate the data, using the conversion factor of 703 x weight (lbs.) / $[\text{height (in)}]^2$, since weight and height data are available in the imperial system (CDC, 2022).

Pre-pregnancy body mass index (PrePBMI) is calculated based on self-reported or measured maternal pre-pregnancy weight and maternal height. PrePBMI is calculated as the weight ratio in kilograms to the square height in meters squared. PrePBMI is an ordinal variable and will be categorized as underweight (BMI <18.5), average weight (BMI 18.5 to 24.9), overweight (BMI 25.0 to 29.9), obese class I (BMI 30.0 to 34.9), obese class II (BMI 35.0 to 39.9) and obese class II (BMI ≥ 40.0) (CDC, 2022).

Study Variables: Prenatal Care Factors

For this study, prenatal care factors are defined as the timings of initiation of prenatal care, frequency or the number of prenatal care visits, number of prenatal care visits, prenatal care group participation, health insurance (private or Medicaid), and WIC enrollment.

Prenatal Care Visits

Prenatal care visits are part of the integrated and coordinated approach to medical care and psychosocial support for women before, during, and after pregnancy. The American Congress of Obstetrics and Gynecology (ACOG) and The American Academy of Pediatrics recommend one visit every 4 weeks or once a month between weeks 4 and 28 of pregnancy, one visits every 2 weeks or twice a month between weeks 28 and 36 of pregnancy, and one visit every week after that until delivery (A.C.O.G., 2017; Simpson & Creehan, 2013). For the last ten years, 12 to 14 in-person prenatal visits were considered acceptable and beneficial as part of the schedule or thought to improve maternal and infant outcomes. The total number of prenatal visits

is available in the PeriData.Net® worksheet as a continuous variable. The variable was categorized into three categories: "less than or equal to 5 visits," "6-10 visits," and "greater than ten visits." The median number of prenatal care visits in the United States is 11, so greater than ten visits were used as the cut-off point for high utilization (Buekens et al., 1993).

WIC enrollment

Women enrolled in WIC food for themselves during this pregnancy. The database measures this variable based on the question, "Did the mother get WIC food for herself during this pregnancy?" It will be measured as a dichotomous variable (Yes/No) to evaluate the potential impact on the study outcome variables.

Health Insurance

The principal payment source for the birth in the dataset will be used to measure health insurance status. Multiple fields indicate the source of payment for prenatal care and delivery services. Two options will provide the information for this study: the principal source of payment for this delivery and the principal source of payment for prenatal care. Health insurance status will be categorized as "private," "government," and "other" for this study. Categories include "Medicaid/Badger Care Plus," "Private Insurance," "Self-pay," "Indian Health Services," "Champus/Tricare," "other government" (federal, state, local), "other," and "unknown." They are grouped as private, government, and others.

Group Prenatal Care

An alternative model of prenatal care delivery is one in which a small group of pregnant women with similar due dates participates in a structured prenatal care program facilitated by a clinician. The most publicized model is Centering Pregnancy, which incorporates education, social support, and self-care.

Table 4

Study Variable and Their Measurements

Variables	Measurement
	Women's Characteristics
Age (ratio)	18 and older
Parity (ratio)	0, 1, 2, and ≥3
Race/ Ethnicity (nominal)	Non-Hispanic White (NH-W)
	NH African American (NH-AA)
	Hispanic, NH Asian (NH-A)
	NH American Indian/Alaskan Native (NH-AI/AN) NH Native-Hawaiian/Other Pacific Islander (NH-NHP)
	More than one race
Education (ordinal)	8th grade or less
	9th-12th grade, no diploma
	High school degree or GED
	Some college, no degree
	College degree
Nativity (nominal/dichotomous)	Yes (United States- born)
	No (born outside of the United States)
Marital Status (nominal)	Unknown
	In relationship
	Not in a relationship
	Prenatal Care Factors
Number of Prenatal Care Visits (ordinal)	£ 5 visits
	6-10 visits
	3
Group Prenatal Care (nominal/dichotomous)	Yes (then further divided into Centering Pregnancy-yes/no)
	No
Health Insurance (nominal/dichotomous)	Private
	Public

Variables	Measurement
WIC enrollment (nominal/dichotomous)	Yes No
	Pregnancy-Related Weight Variations
Pre-Pregnancy BMI (ratio and ordinal)	a) Continuous: 8 through 69 kg/m^2 b) Categorical Underweight: BMI is less than 18.5 Normal weight: BMI 18.5 to <25 Overweight: BMI is 25.0 to <30 Obese: BMI is 30.0 or higher • Class 1: BMI of 30 to < 35 • Class 2: BMI of 35 to < 40 • Class 3: BMI of >40 "severe"
GWG (ratio and ordinal)	a) Continuous: weight in kilograms b) Categorical (based on IOM GWG guidelines): Inadequate Adequate Excessive
IBW-FOR-GAP (ordinal)	SGA- birth weight below the 10th percentile AGA- birth weight between 10th and 90th percentile LGA- birth weight above the 90th percentile

Note:

Data Analysis Plan

Descriptive Statistics

This section will describe the specified analyses to address the research questions. Data tables will be organized by research question to address the findings for each study objective and research question.

Research Question 1

Descriptive statistics will be used to answer the first research question. All statistical analyses will be performed using the latest IBM SPSS Statistics software version. The significance level will be set to .05. For women's characteristics, PrePBMI will be summarized according to GWG and -FOR-GAP categories (SGA, AGA, LGA). Mean and SD will be used to summarize continuous variables. Continuous variables (age, PrePBMI, GWG, GA, and birth weight) will be assessed for normality. The distribution of all continuous variables will be examined for skewness and missing values. The asymmetry values between –2 and +2 standard deviation (SD) are considered acceptable to prove univariate distributions. Skewness values might be too sensitive with large samples, so the data's normality will be assessed using histograms and boxplots to provide a graphical presentation. If skewness is detected, log transformation might be necessary to normalize the data.

Pearson chi-square test (x squared) will be conducted to compare PrePBMI, GWG categories, and IBW-FOR-GAP (SGA, AGA, LGA). The Chi-square [x^2] test will aid in comparing maternal demographic characteristics and IBW-FOR-GAP between each category and the frequencies of the SGA and LGA. Count and percentage will be used to summarize categorical variables. Results will be presented in tabular and graphic format. Findings will be presented in table format to describe the patient sample and relevant sub-categories, such as ethnicity, to be used for subsequent analyses.

Inferential Statistic

Research Question 2

Multinomial logistic regression is a suitable statistical analysis when the purpose of research is to assess whether a set of nominal, ordinal, or interval/ratio predictor variables predict a dependent variable with more than two levels. To examine research question 2, multinomial logistic regressions will be conducted to investigate whether the number of prenatal care visits (continuous), group prenatal care (categorical), WIC enrollment (categorical), and the type of health insurance (categorical) predicts GWG (categorical), defined as inadequate, adequate, and excessive GWG. Figure 3 displays the model for the proposed relationships in research question 2.

Multinomial logistic regressions, by design, overcome many of the restrictive assumptions of linear regression. For example, the residuals' normality, linearity, and homoscedasticity are not assumed. However, evaluating sample size, multicollinearity, outliers, and missing data is crucial to ensure the quality of outputs. Dichotomous independent variables, including WIC enrollment, type of health insurance, and group prenatal care, will be coded as 0 and 1. The value 0 will be assigned to whichever response indicates a lack or absence of the characteristic of interest. For example, if the woman is enrolled in WIC, it will be coded as 1. If they are not enrolled, then it will be coded as 0.

Descriptive statistics on each predictor variable in the prenatal care groups of variables will help determine the need to collapse or remove categories if they have a limited number of cases. Logistic regression does require that there should be no multicollinearity among the independent variables. Multicollinearity will be assessed by calculating variance inflation factors (VIF). VIF values over 10 will suggest the presence of multicollinearity (Menard, 2009). Highly

intercorrelating variables will be removed from the models. The presence of outliers will be identified by inspecting the residuals. This is particularly important when there is an issue with the model's goodness of fit.

The overall model significance for the multinomial logistic regression will be examined by the collective effect of the independent variables using the χ^2 omnibus test of model coefficients. McFadden's R^2 will be used to estimate the variability accounted for by the independent predictor variable. The Wald coefficient will assess individual predictors to test the significance of each coefficient. Predicted probabilities of an event occurring will be determined by the exponentiated value of the coefficient (e^{β}), the odds ratio. Since logistic regression models assume a nonlinear relationship between the independent and dependent variables, the coefficient indicates the log odds. Since log odds are not readily interpretable, the e^{β} supplies the odds ratio for the independent variable, controlling for other independent variables in the model. For significant predictors, an odds ratio greater than one indicates that with a one-unit increase in the independent variable, the dependent variable will be many times more likely to be coded 1. Significant predictors with an odds ratio of less than one will be evaluated by $1/e^{\beta}$, meaning that a one-unit increase in the independent variable will likely be coded 0. All findings will be presented in a table and graphic format to address the research question.

Research Question 3

Multinomial logistic regression is a suitable statistical analysis when the purpose of research is to assess if a set of nominal, ordinal, or interval/ratio predictor variables predict a dependent variable with more than two levels. To examine research question 3, multinomial logistic regressions will be conducted to investigate whether number of prenatal care visits (continuous), group prenatal care (categorical), WIC enrollment (categorical), and the type of

health insurance (categorical) predicts IBW-FOR-GAP (SGA, AGA, LGA). Figure 4 displays the model for the proposed relationships in research question 3.

Multinomial logistic regressions, by design, overcome many of the restrictive assumptions of linear regression. For example, the residuals' normality, linearity, and homoscedasticity are not assumed. However, evaluating sample size, multicollinearity, outliers, and missing data is crucial to ensure the quality of outputs. Dichotomous independent variables (WIC enrollment, type of health insurance, and group prenatal care) will be coded as 0 and 1. The value 0 will be assigned to whichever response indicates a lack or absence of the characteristic of interest. For example, if the woman is enrolled in WIC, it will be coded as 1. If they are not enrolled, then it will be coded as 0.

Evaluation of descriptive statistics, multicollinearity, and the presence of outliers for the four predictors will be available from the statistical analyses for research question 2. The overall model significance for the multinomial logistic regression will be examined by the collective effect of the independent variables using the χ^2 omnibus test of model coefficients. McFadden's R^2 will be used to estimate the variability accounted for by the independent predictor variable. The Wald coefficient will assess individual predictors to test the significance of each coefficient. Predicted probabilities of an event occurring will be determined by the exponentiated value of the coefficient (e^{β}), the odds ratio. Since logistic regression models assume a nonlinear relationship between the independent and dependent variables, the coefficient indicates the log odds. Since log odds are not readily interpretable, the e^{β} supplies the odds ratio for the independent variable, controlling for other variables in the model. For significant predictors, an odds ratio greater than one indicates that with a one-unit increase in the independent variable, the dependent variable will be many times more likely to be coded 1. Significant predictors with an

odds ratio of less than one will be evaluated by $1/e^{\beta}$, meaning that a one-unit increase in the independent variable will likely be coded 0.

Multinomial logistic regression models with robust standard errors will aid in the estimation of odds ratios (ORs) and 95% confidence intervals (CIs) for infant weight based on PrePBMI categories (underweight, normal weight, overweight, and obese classes I, II, and III) and GWG categories (inadequate, adequate and excess) while adjusting or controlling for potential confounders such as maternal age; race/ethnicity; nativity; education level; marital status; smoking, alcohol, and substance use status during pregnancy; parity, infant sex.

Stratified models and models with interaction terms will aid in examining interactions between maternal and prenatal care factors and pre-pregnancy BMI status on GWG and infant birthweight. Values considered normal PrePBMI, adequate GWG, and AGA will be reference groups during analyses.

Strengths and Limitations

The study has several strengths. In particular, the sample represents a unique cohort of women who delivered their infant at one hospital in the Midwest during a specific time frame. The data items selected have been defined and developed by maternal-infant specialists, and the data collection has taken place by trained extractors. The large dataset includes multiple variables, which allows for evaluating factors affecting gestational weight gain and IBW-FOR-GAP. First, the study's findings will contribute to the knowledge of perinatal factors influencing the relationships between GWG and infant birthweight, thus informing future pregnancy weight recommendations. Second, the study uses a large sample of childbearing-age women with singleton deliveries. For pregnant women, findings may contribute to the revisions of gestational

weight gain-related recommendations, guidelines, and practices. This study will be a foundation for future studies.

This study represents the cohort of deliveries from January 1st, 2012 through December 31st, 2018 at one Midwestern hospital. This hospital may attract a sub-population of women in the community served by the hospital. Still, it may not represent Wisconsin's general population of childbearing age women. It is beyond the scope of this initial study to examine multiple weight data points/longitudinal weight trajectories trending across multiple pregnancies and link mother-infant weight trajectories. Selection bias might be a potential concern since groups are not formed randomly but through self-selection by having their birth at this hospital. Researchers cannot assume that the groups being compared are similar before the occurrence of independent variables. Recollection bias can potentially add to the misclassification of BMI categories due to self-report of weight. Using self-reported pre-pregnancy weight to determine pre-pregnancy BMI and GWG could have resulted in under or over-estimating the association found in this study; however, earlier studies have confirmed the strength and validity of self-reported weight at the beginning of pregnancy. Another limitation is the inability to account for all confounders. Information about physical activity, diet, social support, stress level, and coping abilities was not available in the dataset. We cannot prove the cause of GWG and IBW-FOR-GAP outcomes.

Chapter Summary

This retrospective descriptive correlational study investigates the relationships between pregnancy-related weight variations, women's characteristics, prenatal care factors, and IBW. The study's findings will contribute to the current understanding of the women at risk of delivering an SGA or LGA infant and factors that might help identify women more susceptible to these outcomes. Additionally, the life course approach has implications for developing an

effective health policy that moves beyond identifying the type of intervention and the right timing of these interventions (Mishra, Cooper, & Kuh, 2009). This chapter provided an overview of the sample, data collection procedures used in the primary survey, data management plan, research methods, and data analysis for the study. Finally, this chapter described the strengths and limitations of the study.

Chapter 4: Results

In the last couple of decades, women have entered their pregnancy with higher weights and more comorbidities than ever in the United States, despite increased efforts to improve maternal and infant mortality. Weight gain during pregnancy and infant birth weight are proxies for maternal and infant health. Current GWG guidelines are from 2009 and are based on research not specific to a diverse population (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines, 2009). Despite the updated GWG guidelines, maternal and infant health outcomes have yet to improve as they may need to be systematically applied or reflect the current diverse individual, prenatal care, and weight-related factors childbearing-age women face.

This study focuses on weight-related issues; this dissertation explores factors associated with pregnancy-related weight variations and infant birth weight. This study aims to explore the relationships between (a) women's characteristics, (b) prenatal care factors, and (c) pregnancy-related weight variation (PrePBMI and GWG), which impact maternal weight gain during pregnancy and IBW. The factors associated with these patterns in weight variation will be interpreted within the context of the IOM guidelines.

This chapter presents findings from the statistical analyses conducted in SPSS (version 28) using PeriData.Net®, a secondary dataset collected by a Midwest hospital on all births between 2012 and 2018. First, descriptive analyses were used to characterize the study sample using frequencies, percentages (%), and measures of central tendencies, such as mean (M) and standard deviation (SD). Second, bivariate analysis was conducted using chi-square tests [x^2] of independence to assess the differentials in the prevalence of GWG (inadequate, adequate, excessive) and IBW-FOR-GAP (SGA, AGA, LGA) categories across all the independent

variables. Third, multinomial logistic regressions were conducted to answer research questions two and three addressing the relationships between women's characteristics, prenatal care factors, and pregnancy-related weight variations.

Description of the Sample

The original sample size had 9,962 cases. The sample for this study included 8,966 women with a live birth at an urban Midwest hospital between 2012 and 2018. Figure 8, in Appendix A, shows that 996 (10% of the total original sample size) cases did not meet the inclusion criteria or had missing values and were excluded from the study. Women included were aged 18 and 44 years, who gave birth to live, singleton infants between 24 weeks +0 days to 42 weeks +6 days gestation, and for whom information on PrePBMI (or prepregnancy weight and height), GWG, IBW-FOR-GAP, and PNC visits was available and plausible. Univariate and bivariate statistics were employed to answer research question 1. Multivariate statistics were used to answer research questions 2 and 3.

Research Question 1

What are the characteristics of women (age, parity, race/ethnicity, nativity, zip code, and marital status) who gave birth to SGA and LGA infants compared to women who gave birth to AGA infants, stratified by PrePBMI and GWG categories?

Univariate Analysis of the Study Variables

Descriptive statistical analysis was performed to provide an overview of the study sample, including mean, standard deviation, range, frequency, and distribution. Frequencies and percentages were calculated for all categorical variables, including (a) age categories, (b) education, (c) race, (d) marital status, (e) parity, (f) PrePBMI, (g) nativity, (h) GWG, (i) health insurance, (j) group prenatal care, (k) prenatal care categories, and (l) WIC enrollment status.

Mean with standard deviation was calculated for continuous study variables to understand the distribution of the data, including (a) age, (b) PrePBMI, (c) prepregnancy weight, (d) weight at delivery, (e) GWG, (f) the number of PNC visits, (g) IBW-FOR-GAP, and (h) gestational age (GA). Table 5 and Table 6 provide the demographic characteristics of the sample based on continuous and categorical variables, respectively. Table 7 presents the study sample's PrePBMI, GWG, and IBW-FOR-GAP.

Table 5

Descriptive Statistics of the Study Variables (Continuous)(N=8,966)

	M	*SD*
Age (yrs.)	28	6
Pre-pregnancy weight (lbs.)	168	47
Post-pregnancy weight (lbs.)	197	46
BMI (kg/m2)	28.50	7.59
GWG (lbs.)	28	17
GA (weeks)	38	2
IBW (grams)	3255	570
PNC visits (count)	11	3

Note: BMI = Body Mass Index, GWG = Gestational Weight Gain, GA = Gestational Age, IBW = Infant Birth Weight, PNC =Prenatal Care.

Ages varied from 18 to 44 years, with a mean of 28 years (SD=6). The most frequently observed age category was 20 through 29 years. Over half (55%) of the sample was White, and 22% identified as Hispanic. Most women were born in the United States (91%) and completed high school education or less (46%). Most of the sample was unmarried (59%). The most frequently observed category of parity was nullipara (57%). Most women had governmental health insurance (61%), about 10% participated in group prenatal care, and 51% of the sample was enrolled in the supplemental nutrition program, Women, Infants and Children (WIC). The average number of prenatal care (PNC) visits for this study sample was 11 (SD = 3.19, SE_M =

0.03, Min = 1.00, Max = 40.00, Skewness = 0.07, Kurtosis = 4.33). When the skewness is greater than 2 in absolute value, the variable is asymmetrical about its mean. When the kurtosis is greater than or equal to 3, the variable's distribution is markedly different from a normal distribution in its tendency to produce outliers (Westfall & Henning, 2013). PNC visits are scheduled during the pregnancy's last trimester, explaining the variable's non-normal distribution.

Table 6

Descriptive Statistics of the Study Variables (Categorical)(N=8,966)

		Count	Column N %
Age groups	18 through 23 years	2,378	26.5%
	24 through 27 years	2,229	24.9%
	28 through 31 years	2,121	23.7%
	32 through 44 years	2,238	25.0%
Race	White	4,983	55.6%
	Black or African American	2,070	23.1%
	Other	1,913	21.3%
Hispanic	Yes	2,014	22.5%
	No	6,952	77.5%
United States-born	Yes	8,048	89.8%
	No	9,18	10.2%
Education	Highschool degree or less	4,111	45.9%
	Some college credits	2,538	28.3%
	Undergraduate degree	1,984	22.1%
	Graduate degree	214	2.4%
	Unknown	119	1.3%
Married	Yes	3,701	41.3%
	No	5,265	58.7%
Nullipara	Yes	2,251	25.1%
	No	6,715	74.9%
Health insurance	Medicaid/Badger Care Plus	5,320	59.3%
	Private	3,486	38.9%
	Other	160	1.8%

Group prenatal care	Yes	932	10.4%
	No	8,034	89.6%
WIC enrollment	Yes	4,482	50.0%
	No	4,484	50.0%

Note: Married at birth or anytime between conception and birth, WIC = Women Infants and Children,

When classified according to BMI, GWG, and IBW-FOR-GAP, 61% of women fell into the overweight (26%) or obese (35%) PrePBMI category, with 72% of the sample gaining inadequate (24%) or excessive (48%) weight during pregnancy, and about 20% of women having SGA or LGA infants. The mean weight before and after pregnancy was statistically significant based on an alpha of .05, t (8678) = -159.49, $p < .001$, with an average of 28.41 BMI before the pregnancy (SD = 7.61, SE_M = 0.08, Min = 7.20, Max = 74.20, Skewness = 1.08, Kurtosis = 1.74). The average GWG among the study sample was 28.55 lbs. (SD = 16.68, SE_M = 0.18, Min = -40.00, Max = 136.00, Skewness = 0.27, Kurtosis = 0.88). The average gestational age (GA) of infants was 38.41 (SD = 1.89, SE_M = 0.02, Min = 24.00, Max = 44.00, Skewness = -2.97, Kurtosis = 14.33), while IBW' average was 3,255.03 grams (SD = 568.66, SE_M = 6.10, Min = 510.00, Max = 5,723.00, Skewness = -0.69, Kurtosis = 2.37).

Table 7

Descriptive Statistics of the Study Weight Variables (Categorical)(N=8,966)

		n	%
BMI categories	1 Underweight	250	2.8%
	2 Normal weight	3,132	34.9%
	3 Overweight	2,389	26.6%
	4 Obese Class I	1,563	17.4%
	5 Obese Class II	900	10.0%
	6 Obese Class III	732	8.2%
GWG categories	1 Inadequate	2,138	23.8%

	2 Adequate	2,490	27.8%
	3 Excessive	4,338	48.4%
IBW-FOR-GAP	1 SGA	875	9.8%
	2 AGA	7,179	80.1%
	3 LGA	912	10.2%

Note: BMI = Body Mass Index, GWG = Gestational Weight Gain, IBW = Infant Birth Weight, SGA = Small-for-Gestational Age, AGA = Appropriate-for-Gestational Age, LGA = Large-for-gestational-Age.

Bivariate Analyses of Study Variables by GWG Adequacy

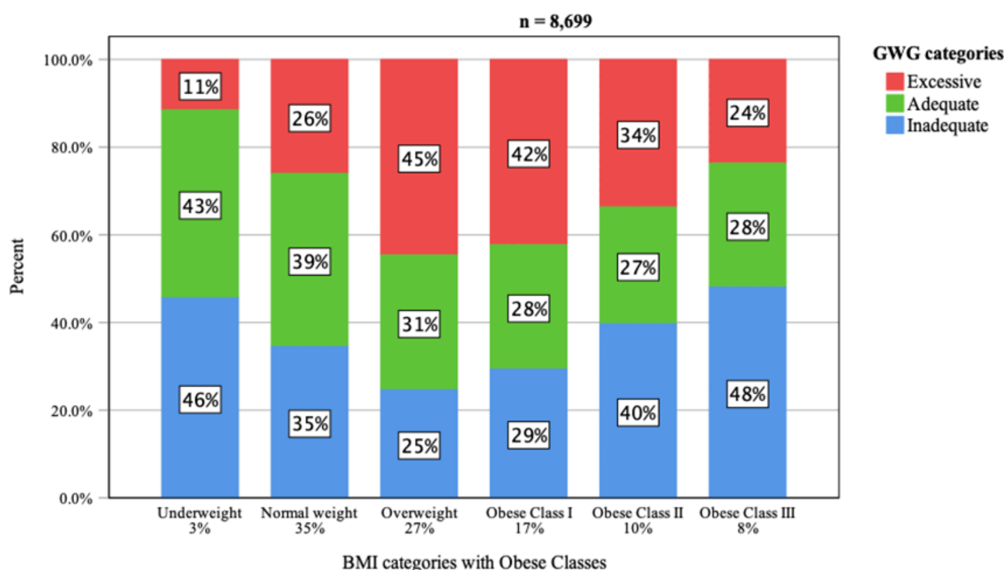
A chi-square test of independence was performed to examine the relationships between women's characteristics (age, race, ethnicity, nativity, education, marital status, parity), prenatal care factors (health insurance, group prenatal care, WIC enrollment status), PrePBMI and GWG. The first assumption of adequate cell size was met. All cells had expected values greater than zero. Additionally, all cells had expected frequencies of at least five, indicating that the second assumption of the chi-square test was also fulfilled. Adjusted residuals were evaluated to determine which cells contribute the most and the least to the strength of the differences between observed and expected values. All relationships were statistically significant based on an alpha value of .05. Table 8 summarizes the bivariate relationships between GWG adequacy and the other categorical study variables.

PrePBMI

Adequate GWG was more likely in women with underweight (42%) or normal PrePBMI (35%). Excessive weight gain was most prevalent in women with a PrePBMI in the overweight (60%) or obese (51%) category. Women who entered pregnancy with a PrePBMI in the normal weight (26%) and underweight category (38%) were more likely to have inadequate GWG. See Figure 5 for more details.

Figure 5

GWG Adequacy in the Study Sample, PeriData 2012-2018



Women's Characteristics

Women aged 28 and older, 22% for ages 32 through 44 and 22% for ages 28 through 31, were less likely to gain inadequately during their pregnancy. In comparison, women aged 24 and 27 (22%) had a slightly higher risk of not gaining enough weight during pregnancy. White women were at higher risk (53%) for excessive weight gain during pregnancy than other races and less likely (20%) to have inadequate GWG. In comparison, Black or African American women had a higher risk of not gaining (31%) enough weight during pregnancy. Women who identified as Hispanic were more likely than women who were not Hispanic to experience inadequate (27%) and adequate (31%) GWG and they were less likely (43%) to gain above the IOM recommendations. Women not born in the United States were more likely (36%) to gain adequately during their pregnancy and less likely to gain in excess. Women with a high school degree or less (28%) were most likely to have inadequate weight gain. Women with

undergraduate degrees (54%) were more likely to gain in excess during pregnancy. Women who were not married (27%) were more likely than women who were married (20%) to experience inadequate GWG. Parity also played a role in GWG. Nulliparous women (55%) were more likely than women who were not nulliparous to experience excessive GWG.

Prenatal Care Factors

Women who used Medicaid insurance (28%) were more likely to experience inadequate GWG, while women with private insurance (54%) were more likely to experience excessive GWG. Interestingly, women participating in group prenatal care had a slightly higher odd of excessive GWG (53%). Compared to participants who were not enrolled in WIC, participants enrolled in WIC had a higher chance of gaining inadequate weight (28%). Additionally, 80% of women with ten or fewer prenatal care visits were likelier to experience inadequate GWG. Those attending more than ten prenatal care visits (20%) were also more likely to experience excessive GWG. Medicaid enrollees, WIC users, and women with fewer than ten prenatal care visits were more likely to demonstrate inadequate weight gain during pregnancy. Those with private insurance, participating in group prenatal care sessions, and attending more than ten prenatal care visits were more likely to show excessive weight gain.

Table 8

GWG Categories Based on IOM Recommendations by Women's Characteristics, Prenatal Care Factors, and PrePBMI Categories (N=8966)

Women's Characteristics (%)	Inadequate GWG (n=2138)	Adequate GWG (n=2490)	Excessive GWG (n=4338)	Chi-Square	p-value
Entire sample (%)	23.8%	27.8%	48.4%		
PrePBMI categories				362.489	<.001
Underweight	38.4	42.0	19.6		
Normal weight	25.9	34.5	39.6		
Overweight	16.3	23.8	59.9		
Obese	26.3	23.1	50.6		

Women's Characteristics (%)	Inadequate GWG (n=2138)	Adequate GWG (n=2490)	Excessive GWG (n=4338)	Chi-Square	p-value
Entire sample (%)	23.8%	27.8%	48.4%		
Age in years				24.949	<.001
18-23 years	25.4	27.4	47.2		
24-28 years	26.5	27.1	46.5		
28-31 years	21.7	27.6	50.7		
32-44 year	21.6	29.0	49.4		
Race				134.556	<.001
White	19.8	27.6	52.6		
Black of AA	31.0	25.5	43.5		
Other/Mixed	26.5	30.7	48.4		
Hispanic				30.756	<.001
Yes	26.5	30.5	42.9		
No	23.1	27.0	50.0		
United States-born				59.734	<.001
Yes	23.5	26.8	49.7		
No	27.0	36.3	36.7		
Education				110.041	<.001
Highschool or less	27.9	27.4	44.6		
Some college	23.4	26.5	50.1		
Undergrad degree	16.7	29.6	53.7		
Grad degree	15.0	31.8	53.3		
Unknown	26.1	29.4	44.5		
Married				62.881	<.001
Yes	19.6	29.3	51.1		
No	26.8	27.8	48.4		
Nullipara				73.643	<.001
Yes	18.1	26.6	55.4		
No	25.8	28.2	46.0		
PNC factors					
Health insurance				131.837	<.001
Medicaid/Badger	27.8	27.3	44.9		
Private	17.6	28.7	53.7		
Other	30.6	22.5	46.9		
Group prenatal care				10.254	.006

Women's Characteristics (%)	Inadequate GWG (n=2138)	Adequate GWG (n=2490)	Excessive GWG (n=4338)	Chi-Square	p-value
Entire sample (%)	23.8%	27.8%	48.4%		
Yes	20.8	26.0	53.2		
No	24.2	28.0	47.8		
PNC visits				201.157	<.001
< 5 visits	42.7	25.6	31.7		
6-10 visits	28.9	28.3	42.8		
>10 visits	20.0	27.7	52.3		
WIC enrollment				87.113	<.001
Yes	27.9	27.3	44.8		
No	19.8	28.2	52.0		

Bivariate Analyses of Study Variables by IBW-FOR-GAP

A chi-square test of independence was performed to examine the relationships between women's characteristics (age, race, ethnicity, nativity, education, marital status, parity), prenatal care factors (health insurance, group prenatal care, WIC enrollment status), pregnancy-related weight variations (PrePBMI and GWG), and IBW-FOR-GAP. The first assumption of adequate cell size was met. All cells had expected values greater than zero. Additionally, all cells had expected frequencies of at least five, indicating that the second assumption of the chi-square test was also fulfilled. Table 9 summarizes the bivariate relationships between GWG adequacy and the other categorical study variables. Group prenatal care (p =.971), Hispanic (p = .078), and United States-born (p = .670) variables were not statistically associated with IBW-FOR-GAP. However, all other relationships were statistically significant based on an alpha value of .05 (p < .001).

PrePBMI and GWG

Women who had a prepregnancy BMI in the obese category, with a PrePBMI of 46%, were more likely to have LGA infants compared to normal-weight women (7%). Women in the obese PrePBMI category (8%) were also less likely to have an SGA infant compared to women in the underweight PrePBMI category (17%). Women with inadequate GWG (14%) were more likely to have an SGA infant than women with excessive GWG (10%). Consequently, women with inadequate GWG (5%) were less likely to have an LGA infant than women with excessive GWG (14%). In summary, women with an obese PrePBMI and excessive GWG were more likely to have an LGA infant. Women with normal or underweight PrePBMI and inadequate GWG were more likely to deliver an SGA infant.

Figure 6

Percentages of IBW-FOR-GAP per PrePBMI Categories

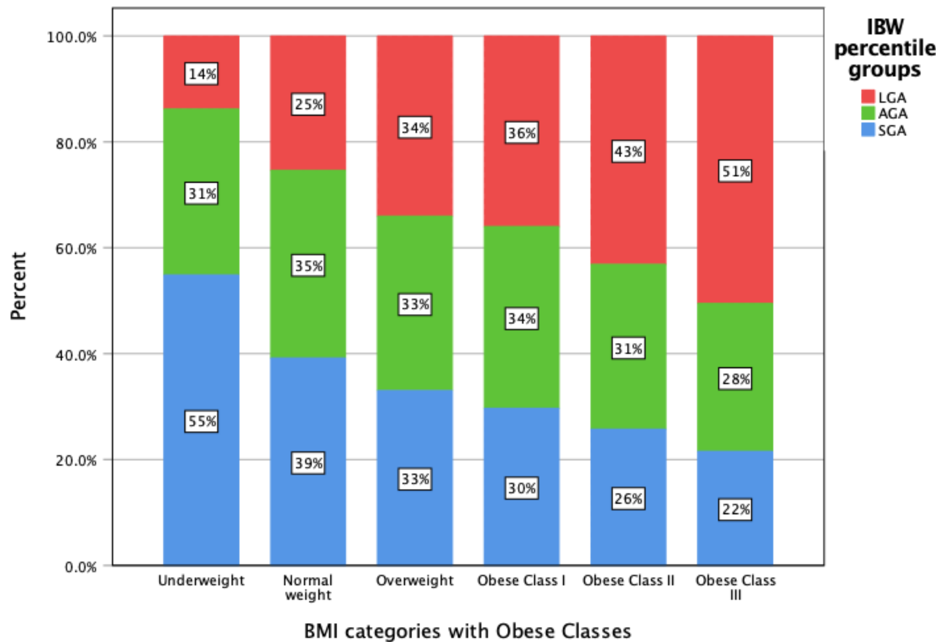
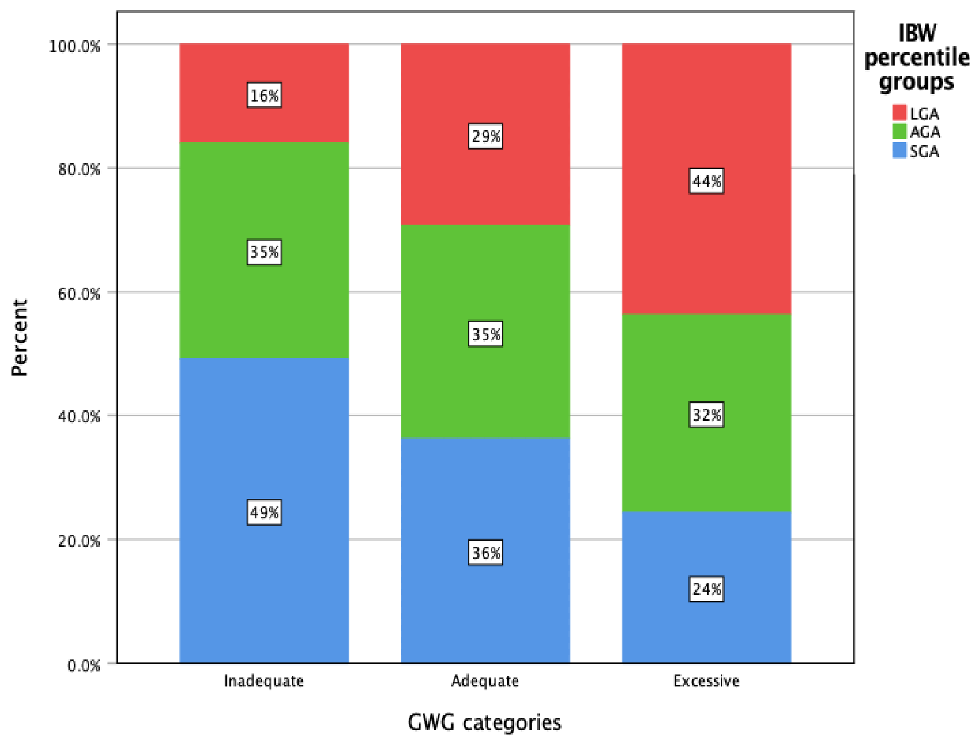


Figure 7

Percentages of IBW-FOR-GAP per GWG Categories



Women's Characteristics

Women between ages 32 and 44 (14%) were associated with a higher risk of having an LGA infant, and women ages 18 to 23 (6%) are the least likely to have an LGA infant. Women ages 18 to 23 (12%) were more likely to have an SGA infant than women between 32 and 44 (7%) years of age. The number of observed LGA infants were higher in White women (13%),

and Black or African American women (17%) had a higher risk of having an SGA infant. Ethnicity and nativity had no significant association with IBW-FOR-GAP. High school education or less (12%) increased the risk of women having an SGA infant, and women with an undergraduate degree (14%) had a higher risk of delivering an LGA infant. Married women (14%) had a higher risk of delivering an LGA infant compared to women who were not married (8%). Additionally, nulliparous women (12%) were more likely to deliver an SGA infant compared to women who were not nulliparous (9%). This study noted an increased risk/likelihood of an LGA for older White women with multiple pregnancies and greater than high school educations.

Prenatal Care Factors

Health insurance, PNC visits, and WIC enrollment were associated with IBW-FOR-GAP. Group prenatal care was not associated with IBW-FOR-GAP. Women with Medicaid or Badger Care Plus health insurance (11%) were likelier to deliver SGA infants than women with private health insurance (7%). Women with more than 10 PNC visits (9%) were less likely to deliver SGA infants and more likely (11%) to deliver LGA infants. Additionally, women who utilized WIC (12%) were more likely to have SGA infants compared to women who did not have WIC.

Age, education, group PNC, GWG, health insurance, ethnicity, parity, marital status, and race were associated with PNC visits ($p < .001$). PrePBMI ($p = 0.611$) and nativity ($p = 0.52$) were not associated with PNC visits. Women aged 28 through 31 (71%) were more likely to have PNC visits greater than 10, and women aged 18-23 (42%) were more likely to have PNC visits less than 10. Women with undergraduate degrees (56%) were more likely to have more than 10 PNC visits, and women with high school degrees or less (44%) were more likely to have fewer than 10 PNC visits during pregnancy. Group PNC was associated with the number of

PNC visits. Women enrolled in group PNC (80%) were more likely to attend more than 10 PNC visits compared to women who did not participate in group PNC. Participants with an excessive GWG (70%) were more likely to have 10 or more PNC visits than women with inadequate GWG (55%). Women with private insurance (78%) were more likely to have more than 10 PNC visits compared to women with Medicaid or Badger Care Plus insurance (57%). Women of Hispanic (33%) ethnicity were more likely to have fewer than 10 PNC visits than women who did not identify as Hispanic. Nulliparous women (71%) were also more likely to attend more than 10 PNC visits than women with more than one pregnancy (63%). Married women (74%) attended more than 10 PNC visits compared to unmarried women (59%). White women (71%) were more likely to attend more than 10 PNC visits than Black or African American women (53%).

Table 9

IBW-FOR-GAP by Women's Characteristics, Prenatal Care Factors, PrePBMI, and GWG Categories

Women's Characteristics (%)	SGA (n=875)	AGA (n=7179)	LGA (n=912)	Chi-square	p-value
Entire sample	9.8%	80.1%	10.2%		
PrePBMI categories				88.185	<.001
Underweight	16.8	78.8	4.4		
Normal weight	39.3	81.6	7.4		
Overweight	9.8	79.8	10.5		
Obese	8.0	78.9	13.1		
GWG categories				187.991	<.001
Inadequate	14.0	81.3	4.7		
Adequate	10.4	80.9	8.7		
Excessive	7.3	79	13.7		
Age in years				137.795	<.001
18-23 years	12.4	81.6	6.0		
24-28 years	11.2	80.2	8.6		
28-31 years	8.1	79.5	12.4		
32-44 year	7.1	78.9	14.1		
Race				247.464	<.001
White	7.0	79.9	13.1		
Black of AA	16.7	78.6	4.7		
Other/Mixed	9.4	82.1	8.5		

Women's Characteristics (%)	SGA (n=875)	AGA (n=7179)	LGA (n=912)	Chi-square	p-value
Hispanic				5.094	.078
Yes	8.8	81.8	9.4		
No	10.0	79.6	10.4		
Unites States-born				.801	.670
Yes	9.8	80.0	10.1		
No	9.0	80.3	10.7		
Education				247.464	<.001
Highschool or less	12.2	79.8	8.0		
Some college	8.9	80.8	10.3		
Undergrad degree	6.4	79.4	14.2		
Grad degree	6.5	77.6	15.9		
Unknown	5.9	88.2	5.9		
Married				157.890	<.001
Yes	6.5	79.5	14.0		
No	12.0	80.5	7.5		
Nullipara				35.452	<.001
Yes	12.4	79.6	8.0		
No	8.9	80.2	10.9		
Prenatal care factors (%)					
				105.093	<.001
Health insurance					
Medicaid/Badger C	11.4	80.4	8.2		
Private	7.0	79.7	13.4		
Other	15.0	77.5	7.5		
Group prenatal care				.059	.971
Yes	10.0	79.8	10.2		
No	9.7	80.1	10.2		
Prenatal care visits				51.350	<.001
< 5 visits	12.5	84.0	3.5		
6-10 visits	11.5	79.6	8.9		
>10 visits	8.7	80.0	11.3		
WIC enrollment				99.359	<.001
Yes	12.0	80.3	7.7		
No	7.5	79.8	12.6		

For the following and last two research questions, multinomial logistic regression analyses were employed because the dependent variables had three categories. IBW-FOR-GAP

had SGA, AGA, and LGA categories, with AGA as the reference category. GWG had inadequate, adequate, and excessive categories, with AGA as the reference category.

Assumptions of Multinomial Regression

Analysis

Multinomial logistic regression dictates that the dependent variable must have three or more mutually exclusive categories. GWG has three mutually exclusive categories such as inadequate, adequate, and excessive, and cases cannot belong to two categories (mutually exclusive). Women either do not gain enough, gain accordingly, or gain excess weight based on the IOM GWG recommendations. The independent variables are continuous or categorical. Ordinal variables must be treated as continuous or categorical variables in multinomial regression. All independent variables are categorical or continuous. The independence of observations is assumed, and each case represents one delivery. Multicollinearity can affect the coefficients and the p-values; however, it does not affect predictions, the prediction's precision, and the goodness-of-fit statistics (Polit & Beck, 2017). The fact that some or all predictor variables are correlated does not generally inhibit our ability to obtain a good fit, nor does it tend to affect inferences about mean responses or predictions of new observations (Applied Linear Statistical Models, p. 289, 4th Edition). No outliers, high-leverage values, or highly influential points are present in the data.

Research Question 2

The second research question is: Do prenatal care factors (total number of prenatal care visits, group prenatal care, WIC enrollment, and type of health insurance) predict IOM recommended GWG while controlling for women's characteristics and PrePBMI?

A multinomial logistic regression analysis was conducted to assess whether women's age, race, ethnicity, parity, marital status, nativity, education, PrePBMI, and prenatal care factors such as health insurance, number of prenatal care visits, WIC enrollment status, and group prenatal care membership had a significant effect on meeting IOM GWG guidelines. The assumption of the absence of multicollinearity was examined using the variance inflation factors (VIFs). VIFs were calculated to detect the presence of multicollinearity between the independent variables for research question 2. All independent variables in the regression model had VIFs less than 3, indicating no collinearity (Mean VIF = 1.53, Max VIF = 2.33, Min VIF = 1.04). Table 9 presents the VIF for each independent variable in the model.

Multivariate Analyses of GWG Adequacy

Based the Goodness-of-Fit test (Table 10) and on the Likelihood Ratio Test, $x^2(36)$ = 785.920*, p* <.001 (Table 11), the model fits the data well (non-significance proves good data fit), the full model containing all variables was statistically significant (p<.001) compared to the intercept alone. The model was evaluated based on an alpha of .05. The results of the multinomial logistic regression model were significant, χ^2 (36) = 785.920, $p < .001$, suggesting that age, race, being Hispanic, being United States-born, education, marital status, parity, health insurance, group prenatal care, WIC enrollment status, number of PNC visits, and PrePBMI categories had a significant effect on the odds of observing at least one response category (inadequate and excessive) in the GWG categories relative to adequate GWG. McFadden's R-squared (R^2) was calculated to examine the model fit, where values greater than .2 indicate models with an excellent fit (Louviere et al., 2000).

Table 10

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	17096.084			
Final	16310.164	785.920	36	<.001

The McFadden R^2 value calculated for this model was 0.04. Therefore, the model fit is moderate, indicating that the model was able to distinguish between women who gained weight inadequately or in excess during pregnancy compared to women who gained adequate weight based on IOM GWG recommendations. McFadden's R^2 is an index of the proportionate improvement in model fit relative to the null model (Pituch & Stevens, 2016). The Pseudo (is like a least-squares-based R^2, which indicates the proportion of the variance explained by the model. However, in multinomial regression, these indexes are reported as an approximation to an R^2 from least-squares regression rather than the percentage of variance explained. The number of prenatal care visits, BMI categories, parity, race, and being United States-born, made a unique statistically significant contribution to the model.

Table 11

Likelihood Ratio Tests-GWG Multinomial Regression

	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	*p*
Intercept	16310.164[a]	.000	0	.
Age (yrs.)	16318.301	8.137	2	.017
PNC visits (count)	16424.867	114.703	2	<.001
BMI categories	16702.192	392.028	6	<.001
Education	16321.790	11.626	8	.169
Group prenatal care	16311.435	1.271	2	.530
Health insurance	16321.803	11.639	4	.020
Hispanic	16317.243	7.079	2	.029
Race	16344.584	34.421	4	<.001
United States-born	16331.210	21.046	2	<.001
WIC	16315.107	4.943	2	.084
Married	16311.321	1.157	2	.561

Note: The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Factors Associated with Gaining Inadequate GWG versus Adequate GWG

Table 12 summarizes the factors associated with inadequate GWG compared to adequate GWG. The model indicated that PrePBMI in the obese category was a risk factor for inadequate weight gain during pregnancy. Compared with a normal PrePBMI, obese PrePBMI (OR =2.03 , 95%CI [1.79, 2.30]) increased the odds of failing to gain adequate weight.

Black or African American women had increased odds of gaining inadequate weight during pregnancy (OR = 1.25, 95%CI [1.06, 1.47]), compared to White and other/mixed-race women. Women who were not nulliparous had an increased odds of gaining below the IOM GWG recommendations (OR =1.25, 95%CI [1.07, 1.47]). Having an undergraduate degree (OR =0.77, 95%CI [0.63, 0.93]) and private insurance (OR =0.85, 95%CI [0.72, 1.00]) decreased the odds of inadequate GWG . Also, for every additional PNC visit, the odds of inadequate GWG decreased (OR =1.04, 95%CI [1.03, 1.06]), controlling for all other factors in the model. In summary, women at increased risk of gaining inadequate GWG are women with an obese PrePBMI, who are Black or African American, and not nulliparous. Women with a lower chance of gaining inadequately are women with an undergraduate degree and private insurance. Additionally, with every PNC visit, the risk of gaining less than recommended during pregnancy decreases by 5%.

Table 12

Multinomial Logistic Regression GWG

	Inadequate GWG			Excessive GWG		
Variable	*p*	*OR*	95.00% CI	*p*	*OR*	95.00% CI
(Intercept)	.277			.577		
Age (yrs.)	.739	1.00	[0.99, 1.01]	.638	1.00	[0.99, 1.01]
Race: White (reference)						
Race: Black or African American	.007	1.25	[1.06, 1.47]	.010	0.83	[0.72, 0.96]
Race: Other	.404	1.09	[0.90, 1.32]	.385	0.93	[0.79, 1.10]
Hispanic: Yes (reference)						
Hispanic: No	.788	1.03	[0.85, 1.23]	.022	1.20	[1.03, 1.41]
US Born: Yes (reference)						
US Born: No	.200	0.87	[0.70, 1.08]	< .001	0.63	[0.52, 0.76]
Education: Highschool or less (reference)						
Education: Some college credits	.546	0.96	[0.83, 1.11]	.791	1.02	[0.90, 1.16]

	Inadequate GWG			Excessive GWG		
Variable	*p*	*OR*	95.00% CI	*p*	*OR*	95.00% CI
Education: Undergraduate degree	.008	0.77	[0.63, 0.93]	.568	0.95	[0.81, 1.31]
Education: Graduate degree	.139	0.71	[0.45, 1.12]	.380	0.86	[1.03, 1.12]
Education: Unknown	.513	0.85	[0.52, 1.39]	.940	0.98	[0.63, 1.53]
Married: Yes (reference)						
Married: No	.232	1.10	[0.94, 1.28]	.978	1.00	[0.88, 1.14]
Nullipara: Yes						
Nullipara: No	.005	1.25	[1.07, 1.47]	< .001	0.77	[0.68, 0.87]
PNC Visits (count)	< .001	0.95	[0.93, 0.97]	< .001	1.04	[1.03, 1.06]
Group Prenatal Care: Yes (reference)						
Group Prenatal Care: No	.338	0.90	[0.74, 1.11]	.532	0.95	[0.80, 1.12]
HI: Medicaid/Badger Care (reference)						
Health Insurance: Private	.052	0.85	[0.72, 1.00]	.833	0.98	[0.85, 1.14]
Health Insurance: Other	.094	1.46	[0.94, 2.28]	.284	1.25	[0.83, 1.90]
WIC enrollment: Yes (reference)						
WIC Enrollment: No	.745	0.98	[0.84, 1.13]	.190	1.09	[0.96, 1.25]
PrePBMI: Normal (reference)						
PrePBMI Categories: Underweight	.347	1.15	[0.86, 1.55]	< .001	0.40	[0.28, 0.57]
PrePBMI Categories: Overweight	.060	0.86	[0.73, 1.01]	< .001	2.32	[2.04, 2.65]
PrePBMI Categories: Obese	< .001	1.38	[1.20, 1.58]	< .001	2.03	[1.79, 2.30]

Factors Associated with Gaining Excessive GWG versus Adequate GWG

Table 12 summarizes the factors associated with excessive GWG compared to adequate GWG. Compared with normal PrePBMI, being in the overweight (OR =2.32, 95%CI [2.04, 2.65]) and obese category (OR =2.03, 95%CI [1.79, 2.30]) increased the likelihood of excessive GWG. Women in the overweight and obese category were more than twice as likely as women with a normal weight to gain excessively during their pregnancy. Black or African American women were less likely to experience excessive GWG than White women (OR =0.83, 95%CI

[0.72, 0.96]). Women born outside of the United States had a decreased odds of experiencing excess GWG (OR =0.63, 95%CI [0.52, 0.76]). Additionally, non-Hispanic women had an increased likelihood of experiencing excessive GWG (OR =1.20, 95%CI [1.03, 1.41]). Also, for every additional PNC visit, the odds of excessive GWG increased (OR =1.04, 95%CI [1.03, 1.06]), controlling for all other factors in the model.

In summary, non-Hispanic women with a PrePBMI in the overweight or obese categories are at increased risk of gaining more weight than recommended per IOM during pregnancy. Also, with every additional PNC visit, there is an increased association of gaining excess GWG increases by 4%. Women at lower risk of excessive GWG are born outside of the United States, have had more than one pregnancy, are underweight, and identify as Black or African American.

The model predicted 88% (n = 3,817) of the total cases in the sample with excessive GWG (48%, n = 4,338). Inadequate and adequate GWG was predicted at 17% and 14%, respectively. Re-ran the multinomial regression analysis with the seven significant independent variables only. It did not improve the model fit. Therefore, the initial model was reported with all independent variables for research question two. Refer to Table 5 for the model prediction of GWG.

Table 13

Classification

	Model Prediction of GWG			
Observed	1 Inadequate	2 Adequate	3 Excessive	Percent Correct
1 Inadequate GWG	355	246	1471	17.1%
2 Adequate GWG	235	341	1861	14.0%
3 Excessive GWG	259	232	3678	88.2%
Overall Percentage	9.8%	9.4%	80.8%	50.4%

Research Question 3

The third research question is: Do prenatal care factors (total number of prenatal care visits, group prenatal care, WIC enrollment, and type of health insurance) predict infant birth weight (SGA, AGA, LGA) while controlling for women's characteristics and PrePBMI? This question extends the findings from research question 2 as the outcome of IBW-FOR-GAP and the characteristics that predict IBW-FOR-GAP. A multinomial logistic regression analysis was conducted to assess if women's age, race, ethnicity, parity, marital status, nativity, education, and prenatal care factors such as health insurance, number of prenatal care visits, WIC enrollment status, group prenatal care, PrePBMI, and GWG had a significant effect on the odds of delivering SGA or LGA infant relative to AGA. The results are presented as odds ratios (OR) and their respective 95% confidence intervals (CIs). The assumption of the absence of multicollinearity was examined using WIFs. All independent variables in the regression had VIFs less than 3, indicating no evidence of collinearity among the independent variables (Mean VIF = 1.50, Max = 2.34, Min = 1.04); therefore, all variables were included in the multinomial regression analyses.

Multivariate Analyses of IBW-FOR-GAP

The model was evaluated based on an alpha of .05. The model's fitness was assessed using chi-square statistics. The multinomial logistic regression model results were significant, χ^2 (40) = 652.489, $p < .001$, suggesting that the relationships between the independent and dependent variables are significant (Table 14). McFadden's squared was calculated to examine the model fit, where values greater than .2 indicate excellent model fit (Louviere et al., 2000). The McFadden R^2 value calculated for this model was 0.06, indicating a moderate model fit.

Table 14

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	7722.365	7736.503	7718.365			
Final	7153.876	7464.892	7065.876	652.489	42	<.001

Note:

Table 15

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	7153.876	7464.892	7065.876[a]	.000	0	.
Age	7165.218	7447.960	7085.218	19.342	4	<.001
Education	7152.502	7421.107	7076.502	10.626	6	.101
Race	7257.546	7540.288	7177.546	111.669	4	<.001
Hispanic	7150.892	7447.771	7066.892	1.016	2	.602
United States-Born	7151.254	7448.133	7067.254	1.378	2	.502
Parity	7158.747	7455.626	7074.747	8.870	2	.012

Married	7158.759	7455.638	7074.759	8.882	2	.012
Health Insurance	7149.971	7446.850	7065.971	.094	2	.954
WIC Enrollment	7152.235	7449.114	7068.235	2.358	2	.308
Group PNC	7153.791	7450.670	7069.791	3.914	2	.141
PNC Visits	7158.255	7440.997	7078.255	12.379	4	.015
BMI Categories	7240.816	7509.421	7164.816	98.940	6	<.001
GWG Percentile	7282.963	7565.705	7202.963	137.086	4	<.001

Note: The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Factors Associated with Delivering SGA versus AGA Infants

When holding all other predictors constant in the model, women in the obese PrePBMI category have decreased odds of having an SGA infant compared to women with a PrePBMI in the normal category (OR =0.68, 95%CI [0.57, 0.82]) (see Table 16). Additionally, women who gain inadequate weight during pregnancy, holding all other predictors constant, have increased odds of having an SGA infant compared to women who gain adequate weight during pregnancy (OR =1.26, 95%CI [1.05,1.51]). Women who gain in excess during pregnancy have decreased odds of having an SGA infant compared to women who gain within the IOM GWG recommendations (OR =0.74, 95%CI [0.62,0.88]). Black or African American women have increased likelihood odds of delivering an SGA infant compared to White women (OR =2.05, 95%CI [1.71, 2.47]). Women with more than one pregnancy (including this pregnancy) have decreased odds of having an SGA infant (OR =0.63, 95%CI [0.53, 0.75]). Unmarried women had a higher risk of delivering an SGA infant (OR =1.21, 95%CI [0.99, 1.48]). As education

increased, the risk of delivering an SGA infant decreased. Age did not significantly contribute to the model, suggesting that having an SGA compared to an AGA infant is not affected by age. Women at increased risk for delivering an SGA infant identify as Black or African American, unmarried, and have inadequate GWG. A lower risk of having an SGA infant is associated with having undergraduate degree or unknown education, more than one pregnancy, excessive GWG, and an obese PrePBMI.

Table 16

Multinomial Logistic Regression IBW-FOR-GAP

	SGA			LGA		
Variable	*p*	*OR*	95.00% CI	*p*	*OR*	95.00% CI
(Intercept)	< .001			< .001		
Age	.350	1.01	[0.99, 1.03]	.004	1.02	[1.00, 1.04]
Race: White (reference)						
Race: Black or African American	< .001	2.05	[1.71, 2.47]	< .001	0.46	[0.38, 0.58]
Race: Other	.175	1.19	[0.93, 1.52]	.008	0.72	[0.56, 0.92]
Hispanic: Yes (reference)						
Hispanic: No	.317	1.13	[0.89, 1.43]	.801	1.03	[0.82, 1.29]
United States-born: Yes (reference)						
Unites States-Born: No	.933	1.01	[0.76, 1.35]	.170	1.21	[0.92, 1.59]
Married: Yes (reference)						
Married: No	.056	1.21	[0.99, 1.48]	.024	0.82	[0.69, 0.97]
Education: Highschool or less (reference)						
Education: Some college credits	.017	0.81	[0.68, 0.96]	.677	1.04	[0.87, 1.25]
Education: Undergraduate degree	.026	0.75	[0.58, 0.97]	.369	1.10	[0.89, 1.37]
Education: Graduate degree	.470	0.80	[0.45, 1.45]	.499	1.16	[0.76, 1.77]
Education: Unknown	.040	0.44	[0.20, 0/96]	.279	0.65	[0.30, 1.42]
Nullipara: Yes (reference)						
Nullipara: No	< .001	0.63	[0.53, 0.75]	.001	1.36	[1.13, 1.65]
GWG: adequate (reference)						
GWG: Inadequate	.014	1.26	[1.05, 1.51]	< .001	0.56	[0.44, 0.72]
GWG: Excessive	< .001	0.74	[0.62, 0.88]	< .001	1.47	[1.24, 1.75]
PrePBMI: Normal weight (reference)						
PrePBMI: Underweight	.097	1.36	[0.95, 1.95]	.488	0.80	[0.43, 1.50]
PrePBMI: Overweight	.463	0.93	[0.77, 1.12]	.002	1.36	[1.12, 1.66]
PrePBMI: Obese	< .001	0.68	[0.57, 0.82]	< .001	2.01	[1.68, 2.41]

WIC enrollment: Yes (reference)						
WIC Enrollment: No	.124	0.87	[0.72, 1.04]	.142	1.16	[0.95, 1.40]
PNC Visits (count)	.455	0.99	[0.97, 1.01]	.010	1.03	[1.00, 1.06]
HI: Medicaid/Badger CP (reference)						
HI: Private	.587	0.94	[0.77, 1.16]	.794	1.03	[0.84, 1.25]
HI: Other	.072	1.53	[0.96, 2.42]	.467	0.79	[0.43, 1.48]
Group Prenatal Care: Yes (reference)						
Group Prenatal Care: No	.578	0.93	[0.74, 1.19]	.414	1.10	[0.87, 1.39]

Note:

Factors Associated with Delivering LGA versus AGA Infants

The overweight and obese PrePBMI category was a risk factor for delivering LGA infants. Compared with having an AGA infant, being overweight and obese increased the odds of LGA infants by 1.36 (1.12, 1.66) and 2.01 (1.68, 2.41) (see Table 16). Women with an obese PrePBMI category were twice as likely as women with a normal PrePBMI to have an LGA infant. Inadequate GWG decreased the odds by 0.56 (0.44, 0.72), while excessive GWG increased the odds by 1.47 (1.24, 1.75) of having an LGA infant compared to women who gained within the IOM recommendations. Black and other or mixed-race women had decreased odds of delivering an LGA infant compared to White women, 0.46 (0.38, 0.58) and 0.72 (0.56, 0.92), respectively. Unmarried women had a decreased odds of delivering an LGA infant by 0.82 (0.69, 0.97). Additionally, women with more than one pregnancy had an increased risk of having an LGA infant by 1.36 (1.13, 1.65). In summary, the risk of having an LGA infant is associated with overweight and obese PrePBMI, excessive GWG, and multiple pregnancies. Additionally, with every 1-year increase in age, the risk of LGA increases by 2%. Also, with every PNC visit, the risk of LGA increases by 3%. The risk of LGA decreases with the race of “Black” or “Other,” being unmarried, and gaining inadequate weight during pregnancy.

Chapter Summary

The main purpose of this study was to determine the associations between women's characteristics, prenatal care factors, and pregnancy-related weight variations. Findings indicated that age, PNC visits, PrePBMI, health insurance, race, ethnicity, and nativity were associated with GWG. Additionally, age, race, parity, marital status, PNC visits, PrePBMI, and GWG were associated with IBW-FOR-GAP. Furthermore, this study identified risk factors related to the risk of inadequate and excessive GWG and delivering an SGA or LGA infant.

Chapter 5: Discussion

This study focused on the associations of women's characteristics, prenatal care factors, and pregnancy-related weight variations. This chapter will contextualize the findings of this study and explain the contribution to existing scientific literature. The first section will present an overview of the study's key findings. The second section will discuss the interpretation of the findings and how the results are similar or different from existing research. The third section will address the limitations and strengths of the study. The chapter will conclude with recommendations for future research and policy in the context of IOM GWG recommendations and care of diverse populations of women.

Overview of the Key Findings

The study explored the associations between women's characteristics, prenatal care factors, and pregnancy-related weight variations in women and their infants. The study's first objective was to evaluate and describe the characteristics of women who gave birth to SGA or LGA infants compared to women who gave birth to AGA infants, stratified by PrePBMI and GWG categories. The last two objectives were to evaluate the role of women's characteristics and prenatal care factors in GWG and IBW-FOR-GAP. In summary, this study highlights that multiple factors, demographic, social determinants of health, and physiological responses are associated with GWG and IBW-FOR-GAP. The study also indicated the need to understand how IOM GWG recommendations may serve a diverse population of women. The findings for each research question will be summarized below.

Research Question 1. What are the characteristics of women (age, race, ethnicity, nativity, education, parity, marital status) who gave birth to SGA and LGA infants compared to women who gave birth to AGA infants, stratified by PrePBMI and GWG categories?

In this study, the relationships between women's characteristics (age, race, ethnicity, nativity, education, marital status, parity), prenatal care factors (health insurance, group prenatal care, number of prenatal care visits, WIC enrollment), PrePBMI were statistically significant associated with GWG. Only group prenatal care, ethnicity, and nativity did not contribute significantly to IBW-FOR-GAP in this study. However, all other variables related to women's characteristics, prenatal care factors, PrePBMI, and GWG were all significantly associated with IBW-FOR-GAP.

Research Question 2 (RQ2): Do prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, and type of health insurance) predict IOM recommended GWG while controlling for women's characteristics and PrePBMI?

Race, ethnicity, nativity, parity, health insurance, number of PNC visits, and PrePBMI significantly affected the odds of observing inadequate or excessive GWG relative to adequate GWG. Age, education, group prenatal care, WIC status, and marital status did not significantly affect GWG. Women who gained adequate GWG have the following characteristics: normal PrePBMI, 18-23 years old, enrolled in private insurance, non-Hispanic, married, nulliparous, White, non-United States-born, and not enrolled in WIC supplemental program. Age-related weight gain cannot be discounted, and older women are more likely to have more than one pregnancy (Yakusheva et al., 2017). Women who gained inadequate GWG tend to have the following factors: underweight PrePBMI category, 24-28 years old, Black or African American, Hispanic, non-Unites States-born, having a high school education or less, not married, having more than one pregnancy, not enrolled in group prenatal care, enrolled in WIC, and attending five or fewer PNC visits.

Women who gained excess GWG had the following factors: overweight or obese PrePBMI, 28-44 years old, White and other/mixed race, non-Hispanic, United States-born, having higher education (more than a high school degree), married, nullipara, private insurance, attending more than 10 PNC visits, and not enrolled in WIC. The summary findings of the research questions are presented in Table 13. Increased odds of both inadequate and excessive GWG are related to obesity. Interestingly, not being nullipara increased the odds of inadequate GWG and was protective against excessive GWG. A possible counter-intuitive finding is that more PNC visits are aligned with excessive GWG. This finding requires further investigation as the additional visits could be due to developing/chronic conditions, such as gestational diabetes or hypertension.

Table 17

Odds of Inadequate and Excessive GWG

	Inadequate GWG	Excessive GWG
↑ Odds	Black or African American	Non-Hispanic
	Obese PrePBMI	One additional visit PNC visits
	Not nullipara	Overweight PrePBMI
		Obese PrePBMI
↓ Odds	Undergraduate degree	Black or African American
	Private insurance	Not United States-born
	PNC visits	Not nullipara
		Underweight PrePBMI

Notes: details of this table available in Appendix Table, odds ratios added for clarification. All percentages in the table will be replaced with OR

Research Question 3 (RQ3): Do prenatal care factors (number of PNC visits, group prenatal care, WIC enrollment, and type of health insurance) predict IBW-FOR-GAP (SGA, AGA, LGA) while controlling for women's characteristics and PrePBMI?

Age, race, parity, marital status, PNC visits, PrePBMI, and GWG significantly affected the odds of observing SGA or LGA infants compared to AGA infants. Women who had SGA infants had a PrePBMI in the normal range, inadequate GWG, a high-school or lower education, and were aged 18-23 years, Black or African American, non-Hispanic, not marred, nullipara, were enrolled in health insurance other than private or Medicaid, had five or fewer PNC visits, and were enrolled in WIC. Women who had LGA infants are most likely to have a PrePBMI in the obese category, excessive GWG, an undergraduate or higher degree, and by age 32-44 years, White, non-Hispanic, married, have had multiple pregnancies, private insurance, and more than 10 PNC visits, and were not enrolled in WIC. Education, ethnicity, nativity, health insurance, WIC enrollment, and group prenatal care did not significantly affect IBW-FOR-GAP.

Table 18

Odds of SGA and LGA Infants

	SGA	LGA
↑ Odds	Black or African American	Age
	Unmarried	Obese PrePBMI
	Inadequate GWG	Overweight PrePBMI
		Excessive GWG
		Not nullipara
↓ Odds	Some college credits	Black or African American (
	Undergraduate degree	Race: Other
	Not nullipara	Unmarried

	Excessive GWG	Inadequate GWG
	Obese PrePBMI	

Note: all percentages will be replaced with ODDS ratios in the table

Interpretation of Findings

In this study, the majority of women, over 70%, at a Midwest urban hospital in the United States, between 2012 and 2018, did not achieve recommended GWG based on 2009 IOM guidelines. Only 35% of women had a normal PrePBMI before pregnancy, with 3% in the underweight category and 62% of women having a PrePBMI in the overweight or obese category. Interestingly, women aligning weight gain with IOM guidelines were more likely to have a normal PrePBMI. Overall, the percentage of women entering their pregnancy with a normal PrePBMI was considerably lower in this study compared to the prevalence of normal BMI in the study's state before pregnancy (Deputy, 2018). Across all PrePBMI categories, women had challenges gaining adequate GWG as recommended by IOM. According to the IOM guidelines, only 28% of women across all PrePBMI categories gained adequate weight during pregnancy. Of all the women in this study, 80% had an AGA infant. The prevalence of SGA and LGA infants in high-income countries, is 5% to 15% and 5% to 20 %, respectively (Ruiz et al., 2015). The percentage of women with LGA (10%) in this cohort was slightly higher, compared to the 8% of all live-born infants in the United States who weighed 4000 g (about 8.82 lbs.) or more in 2019 (Martin et al., 2021).

In this study, the majority of women, over 70%, at a Midwest urban hospital in the United States, between 2012 and 2018, did not achieve recommended GWG based on 2009 IOM guidelines. Only 35% of women had a normal PrePBMI before pregnancy, with 3% in the underweight category and 62% of women having a PrePBMI in the overweight or obese category.

Inadequate or Excessive GWG based on IOM GWG Guidelines (Research Question 2)

The findings on GWG are largely consistent with previous studies, which showed significant associations between certain women's characteristics and prenatal care factors (Ferraro et al., 2012; Rogozińska et al., 2019; Siega-Riz et al., 2020). The prevalence of excessive GWG in this study (48%) was slightly higher than the prevalence reported nationally (47%) and in the study's state (46%) based on birth certificate data (Deputy, 2018; Deputy et al., 2015). The prevalence of GWG adequacy categories was slightly higher in this study compared to a recent multinational meta-analysis (Goldstein et al., 2017; LifeCycle Project, 2019). In this study, differences in the prevalence of insufficient and excessive GWG were also noted by obesity classes.

Women who entered pregnancy with a PrePBMI in the overweight or obese category had twice the odds of excessive GWG as women with a normal PrePBMI. In alignment with other studies, obese PrePBMI also increased the odds of inadequate GWG compared to normal PrePBMI. Women in the underweight PrePBMI category had lower odds of excessive GWG than women with normal PrePBMI, which is not surprising (Amyx et al., 2021). Based on previous research, higher than normal PrePBMI (overweight and obese categories) are significant predictors of excessive GWG (Lackovic et al., 2020). While inadequate GWG is more common among women with an underweight PrePBMI and excess GWG is more common in obese and overweight PrePBMI, more than 50% of normal PrePBMI women gained outside the IOM recommendations, with 40% gaining excessive and 26% gaining inadequate GWG in the study's cohort. Additionally, obese women also have an increased odds of gaining inadequately during pregnancy, and when examining obesity class is separately excessive GWG decreased from obese Class I to III. These are important findings since the current recommendations for all

obesity classes are one range, 11-20 lbs. (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines, 2009)

In contrast, inadequate GWG increased from obese class I to III. Although it was verified in this study, the findings were true in other studies when adjusted analyses were repeated to evaluate obesity classes I-III separately. The decrease in GWG persisted when compared with the normal PrePBMI (Amyx et al., 2021; Deputy, Sharma, Kim, et al., 2015). Given the high risk of adverse outcomes with excessive GWG, regardless of PrePBMI categories, and the challenges to limit GWG, it is important to provide nutrition and physical activity information. Another barrier, according to a recent systematic review, healthcare providers have insufficient knowledge of the IOM recommendations (Callaghan et al., 2020).

The current study found that several women's characteristics and prenatal care factors were associated with inadequate and excessive GWG, though the evidence is inconclusive and mixed in previous literature. In this study, nulliparous women were more likely to have increased GWG than women with more than one pregnancy. According to one systematic review, while parity was associated with higher PrePBMI, evidence for the role of parity is inconsistent due to the complex role of parity in GWG (Hill et al., 2016). Interestingly, in this study, 65% of women with more than one pregnancy had higher than normal PrePBMI; 38% were obese and 27% had an overweight PrePBMI. According to previous studies, women with more than one pregnancy tend to gain inadequately during pregnancy, but they also are twice as more likely to be obese at the beginning of their pregnancies when compared to nulliparas (Abrams et al., 2013; Hill et al., 2016; Hinkle et al., 2014; Iversen et al., 2018; Paulino et al., 2016).

In this study, women born outside of the United States had lower odds of gaining excessive GWG than those born in the United States. While the healthy foreign-born effect has

been proven in previous studies, a recent study showed that while immigrants are less likely than United States-born women to experience excessive GWG and obese PrePBMI, the perinatal outcomes vary and depend on the length of stay in the United States (Green et al., 2021). In this study, the evaluation of the length of stay in the United States was not possible due to a lack of data. While only 10% of the sample was born outside of the United States this is important to note and continue to explore further to understand the changes that might have caused the shift in risk of gaining more than less during pregnancy as time since entry to the United States has lengthened.

This study found that Black or African American women had increased odds of gaining inadequate GWG when holding all other variables constant. Obesity is higher among Black or African American women in this study and existing studies (Atreya et al., 2017; Bruce et al., 2007; Sackoff & Yunzal-Butler, 2015b). While research has shown that being in the obese PrePBMI category increases the risk for excessive weight gain (Lackovic et al., 2020; Subhan et al., 2017), these findings are consistent with an existing study, which found that African Americans and Hispanics were twice less likely than White women to exceed the IOM GWG recommendations (Headen et al., 2015; Liu et al., 2014; Sackoff & Yunzal-Butler, 2015a). Contributing factors to inadequate GWG in women's subpopulations are still poorly understood.

The adequate number of prenatal care visits to reduce adverse maternal and infant outcomes is unclear and not supported by evidence (Carter et al., 2016; Peahl & Howell, 2021; Yeo et al., 2016). The prenatal care visits schedule has stayed the same since the Children's Bureau's 1930 drafting of the first prenatal visitation schedule, despite the requests for changes in prenatal care delivery from the National Institutes of Health Task Force in 1989. (Peahl & Howell, 2021) (American Academy of Pediatrics & American College of Obstetricians and

Gynecologists, 2017). Based on a comprehensive literature review of the key components of prenatal care services in the United States, higher numbers of PNC visits did not improve poor outcomes in women regardless of the risk (Barrera et al., 2021). This study showed a statistically significant effect on the number or frequency of PNC visits and membership in the LGA group.

The results of this study also suggest that a higher number of PNC visits, usually greater than 10, was not associated with better outcomes related to excessive GWG. Every additional PNC visit increased the risk of excessive GWG by 4%. Other studies have had similar results (Carter et al., 2016; Peahl & Howell, 2021; Yeo et al., 2016). Carter et al. (2016) concluded no difference in neonatal composite outcomes between low-risk women with more than 10 PNC visits compared to those with fewer than 10 PC visits. There was also no indication that adequate prenatal care was associated with a reduced risk of excessive GWG (Yeo et al., 2016).

ACOG recommends early and frequent PNC visits, including an initial visit during weeks 8 and 10, continuing with monthly visits up to 28 weeks of gestation, bi-weekly visits after that up until week 36 of gestation, and weekly visits until delivery, totaling 12-14 PNC visits if women follow the recommendations. The U.S. Department of Health and Human Services (USDHHS) Expert Panel on the Content of Prenatal Care, the National Guidelines Clearinghouse (NGC), and the Institute for Clinical System Improvement (ICSI) 2010 recommendations provide similar guidelines, which have not changed drastically since the 1930s despite advances in medical practice and technology. The coronavirus disease 2019 (COVID-19) pandemic has challenged the current prenatal care guidelines in the United States due to the reduced number of in-person clinic visits to reduce viral exposure and the scarce availability of healthcare resources. Practices across the United States rapidly adopted reduced prenatal care visit schedules with options for virtual visits. For the first time in decades, ACOG endorsed the reduced number of

PNC and virtual visits (*COVID-19 FAQs for Obstetrician-Gynecologists, Obstetrics*, n.d.). The adequate number of PNC visits and modality (in-person, virtual, group care, individual care) remains elusive.

The relationship between prenatal care and the adequacy of GWG is inconclusive, but these visits are great opportunities to reach women, guide them, and counsel them throughout their pregnancy. It is a crucial and sensitive time, according to the LCT. Tailoring services to women's medical and social needs has also been challenging. Individualized care that targets specific women's sub-populations is needed. Additional services to address psychosocial or nutritional risk factors might be better delivered outside of routine prenatal care visits, such as support programs, peer support, or dietary programs.

SGA and LGA Infants (Research Questions 3)

This study showed that inadequate GWG increases the odds of SGA infants compared to adequate GWG, and excessive GWG increases the odds of LGA infants. Consistent with the results, a recent meta-analysis of 23 studies evaluating associations between inadequate and excessive GWG and perinatal outcomes showed an increased risk of SGA infants due to inadequate GWG (Goldstein et al., 2017, 2018). However, a current systematic review and meta-analysis showed no significant increase in SGA rates in pregnancies with inadequate GWG for all classes of obesity. Additionally, gaining less than the recommended GWG was associated with a lower rate of LGA for all classes of obesity (Mustafa et al., 2022). Balancing maternal and fetal outcomes is a challenge in pregnancies with higher-than-normal PrePBMI. The fetus, placenta, amniotic fluid, expansion of blood, and other extracellular fluids comprise 6 to 7 kgs of the total GWG, so new GWG recommendations must carefully consider balancing the risks for the maternal-infant dyad.

In this study, Black or African American women had twice the odds of delivering an SGA infant compared to white women and are also at increased risk of inadequate GWG; however, they are more likely to have a PrePBMI in the obese category. Based on previous studies, Black women in the United States have disproportionately more adverse birth outcomes and are three times as likely to die within the first year of life as White infants between 2017 and 2019 in the study's state. Black infants were about three times as likely as Asian/Pacific Islander infants to die during the first year of life in the United States between 2017 and 2019 (March of Dimes, 2020).

The relationship between PrePBMI and SGA is inconsistent. In this study, obese PrePBMI decreased the odds of SGA. Some studies argue that underweight PrePBMI increases the risk of SGA infants, and overweight and obese PrePBMI categories decrease the risk of SGA infants (Tabet et al., 2015; Kim et al., 2016; Cosson et al., 2016). Other studies found no significant association between PrePBMI and the risk for SGA infants (Xiao et al., 2017; Song et al., 2018). The mean (38) and standard deviation (1.38) of the SGA infant groups was the same as the sample's mean and standard deviation. According to previous studies, the likelihood of pathologically small infants decreases as gestational age increases, and the number of constitutionally small infants increases (Ananth & Vintzileos, 2009). These infants are not frequently or strategically identified antenatally, especially in women who are low-risk (Madden et al., 2018), yet they have a 20%-200% higher odds of in-hospital death compared to non-SGA infants (Ewing et al., 2017; Malin et al., 2014). This study did not evaluate infant adverse outcomes, but future studies should focus on excluding women with known risk factors such as diabetes mellitus, hypertension and previous IUGR to identify the population of women at risk.

It is important to select the appropriate growth versus reference charts as the rates of SGA can differ significantly based on the choice of the reference population. There are two kinds of charts available: standard and reference charts. Growth charts, prescriptive in nature, indicate how a population should grow under ideal environmental and health conditions and are based on low-risk pregnancies. Reference charts, descriptive in nature, include both low-risk and high-risk pregnancies and specify growth in a specific location and time. The INTERGROWTH-21st Project group published a standard sex-specific birth weight for GA charts based on neonatal growth measures with ultrasound-assessed GA from healthy women in eight countries. The institution from which the sample was collected, and many other institutions, continue to use an older fetal growth chart for determining SGA and LGA. This may impact the results based on the parameters infants were categorized compared to newer, more comprehensive charts. It is worthwhile to explore other growth or reference charts based on the specific needs of the populations.

In this study, women with more than one pregnancy had increased odds of delivering an LGA infant despite having increased odds of inadequate GWG. LGA infants are at risk for adverse short-term delivery complications such as NICU admissions, respiratory distress, metabolic dysregulations, birth trauma, stillbirth, and even death. However, LGA is not independently associated with perinatal mortality (Chavkin et al., 2019). Other researchers argue that the 97th percentile or greater (2 SD above the mean) should be considered LGA (Boulet et al., 2003, Xu; Simonet & Luo, 2010). In this study, LGA refers to a birth weight greater than the 90th percentile.

PNC factors such as the number of PNC visits, health insurance, group prenatal care, and WIC enrollment were evaluated in relationship with IBW-FOR-GAP. With each increase in PNC

visits, the odds of LGA also increased. Also, women who participated in more than 10 PNC visits were more likely to have an LGA infant. These results concurred with previous studies, where intermediate and inadequate PNC where more than adequate PNC (>10) was associated with increased odds of LGA (Carter et al., 2016). Some women at the time of the first visit may already be on the trajectory toward excess GWG. Nutritional consultation can target women during this time since it is a sensitive period when women might receive guidance and act on it to protect the fetus. While nutritional and physical education does not curb the GWG at the time, it might impact the woman's future pregnancies in a positive way.

Consistent with previous findings, adherence to IOM GWG guidelines helps achieve optimal GWG and IBW-FOR-GAP. Despite the updates and recommendations, women find it difficult to adhere to them (Ferraro et al., 2012; Rogozińska et al., 2019). Changes are necessary to address specific guidelines for PrePBMI ≥ 30 since the recommendations are to gain the least weight, ranging from 11-20 pounds, for all classes in the obese category (Siega-Riz et al., 2020).

Limitations

There were several limitations to the study. First, PrePBMI was self-reported. Additionally, parts of the medical history and prenatal care data relied on women's ability to recall information during delivery. Therefore, women may not have accurately recalled information or been inclined to underreport their weight by approximately 2-6 pounds on average, affecting how women were categorized into PrePBMI categories. So, recall bias cannot be excluded as a limitation. Based on previous studies, self-reported weight, height, or BMI have yielded accurate results and have been used in research (Bannon et al., 2017; Han et al., 2016; Natamba et al., 2016; Rangel Bousquet Carrilho et al., 2020; Sharma et al., 2021). Furthermore, most women recall their height within one inch of their measured height. However, greater

variations have been common among women with below-average height, called the social desirability bias (Burke & Carman, 2017).

Secondly, gestational age and IBW were used to calculate SGA, AGA, and LGA categories. Any erroneous categorization of the IBW-FOR-GAP was due to inaccurate entries in the database that may have carried forward inadvertently and affected results and conclusions drawn upon the results. The errors in data gathering were random due to self-reports, errors in documenting medical records, and errors in entering data for PeriData.Net®, collection. Extreme values are minimized due to sample size. PrePBMI, GWG, and IBW-FOR-GAP are great examples of extreme values. After carefully evaluating cases, these were included to reflect the sample demographics and fulfill the study's purpose.

Thirdly, fetal growth measurements and pregnancy-related weight variations, such as PrePBMI and GWG, have a multidirectional effect on the fetal growth (Lewandowska, 2021). SGA and LGA are based on arbitrary cutoff points. Such gross categorization might miss the opportunity to identify the risk variation in a diverse population of women (Gillman, 2002; Oken et al., 2003). Adequate and standard categorization of infants into SGA and LGA is crucial for accurately identifying infants and women at risk for perinatal complications. Currently, the definitions of SGA and Intrauterine-Growth-Restricted (IUGR) overlap, and these terms are used interchangeably in the literature. However, not all small infants are restricted to growth. Maternal race, ethnicity, and PrePBMI are factors affecting infants' size. Also, not all IUGR infants are small. This flaw in defining and categorizing infants might have affected the findings and conclusions. IUGR and SGA use different methodologies for grouping or defining groups (Akhtar et al., 2019).

Strengths

There were several strengths identified. First, the study used a large population-based data set, PeriData.Net®, utilized in the Midwest to collect multiple data points on women delivering in 80% of the hospitals in the state. Secondly, the dataset has not been explored for many research opportunities, so this study provides a great insight into the population studied. Thirdly, the dataset included a few hundred variables from which the researcher could select. This rich database had information on parenteral health, medical history, substance use, prenatal care services, and maternal and fetal-infant outcomes.

Additionally, gestational age measurements have been defined as an estimate of the infant's gestation in weeks based on ultrasound and the final estimate of the birth attendant (NCHS, 2012) as established by the U.S. Standard Certificate of Live Birth in 2003 as a new measurement standard. This provided the accuracy of GA measurement in the data analyses. Lastly, the data spanned over a longer period and had a few missing values. Unique database that offered a great opportunity to answer the research questions.

Contribution to Nursing and Previous Research

The results of this study contribute to existing research on PrePBMI, GWG, and IBW and how women's characteristics and prenatal care factors may contribute to pregnancy-related weight variations in diverse populations of childbearing women. Utilizing a clinical registry, such as PeriData.Net®, offers rich information and is a novel strategy that has not been fully explored.

Delineations of specific recommendations for women with different characteristics and factors who could be at risk for delivering infants too small or too big. Women in all classes (I, II, and III) of obesity are recommended to gain the same weight during pregnancy. This study

demonstrated then that the current IOM guidelines, though validly based on research at the time of updates in 2009, are less likely to reflect the characteristics of the general population because over one-third are currently obese. Subsequently, the weight gain recommendation does not consider the increased diversity of the women nor the differential risk we see with GWG between pops and IBW-FOR-GAP for different populations. The one-size-fits-all approach of the IOM GWG guidelines needs to address the needs of the women in the study population.

Factors impacting GWG and IBW-FOR-GAP are complex and difficult to identify in large clusters. Sub-populations of women who gained inadequate, adequate, or excessive GWG are always moving targets. Therefore, the practice recommendations are three timely approaches. First, focus on women before conception since it is too late to change or improve PrePBMI before delivery by the time they enter pregnancy. Considering the changing demographics and individual healthcare needs of the current women of childbearing age population, family planning should start early, potentially in the middle through high school. Second, reaching women during the first prenatal care visit is crucial. A comprehensive evaluation of all risk and protective factors must be completed to guide women through their GWG journey. Tailoring prenatal care visits to meet the needs of individual women based on their PrePBMI, comorbidities, individual characteristics, and resources can support a sub-population of women to ensure optimal perinatal outcomes. Considering prenatal care visits frequency and modality, virtual versus in-person, and group versus individual care, can avoid the assumptions that all women need the same guidance and advice during pregnancy. IOM GWG guidelines must be re-evaluated based on identified factors in research. Additionally, recommendations must be developed for all classes of obesity, weighing the risks and benefits for both the woman and their infant. Third, the continuation of follow-up visits post-pregnancy or between pregnancies is

crucial to provide much-needed support for women during this period, such as post-partum weight retention, getting ready for the next pregnancy, nutritional and mental health counseling, paid maternal leave, support groups outside of healthcare settings, and supplemental programs.

Health Policy Implications

Increased levels of obesity are observed in women of childbearing age. The impact of the IOM guidelines is limited as it needs to address the specific sub-populations with specific needs regarding their PrePBMI, GWG, and IBW-FOR-GAP. Though not studied here, the impact of outdated and non-specific IOM guidelines on practice guidelines and recommendations may inadvertently lead to adverse outcomes. Expanding state-based health insurance and supplemental programs, such as WIC, is recommended to cover weight management services and teach women the skills to become or stay healthy.

Recommendations

A national emphasis on specific sub-populations particular risk profiles, that dictate a specific strategy, in line with cultural preferences and individual characteristics. Further studies should include qualitative studies to understand the relationships between social, family, and environmental factors and women's lived experiences. Further recommendations include subgroup analyses to assess modifying effects of race/ethnicity, maternal age at delivery, parity, and nativity on the associations.

Chapter Summary

The results from this study provided a rationale for the need to revise the 2009 IOM guidelines and design policies and health programs to improve PrePBMI and GWG while considering all risk and protective factors. While PrePBMI and GWG are strong determinants of IBW, it is important to consider additional factors associated with outcomes, such as age, parity,

race, ethnicity, marital status, PNC coordination, access to health insurance, and WIC enrollment. Differences in characteristics and prenatal care factors lead to differences in outcomes. Modifiable risks identified for one sub-population of women can protect other sub-populations. IOM makes recommendations based on PrePBMI, but this study shows a distinct difference between women who gain outside of IOM recommended ranges and those who gain within. Therefore, the IOM guidelines may be too generic for women with SGA or LGA infants and not speak to specifics for different risk factors.

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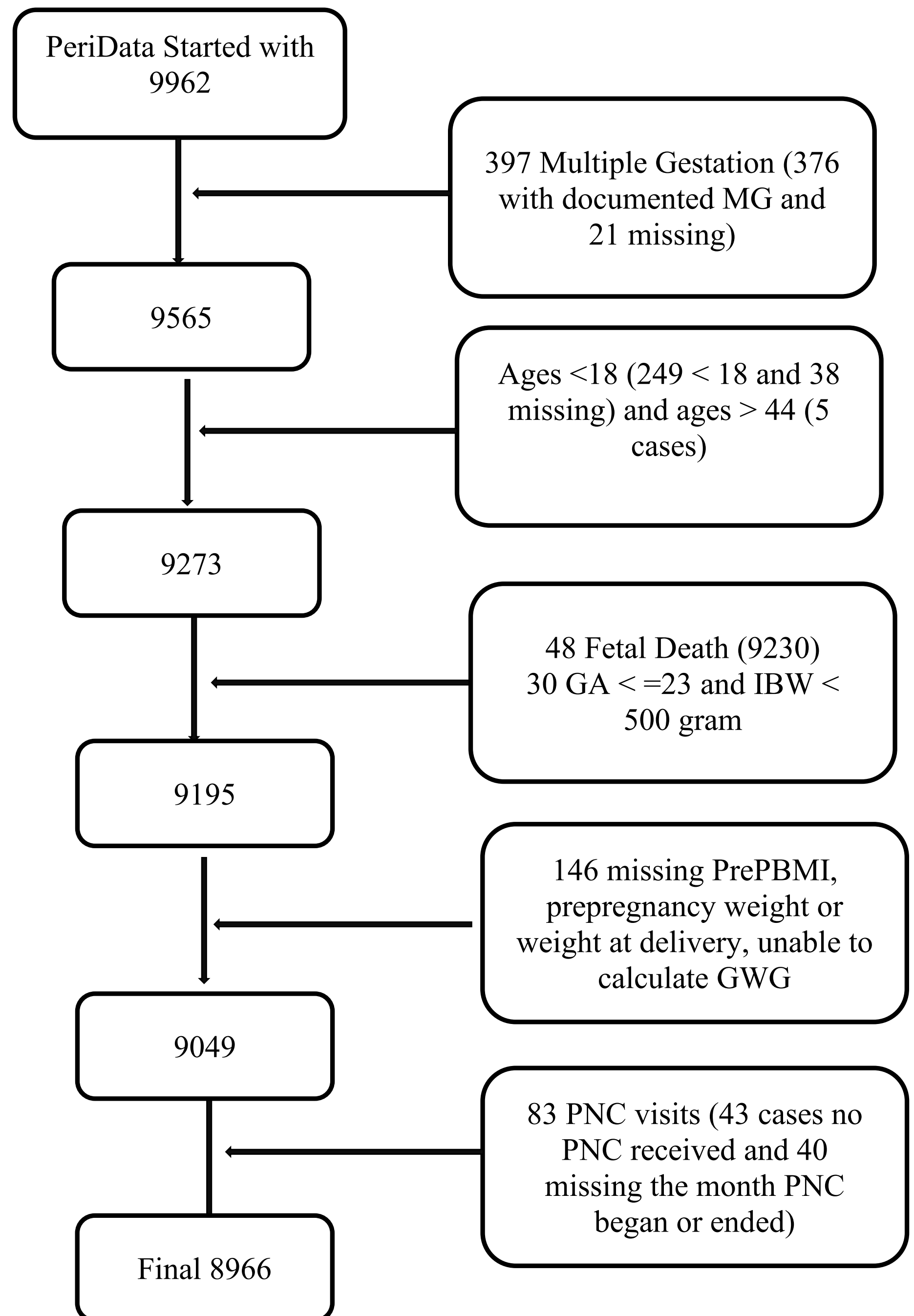
APPENDIX A: STUDY SAMPLE

Figure 8 *Exclusion Flowchart*



APPENDIX B: PERIDATA FORM

PeriData.Net® Birth Worksheet

All Fields (rev. 09/29/2021)

This worksheet contains all of the fields included in the PeriData.Net birth record. This worksheet is arranged to reflect the order that the fields appear in the PeriData.Net birth record screens.

Legend

State-required fields are indicated by bold text

Hospital WHA (CheckPoint)-required fields are indicated by italicized text

Both state- and hospital WHA (CheckPoint)-required fields are indicated by bold and italicized text

* Indicate fields that are required for the WisPQC initiatives
** Indicate fields that are required for the HIV project

Birth Circumstances

Legal

- ☐ **Potential Adoption**
- ☐ ***Foundling***
- ☐ **Refusal**
- ☐ ***Safe Haven***
- ☐ **Surrogate**

Birthplace

Type of birth facility**

- ☐ Hospital
- ☐ Free standing birthing center
- ☐ Home (intended)
- ☐ Home (not intended)
- ☐ Home (unknown if intended)
- ☐ Clinic/doctor's office
- ☐ Other, specify type of facility ____________
- ☐ En route to hospital
- ☐ Another hospital

Infant/Fetal Mortality

Fetal death

- ☐ ***Prenatal***
- ☐ ***Intrapartum***
- ☐ ***None***

Infant death

- ☐ ***Neonatal***
- ☐ ***Post-neonatal***
- ☐ ***None***

Plurality and Birth Order

Number of fetuses delivered (plurality) ________

Birth order

Mother

Mother's medical record number* ____________

Mother's hospital admission number ____________

Mother's Current Legal Name

First ____________

Middle ____________

Last ____________

Suffix ____________

Mother's Name Prior to First Marriage

First ____________

Middle ____________

Last ____________

Suffix ____________

SSN ____________

Date of birth* ____ / ____ / ____

*Reported age*** ________

Mother's Birthplace

Country ____________

State ____________

Mother's Medical Record No. ____________

Child's Medical Record No. ____________

Mother's Name ____________

Child's Name ____________

Child's Date of Birth ____ / ____ / ____

Abstractor ____________

Mother

Phone Number

Phone type

- ☐ Cell
- ☐ Residence
- ☐ Work
- ☐ No Phone

Mother's phone # ____________

Marriage/Paternity

- ☐ **Was the mother married at birth or at any time between conception and birth?**
- ☐ Has the mother ever been married?
- ☐ **If no, has a paternity acknowledgement been signed?**
- ☐ Is the biological father the legal husband of the mother?

Labels selected for Birth Certificate

- ☐ Mother/Father
- ☐ Parent/Parent
- ☐ Unknown

Mother's Race*

- ☐ Unknown
- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native ____________
- ☐ Asian Indian
- ☐ Chinese
- ☐ Filipino
- ☐ Japanese
- ☐ Korean
- ☐ Vietnamese
- ☐ Laotian
- ☐ Hmong
- ☐ Other Asian ____________
- ☐ Native Hawaiian
- ☐ Guamanian or Chamorro
- ☐ Samoan
- ☐ Other Pacific Islander ____________
- ☐ Other ____________

Primary race** ____________

Mother's Hispanic Origin**

- ☐ Hispanic
- ☐ Mexican
- ☐ Puerto Rican
- ☐ Cuban
- ☐ Other ____________

Mother's Education

Select best category for highest degree or level of school completed**:

- ☐ 8th grade or less
- ☐ 9th - 12th grade; no diploma
- ☐ High school degree or GED
- ☐ Some college credit, but not a degree
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctorate or professional degree

Mother's Employment (1 year ago)

Occupation ____________

Type of firm ____________

Informant

Name ____________

Relation to infant

- ☐ Mother
- ☐ Father
- ☐ Grandmother
- ☐ Interpreter
- ☐ Friend
- ☐ Other ____________

☐ Interpreter used?

Mother Address

Mailing

In care of (c/o) ______

Street ______

City/Locality ______

State ______

ZIP code ______

Unit Type ______

Unit Number/Range ______

Residence Location

Does the mother physically reside at the standardized mailing address?

- ☐ Yes
- ☐ No

Country ______

State/Province ______

*County*** ______

*City/village/township*** ______

Residence Street

Street ______

ZIP code ______

Infant

*Infant's medical record number** ______

Infant's hospital admission number ______

Infant's Name

First ______

Middle ______

Last ______

Suffix ______

Infant's Sex

Sex from data sheet

- ☐ Male
- ☐ Female
- ☐ Not yet determined

Sex from infant's first name

- ☐ Male
- ☐ Female
- ☐ Cannot determine from name

Date/Time of birth

*Date of birth** ______ / ______ / ______

Time of birth* ______ : ______ a.m. p.m.

- ☐ **Social security number requested for infant**
- ☐ **Parent signature captured for SSN request**

Husband

Husband's Current Legal Name

First ______

Middle ______

Last ______

Suffix ______

Husband's Name Prior to First Marriage

First ______

Middle ______

Last ______

Suffix ______

SSN ______

Date of birth ______ / ______ / ______

Reported age ______

Husband's Birthplace

Country ______

State ______

Husband's Race

- ☐ **Unknown**
- ☐ **White**
- ☐ **Black or African American**
- ☐ **American Indian or Alaska Native** ______

Husband

- ☐ **Asian Indian**
- ☐ **Chinese**
- ☐ **Filipino**
- ☐ **Japanese**
- ☐ **Korean**
- ☐ **Vietnamese**
- ☐ **Laotian**
- ☐ **Hmong**
- ☐ **Other Asian** ______
- ☐ **Native Hawaiian**
- ☐ **Guamanian or Chamorro**
- ☐ **Samoan**
- ☐ **Other Pacific Islander** ______
- ☐ **Other** ______

Primary race ______

Husband's Hispanic Origin

- ☐ *Hispanic*
- ☐ Mexican
- ☐ Puerto Rican
- ☐ Cuban
- ☐ Other ______

Husband's Education

Select best category for highest degree or level of school completed:

- ☐ 8th grade or less
- ☐ 9th - 12th grade; no diploma
- ☐ High school degree or GED
- ☐ Some college credit, but not a degree
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctorate or professional degree

Husband's Employment (1 year ago)

Occupation ______

Type of firm ______

Father

Father's Current Legal Name

First ______

Middle ______

Last ______

Suffix ______

SSN ______

Date of birth ______ / ______ / ______

Reported age ______

Father's Birthplace

Country ______

State ______

Father's Race

- ☐ Unknown
- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native ______
- ☐ Asian Indian
- ☐ Chinese
- ☐ Filipino
- ☐ Japanese
- ☐ Korean
- ☐ Vietnamese
- ☐ Laotian
- ☐ Hmong
- ☐ Other Asian ______
- ☐ Native Hawaiian
- ☐ Guamanian or Chamorro
- ☐ Somoan
- ☐ Other Pacific Islander ______
- ☐ Other ______

Primary race ______

Father's Hispanic Origin

- ☐ Hispanic
- ☐ Mexican
- ☐ Puerto Rican
- ☐ Cuban
- ☐ Other ______

Child's name ______ Child's Date of Birth ______ / ______ / ______

Father

Father's Education

Select best category for highest degree or level of school completed:

- ☐ 8th grade or less
- ☐ 9th - 12th grade; no diploma
- ☐ High school degree or GED
- ☐ Some college credit, but not a degree
- ☐ Associate degree
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ Doctorate or professional degree

Father's Employment (1 year ago)

Occupation ______________________________

Type of firm

Pregnancy History

Did the mother have any previous pregnancies?

- ☐ Yes
- ☐ No

Number of pregnancies including current pregnancy ________

Pregnancies ending full term, number __________

Pregnancies ending preterm, number __________

Previous Live Births

Number of previous live births now living __________

Number of previous live births now deceased __________

Month of last live birth __________

Year of last live birth ________________

Other Terminations: Spontaneous or Induced

Number of all previous other pregnancy outcomes ______

Number of previous other pregnancy outcomes at greater than or equal to 20 weeks __________

Month of last other termination __________

Year of last other termination ________________

Current Pregnancy

Payment

Principal source of payment for this delivery*

- ☐ Medicaid/BadgerCare Plus
- ☐ Private insurance
- ☐ Self pay
- ☐ Indian Health Service
- ☐ CHAMPUS/TRICARE
- ☐ Other Government (Federal, State, Local)
- ☐ *Other* ______________________________

Medicaid version

- ☐ Medicaid fee-for-service (T19)
- ☐ Medicaid HMO

Principal source of payment for prenatal care*

- ☐ Medicaid/BadgerCare Plus
- ☐ Private insurance
- ☐ Self pay
- ☐ Indian Health Service
- ☐ CHAMPUS/TRICARE
- ☐ Other Government (Federal, State, Local)
- ☐ Other ______________________________

Medicaid version

- ☐ Medicaid fee-for-service (T19)
- ☐ Medicaid HMO
- ☐ Enrolled in prenatal care coordination
- ☐ **Did mother get WIC food for herself during this pregnancy?**

Mother's Height

Feet __________

Inches __________

Mother's Weight

Prepregnancy - pounds __________

At delivery - pounds __________

Estimated Date of Delivery

Date last normal menses began ______ / ______ / ______

Estimated date of delivery from last menstrual period ______ / ______ / ______

Estimated date of delivery from ultrasound ______ / ______ / ______

Current Pregnancy

Prenatal Care

Received prenatal care

- ☐ **Yes**
- ☐ **No**

Month of pregnancy prenatal care began** __________

Date of first prenatal care visit* ______ / ______ / ______

Week of pregnancy prenatal care began __________

Date of last prenatal care visit ______ / ______ / ______

Week of last prenatal visit __________

Total number of prenatal visits* __________

Group prenatal care

- ☐ ***Yes***
- ☐ ***No***

Care transferred during pregnancy (weeks) __________

Transfer reason ______________________________

Prenatal Labs/Postpartum vaccines

Mother's blood group

- ☐ O
- ☐ A
- ☐ B
- ☐ AB

Mother's RH status

- ☐ Positive
- ☐ Negative

☐ Rh Immune Globulin/Rhogam – postpartum

- ☐ Yes
- ☐ No
- ☐ Unknown

Rubella immune

- ☐ Yes
- ☐ Equivocal
- ☐ No

Rubella given postpartum

- ☐ Yes
- ☐ No
- ☐ Unknown

MS-AFP

- ☐ Normal
- ☐ High
- ☐ Low
- ☐ Not done
- ☐ Unknown

- ☐ *HIV tested***
- ☐ **HIV positive**
- ☐ Hepatitis B tested
- ☐ **Hepatitis B positive**
- ☐ Hepatitis C tested
- ☐ **Hepatitis C positive**
- ☐ ***Genital herpes/herpes simplex virus (HSV)***
- ☐ ***Genital herpes/herpes simplex virus (HSV), treated***
- ☐ *Genital herpes/herpes simplex virus (HSV), active at delivery*
- ☐ *Genital warts/human papilloma virus (HPV)*
- ☐ *Genital warts/human papilloma virus (HPV), treated*
- ☐ Chlamydia
- ☐ ***Chlamydia, treated***
- ☐ *Gonorrhea*
- ☐ *Gonorrhea, treated*
- ☐ **Syphilis**
- ☐ Syphilis treated
- ☐ Cytomegalovirus (CMV)
- ☐ Other STD ______________________________

Tobacco Use

Cigarette use three months prior to pregnancy or during pregnancy

- ☐ Yes
- ☐ No

Cigarettes or packs

- ☐ Cigarettes
- ☐ Packs

Average per day 3 months prior to pregnancy __________

Average per day in first 3 months of pregnancy __________

Average per day in second 3 months of pregnancy ______

Average per day in last 3 months of pregnancy __________

Mother lives with smoker

- ☐ Yes
- ☐ No

Child's name ______________________________ Child's Date of Birth ______ / ______ / ______

Current Pregnancy

Alcohol Use
Alcohol use during pregnancy
- ☐ Yes
- ☐ No

Average number of drinks per week during pregnancy ____

Clinical Trials
- ☐ Experimental clinical trial affecting pregnancy
- ☐ Enrolled in clinical trial affecting exclusive breast milk feeding

Antepartum Risk Factors/Previous Pregnancies

- ☐ **NO PREVIOUS PREGNANCY RISK FACTORS (ALL FIELDS IN THIS SECTION ARE NO)**
- ☐ ***Previous Cesarean***

Number of previous Cesareans __________
- ☐ **Previous preterm birth**
- ☐ Previous precipitous labor
- ☐ Previous LBW (Low birth weight is defined as an infant weighing LESS THAN 2500gm (from 1500gm to 2499gm/5lb 8oz) at birth)
- ☐ Previous VLBW (Very low birth weight is defined as an infant weighing LESS THAN 1500gm (from 100gm/2lb 3oz to 1499gm/3lb 5oz) at birth)
- ☐ Previous ELBW (Extremely low birth weight is defined as an infant weighing LESS THAN 1000gm/2lb 3oz at birth)
- ☐ *Other previous poor pregnancy outcome*
- ☐ Previous SGA
- ☐ Previous IUGR
- ☐ *Previous fetal death/stillbirth*
- ☐ Previous macrosomia
- ☐ Previous postpartum depression
- ☐ Previous Preeclampsia*

Antenatal Risk Factors/Current Pregnancy

- ☐ **NO CURRENT PREGNANCY RISK FACTORS (ALL FIELDS IN THIS SECTION ARE NO)**

Infertility
- ☐ **Infertility treatment**
- ☐ **Assisted reproduction technology**
- ☐ **Fertility enhancing drugs**

Diabetes
- ☐ ***Prepregnancy (diagnosis prior to this pregnancy)***
- ☐ Insulin used
- ☐ ***Gestational (diagnosis in this pregnancy)***
- ☐ Insulin used

Hypertension
- ☐ Chronic hypertension in pregnancy*
- ☐ Gestational hypertension*
- ☐ Preeclampsia without severe features*
- ☐ Preeclampsia WITH severe features*
- ☐ Chronic HTN with superimposed preeclampsia without severe features*
- ☐ Chronic HTN with superimposed preeclampsia WITH severe features*

Hypertensive Emergency*
- ☐ Yes
- ☐ No

Hypertensive emergency treatment within 1 hour*
- ☐ Yes
- ☐ No
- ☐ *Eclampsia*

Vital Records Hypertension
- ☐ ***Prepregnancy (chronic)***
- ☐ ***Gestational (PIH, preeclampsia)***

Obstetric History
- ☐ Preterm labor this pregnancy
- ☐ Preterm labor this pregnancy, treated
- ☐ Incompetent cervix
- ☐ *Prior uterine surgery*
- ☐ Uterine or cervical anomaly
- ☐ *Prolonged preterm ROM (>24 hours)*
- ☐ Prolonged preterm ROM (>24 hours), treated
- ☐ *Hydramnios*
- ☐ Hydramnios, treated
- ☐ *Oligohydramnios*
- ☐ Oligohydramnios, treated
- ☐ *Vaginal bleeding during this pregnancy prior to onset of labor*
- ☐ *Placenta previa this pregnancy*
- ☐ Multiple gestation this pregnancy

Antenatal Risk Factors/Current Pregnancy

Substance use/abuse
- ☐ Cocaine
- ☐ Methamphetamine
- ☐ Heroin
- ☐ Hallucinogens
- ☐ Rohypnol
- ☐ Marijuana

Specify other ____________

STDs/Communicable Diseases
- ☐ ***HIV positive *****
- ☐ **Hepatitis B**
- ☐ **Hepatitis C**
- ☐ Genital herpes/herpes simplex virus (HSV)
- ☐ Genital herpes/herpes simplex virus (HSV), treated
- ☐ Genital herpes/herpes simplex virus (HSV), active at delivery
- ☐ Genital warts/human papilloma virus (HPV)
- ☐ Genital warts/human papilloma virus (HPV), treated
- ☐ **Chlamydia**
- ☐ Chlamydia, treated
- ☐ **Gonorrhea**
- ☐ Gonorrhea, treated
- ☐ **Syphilis**
- ☐ Syphilis treated
- ☐ Cytomegalovirus (CMV)
- ☐ Other STD ____________

Infections
- ☐ Bacterial vaginosis
- ☐ Bacterial vaginosis, treated
- ☐ Yeast
- ☐ Yeast, treated
- ☐ Trichomoniasis
- ☐ Trichomoniasis, treated
- ☐ Other vaginal infections, treated ____________
- ☐ Listeria
- ☐ Parvovirus (Parvovirus B19)
- ☐ Toxoplasmosis

Covid-19
- ☐ COVID-19 ever diagnosed?
  - ☐ COVID-19 Diagnosis date: ____________
- ☐ COVID-19 diagnosis during pregnancy
  - ☐ Yes, during pregnancy
  - ☐ Yes, at admission
  - ☐ No
  - ☐ Unknown
- ☐ Gestational week at diagnosis (*Calculated in Peridata.Net)*
- ☐ COVID-19 vaccination received
- ☐ Type of COVID-19 vaccination received
  - ☐ Pfizer
  - ☐ Moderna
  - ☐ Johnson & Johnson
  - ☐ AstraZeneca
  - ☐ Other
  - ☐ Unknown
- ☐ Most recent COVID-19 vaccination date____________
- ☐ Other infectious diseases ____________

Maternal Conditions
- ☐ Group B strep positive
- ☐ Group B Strep Collection Date
- ☐ Abnormal PAP smear during pregnancy
- ☐ Urinary tract infections this pregnancy
- ☐ Urinary tract infections this pregnancy, treated
- ☐ Anemia this pregnancy (HCT < 30/Hgb <10)
- ☐ Hemoglobinopathy this pregnancy
- ☐ *Coagulation disorder*
- ☐ *Rh sensitization*
- ☐ *Other iso-immunization*
- ☐ *Biliary/liver disorder*
  - ☐ Yes at delivery
- ☐ *Cardiac disorder or disease*
- ☐ *Autoimmune disease* ____________
- ☐ *Antiphospholipid syndrome*

Specify collagen vascular disease ____________
- ☐ Asthma
- ☐ Acute or chronic lung disease
- ☐ *Renal disorder/disease* ____________
- ☐ Renal dialysis or end stage renal disease
- ☐ Thyroid disease
- ☐ Cancer this pregnancy ____________

Child's name ______________________________ Child's Date of Birth ______ / ______ / ______

Antenatal Risk Factors/Current Pregnancy

- ☐ Cancer treatment this pregnancy

Fetal Conditions

- ☐ Decreased fetal movement
- ☐ Abnormal heart rate/rhythm
- ☐ Suspected IUGR this pregnancy
- ☐ *Fetal compromise this pregnancy*
- ☐ Suspected fetal CNS anomaly
- ☐ *Diagnosed fetal anomaly* ____________
- ☐ *Fetal damage*
- ☐ Postterm, > 41 6/7 weeks

Maternal Characteristics

- ☐ Maternal traumatic injury during this pregnancy
- ☐ Domestic violence during this pregnancy
- ☐ Maternal surgical procedure during this pregnancy
- ☐ Other antenatal risk factors during this pregnancy ____________

Psychiatric Disorders

- ☐ Pre-pregnancy Depression
- ☐ Depression, during pregnancy
- ☐ Other psychiatric disorder(s) ____________

Antenatal Procedures

☐ **NO ANTENATAL PROCEDURES (ALL FIELDS IN THIS SECTION ARE NO)**

Procedures

- ☐ Antenatal Testing findings: delivery indication
- ☐ *Non-stress test*

Result

- ☐ Reactive
- ☐ Non-reactive
- ☐ Biophysical profile

Score ____________

- ☐ Amniocentesis this pregnancy

Reason

- ☐ Genetic diagnosis
- ☐ Lung maturity
- ☐ Reduction of polyhydramnios
- ☐ Other
- ☐ Chorionic Villus Sampling (CVS)
- ☐ *Unstable lie at term*
- ☐ **Failed external cephalic version this pregnancy**
- ☐ **Successful external cephalic version this pregnancy**
- ☐ **Cervical cerclage this pregnancy**
- ☐ **Tocolysis this pregnancy**
- ☐ Percutaneous umbilical blood sampling this pregnancy
- ☐ Fetal surgery
- ☐ Other procedures

Hospitalization

- ☐ **Hospitalized antenatally this pregnancy**
  Inpatient pregnancy-related hospital days prior to delivery ____________
  Number of antenatal inpatient admissions excluding birth admission ____________
- ☐ **Mother transferred into this facility for maternal medical or fetal indications for delivery**
  Name of facility mother transferred from ____________

Antepartum Medications

☐ **NO ANTEPARTUM MEDICATIONS (ALL FIELDS IN THIS SECTION ARE NO)**

- ☐ Prenatal vitamins (OTC and/or prescribed)
- ☐ Prenatal iron
- ☐ Antibiotics

Group B strep, adequacy of treatment

- ☐ Antibiotics less than 4 hours prior to birth
- ☐ Antibiotics more than 4 hours prior to birth
- ☐ Antibiotics given but unknown time frame
- ☐ Antibiotics indicated but not given
- ☐ Scheduled C-section - antibiotics not indicated
- ☐ Anticonvulsants
- ☐ Hormones
- ☐ Analgesics
- ☐ Antidepressants
- ☐ Psychotropics
- ☐ Tocolytics prior to birth admission
- ☐ Anticoagulants

Antepartum Medications

- ☐ *Steroids for fetal lung maturity*

Steroids course

- ☐ Partial course
- ☐ Full course
- ☐ *Provider (LIP)-documented reason for not initiating*

Other antepartum medications ____________

Intrapartum Data

Date of admission ______ / ______ / ______

Time of admission ________ : ________ a.m. p.m.

Date labor began ______ / ______ / ______

Time labor began ________ : ________ a.m. p.m.

- ☐ In labor on admission
- ☐ 2 or more contractions every 10 minutes on admission
- ☐ Cervical dilation of 3 or more cm on admission

Events of labor and/or delivery

☐ **NO EVENTS OF LABOR AND/OR DELIVERY (ALL FIELDS IN THIS SECTION ARE NO)**

- ☐ *Placenta previa (labor and delivery)*
- ☐ *Vasa previa*
- ☐ Prolonged latent phase
- ☐ Prolonged active phase
- ☐ Arrested in active phase
- ☐ **Precipitous labor (< 3 hours)**
- ☐ **Prolonged labor (20 hours or more)**
- ☐ Dysfunctional labor
- ☐ Cephalopelvic disproportion
- ☐ Shoulder dystocia
- ☐ ***Fetal intolerance of labor***
- ☐ **Moderate/heavy meconium staining of the amniotic fluid**
- ☐ *Premature rupture of the membranes less than 12 hours prior to the onset of labor*
- ☐ ***Premature rupture of the membranes greater than or equal to 12 hours prior to the onset of labor***
- ☐ Premature/Prolonged 12-17 hours
- ☐ Premature/Prolonged 18-23 hours
- ☐ Premature/Prolonged 24 hours or more
- ☐ ***Clinical chorioamnionitis***
- ☐ Febrile
- ☐ Seizures
- ☐ Nuchal cord
- ☐ True knot in cord
- ☐ *Cord prolapse*
- ☐ *Abruptio placenta*
- ☐ *Abnormal/excessive bleeding*

☐ *Ruptured uterus*

Ruptured uterus timing

- ☐ Prior to labor onset
- ☐ After labor onset or during delivery
- ☐ Unspecified
- ☐ *HELLP Syndrome*
- ☐ Uterine atony
- ☐ Retained placenta
- ☐ *Placenta accreta/percreta*
- ☐ Inverted uterus
- ☐ Anesthetic complications ____________

Blood Loss/Hemorrhage

- ☐ *Uterine bleeding*

Blood Loss: ____________

- ☐ Obstetric hemorrhage (multi-select)
  - ☐ Antepartum (pre-labor)
  - ☐ Intrapartum (labor to <2hrs post-delivery)
  - ☐ Postpartum (>2hrs post-delivery)
- ☐ **Maternal transfusion**
  - ☐ 4 or more units transfused

Intrapartum Medications

☐ **NO INTRAPARTUM MEDICATIONS (ALL FIELDS IN THIS SECTION ARE NO)**

Intrapartum Medications

Hypertension/Preeclampsia Management

Antiplatelet agent -

- ☐ Aspirin*
  - ☐ Yes pregnancy only
  - ☐ Yes pregnancy and postpartum
  - ☐ Unknown

Antihypertensive agents -

Hydralazine*	☐ Pregnancy only	☐ Pregnancy & postpartum
Labetalol*	☐ Pregnancy only	☐ Pregnancy & postpartum
Methyldopa*	☐ Pregnancy only	☐ Pregnancy & postpartum
Nifedipine*	☐ Pregnancy only	☐ Pregnancy & postpartum

Seizure prophylaxis or control –

☐ Magnesium sulfate*

☐ Pregnancy only ☐ Pregnancy & postpartum

Postpartum therapy length* ☐ <24 hours of therapy

☐ >=24 hours of therapy

- ☐ Analgesia ______
- ☐ Antihypertensives
- ☐ Tocolytics during birth admission
- ☐ Magnesium sulfate
- ☐ Tocolysis
- ☐ Neuroprotection
- ☐ **Antibiotics**

Other ______

Intrapartum Procedures

Anesthesia

- ☐ General
- ☐ Epidural
  - Epidural, type
    - ☐ Labor with vaginal delivery
    - ☐ Labor with C-section
    - ☐ C-section only
- ☐ Spinal
- ☐ Pudendal
- ☐ Paracervical
- ☐ Local
- ☐ Other

Vital Records Anesthesia

- ☐ **Anesthesia (epidural or spinal)**

Labor

- ☐ *Induction*
- ☐ Cervical ripening
  - Method/agent for cervical ripening
    - ☐ Prostaglandin – misoprostol
    - ☐ Prostaglandin - dinoprostone
    - ☐ Prostaglandin - other
    - ☐ Balloon Catheter
    - ☐ Membrane Stripping
    - ☐ Laminaria
    - ☐ Other
    - ☐ Unknown
- ☐ Induction by oxytocin/pitocin
- ☐ Induction by AROM
  - Bishop score ______
  - ☐ **Augmentation**
  - ☐ Augmentation by AROM
  - ☐ Augmentation by Oxytocin/pitocin

Membranes

- ☐ *Spontaneous rupture*
  - Spontaneous rupture onset
  - ☐ Prior to the initiation of induction
  - ☐ After the initiation of induction
  - ☐ Unknown
- Fluid
  - ☐ Clear
  - ☐ Meconium stained
  - ☐ Bloody
  - ☐ No fluid

Monitoring

- ☐ External auscultation
- ☐ Electronic fetal internal
- ☐ Electronic fetal external
- ☐ Uterine contraction, internal
- ☐ Uterine contraction, external
- ☐ Fetal pulse oximetry
- ☐ Fetal scalp sampling
- ☐ Ultrasound (during labor and delivery only)

Other Perinatal Procedures

Intrapartum Procedures

☐ **NO OTHER PERINATAL PROCEDURES (ALL FIELDS IN THIS SECTION ARE NO)**

- ☐ Amnioinfusion
- ☐ Hysterotomy/Hysterectomy
- ☐ Postpartum sterilization
- ☐ **Maternal admission to ICU**
- ☐ **Unplanned operating room procedure following delivery**
- ☐ **Unplanned hysterectomy**
- ☐ Water birth
- ☐ Intrapartum procedures - other

Attendant

Primary Provider Information

*Primary obstetric provider*** ______

Primary pediatric provider ______

Attendant Information

Attendant first name** ______

Attendant last name** ______

*Attendant title***

- ☐ ***MD***
- ☐ ***DO***
- ☐ ***CNM***
- ☐ ***Licensed Midwife***
- ☐ ***Other Midwife***
- ☐ *Other* ______

Wisconsin License number** ______

Resident attendant 1 ______

Resident attendant 2 ______

Resident attendant 3 ______

Student attendant ______

Nurse attendant 1 ______

Nurse attendant 2 ______

Pediatric attendant ______

Additional attendant 1 ______

Additional attendant 2 ______

Anesthesiologist/Anesthetist ______

Anesthesia resident ______

Neonatologist ______

Delivery

Number of fetuses delivered (plurality) ______

Number of fetal deaths this delivery ______

Number of infants delivered alive ______

Birth order ______

Multiple Birth ID ______

Presentation

Fetal presentation

- ☐ Cephalic
- ☐ Breech
- ☐ Other

☐ ***Non-vertex presentation***

Fetal presentation, specify

- ☐ Other malpresentation
- ☐ Compound
- ☐ Shoulder/transverse lie
- ☐ Chin
- ☐ Brow
- ☐ Face

Malpresentation, other ______

Method

- ☐ *Planned Cesarean*
- ☐ **Forceps attempted but unsuccessful**
- ☐ **Vacuum attempted but unsuccessful**

Final route and method of delivery

- ☐ Vaginal Spontaneous
- ☐ Vaginal Forceps
- ☐ Vaginal Vacuum
- ☐ Cesarean
- ☐ Breech extraction

Method: Vaginal

- ☐ VBAC

Delivery

Forceps applied
- ☐ Low
- ☐ Mid

Method: Cesarean

Type
- ☐ Primary C-section
- ☐ Repeat C-section

Uterine incision
- ☐ Transverse
- ☐ Vertical
- ☐ Classical
- ☐ Cesarean with forceps
- ☐ Vacuum-assisted Cesarean
- ☐ ***Trial of labor attempted***
- ☐ *In labor prior to cesarean*

Operative Delivery Indications
- ☐ Trial of labor refused/maternal choice
- ☐ Cephalopelvic disproportion
- ☐ Dystocia
- ☐ Malpresentation
- ☐ Fetal intolerance of labor
- ☐ Failure to progress
- ☐ Failure to descend
- ☐ Malposition
- ☐ Labor not medically indicated due to fetal indication
- ☐ Labor not medically indicated due to maternal indication
- ☐ Other ________________________________

Placenta

Grade, if available from US report ____________________
- ☐ *Suspected chorioamnionitis*
- ☐ Velamentous insertion
- ☐ Sent to pathology

Birth Outcome

Gestational Age

By LMP (weeks) __________

By ultrasound (weeks) __________

OB clinician's final estimate (weeks)* __________

OB clinician's final estimate (days)* __________

Newborn assessment ______________________________

Birth Weight

Pounds __________

Ounces __________

Grams __________

Size for Gestational Age
- ☐ AGA
- ☐ SGA
- ☐ LGA

Crown Heel Length

Inches __________

Centimeters __________

Head Circumference

Inches __________

Centimeters __________

APGAR

1 minute __________

5 minute __________

10 minute __________

Laceration

Perineal
- ☐ ***First or second degree***
- ☐ ***Third degree***
- ☐ ***Fourth degree***
- ☐ ***No***

Other
- ☐ Labial
- ☐ Periurethral
- ☐ Sulcus
- ☐ Vaginal
- ☐ Cervical
- ☐ None
- ☐ Other

Maternal Postpartum Complications

☐ **NO MATERNAL POSTPARTUM COMPLICATIONS (ALL FIELDS IN THIS SECTION ARE NO)**

Mortality
- ☐ Maternal death

Date ______ / ______ / ______

Time ________ : ________ a.m. p.m.

Postpartum Hypertension

New Onset Postpartum Hypertension –
- ☐ Postpartum onset preeclampsia without severe features*
- ☐ Postpartum onset preeclampsia WITH severe features*
- ☐ Chronic HTN with postpartum onset superimposed preeclampsia without severe features*
- ☐ Chronic HTN with postpartum onset superimposed preeclampsia WITH severe features*
- ☐ Postpartum onset gestational hypertension*
- ☐ Chronic HTN with superimposed preeclampsia WITH severe features*

Antihypertensive Agents –
- Hydralazine* ☐ Yes, postpartum only
- Labetalol* ☐ Yes, postpartum only
- Methyldopa* ☐ Yes, postpartum only
- Nifedipine* ☐ Yes, postpartum only

Seizure prophylaxis or control –

☐ Magnesium sulfate* ☐ Yes, postpartum only

Postpartum therapy length* ☐ <24 hours of therapy ☐ >=24 hours of therapy

Morbidity
- ☐ Wound infection
- ☐ Mastitis
- ☐ Endometritis
- ☐ Antibiotics
  - ☐ Yes, <24 hrs post delivery
  - ☐ Yes, >24 hrs post delivery
  - ☐ No
  - ☐ Unknown
- ☐ Thromboembolic disease ____________________
- ☐ Anemia with transfusion
- ☐ Anemia with iron supplement
- ☐ HCT < 22.0 or hemoglobin < 7.0
- ☐ Drop in HCT>11 or Hemoglobin>3.5
- ☐ UTI
- ☐ Depression
- ☐ Other postpartum complications ______________

Delivery

Episiotomy

Episiotomy
- ☐ Midline
- ☐ Mediolateral
- ☐ Paramedian (combined or hockey stick)
- ☐ None

Neonatal Procedures

☐ NO NEONATAL PROCEDURES (ALL FIELDS IN THIS SECTION ARE NO)

☐ *Assisted ventilation required*
If yes,
☐ **Assisted ventilation required immediately after delivery**
☐ **Assisted ventilation required** for more than 6 hours
☐ **Surfactant**
☐ **Antibiotics for neonatal sepsis**

Cardiorespiratory Conditions
☐ Treatments and procedures for cardiorespiratory conditions
☐ Ventilator
☐ CPAP
☐ Assisted ventilation intermittent positive
☐ Assisted ventilation continuous negative
☐ Assisted ventilation intermittent negative pressure
☐ Hyperbaric, intermittent or continuous
☐ Laryngoscopy
☐ Oxygen
☐ Nitric Oxide
☐ ECMO
☐ Thoracentesis or chest tube

Imaging Procedures
☐ Yes
☐ CT of brain, head, and/or neck
☐ MRI brain and/or spinal cord

GI/GU Procedures
☐ Yes
☐ **TPN/intralipid**
☐ PEG tube or G tube

Procedures for Infectious Process
☐ Yes
☐ GBS Observation
☐ GBS Treated

Neonatal Procedures – Cont'd

Hematologic/Metabolic Procedures
☐ Yes
☐ Hematologic/Metabolic
☐ Phototherapy
☐ Glucose gel for hypoglycemia
☐ IV for hypoglycemia
☐ Transfusions

Neurological Conditions
☐ Tests, treatments and procedures for neurological conditions
☐ EEG
☐ Cooling Protocol
☐ Anticonvulsants

Vascular Access Lines
☐ Yes
☐ Umbilical arterial catheter (UAC)
☐ Umbilical venous catheter (UVC)
☐ PVCL or PICC line
☐ Peripheral arterial line

Surgical Procedures
☐ Yes
☐ Specify: ____________________
☐ Circumcision

Other Procedures
Other Neonatal Procedures
☐ Yes
☐ Other neonatal procedures, specify:
____

Nursery Care

NICU Admission
☐ ***NICU admission***
NICU admission date ______ / ______ / ______
NICU care options
☐ Mother-baby care, then transferred to high risk nursery/NICU
☐ High risk nursery/NICU directly from labor/delivery
☐ High risk nursery/NICU then transferred to mother-baby care
Newborn nursery care options
☐ Normal newborn nursery/Mother-baby care
☐ Transitional observation
☐ Palliative care

Infant External Transfer
☐ **Transferred within 24 hours of delivery**
☐ *Transferred after 24 hours of delivery*
Facility ______________________________
Date ______ / ______ / ______

Other Postpartum or Neonatal Information

Other Postpartum or Neonatal Information

Feeding

Feeding – all infants

Maternal plan on admission for feeding IN HOSPITAL
- ☐ *Breast milk*
- ☐ Breast milk and formula
- ☐ *Formula*
- ☐ *Unknown*

Maternal or newborn indications for NOT breast milk feeding
- ☐ Yes and documented in the newborn record
- ☐ *None*
- ☐ Unable to determine from newborn documentation
  - ☐ *Galactosemia*

☐ **Breast milk at discharge**

☐ Was donor milk used during hospitalization

Breast milk level at discharge
- ☐ Exclusive
- ☐ Non-exclusive due to provider decision to supplement
- ☐ Non-exclusive due to maternal decision
- ☐ Non-exclusive for unknown reasons
- ☐ *Unknown*

"NICU feeding – 28 days

☐ Infant in NICU at 28 days of life"

Any breast milk feeing during 28th day of life"
- ☐ Yes
- ☐ No - formula
- ☐ No - NPO
- ☐ Unknown

Type of breast milk feeding"
- ☐ Mother's breast milk
- ☐ Combination Mother's and donor breast milk
- ☐ Donor breast milk
- ☐ Unknown

"NICU feeding – discharge

☐ Enteral feeding at discharge"
- ☐ Human milk only
- ☐ Human milk with either formula or fortifier
- ☐ Formula only
- ☐ None/NPO

"NICU feeding – general

☐ Initiation of breast milk in the NICU"
- ☐ Yes
- ☐ No
- ☐ Not Applicable
- ☐ Unknown

Breast milk at 28 days of life
- ☐ Exclusive
- ☐ Non-exclusive due to provider decision to supplement
- ☐ Non-exclusive due to maternal decision
- ☐ Non-exclusive for unknown reasons
- ☐ Not applicable
- ☐ None
- ☐ *Unknown*

"Skin-to-Skin with Infant

Skin-to-skin initiation after birth"
- ☐ Yes, immediately after birth
- ☐ Yes, but not immediately after birth
- ☐ No
- ☐ Unknown

Reason for separation relative to interacting with infant"
- ☐ Infant not medically stable
- ☐ Mother not medically stable
- ☐ Maternal refusal or no interest
- ☐ Not offered by clinicians
- ☐ Unknown

Skin to Skin Duration"
- ☐ 60 mins or more
- ☐ 45-59 mins
- ☐ 30-44 mins
- ☐ Under 30 mins
- ☐ Unknown

NB Procedures and assessments done skin-to-skin"

Other Postpartum or Neonatal Information

Mother/Baby Interaction

☐ Rooming in at least 23 hours per day*

Reason for not rooming in*
☐ Diminished responsiveness to infant cues
☐ Remained together during day but not rooming in at night
☐ Medical Reason – maternal
☐ Medical Reason – infant
☐ Maternal refusal
☐ Unknown

☐ Maternal/newborn separation*
Maternal pumping or manual expression*
☐ Yes
☐ No, but plans to breast feed
☐ No, plans to formula feed
☐ Unknown
Timing of first pump or expression after separation*
☐ <= 2 hours
☐ 3 – 4 hours
☐ 5 – 6 hours
☐ 7 or more hours
☐ Unknown

Other Information

☐ **Hepatitis B vaccine administered – infant**

Hepatitis B vaccine administered date – infant
Date ______ / ______ / ________

Hepatitis vaccine administered time – infant
Time ________ : ________ a.m. p.m.

Hepatitis B lot number – Infant: ________
Reason Hepatitis B vaccine not given:
☐ Parental Refusal
☐ Provider Preference
☐ Unknown

Hepatitis B lot number-infant ____________________

☐ **HBIG-infant**
☐ **HBIG administered date – infant**

Date ______ / ______ / _______

☐ HBIG administered time – infant

Time ________ : ________ a.m. p.m

☐ HIV tested – infant
☐ COVID tested - infant
☐ COVID positive - infant

Toxicology

☐ Tox screen-infant
Tox screen results-infant
☐ Positive
☐ Negative
IF positive,
☐ Amphetamines
☐ Barbituates
☐ Cocaine
☐ Marijuana
☐ Opiates
☐ Other substances

Abnormal Conditions of the Newborn

☐ NO ABNORMAL CONDITIONS OF THE NEWBORN (ALL FIELDS IN THIS SECTION ARE NO)

☐ **Seizure or serious neurologic dysfunction**
☐ Other Serious Neurological dysfunction

☐ Significant Birth Injury
☐ Specify birth injury: ____________________

☐ Respiratory
☐ Apnea
☐ Aspiration, not meconium
☐ Atelectasis
☐ Interstitial emphysema
☐ Meconium aspiration syndrome
☐ Pneumomediastinum
☐ Pneumonia
☐ Pneumopericardium
☐ Pneumothorax
☐ Respiratory arrest or failure
☐ Respiratory Distress Syndrome/Hyaline membrane disease
☐ Respiratory hemorrhage (includes airway, tracheal, bronchial and pulmonary)
☐ Transient Tachypnea (TTN)
☐ Cardiac/Hemodynamic
☐ Cardiac arrest
☐ Cardiac failure
☐ Myocardial ischemia
☐ Shock
☐ GI/GU/internal organs
☐ Acute kidney failure
☐ Necrotizing enterocolitis (NEC)
☐ Solid organ injury
☐ Infectious process
☐ Bacteremia
☐ Sepsis -GBS
☐ Sepsis – Other organisms
☐ Septic shock
☐ Hematologic/Metabolic
☐ Anemia
☐ DIC
☐ Hemolytic Disease
Specify hemolytic disease: ____________
☐ Hypoglycemia
☐ Isoimmunization
☐ Jaundice (hyperbilirubinemia)
Highest bilirubin value in mg/dL: __________
☐ Neurologic/brain/nerves
☐ Intraventricular hemorrhage (IVH) – nontraumatic
☐ Intraventricular hemorrhage (IVH) – traumatic
☐ Intracranial hemorrhage (ICH) – nontraumatic
☐ Soft tissue hemorrhage – head
☐ Traumatic brain hemorrhage or injury
☐ Asphyxia or hypoxemia
☐ Neonatal encephalopathy
☐ Seizures
☐ Central and peripheral nervous system injury
☐ Musculoskeletal or skin
☐ Skeletal fracture
☐ Clavical(s) fracture
☐ Extensive ecchymosis (bruising)
☐ Umbilical hemorrhage
☐ Other
☐ Specify other: __________________
☐ External Trauma
☐ No
☐ Antenatal
☐ Postnatal
☐ Unknown
Specify external birth trauma: _______________

Abnormal Conditions of the Newborn

☐ Newborn withdrawal syndrome

If Yes,

*Infant at Risk for NAS/NOWS**
- ☐ Yes
- ☐ No

*Infant with NAS/NOW**
- ☐ Yes
- ☐ No

*Basis of NAS Diagnosis**

Maternal History (Select all that apply)*
- ☐ AODA screening
- ☐ PDMP
- ☐ Biological testing
- ☐ Other mental health issues

Source of maternal substance (Select all that apply)*
- ☐ Supervised prescribed replacement therapy
- ☐ Supervised prescribed pain therapy
- ☐ Prescribed for psychiatric or neurological condition
- ☐ Prescription substance obtained without prescription
- ☐ Non- prescription substance
- ☐ Unknown

*Infant Clinical signs of NAS/NOWS**
- ☐ Yes
- ☐ No

*Screening tool completed**
- ☐ Yes
- ☐ No

*Screening tool used**
- ☐ Finnegan
- ☐ Lipsitz
- ☐ Other, specify: ________________

*Confirmatory test for opioids positive**
- ☐ Yes
- ☐ No

Treatment

NAS/NOW Treatment*
- ☐ Yes
- ☐ No

Feeding type*
- ☐ Breastfeeding/ breast milk
- ☐ Formula
- ☐ Specialty formula
- ☐ Formula and breast milk

Behavioral and environmental management*
- ☐ Yes
- ☐ No

Date started* ________/_______/________

Time started* ________:_________ a.m p.m.

Level of care within the facility*
- ☐ Level I (mom/baby care)
- ☐ Level II (special care nursery)
- ☐ Level III (NICU)
- ☐ Level IV (NICU)

Pharmacological treatment*
- ☐ Yes
- ☐ No

Date started* ________/________/________

Time started*_________:_________ a..m. p.m.

Date ended* ________/________/________

Time ended* __________:_________ a.m. p.m.

Duration of pharmacological treatment (in days): _______

Abnormal Conditions of the Newborn

Medications used for NAS treatment* (Select all that apply)
- ☐ Morphine sulfate
- ☐ Methadone
- ☐ Phenolbarbital
- ☐ Clonindine
- ☐ Other, specify: ________________________

Level of care within the facility*
- ☐ Level I (mom/baby care)
- ☐ Level II (special care nursery)
- ☐ Level III (NICU)
- ☐ Level IV (NICU)

Protocol

Standardized protocol used
- ☐ Yes
- ☐ No

☐ Infection
- ☐ Specify infection: ___________________

Reason standardized protocol not used
- ☐ Infant ineligible
- ☐ Provider preference
- ☐ No protocol adopted
  - ☐ Other: ___________________

Iatrogenic*

Diagnoses with potential for state dysregulation independent of perinatal substance exposure*
- ☐ No
- ☐ Seizure disorder documented on EEG
- ☐ Stroke or intracranial hemorrhage
- ☐ Major CNS malformation
- ☐ Other

Diagnoses or procedures requiring protracted sedation and/or analgesia*
- ☐ Yes
- ☐ No

Total days prescribed sedation and/or analgesia*

____

Congenital Anomalies of the Newborn

☐ **NO CONGENITAL ANOMALIES OF THE NEWBORN (ALL FIELDS IN THIS SECTION ARE NO)**

Central Nervous System
- ☐ ***Anencephalus***
- ☐ ***Meningomyelocele***
- ☐ ***Spina bifida***
- ☐ *Hydrocephalus*
- ☐ *Microcephalus*
- ☐ *Other central nervous system anomalies*

____

Circulatory/ Respiratory System
- ☐ ***Cyanotic congenital heart disease***
- ☐ *Acyanotic congenital heart disease*
- ☐ *Other heart malformations*
- ☐ *Other circulatory/respiratory anomalies*

____

Gastrointestinal
- ☐ *Rectal atresia/stenosis*
- ☐ *Tracheo-esophageal fistula/esophageal atresia*
- ☐ **Omphalocele**
- ☐ **Gastroschisis**
- ☐ *Other gastrointestinal anomalies*

____

Urogenital
- ☐ *Malformed genitalia*
- ☐ *Renal agenesis*
- ☐ **Hypospadius**
- ☐ *Other urogenital anomalies* ______________________

Musculoskeletal/Integumentary Anomaly
- ☐ ***Cleft lip with or without cleft palate***

Child's name ____ Child's Date of Birth ______ / ______ / ______

Feeding type at discharge*
- ☐ Breastfeeding/breast milk
- ☐ Formula
- ☐ Specialty Formula
- ☐ Formula and breast milk

Home medications prescribed *
- ☐ None
- ☐ Morphine
- ☐ Methadone
- ☐ Phenolbarbital
- ☐ Clonidine
- ☐ Other, specify ____________________

Developmental follow-up referral*
- ☐ Yes
- ☐ No
- ☐ NA – transferred to another facility for a higher level of care
- ☐ Public health referral

Newborn blood screen number ____________

Hearing Screening
- ☐ Newborn hearing screening performed

Left ear
- ☐ Pass
- ☐ Fail

Right ear
- ☐ Pass
- ☐ Fail

Reason not screened
- ☐ Broken appointment
- ☐ Could not test
- ☐ Missed
- ☐ Refused
- ☐ Infant medically ineligible
- ☐ Invalid
- ☐ Deceased
- ☐ Transferred
- ☐ Scheduled
- ☐ Incomplete
- ☐ No information
- ☐ Other ____________________

Congenital Anomalies of the Newborn

- ☐ Cleft lip alone
- ☐ ***Cleft palate alone***
- ☐ Polydactyly/Syndactyly/Adactyly
- ☐ Club foot
- ☐ **Limb reduction defect**
- ☐ ***Diaphragmatic hernia***
- ☐ *Other musculoskeletal/ integumentary anomaly* ____________________

Chromosomal
- ☐ ***Down syndrome***
- ☐ **Down karyotype pending**
- ☐ **Down karyotype confirmed**
- ☐ ***Suspected chromosomal disorder***
- ☐ **Suspected chromosomal disorder, karyotype pending**
- ☐ ***Suspected chromosomal disorder, karyotype confirmed***
- ☐ Suspected chromosomal disorder, specify ____________________
- ☐ Autosomal recessive polycystic kidney disease
- ☐ *Lethal chromosomal anomalies*
- ☐ *Other chromosomal anomalies* ____________________

Other anomalies
- ☐ *Other congenital anomalies* ____________________

Maternal Discharge

*Type of discharge**
- ☐ Home
- ☐ Death
- ☐ Transferred to other facility

Date ______ / ______ / ______

Time ________ : ________ *a.m. p.m.*

Infant Discharge

- ☐ *Discharged with mother*
- ☐ Not discharged at time birth certificate filed

Discharge destination*
- ☐ *Home*
- ☐ *Foster care*
- ☐ *Acute care facility*
- ☐ *Other, specify* ____________________
- ☐ Infant Discharge Pending

*Date of discharge** ______ / ______ / ______

Time of discharge* ________ : ________ a.m. p.m.

Perinatal Mortality

Date of death ______ / ______ / ______

Time of death ________ : ________ a.m. p.m.

Estimated time of fetal death
- ☐ Dead at time of first assessment, no labor ongoing
- ☐ Dead at time of first assessment, labor ongoing
- ☐ Died during labor, after first assessment
- ☐ Died during delivery
- ☐ Unknown time of fetal death
- ☐ Autopsy
- ☐ Placental exam performed

Initiating cause/condition of fetal death

Initiating cause/condition of fetal death
- ☐ Pending
- ☐ Rupture of membranes prior to onset of labor
- ☐ Abruptio placenta
- ☐ Placental insufficiency
- ☐ Prolapsed cord
- ☐ Chorioamnionitis
- ☐ Other complications of placenta, cord, or membranes ____________________
- ☐ Maternal conditions/disease ____________________
- ☐ Other obstetrical or pregnancy complications ____________________
- ☐ Fetal anomaly ____________________
- ☐ Fetal injury ____________________
- ☐ Fetal infection ____________________
- ☐ Other fetal conditions/disorders ____________________
- ☐ Unknown time of fetal death

Other Significant Causes/Conditions of Death
- ☐ **NO OTHER SIGNIFICANT CAUSES/CONDITIONS OF DEATH (ALL FIELDS IN THIS SECTION ARE NO)**
- ☐ Rupture of membranes prior to onset of labor
- ☐ Abruptio Placenta
- ☐ Placental Insufficiency
- ☐ Prolapsed Cord
- ☐ Chorioamnionitis
- ☐ Other complications of placenta, cord, or membrane ____________________
- ☐ Maternal diseases/conditions ____________________
- ☐ Other obstetrical or pregnancy complications ____________________
- ☐ Fetal anomaly ____________________
- ☐ Fetal injury ____________________
- ☐ Fetal infection ____________________
- ☐ Other fetal conditions/disorders ____________________

Disposition of the Fetus

Method of disposition
- ☐ Burial
- ☐ Cremation
- ☐ Hospital Disposition
- ☐ Donation
- ☐ Other ____________________
- ☐ Removal from state

Name of disposing facility ____________________

Address of facility disposing of remains (street address, city, state, ZIP code) ____________________

Perinatal Mortality

Cause of Infant Death

Immediate cause of death

- ☐ Asphyxia
- ☐ Blood group incompatibility
- ☐ Congenital anomaly
- ☐ Immaturity
- ☐ Infection
- ☐ IUGR
- ☐ Metabolic disorder
- ☐ RDS
- ☐ Trauma
- ☐ Other ______________________

Source

- ☐ ***Fetal cause***
- ☐ ***Maternal cause***

Contributing cause of death 1 ______________________

Source

- ☐ Fetal cause
- ☐ Maternal cause

Contributing cause of death 2 ______________________

Source

- ☐ Fetal cause
- ☐ Maternal cause

Disposition of the Infant

Group responsible for disposition

- ☐ Funeral Home
- ☐ Family
- ☐ Coroner/Medical Examiner Removal
- ☐ Hospital

Funeral home of disposition ______________________

Funeral home of disposition city ______________________

Funeral home of disposition phone number