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Maternal Pre-pregnancy Body Mass Index, Prenatal Sugar Consumption, Gestational Weight Gain, and Postpartum Mental Health

by

Lucinda L. Scott

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Committee Approval

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of LUCINDA L SCOTT find it satisfactory and recommend that it be accepted.

_____
Nicki Aubuchon-Endsley,
Major Advisor

_____
Erin Rasmussen,
Committee Member

_____
Allisha Weeden,
Graduate Faculty Representative

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Thesis Abstract-Idaho State University (2019)

Elevated pre-pregnancy body mass index (BMI) is associated with increased risk of perinatal anxiety, depression, and stress symptoms, and with excessive gestational weight gain (GWG), which predicts postpartum maternal mental health. Sugar intake is similarly associated with mental health and weight gain, but has not been thoroughly investigated in relation to postpartum mental health. More studies are needed in underserved areas, including HPSAs wherein barriers to healthcare may be more prevalent and impactful. Therefore, this study investigated whether the amount of third trimester added sugar consumed interacted with pre-pregnancy BMI to predict GWG and postpartum mental health in a perinatal sample in an HPSA for primary care and mental health. Though no moderated mediation models were statistically significant, results indicated a correlation between prenatal added sugar intake and 6-month postpartum depression, anxiety, and perceived stress symptoms. Further, greater pre-pregnancy BMI predicted decreased GWG and increased 6-month postpartum depressive symptoms. Associated practical implications and future directions are discussed in detail.

Key Words: Pregnancy, female, maternal diet, health professional shortage area, third trimester

Maternal Pre-pregnancy Body Mass Index, Prenatal Sugar Consumption, Gestational Weight Gain, and Postpartum Mental Health

The average United States (U.S.) woman is 5 feet, 3.7 inches tall and weighs 170.6 pounds, corresponding to a body mass index (BMI) of 29.6, which is in the "overweight" range, up from an average BMI of 25.2 in 1964 (Fryar, Kruzon-Moran, Gu, & Ogden, 2018; Stoudt, Damon, McFarland, & Roberts, 1964). Trends from 2011 to 2016 indicate that pre-pregnancy BMI is also increasing, with 52% of those giving birth having had a pre-pregnancy BMI in the overweight or obese range (Branum, Kirmeyer, & Gregory, 2018; Deputy, Dub, & Sharma, 2018). The evidence linking pre-pregnancy obesity to increased risk of detrimental psychological and physiological outcomes for both mother and infant is clear, including greater rates of maternal gestational diabetes, gestational hypertension, preeclampsia (Hung & Hsieh, 2016; Li et al., 2013; Lucovnik et al., 2018; Metsälä, Stach-Lempinen, Gissler, Eriksson, & Koivusalo, 2016; Zhao, Xu, Wu, Huang, & Cao, 2018; Zhou et al., 2015), preterm or cesarean delivery, stillbirth (Chu et al., 2007; Li et al., 2013; Liu et al., 2016; Lucovnik et al., 2018), and antenatal depression (Molyneaux, Poston, Khondoker, & Howard, 2016) and anxiety (Mina et al., 2015) in obese women compared to those with a normal pre-pregnancy BMI. Further, those with pre-pregnancy obesity are more likely to have excessive gestational weight gain (EGWG; Morisset, Dubois, Colapinto, Luo, & Fraser, 2017), or weight gain exceeding Institution of Medicine (IOM) guidelines, over the course of their pregnancy, which predicts symptoms of depression during pregnancy and postpartum (Bodnar, Wisner, Moses-Kolko, Sit, & Hanusa, 2009; Bolton et al., 2017). Given the high incidence and salient mental and physical health effects of excessive pre-pregnancy weight and weight gain, further studies are needed to understand these complex relationships and inform prevention/intervention research.

Maternal diet also has been found to impact GWG in similar ways as pre-pregnancy BMI, with diets high in sugar predicting increased GWG (Olafsdottir, Skuladottir, Thorsdottir, Hauksson, & Steingrimsdottir, 2006), more added sugar consumption predicting increased odds of EGWG (Renault et al., 2015) and poorer maternal mental health, and diets high in sugary foods predicting antenatal depression symptoms (Baskin, Hill, Jacka, O'Neil, & Skouteris, 2017; Chatzi et al., 2011; Miyake et al., 2018; Paskulin et al., 2017). Therefore, models of relations among perinatal weight and maternal mental health outcomes should include examination of maternal diet. Literature suggests that using overall dietary pattern may obfuscate the influence of specific nutrient consumption, such as added sugar (Tielemans et al., 2015), which has been preliminarily linked to gestational weight and maternal perinatal mental health symptoms in human samples. Indeed, Knüppel, Shipley, Llewellyn, and Brunner (2017) found that sugar intake negatively impacted mental health longitudinally, and sugar-sweetened beverage consumption was found to increase risk of depressive symptoms (Hu, Cheng, & Jiang, 2019). Animal models further suggest that diets high in sugar increase anxious and depressive behavior in rats (Avena, Bocarsly, Rada, Kim, & Hoebel, 2008; Décarie-Spain et al., 2018). However, while research suggests that some women increase their added sugar consumption during pregnancy (Graham, Mayan, McCargar, & Bell, 2013), literature regarding the effect of added sugar on antenatal mental health was not found.

Women in rural areas may be disproportionately impacted by complex relationships among pre-pregnancy weight, maternal diet, and postpartum symptoms of depression, anxiety, and perceived stress. In the U.S., rural areas are not technically defined. Rather, areas outside of what are known as Urbanized Areas (UAs) of "50,000 people or more," and Urban Clusters (UCs) of at "least 2,500 and less than 50,000 people" are known as "rural" areas (U.S.

Department of Health and Human Services, 2018). Women in rural areas have higher odds of being overweight or obese prior to pregnancy than women in more densely populated areas (Gallagher, Liu, Probst, Martin, & Hall, 2013). Interestingly, however, they are less likely to exceed IOM guidelines for prenatal weight gain than women in urban areas (Gallagher et al., 2013). Even so, while the Center for Disease Control and Prevention (CDC) estimates rates of postpartum depressive symptoms in the general population to be approximately 11.5%, prevalence rates across studies of rural women are estimated at 16.7% to 32.7%, with higher rates among rural women with less income (Ko, Rockhill, Tong, Morrow, & Farr, 2017; Mollard, Hudson, Ford, & Pullen, 2016; Price & Proctor, 2009). Further, women in rural areas have barriers to healthcare, including a dearth of local services, lack of expectation of care from primary healthcare providers, and preferences for informal social support over professional services (Mollard et al., 2016). Even in areas not classified as rural, barriers to healthcare service utilization can occur among those in Health Professional Shortage Areas (HPSAs), particularly those who live in Primary Care and Mental Health HPSAs. HPSAs are defined as those with a "shortage of health services for an entire population within an established geographic area," or a "shortage of services for a specific population subset" within that area (Health Resources & Services Administration, 2019). However, research investigating the relationships among pre-pregnancy BMI, GWG, and postpartum mental health of women in rural or HPSAs was not found.

With the currently high rates of obesity in U.S. women, which disproportionately impact women with barriers to healthcare, it is important to address this gap in the literature to identify a modifiable health behavior during pregnancy that may reduce risk of postpartum distress and associated maternal and offspring health difficulties. Therefore, this project aims to investigate

the influence of sugar consumption on the relationship among pre-pregnancy BMI, GWG, and postpartum mental health. Specifically, this study will investigate the role of sugar consumption in the third trimester in a perinatal population who reside in an HPSA to determine whether the amount of prenatal sugar consumption interacts with pre-pregnancy BMI to predict GWG and postpartum depressive symptoms, symptoms of anxiety, and perceived stress, respectively. The focus of this study is on maternal mental health outcomes given the dearth of literature in this area in comparison to maternal pregnancy and neonatal outcomes. However, because maternal pregnancy and neonatal health outcomes are not independent from maternal mental health, a brief review of maternal pregnancy outcomes and neonatal outcomes follows and studies focused on maternal mental health will be highlighted. This will also assist in underscoring the importance of this area of examination.

Perinatal Obesity, Body Mass Index, and Gestational Weight Gain

Body Mass Index Definition

Deviation from "normal" maternal perinatal body mass index (BMI), as quantified by the World Health Organization (WHO), has been tied to risk during pregnancy as well as adverse birth and neonatal outcomes (Ashley-Martin & Woolcott, 2014; Hung & Hsieh, 2016; Ketterl, Dundas, Roncaioli, Littman, & Phipps, 2018; Li et al., 2013; Liu et al., 2016; Lucovnik et al., 2018; Metsälä et al., 2016; Zhao et al., 2018; Zhou et al., 2015). BMI is a ratio determined by dividing one's weight in kilograms by the square of the individual's height in meters (kg/m^2), with scores under 18.5 kg/m^2 indicating that an individual is "underweight," scores from 18.5–24.9 kg/m^2 indicating "normal weight," 25.0–29.9 kg/m^2 indicating "pre-obesity" or overweight, scores from 30.0–34.9 kg/m^2 indicating that an individual is considered "obese" or obesity class I,

scores from 35.0-39.9 kg/m^2 indicating an individual is class II obese, and those with scores above 40.0 kg/m^2 considered class III obese (WHO, n.d.).

Pre-pregnancy Body Mass Index

Relations with gestational weight gain. Pre-pregnancy BMI has been found to predict gestational weight gain, with increased risk of exceeding IOM guidelines for women in the overweight and obese BMI categories. Morisset et al. (2017) found that pre-pregnancy BMI was predictive of GWG, with a significantly higher proportion of women in the overweight and obese categories for pre-pregnancy BMI gaining in excess of IOM guidelines (EGWG) than those in the underweight or normal BMI categories prior to pregnancy. In their study of pregnancy in Puerto Rican women, Guilloty et al. (2015) found that women in the obese or overweight categories prior to pregnancy were "38.8% and 31.2%" more likely to have EGWG as compared to those in the underweight or normal weight categories, respectively. Further, they found that women who were underweight prior to pregnancy were the most likely to have inadequate GWG as compared to women in normal, overweight, and obese categories (Guilloty et al., 2015). However, the relationship between pre-pregnancy BMI and EGWG may depend on environmental factors, as the likelihood of women in urban areas to exceed IOM guidelines has been higher than those in rural areas (Babanezhad, 2017; Gallagher et al., 2013). Timing of gestational weight gain may also be important given that Overcash, Hull, Moore, and LaCoursiere (2015) found that for women in the obese BMI category, accelerated weight gain during the 12 to 14-week period significantly predicted EGWG during pregnancy, but pre-pregnancy BMI did not. Mixed findings in the literature support a need for further studies in this area.

Pregnancy outcomes. Pre-pregnancy BMI has been linked to several pregnancy, maternal mental health, and infant outcomes. Women who are underweight prior to pregnancy are at an increased risk of placental abruption (Hung & Hsieh, 2016). Pregnancy outcomes including preterm (delivery prior to 37 weeks gestation) or cesarean delivery, or stillbirth are more likely among women who are overweight or obese prior to pregnancy when compared to those in the normal weight category (Li et al., 2013; Liu et al., 2016; Lucovnik et al., 2018). In their meta-analysis, Chu et al. (2007) found that women who were overweight or obese prior to pregnancy were at increased odds (i.e., 1.37 and 2.08 times greater, respectively) of stillbirth, as compared to women with a normal pre-pregnancy BMI. Women who are overweight or obese prior to pregnancy also are at increased risk of complications during pregnancy, including gestational diabetes mellitus (GDM) or hypertensive disorders of pregnancy (HDP), including gestational hypertension and preeclampsia (new onset hypertension and protein in the urine after 20 weeks gestation), as compared to women who are underweight or of normal weight (Hung & Hsieh, 2016; Li et al., 2013; Lucovnik et al., 2018; Metsälä et al., 2016; Zhao et al., 2018; Zhou et al., 2015). Further, women who are overweight or obese prior to pregnancy are more likely to retain their pregnancy weight gain after giving birth than those of normal weight (Ashley-Martin & Woolcott, 2014; Ketterl et al., 2018).

Maternal mental health outcomes. Laraia, Siega-Riz, Dole, and London (2009) found a significant relationship between higher pre-pregnancy BMI categories and greater perceived stress, trait anxiety, and depressive symptoms during pregnancy, with extremely obese women reporting significantly higher rates of trait anxiety than those who were obese. Bodnar et al. (2009) found that increasing pre-pregnancy BMI was strongly associated with greater likelihood of perinatal major depression (as diagnosed using the Structured Clinical Interview for DSM-IV;

SCID-IV). In their meta-analysis, Molyneaux, Poston, Ashurst-Williams, and Howard (2014) found that women with a pre-pregnancy BMI in the obese category had "significantly higher odds of elevated depression symptoms" during pregnancy and postpartum (increased odds 43% and 30%, respectively) than women of normal weight, with those in the overweight category having "intermediate risk." Furthermore, a cohort of pregnant women in obesity class II or III were at significantly greater risk of depression throughout pregnancy and up to 1 year postpartum than normal weight women as indicated by the Edinburgh Postnatal Depression Scale (EPDS; Salehi-Pourmehr, Mohammad-Alizadeh, Jafarilar-Agdam, Rafiee, & Farshbaf-Khalili, 2018). Specifically, those in obesity class II or III were at 3.25-fold, 3.29-fold, and 4-fold greater risk in the first, second, and third trimesters, respectively, and 7.5-fold and 1.83-fold greater risk in 6-8 weeks and 1 year postpartum, respectively, than those in the normal weight group (Salehi-Pourmehr et al., 2018). Indeed, in their cohort of women with a pre-pregnancy BMI in the obese class III category, Mina et al. (2015) found that pre-pregnancy BMI was "independently associated with higher anxiety and depression symptoms throughout pregnancy," even when controlling for prior mental health diagnoses (p.16). Furthermore, they found that weight in the obese class III category was associated with more anxiety and depression symptoms at 3 months postpartum, as compared to women of normal weight (Mina et al., 2015).

However, this relationship may not be exclusive to those over normal BMI, as Ertel et al. (2017) found that women in the underweight, overweight, or obese category at pre-pregnancy had higher odds of elevated depression scores at 6 months postpartum than those of normal weight, indicating a U-shaped relationship between pre-pregnancy BMI and depression scores. This relationship may also depend on maternal ethnicity, as Ertel et al. (2015) found no significant relationship between obesity or GWG and elevated depressive symptoms, and

significantly reduced odds of elevated depressive symptoms during pregnancy in women who were overweight pre-pregnancy in their cohort of pregnant Hispanic women. Similarly, in their study of depressive symptoms and obesity among Black and Hispanic pregnant women, Shieh and Wu (2014) found a significant, positive correlation between pre-pregnancy BMI and depressive symptoms in Black women, but found no such relationship in Hispanic women.

Offspring outcomes. Infants born to women who are overweight or obese prior to pregnancy are at higher risk of being admitted to a neonatal intensive care unit (NICU), being large for gestational age (LGA; birth weight ≥90th percentile) or having macrosomia (birth weight >4500 kg), or being diagnosed with respiratory distress syndrome (Hung & Hsieh, 2016; Li et al., 2013; Liu et al., 2016; Lucovnik et al., 2018; Papazian et al., 2017; Soltani, Lipoeto, Fair, Kilner, & Yusrawati, 2017) than those born to women of normal weight. Infants born to women who were underweight prior to pregnancy are at higher risk of being born preterm, small for gestational age (SGA; birth weight <10th percentile), or low birth weight (LBW; birth weight <2500 kg; Fukuda et al., 2017; Hung & Hsieh, 2016; Liu et al., 2016; Papazian et al., 2017). In offspring, pre-pregnancy BMI in women was positively correlated with child BMI at 14 months, and childhood adiposity at 12 and 24 months (Mesman et al., 2009; Ong et al., 2008). Further, adults born to women with pre-pregnancy BMI in the overweight or obese range were found to have significantly higher BMI and body fat percentage, and larger waist circumference at 21 and 25 years of age (Kaseva et al., 2018; Zalbahar, Najman, McIntrye, & Mamun, 2016).

Pregnancy Body Mass Index

Pregnancy outcomes. Similar to pre-pregnancy BMI, a BMI above "normal" during pregnancy is associated with increased risk for poor pregnancy, labor, and delivery outcomes. Women are at an increased risk of preeclampsia, premature induction of labor, and cesarean

delivery with increased pregnancy BMI, with those with a BMI>30 being at an increased risk of delivering an infant with macrosomia (Yazdani, Yosofniyapasha, Nasab, Mojaveri, & Bouzari, 2012). Bhavadharini et al. (2017) investigated BMI during "early pregnancy" and found that women who were obese were at higher risk for cesarean delivery and preeclampsia than those who were underweight, normal, or overweight. However, rates of macrosomia in infants born to overweight or obese mothers were found to vary significantly by racial/ethnic subgroups, with infants born to non-Hispanic, White women at the highest rates, followed by those born to Hispanic women, non-Hispanic Black women, and Asian women, respectively (Rosenberg, Garbers, Lipkind, & Chiasson, 2005). Women in rural areas of low- and middle-income countries with BMIs categorized as overweight or obese were found to have significantly higher rates of preeclampsia, cesarean delivery or use of interventions at birth (e.g., oxytocin administration), and increased perinatal and neonatal mortality rates (Short et al., 2018).

Maternal mental health outcomes. BMI during pregnancy has been found to be related to depression, anxiety, and stress levels across pregnancy and postpartum. In their review of obesity and antenatal anxiety, Nagl, Linde, Stepan, and Kersting (2015) reported that symptoms of anxiety are more common among obese pregnant women, and ante- and postnatal anxiety symptoms are substantially positively related with obesity during pregnancy. Similarly, Harville, Savitz, Dole, Herring, and Thorp (2009) found that trait and state anxiety levels significantly differed between BMI categories at 20, 24, and 29 weeks gestation, with women in the obese category showing the highest levels (as reported in Nagl et al., 2015). Similarly, Molyneaux et al. (2014) reported that women with BMIs in the obese category had greater odds of elevated anxiety during pregnancy when compared to women of normal weight. Mina et al. (2015) found that those with BMIs in the obesity class III category had increased risk of anxiety, depression,

and psychosocial stress symptoms during pregnancy, as compared to controls in the normal BMI category. Interestingly, a recent population-based, longitudinal study by Silverman, Smith, Lichtenstein, Reichenberg, and Sandin (2018) found a U-shaped association between BMI and "clinically significant depression" within 1 year postpartum, in that women who were underweight or severely overweight (BMI <18.5 or >35, respectively) during their first trimester of pregnancy were at a significantly increased risk of postpartum depression as compared to those in other BMI categories.

Gestational Weight Gain Definition

GWG, or weight gained over the course of pregnancy, has also been found to impact multiple outcomes. Specifically, insufficient or EGWG, as based on the 1990 and 2009 IOM guidelines, can negatively impact pregnancy, maternal, neonatal, infant, and child outcomes. IOM guidelines recommend weight gain during pregnancy of 28-40 lbs. for those with a pre-pregnancy BMI in the underweight category, 25-35 lbs. for those of normal weight, 15-25 lbs. for those in the overweight category, and 11-20 lbs. for those in the obese category (IOM & NRC, 2009).

Psychological Predictors of Gestational Weight Gain

In their path analysis of the relationship between pre-pregnancy BMI, GWG (subtracting pre-pregnancy BMI from weight at 32 weeks gestation), and symptoms of depression and anxiety, McPhie et al. (2015) found that depression symptoms early in pregnancy predicted weight gain in those without EGWG only, and that both depressive and anxious symptoms were stable across pregnancy, regardless of GWG. Kapadia et al. (2015a) found an inverse relationship between psychological distress (as measured by the General Health Questionnaire-12 items; GHQ-12) and GWG in their systematic review, but no relationship between the

psychological factors of perceived stress, state or trait anxiety. Further, in their systematic review of psychological antecedents of EGWG, Kapadia et al. (2015b) failed to substantiate a predictive relationship between anxiety, depression, or perceived stress and EGWG among 35 studies of perinatal populations. However, the relationship between psychological symptoms and GWG may be non-linear, as Mina et al. (2015) found an inverted U-shaped relationship between anxiety and depression early in pregnancy and GWG. Specifically, women with the highest or lowest levels of symptoms gained the least amount of weight over the course of pregnancy. Given their cohort of severely obese women (class III obese), these findings may indicate that pre-pregnancy BMI plays a role in the relationship between GWG and perinatal mood, though more studies are needed to disentangle these relations (Mina et al., 2015) and there appears to be more support for GWG as a predictor, rather than outcome, in relation to maternal perinatal mental health.

Gestational Weight Gain Outcomes

Main effects on pregnancy and offspring outcomes. Overall, women with GWG below the recommended guidelines are at greater risk for preterm delivery (Goldstein et al., 2017, 2018; Kominiarek et al., 2018; Soltani et al., 2017), and their infants are at greater risk of being LBW (Papazian et al., 2017) or SGA (Goldstein et al., 2017, 2018; Soltani et al., 2017; Stotland, Cheng, Hopkins, & Caughey, 2006), when compared to those who gain within IOM recommended guidelines. In their cohort of Taiwanese pregnant women, Hung and Hsieh (2016) found that regardless of pre-pregnancy BMI, women who gained below IOM guidelines were at increased risk of GDM as compared to women who gained within or above guidelines. Women who gained above the recommended guidelines were at increased risk of cesarean delivery (Goldstein et al., 2017, 2018; Kominiarek et al., 2018; Stotland, Hopkins, & Caughey, 2004), preterm delivery and

HDP (Kominiarek et al., 2018), and their infants were at increased risk of being LGA (Goldstein et al., 2017), having macrosomia (Goldstein et al., 2017, 2018; Kominiarek et al., 2018; Papazian et al., 2017), among other negative outcomes (Stotland et al., 2006), as compared to those with GWG within the IOM guidelines. Similarly, Kominiarek et al. (2018) found that women who gained above the IOM recommended guidelines were at increased risk of gestational hypertension, preeclampsia, eclampsia, and hemolysis elevated liver enzymes and low platelets syndrome (HELLP) when compared to those who remained within recommended guidelines.

Main effects on maternal outcomes. Dayan et al. (2018) investigated the occurrence of postpartum depression as indicated by the EPDS among healthy pregnant women, and found that third trimester weight gain was significantly predictive of postpartum depression, but unrelated to IOM guidelines. However, their inclusion criteria were extended to those with a BMI between 18.5 and 30, limiting the generalizability of their findings in those who are underweight or obese (Dayan et al., 2018). In their 2017 study, Bolton et al. found a significant positive correlation between GWG (subtracting pre-pregnancy BMI from the last reported weight prior to delivery) and EPDS scores at 1 month postpartum.

In their cross-sectional research investigating the relationship between GWG and elevated depressive symptoms in Black and Hispanic women during pregnancy, Shieh and Wu (2014) found an inverse correlation between GWG and depressive symptoms in Black women throughout pregnancy, but no relationship between those variables among Hispanic women. Similarly, in their cross-sectional study of Hispanic women, Ertel et al. (2015) found no association between GWG and elevated depressive symptoms during pregnancy. These findings may indicate that there are cultural differences among Black, Hispanic, and White women in terms of the contribution of weight to depressive symptomology.

Long-term maternal outcomes (i.e., ≥6 weeks postpartum) related to GWG were found to be limited to post-pregnancy weight retention (PPWR) and postpartum depression, suggesting that more research is needed on long-term maternal outcomes associated with excess perinatal weight. Montpetit, Plourde, Cohen, & Koski (2012) found that GWG, pre-pregnancy BMI, energy intake, and number of steps taken during pregnancy was predictive of PPWR. In their study of pregnant women with a BMI over 30, Overcash et al. (2015) found that those who exceeded GWG guidelines "retained a significant amount of weight at 6 weeks postpartum," as compared to those who lost their pregnancy weight by that time. Further, Fraser et al. (2011) determined that at 16 years postpartum, women who exceeded GWG recommendations had greater risk of overweight/obesity as compared to those who had recommended levels of GWG during pregnancy, suggesting long-term health effects of EGWG.

Interaction effects with pre-pregnancy body mass index. For women who are considered underweight via pre-pregnancy BMI, those who gain weight above recommended levels are at an increased risk of preeclampsia and cesarean or instrumental delivery as compared to women who were within the recommendations, and their infants are at an increased risk of LGA or macrosomia (Gavard, 2017; Goldstein et al., 2017, 2018; Hung & Hsieh, 2016; Mastroeni et al., 2017). For women who are underweight pre-pregnancy and gain below the recommended levels, their infants at an increased risk of LBW, and SGA than those born to underweight women pre-pregnancy who had GWG within the recommended levels (Gavard, 2017; Goldstein et al., 2018; Hung & Hsieh, 2016). For women with a BMI in the normal range pre-pregnancy, GWG below the IOM guidelines increased risk LBW and SGA in their infants, and GWG above the guidelines increased risk of preeclampsia and cesarean delivery, and macrosomia in their infants (Hung & Hsieh, 2016). For women with a pre-pregnancy BMI in the

overweight or obese category, GWG below guidelines was associated with increased risk of giving birth to an SGA infant, and GWG above the recommendations was associated with increased risk of cesarean delivery, and giving birth to an infant with macrosomia or LGA (Goldstein et al., 2017). For women who were obese prior to pregnancy, weight loss or GWG below IOM guidelines was found to reduce risk of preeclampsia (Kiel, Dodson, Artal, Boehmer, & Leet, 2007) and cesarean delivery, and reduce the risk of infants born LGA or with macrosomia (Goldstein et al., 2017). In their 2009 study, Bodnar et al. found that GWG significantly interacted with elevated pre-pregnancy BMI to predict a greater likelihood of major depression (as diagnosed using the SCID-IV) during pregnancy.

Interaction effects with pregnancy body mass index. Bhavadharini et al. (2017) investigated the relationship between BMI during "early pregnancy" and GWG, and found that women who were obese and gained weight exceeding the IOM recommendations were at higher risk for preterm labor, cesarean delivery, and preeclampsia, than women who were underweight or normal weight, including those who gained more than the recommended guidelines (Bhavadharini et al., 2017). Similarly, they found that infants born to women who were overweight or obese in early pregnancy and gained weight exceeding the IOM recommendations were at higher risk of macrosomia, comparably (Bhavadharini et al., 2017).

Summary

Maternal perinatal BMI has demonstrable effects on maternal and offspring outcomes throughout and after pregnancy (Bhavadharini et al., 2017; Hung & Hsieh, 2016; Li et al., 2013; Liu et al., 2016; Lucovnik et al., 2018; Metsälä et al., 2016; Yazdani et al., 2012; Zhao et al., 2018; Zhou et al., 2015). Further, GWG and EGWG independently predict detrimental pregnancy and offspring outcomes (Goldstein et al., 2018; Kominiarek et al., 2018; Mastroeni et

al., 2017; Papazian et al., 2017; Soltani et al., 2017; Stotland et al., 2006, 2004; Zhou et al., 2015). Pre-pregnancy BMI and pregnancy BMI have been shown to independently predict maternal mental health outcomes such as increased depression, anxiety, and perceived stress symptoms (Ertel et al., 2017; Laraia et al., 2009; Mina et al., 2015; Molyneaux et al., 2014; Nagl et al., 2015; Salehi-Pourmehr et al., 2018; Silverman et al., 2018), as well as interacting with GWG to predict an increased likelihood of major depressive disorder throughout pregnancy (Bodnar et al., 2009). Further, GWG has been indicated as a risk factor for postpartum depression (Bolton et al., 2017). Taken together, results suggest that models of relations between perinatal weight and maternal postnatal health should examine pre-pregnancy BMI and GWG, and that more research in this area is needed in relation to anxiety and perceived stress in the postpartum period. Additionally, more work is needed examining at-risk mothers in HPSAs for primary care and mental health in relation to long-term psychological outcomes. Given that some curvilinear relationships have been found between pre-pregnancy BMI/pregnancy BMI and depressive symptoms and pre-pregnancy BMI and GWG, careful consideration must be made to those relationships in the current study. Further, given the research indicating differences in associations between GWG and perinatal depression among Black and Hispanic women, this study will examine differences among ethnic groups. Given existing literature, maternal diet is important to consider in models linking maternal perinatal weight and postnatal mental health. Therefore, a review of dietary factors and their relationships with maternal perinatal weight and psychological outcomes follows.

Perinatal Diet

The maternal perinatal diet has immediate and far-reaching consequences for both mother and infant. Wachs (2009) detailed models that suggested that deficiencies in maternal nutrition

interact with environmental factors to predict increased risk of maternal depressive symptoms, in turn increasing the risk of behavioral problems and depressive symptomology in offspring, via difficulties in maternal-child interactions. Likewise, Lowensohn, Stadler, and Naze (2016) discuss the established roles of individual macro- and micronutrient intake on maternal and offspring outcomes. Specifically, they found good evidence that folate, iodine, calcium, and vitamins C and D supplementation served as protective factors for negative maternal and offspring health outcomes in U.S. populations (Lowensohn et al., 2016). They also found dietary pattern research promising, noting an association between "Western" dietary patterns and adverse outcomes, and "healthful" patters and reduced risk of pregnancy complications (Lowensohn et al., 2016).

Dietary Diversity

The concept of dietary diversity, or indices of the breadth or variety of food groups represented in one's diet, has been investigated as both a correlate of pre-pregnancy BMI and predictor of infant outcomes (Jamalzehi, Javadi, & Dashipour, 2018; Kornatowski & Comstock, 2018; Saaka, 2012). However, consistent methods of determining dietary diversity are lacking in existing perinatal studies. Minimum Dietary Diversity for Women (MDD-W), a construct developed by the Food and Agriculture Organization of the United Nations, is defined as the adequacy of micronutrients in the diets of women of reproductive age, and includes a cut-off based on consumption of five out of 10 food groups (i.e., "grains, white roots, and tubers, and plantains; pulses; nuts and seeds; dairy; meat, poultry, and fish; eggs; dark leafy green vegetables; other Vitamin-A rich fruits and vegetables; other vegetables; and other fruits;" FAO and FHI 360, 2016, p. 2). Kornatowski and Comstock (2018) found an inverse correlation between pre-pregnancy BMI and MDD-W score at the third trimester of pregnancy, such that

women who were within an obese pre-pregnancy BMI category consumed less than five of the 10 food groups during the third trimester of pregnancy (Kornatowski & Comstock, 2018). Saaka (2012) found that high levels of dietary diversity in the third trimester was associated with a significantly higher birth weight and reduced risk of delivering LBW infants for Ghana women (Saaka, 2012). Jamalzehi et al. (2018) found that those with a dietary diversity score of ≤3 out of the eight represented food groups, which included approximately 70% of their sample, were more likely to give birth to an infant who was SGA. However, dietary diversity was found to be unrelated to maternal perinatal health factors, such as GDM or HDPs (Gicevic et al., 2018). Instead, Gicevic et al. (2018) suggest that dietary quality, as indicated through measures of dietary patterns that differentiate food consumption into categories, such as "healthy" or "unhealthy" were significantly better predictors of risk for maternal GDM and HDP.

Dietary Patterns

Dietary patterns are often determined through food frequency questionnaires focused on grouping similar food products, and extrapolating patterns of food consumption based on participant responses. It has been argued that rather than investigating individual nutrients, the pattern of nutrient consumption of a pregnant woman can account for "biological complexity resulting from interactions between nutrients" (Chen et al., 2016). However, contemporary research findings are mixed with some indicating the importance of dietary patters in perinatal maternal and infant outcomes, some finding significant impacts of individual nutrients, and some finding little to no effect.

Main effects on pregnancy outcomes. In their 2016 review of the literature, Chen et al. found that dietary patterns, specifically those high in animal fats and proteins, snacks, and sugars can increase the risk of GDM, HDPs, preterm birth, and infant SGA. Further, they found that

fertility increased in women following changes in dietary patterns, such as replacing monounsaturated for trans fats, vegetable protein for animal protein, and eating carbohydrates of low glycemic index and full fat dairy. Steenweg-de Graaff et al. (2014) found that perinatal diets high in fresh or processed meats, potatoes, and margarine, and low in soy or "diet products" might increase risk of offspring childhood externalizing behaviors (as cited in Chen et al., 2016). Since their review, Hajianfar, Esmaillzadeh, Feizi, Shahshahan, and Azadbakht (2018, p.3) added to the literature by demonstrating a significant positive relationship between adherence to a "western" dietary pattern, consisting of high loadings of "processed meats, fruit, fruit juice, citrus, nuts, fish, desserts and sweets, sugar, saturated fat, sweet fruit, potato, legumes, coffee, egg, pizza, high fat dairy, whole grain, and soft drinks," in the first trimester of pregnancy and risk of giving birth to a LBW infant. Dietary patterns high in milk products and low in vegetable consumption were found to increase risk of delivering preterm infants for Cantonese women, as compared to those with high vegetable consumption (Lu et al., 2018).

Relations with gestational weight gain. In their cross-sectional evaluation of the relationship between dietary pattern and GWG, Shin, Lee, and Song (2016) found no clear differences between a "healthy" dietary pattern, with high loadings of "cheese, coffee, dairy products, dark green vegetables, eggs, fruits, legumes, nuts and seeds, oils, poultry, seafood, and tomatoes" and low loadings of high-energy drinks and liquor, or a "western" diet pattern of "added sugar, beer, butter, cheese, cured meat, fruit drinks, liquor, margarine, meat, pizza, salad dressing, and solid fats," and GWG (p.2532). However, they found that adherence to a "mixed dietary pattern, with high loadings of "added sugar, butter, cheese, cold breakfast cereals, fruits, vegetables, legumes, meat, and nuts and seeds" correlated inversely with EGWG after adjusting for sociodemographic variables, pre-pregnancy BMI, and levels of physical activity (Shin et al.,

2016, p.2532). Hillesund et al. (2018) observed that a "healthy" diet pre-pregnancy and during early pregnancy (approximately week 15) was associated with a decreased risk of EGWG. Specifically, those who scored high in diet quality (≥6/10), indicating "frequent consumption of main meals, fruits, vegetables, and water, and less frequent consumption of sweetened beverages, sweets, and snacks" were less likely to have EGWG (Hillesund et al., p.7). Tielemans et al. (2015) evaluated dietary patterns longitudinally, and found that early pregnancy patterns high in "margarine, sugar, and snacks" were found to be associated with excessive gestational weight gain in normal weight women after controlling for pre-pregnancy BMI. In their cohort of healthy, pregnant Icelandic women, Olafsdottir et al. (2006) found that eating "more sweets" between 11 to 15 weeks gestation increased their odds of EGWG.

In their meta-analysis of GWG attenuation, Walker et al. (2018) found that dietary interventions accounted for the largest reductions of gestational weight gain. However, Tielemans et al. (2015) suggested that while "dietary patterns represent the combined effects of all foods consumed, which may lead to a more powerful effect than the effects of the individual components…it may also have led to a dilution of the effects of individual components that are associated with GWG" (p.9395). Further, they remarked that combining the effects of dietary patterns might nullify their full impact on GWG (e.g., fruit and vegetable consumption may have an opposite effect on GWG than dairy products; Tielemans et al., 2015, p.9396).

Interaction effects with pre-pregnancy body mass index. Wrottesley, Pisa, and Norris (2017) found that maternal pre-pregnancy BMI interacted with dietary pattern to predict higher GWG in obese women. They found that a diet of brown and whole meal breads, cereals, dairy, added sugar and sweets (identified as the Mixed Pattern) was positively associated with higher GWG in obese women (Wrottesley et al., 2017). Further, in their cohort of women with a pre-

pregnancy BMI≥30, Renault et al. (2015) found that added sugar intake from foods was a significant predictor of GWG.

Main effects on maternal mental health outcomes. In their pregnant cohort of Greek women, Chatzi et al. (2011) found that those who consumed a "western" diet, which included significant loadings of sugar, sugar preserves and confectionary foods, alcoholic and non-alcoholic beverages, salty snacks, cereals and cereal products, starches and meats, were at an increased risk of postpartum depressive symptoms as compared to those with a "health conscious" diet pattern, which included significant loadings of vegetables, fruit, beans, peas and lentils, olive oil, fish and seafood, milk products, and nuts. When further analyzed, they found that maternal consumption of sugar, sugar preserves, and confectionary foods during pregnancy was significantly correlated with high levels of postpartum depressive symptoms as measured by the EPDS (Chatzi et al., 2011). A similar association between high sugar consumption (as compared to average sugar consumption) and symptoms of Major Depressive Disorder was found in Brazilian women during pregnancy, and low consumption of beans was associated with Generalized Anxiety Disorder (Paskulin et al., 2017). Similarly, Miyake et al. (2018) found that adherence to diet patterns low in sugar and candy was inversely correlated with depressive symptoms in their sample of Japanese pregnant women.

In their 2017 cross-sectional study of Australian women, Baskin et al. (2017) found that an "unhealthy" diet pattern (e.g., high in condiments, sweets and desserts, refined grains, high energy drinks, fast foods, hot chips, high-fat dairy, fruit juice and red meats, and low in nuts-based and oil/vinegar-based dressing; p.6) in early pregnancy (≈16 weeks gestation) predicted adherence to an "unhealthy" dietary pattern in late pregnancy (≈32 weeks gestation), and depressive symptoms in early pregnancy predicted depressive symptoms in late pregnancy.

Interestingly, they found that an “unhealthy” diet and depressive symptoms were only concurrently predictive during late pregnancy (Baskin et al., 2017). Further, they found that “healthy” dietary patterns were unrelated to depressive symptoms, which may further indicate that the relationship between unhealthy diet and depressive symptoms are related to detrimental impacts from specific nutrients like sugar, rather than protective factors existing in “healthy” dietary patterns (Baskin et al., 2017).

In their study of eating patterns among Greek women, Yannakoulia et al. (2008) found a significant positive association between high anxiety scores (scores ≥46, as measured by the State-Trait Anxiety Inventory (STAI)), and dietary patterns characterized by high red meat and sweets consumption over the preceding year. Further, Vilela et al. (2015) investigated the relationship between pre-pregnancy diet and anxiety in the second and third trimesters of pregnancy and postpartum, and found that women who adhered to a “processed” dietary pattern, consisting of “bread, sugar, fat, fast food and snacks, soft drinks, and sausages and deli meats (p.1628),” had higher STAI scores when compared to those who adhered to healthier diet patterns. However, the trend was not statistically significant (Vilela et al., 2015). This finding was in line with Hurley, Caulfield, Sacco, Costigan, & Dipietro (2005), who found that consumption of “fats, oils, sweets, and snack[s]” over the course of pregnancy (up to 28 weeks gestation) correlated with perceived stress (PSS; which was also correlated with consumption of breads) and anxiety scores (STAI score) in pregnant women at 28 weeks gestation. When assessing both depression (quantified by EPDS score ≥10) and stress (quantified by the Prenatal Psychosocial Profile–Stress subscale score) in low-income pregnant women, Fowles et al. (2011) found a significant inverse correlation between those scores and dietary quality. However, path analysis revealed that levels of depression and stress predicted dietary quality, rather than dietary

quality predicting mental health (Fowles et al., 2011). This may indicate that stress may be predictive of dietary preferences, which may impact food choice, and in turn increase depressive and/or anxious symptoms during pregnancy and postpartum.

In their cohort of Australian women, Jacka et al. (2010) found that adherence to "western" dietary patterns including sugar, processed or fried foods, and alcohol, were positively correlated with psychological distress scores, as indicated by the GHQ-12 and associated with increased odds of meeting diagnostic criteria for Dysthymia, Major Depressive Disorder, or an anxiety disorder. Similarly, Yazdi, Roohafza, Feizi, Rabiei, and Sarafzadegan (2018) found that in combination with stressful life events (SLE), adherence to a "western" diet pattern, or a diet comprised of butter, cream, organ and processed meats, carbonated drinks, pastas, jams, cakes, cookies and sweets, fast food, and mayonnaise (p.143), was significantly associated with increased odds of psychological distress (as measured by the GHQ; scores ≥4) and anxiety (as measured by the Hospital Anxiety and Depression Scale (HADS); scores ≥8).

Perinatal Sugar Intake

Estimates from the National Health and Nutrition Examination Survey (NHANES) data from 2003 to 2012 suggest that pregnant women consume approximately 85.1 grams of added sugar per day, equating to approximately 329 calories (Cioffi, Figueroa, & Welsh, 2018). Further, 39.2% of the added sugar consumed was through sugar-sweetened beverages (SSBs; (Cioffi et al., 2018). The IOM classified "sugars" as glucose and fructose (monosaccharaides), and sucrose, lactose, and maltose (disaccharides), and "added sugar" as those that are added during processing or manufacturing, or those that are added during preparation prior to consumption, as opposed to those that naturally occur in dairy or fruit (Otten, Hellwig, & Meyers, 2006). The United States Department of Agriculture (USDA) has adopted the IOM definition of

added sugar in their food classification database to determine the amount of added sugar in a given food product (Bowman, 2017). The 2015 to 2020 U.S. dietary guidelines for women recommend that those aged 18-40 consume 1,800-2,000 calories per day, with less than 10% of their total caloric intake coming from added sugars (HHS, 2015). While the dietary guidelines often recommend higher caloric limits for pregnant women (spanning 2000–2600 calories over the course of pregnancy for the average sized U.S. woman, for example), 329 calories per day still far exceeds the 10% sugar recommendation (CDC & NCHS, 2017; USDA, 2018).

In their qualitative study of sugar consumption during pregnancy, Graham et al. (2013) reported that the participants who increased their added sugar intake during pregnancy often supplemented food items with added sugar after removing other foods or behaviors from their lifestyle. Specifically, they found that women in their sample would replace coffee and/or alcohol with carbonated beverages or fruit juices, especially in social situations where they wanted to feel included in their peer group (Graham et al., 2013). Women also reported that the food choices they made to reduce physical symptoms of pregnancy, such as nausea, fatigue, or food cravings, would often result in choosing convenient foods with high added-sugar content (Graham et al., 2013). Further, when depressed mood and stress levels following pregnancy were perceived as greater than prior to pregnancy, women in their sample reported that their added sugar intake increased due to an inability to use coping mechanisms that they previously relied on, such as vigorous exercise, cigarette smoking, or drinking wine (Graham et al., 2013). However, not all women increased their added sugar intake during pregnancy. Some of those with high added sugar intake prior to pregnancy maintained their intake during pregnancy, and some decreased their added sugar intake purposely due to individual perceptions of a healthy diet (Graham et al., 2013).

Added sugar and gestational weight gain. Empirical literature suggests that diets that include sugary foods increase GWG and/or the risk of EGWG (Olafsdottir et al., 2006; Tielemans et al., 2015). However, these results are inclusive of dietary pattern, rather than added sugar intake, which may nullify the impact of added sugar on GWG (Tielemans et al., 2015). Renault et al. (2015) found that in their sample of obese women, intake of added sugar from foods in early pregnancy (assessed at 11 to 14 weeks gestation, accounting for the prior 4 weeks) was significantly positively correlated with GWG, but added sugar from SSB was not. They also found that those who consumed added sugar from foods two or more times per day at week 11 of pregnancy had significantly higher GWG than those with consumption patterns of less than once per week, accounting for an estimated 11.9 lbs. difference in GWG between those with the highest and lowest frequency of intake at baseline. Furthermore, they found that the frequency of sugar consumption was the strongest predictor of GWG (Renault et al., 2015). Maslova, Halldorsson, Astrup, and Olsen (2015) found that the intake of added sugar was significantly correlated with GWG, and independently accounted for increased GWG of approximately 2.51 lbs. over the course of pregnancy, regardless of pre-pregnancy BMI. Additionally, fruit drink consumption of one or more per day was found to increase the likelihood of EGWG in a cohort of Puerto Rican pregnant women Guilloty et al. (2015). Literature regarding a direct effect of SSB consumption during the perinatal period on perinatal mood was not found, suggesting a need to evaluate these relations in future research. Literature regarding a direct effect of added sugar intake during the perinatal period on perinatal mood was not found, thus supporting a need for more research in this area.

Sugar-sweetened beverages and pregnancy and offspring outcomes. In their longitudinal study investigating the relationship between pre-pregnancy SSB consumption and

GDM, Chen, Hu, Yeung, Willett, and Zhang (2009) found that those who had consumed more than five servings per week of sugar sweetened cola prior to pregnancy had a 22% greater risk of GDM than those who consumed less than one serving per month. However, they did not find significant increased risk with other SSBs or artificially sweetened beverages (Chen et al., 2009). In their large prospective cohort of pregnant women, Halldorsson, Strøm, Petersen, and Olsen (2010) found that those who consumed more than one carbonated artificially sweetened beverage (ASB) per day late in pregnancy (~25 weeks gestation) had an adjusted odds ratio (aOR) of 1.38 for preterm delivery as compared to women who consumed no carbonated ASBs, a relationship that did not vary based on maternal weight. They found no such relationship with the consumption of SSBs (Halldorsson et al., 2010). Englund-Ögge et al. (2012) found such a relationship between ASB and preterm delivery in their similarly sized cohort, with daily intake resulting in an aOR of 1.11 as compared to those with no intake. They also found an increased risk of preterm delivery for women who consumed SSB daily, with an aOR of 1.25 as compared to women with no intake, which held after controlling for added sugar consumption (Englund-Ögge et al., 2012). Englund-Ögge et al. (2012) suggested that the different findings between the two studies related to SSB might have be due to the different time periods studied, as participants in the Englund-Ögge et al. cohort who were asked about average dietary intake during pregnancy at 17-22 weeks gestation, and the Halldorsson et al. cohort, which was limited to 1 month prior to gestational week 25. Therefore, more studies are needed which evaluate sugar intake more comprehensively across pregnancy. SSB consumption also impacts the weight trajectory of children. Specifically, Gillman et al. (2017) found that each additional serving of SSB consumed in the second trimester of pregnancy was associated with .15 kg/m^2 of fat mass in their resultant

children at 7 years of age (p.8). Further, those outcomes were independent of child sugar intake, and were stable across child sex, race and/or ethnicity (Gillman et al., 2017).

Sugar and Mental Health

Human studies. Human research regarding relationships between added sugar and mood has been less straightforward. As discussed previously, dietary patterns have been associated with increased risk of depressive and anxious symptoms, but not as clearly or as consistently as in animal models. In their review of the research on dietary patterns and depression, Rahe, Unrath, and Berger (2014) found inconsistent results, and few conclusive protective effects of dietary patterns, with the exception of "Mediterranean" patterns, which typically entail increased consumption of fish, fruits, and vegetables, and reduced intake of processed foods, snacks, and added sugar. In their cross-sectional investigation of the relationship between sugar intake and depression, Knüppel et al. (2017) found that sugar intake negatively impacted mood in men and women, and predicted low mood 5 years later, but mood did not predict changes in sugar intake. Further, their research also indicated sex differences in the effect of sugar on mood, as higher intake of sugar was predictive of increased likelihood of depressive symptoms in men, but not in women (Knüppel et al., 2017). A recent meta-analysis of articles investigating SSB consumption and the associated risk of depression found a significant relationship among both cross-sectional and cohort studies (Hu et al., 2019). Specifically, SSB consumption "indicated an adverse effect on the risk of depression" such that sugar intake from SSBs in the amount of 24 grams per day was associated with a 5% increase in depression risk (Hu et al., 2019). As outlined above, current research regarding the effect of SSB consumption in pregnant populations primarily focuses on pregnancy, neonatal, and childhood outcomes.

Animal models. The impact of high fat, high sugar diets (HFHS) has been investigated thoroughly in animal models, most recently being tied to mood disorders such as anxiety and depression (Avena et al., 2008; Décarie-Spain et al., 2018; Inam, Ikram, Shireen, & Haleem, 2016; Pickering, Alsiö, Hulting, & Schiöth, 2009; Santos et al., 2018). Excessive sugar intake, along with saturated fat intake, was found to increase anxious and depressive behavior in rats, and increase adiposity (but not overall weight or food consumption), as compared to controls (Décarie-Spain et al., 2018). Similarly, Santos et al. (2018) found that increasing only refined carbohydrates in the diets of mice increased adiposity without increasing overall weight or food consumption. Further, following a stress-inducing episode, mice fed with the high refined-carbohydrate diet exhibited more anxious and depressive-like behaviors than the control group (Santos et al., 2018).

Pickering et al. (2009) demonstrated that obesity prone animals that were taken off of a HFHS diet demonstrated withdrawal symptoms, or cravings, for 3 weeks following removal of the food, and were more willing to work for sucrose during the "withdrawal period" than those that were not obesity prone. Those animals also demonstrated increased levels of anxious behavior during the withdrawal period, and reduced intake of healthy food, as compared to the control and non-obesity prone groups (Pickering et al., 2009). Avena et al. (2008) modeled this withdrawal process with similar increases in anxiety with sucrose alone. Inam et al. (2016) demonstrated that female rats were more prone to cravings, increases in anxious behavior, and reduced brain serotonin, as compared to male rats, indicating that there may be differences in relations among BMI, HFHS diet, and psychological symptoms between sexes in human studies as well.

Summary

Overall, several theoretical models link perinatal nutrition to maternal and offspring mental health, but gaps still exist in the empirical literature. Dietary patterns high in sugar and confections interact with pre-pregnancy BMI to predict GWG and these patterns may have a direct effect on both pregnancy outcomes and maternal mental health (Baskin et al., 2017; Chatzi et al., 2011; Miyake et al., 2018; Paskulin et al., 2017), though no existing models investigate these multivariate relationships comprehensively in perinatal samples. Additionally, sugar consumption has specifically been shown to be related to GWG/EGWG, as well as pregnancy and offspring outcomes, but not postpartum mental health. However, existing animal models and human studies support relations between sugar consumption and depression, anxiety, and stress in non-pregnant samples with adult samples suggesting both short- and long-term effects (Knüppel et al., 2017). Therefore, studies should investigate direct and indirect relations between maternal prenatal diet (particularly sugar intake) and postnatal depressive, anxious, and perceived stress symptoms, while considering pre-pregnancy BMI and GWG. Furthermore, while relations between maternal diet and depression and anxiety are more clear, when stress is involved, the predictive nature of this relationship in perinatal samples is ambiguous (Fowles et al., 2011; Hurley et al., 2005), suggesting that studies examine this outcome in particular. Although the literature suggests that some women increase their added sugar consumption during pregnancy (Graham et al., 2013), the impact of added sugar on antenatal mental health has not been investigated and will therefore be the focus of the current thesis study.

Current Study

This study seeks to investigate the relationship between pre-pregnancy BMI and depressive symptoms, symptoms of anxiety, and perceived stress at 6 months postpartum. While

depressive, anxious, and perceived stress symptoms are often correlated, they are not necessarily experienced together, or at the same levels. As such, each will be defined and investigated as separate constructs. This will add to existing literature by determining whether established relations between pre-pregnancy BMI and depression and anxiety generalize to a U.S. sample in an HPSA for primary care and mental health, and add to the dearth of literature examining BMI and stress in human perinatal samples. Further, given that the literature indicates significant relations between perinatal BMI and GWG, and GWG and perinatal depression, this study seeks to determine whether GWG mediates the relationship between pre-pregnancy BMI and postpartum mental health. Similarly, prior empirical studies support relations between postpartum mental health and dietary patterns, of which those high in added sugar, sweets, and confections have been demonstrated to be related to increased depression and anxiety symptoms throughout pregnancy and postpartum. Given support for the interrelated nature of maternal perinatal diet and weight, this study will seek to elucidate interactions between pre-pregnancy BMI and prenatal added sugar intake in predicting GWG and postpartum depression, anxiety, and perceived stress symptoms in the long-term (i.e., 6 months postnatally). This will be the first known study to examine these complex multivariate relationships in a longitudinal sample of U.S. women in HPSAs for primary care and mental health, who have limited access to services.

Hypotheses

Hypothesis 1: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Depression Symptoms

Hypothesis 1a (mediation): GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal depressive symptoms at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict

increased maternal depressive symptoms at 6 months postpartum (see Figure 1 in Proposed Analyses).

Hypothesis 1b (moderation with added sugar): The relationship between elevated pre-pregnancy BMI and maternal postnatal depressive symptoms will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to increased maternal depressive symptoms at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy (see Figure 1 in Proposed Analyses).

Hypothesis 1c (moderated mediation with added sugar): The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to greater GWG in women with greater added sugar intake, which will predict increased maternal depressive symptoms at 6 months postpartum (see Figure 1 in Proposed Analyses).

Hypothesis 2: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Anxiety Symptoms

Hypothesis 2a (mediation): GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal anxiety symptoms at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict increased maternal anxiety symptoms at 6 months postpartum (see Figure 1 in Proposed Analyses).

Hypothesis 2b (moderation with added sugar): The relationship between pre-pregnancy BMI and maternal anxiety symptoms at 6 months postpartum will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-

pregnancy BMI will be more robustly related to increased maternal anxiety symptoms at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy (see Figure 1 in Proposed Analyses).

Hypothesis 2c (moderated mediation with added sugar): The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to greater GWG in women with greater added sugar intake, which will predict increased maternal anxiety symptoms at 6 months postpartum (see Figure 1 in Proposed Analyses).

Hypothesis 3: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Perceived Stress

Hypothesis 3a (mediation): GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal perceived stress at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict increased maternal perceived stress at 6 months postpartum (see Figure 1 in Proposed Analyses).

Hypothesis 3b (moderation with added sugar): The relationship between pre-pregnancy BMI and maternal postnatal perceived stress will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to increased maternal perceived stress at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy (see Figure 1 in Proposed Analyses).

Hypothesis 3c (moderated mediation with added sugar): The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to

greater GWG in women with greater added sugar intake, which will predict increased maternal perceived stress at 6 months postpartum (see Figure 1 in Proposed Analyses).

Methods

Participants

Data for this study have been collected as part of the Infant Development and Healthy Outcomes in Mothers (IDAHO Mom) Study in the Perinatal Psychobiology Lab at Idaho State University (ISU). Aims of the IDAHO Mom Study included determining the influence of maternal health during pregnancy on maternal and infant outcomes at 6 months postpartum. The ISU Human Subjects Committee approved the study. Aims of the IDAHO Mom Study included determining the influence of maternal health during pregnancy on maternal and infant outcomes at 6 months postpartum. Expectant mothers (n=125) attended a prenatal session in their third trimester of pregnancy and the majority (n=96) returned for a follow-up session at 6 months postpartum. In order to protect against inflated effect sizes or power estimates via a sample size of too few or too many participants, *a priori* power analyses were conducted calling for medium effect sizes (which vary depending on the measure), and power estimates of .80 (Ferguson, 2009). Fritz and MacKinnon (2007) determined via mediation model simulation that for a medium effect size for a and b paths (d=0.39) using bias-corrected bootstrapping methods, a sample size of 71 allows for sufficient power (0.80). A G*Power *a-priori* power analysis was used for the present study, indicating that in a linear multiple regression for a fixed model, R-squared increase with 3 tested predictors and up to 5 covariates, a medium effect size (f^2=0.15), low Type I error probability (α=0.05), and power of 0.80 would require a sample size of 77 (Faul, Erdfelder, Lang, & Buchner, 2007). Given these suggestions, the sample of 92 participants was considered adequate for testing current study hypotheses.

Participant data was collected from pregnant women aged 18 to 36 (M_{AGE}=27.29, SD_{AGE}=3.85) at 35 weeks gestation (±2 weeks; $M_{GESTATION}$=34.38, $SD_{GESTATION}$=1.28) and 6 months postpartum (M_{POST}=6 months, 2.27 days, SD_{POST}=7.31 days). Participants identified as White/Caucasian (92%,), Hispanic/Latino (14%), Other (7%), Black or African American (2%,), Native Hawaiian or Other Pacific Islander (2%), American Indian/Alaska Native (1%,), and Asian (1%). Ethnic categories were not mutually exclusive. Participants also identified as married (84%), single/never married (10%), in a committed relationship (3%), engaged (2%), and divorced (1%). In reference to total annual household income, 2% reported income between $5,000 and $9,999, 14% between $10,000 and $19,999, 18.5% between $20,000 and $29,999, 13% between $30,000 and $39,999, 9.8% between $40,000 and $49,999, 28.3% between $50,000 and $74,999, 7.6% between $75,000 and $99,999, and 6.5% earning $100,000 or greater. Participants identified having completed junior high school (1.1%), partial high school (2.2%), a high school degree (including GED; 15.2%), partial college (minimum 1 year or other specialized or technical training; 32.6%), standard college or university degree (i.e., BA/BS; 39.1%), or graduate training with a degree (9.8%). Participants reported having their first-born (40.2%), given birth to one other child (30.4%), two other children (13%), three other children (6.5%), four other children (2.2%), five other children (5.4%), six other children (1.1%), or 8 other children (1.1%). Participants identified their religious preferences as Agnostic (3%), Assembly of God (2%), Atheist (2%), Baptist (2%), Catholic (4%), Church of Jesus Christ of Latter-day Saints (63%), Lutheran (2%), Methodist (1%), Non-denominational (11%), Pentecostal (1%), Presbyterian (1%), Other (13%), or preferred not to answer (9%). Religious categories were not mutually exclusive. Participant addresses were processed via the Rural Health Information Hub's "Am I Rural?" tool, a search tool that categorizes addresses under

various agency definitions of Urbanized Area, in order to determine rural, Health Professional Shortage Area (HPSA), and/or Medically Underserved Area (MUA) status (Rural Health Information Hub, 2019). In reference to addresses outside of Urbanized Areas, or "rural" areas according to the U.S. Census, 17% of participants lived in rural areas and MUAs. Further, 79% of participants lived in areas designated as HPSA for Primary Care physicians, and 100% of participants lived in areas designated as HPSA for Mental Health.

Data collection began on 04/21/2015 for the prenatal sessions, and postnatal sessions began on 11/16/2015. My involvement with the study began in October of 2014 as an undergraduate RA, and again in October of 2016 as a graduate student. Inclusion criteria for the IDAHO Mom study were women ages 18-35 with singleton pregnancies who were fluent in English and between 33-37 weeks gestation. Exclusion criteria for the study were women pregnant with twins or multiples; women who were diagnosed with health conditions such as GDM, HDP, thyroid disorders, human immunodeficiency virus (HIV) or acquired immunodeficiency syndrome (AIDS), or behavioral health conditions such as schizophrenia or bipolar disorder; women who were taking Federal Drug Administration (FDA) category D or X medications (those known to affect infant outcomes); or women who consumed recreational substances or >40 drinks of alcohol over the course of their pregnancy. Overall, 506 women were contacted to participate, and 71 were determined ineligible to continue.

Those for which exclusion criteria were not met were invited to an initial prenatal session, and 124 participants declined the invitation. Reasons for declining to participate included a long commute to the study site (n=53), the required time commitment (n=19), scheduling conflicts (n=15), moving out of the area (n=7), being on bed rest (n=6), concern about going into labor (n=2), not possessing custody of the current baby (n=1), or lack of energy (n=1). An additional

27 women declined to provide a reason or were otherwise uninterested in participating. Many prospective participants were unreachable by telephone, text message, and/or email communication (*n*=179). Participants who completed the prenatal session and the postnatal session were invited to participate in 10- 14- and 18-month postpartum follow-up appointments; however, those data will not be used in the current thesis study. Data collection was completed for the follow-up appointments on 06/29/2018, with 44 participants completing the 10-month postpartum session, 53 completing the 14-month postpartum session, and 54 completing the 18-month postpartum session.

Procedures

Privacy and confidentiality. In order to preserve participant privacy and confidentiality, forms containing identifying information (e.g., names on written consent forms) were held in a locked cabinet in a locked laboratory, separately from participant data. A password-protected desktop computer located in the locked laboratory was used to store information used to contact participants (i.e., phone numbers, mailing and email addresses), and was only accessible by research assistants (RAs). Each participant was assigned a unique number used to code information gained during the study, such as interviews, anthropomorphic, and questionnaire data. These data were stored on an encrypted, password protected laptop computer, which was stored in a locked cabinet in the locked laboratory. A written key connecting participant names and unique identifiers (housed in a separate, locked file cabinet) was utilized briefly to assist with contacting participants between prenatal, postnatal, and follow-up sessions, and will be destroyed when IDAHO Mom Study data analyses are completed.

Recruitment. Participants were recruited from the community in a variety of settings, including local medical and other service providers associated with pregnancy; family

service/product providers; Idaho State University-based services for students; and advertisements on social media. Prospective participants who contacted the lab via the phone number listed on flyers, via email from advertisements, or provided their name and phone number during community events were contacted by RAs for a brief phone screen to determine eligibility and provide information regarding the study design. Those who expressed interest in further participation and did not meet exclusion criteria were invited to attend the prenatal session during their third trimester (35 weeks gestation ±2 weeks).

Prenatal session. Participants met with a trained RA in the lab during their third trimester, where they began by participating in the informed consent process. RAs gave participants information on the purpose of the IDAHO Mom study, any benefits (e.g., incentives) or foreseeable risks (e.g., feelings of discomfort) of participation, limits to confidentiality, and the participant's rights to skip questions or withdraw consent at any time without penalty. RAs provided the information by reading the consent form (written at an eighth-grade reading level) aloud to the participant, who was given a copy of the form if they wished to refer to the document. Participants indicated that they understood the concepts and agreed to participate in the study by signing the consent form.

Participants were then interviewed by trained RAs regarding their current and past pregnancy-related information, brief health history, sociodemographic characteristics, psychological symptoms (modules A-I, L, and O from the Mini International Neuropsychiatric Interview 6.0 (M.I.N.I. 6.0; Sheehan et al., 1998) and depressive symptoms from the EPDS, and substance use. Interviews lasted approximately 40 minutes, following which anthropomorphic measurements were taken (e.g., weight, height, and abdominal circumference), lasting approximately 10 minutes. Participants were then asked to complete several self-report measures

via an encrypted laptop, taking approximately 40 minutes. The self-report measures included in the current thesis study demonstrated good reliability and validity, including the Perceived Stress Scale, 14-item (PSS-14), Dietary Screener Questionnaire (DSQ), and Perinatal Anxiety Screening Scale (PASS), in addition to the Eating Behavior Questionnaire (meal and fast food frequency questionnaire; National Heart Lung and Blood Institute, 2011), Perinatal Obsessive-Compulsive Scale (self-report of obsessional thoughts and compulsive behavior during the perinatal period; Lord, Rieder, Hall, Soares, & Steiner, 2011), Domain-Specific Risk-Taking Scale (self-report measure of risk-taking behavior; Blais & Weber, 2006), Severity of Violence Against Women Scale (self-report of interpersonal conflict between participant and an identified romantic partner; Marshall, 1992); Trauma History Questionnaire (self-report of experience of past or current traumatic experiences; Hooper, Stockton, Krupnick, & Green, 2011); and Infant Crying Questionnaire-Prenatal Version (maternal sensitivity and responsiveness questionnaire; Leerkes et al., 2014). Participants were reimbursed $30 for their time in completing the session. Following reimbursement, the RA explained the 3-day saliva sampling procedure to the participant, and a time to collect saliva sampling packets from participants was prearranged, as well as reimbursement for competing the packets. Participants who endorsed critical items on any of the measures, or reported experiencing any distress during the visit, were provided a mental health resource list, which was reviewed by the RA before ending the session. Those who completed the saliva samples were reimbursed $15 for their time upon retrieval of the sampling packets.

Postnatal session. RAs contacted participants by phone, email, and/or postal service approximately 1 month after the participant's due date to schedule their 6-month postnatal session. Participants were contacted at 1 month, 1 week, and 1 day prior to their 6-month session

by RAs to confirm the scheduled session. During the postnatal session, participants and their infants completed a series of video recorded behavioral tasks, including: (1) a free-play interaction, (2) observation of baby playing with blocks, and (3) gentle infant arm holding by RA (Goldsmith & Rothbart, 1988), which took about 20 minutes. As part of the behavioral task protocol, participants began the Infant Health and Sleep Questionnaire during the observation task, and completed the questionnaire with the other self-report measures later in the session. Participants and their infants were then weighed, and height/length and abdominal circumference was measured by RAs, which took roughly 10 minutes. RAs then interviewed participants regarding their health since the prenatal session, their infant's health, psychological health (via the M.I.N.I. 6.0), and substance use, which took approximately 30 minutes. Participants were provided an encrypted laptop to complete the following self-report measures: EPDS, PSS-14, DSQ, PASS, Eating Behavior Questionnaire, Perinatal Obsessive-Compulsive Scale-Postnatal, Infant Crying Questionnaire-Postpartum Version (Leerkes et al., 2014), and Infant Behavior Questionnaire-Revised-Short Form (maternal report of the frequency of infant behaviors; Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014), which took about 60 minutes. Participants were reimbursed $30 for their time in completing the session.

Data disposal. All non-identifying quantitative and qualitative data will be submitted for archiving. Following American Psychological Association (APA) Record Keeping Guidelines (APA, 2007), data at ISU will be stored for no less than 3 years after infants in the study reach 21 years of age. Data will be stored in hard copy and/or electronic files and backed up onto the ISU Box electronic server and will be destroyed in such a manner as to protect the confidentiality of all participants once all projects related to the IDAHO Mom Study are completed.

Measures

Variables examined in the current thesis study include maternal pre-pregnancy BMI, gestational weight gain, added sugar intake in the third trimester, postnatal depression and anxiety symptoms, and postnatal perceived stress at 6 months postpartum. As indicated by prior research, potential covariates include maternal age at prenatal session, ethnicity, educational attainment, household income, and parity.

Maternal pre-pregnancy BMI. Maternal pre-pregnancy BMI was determined by dividing participants' pre-pregnancy weight in kilograms by the square of her height in meters (kg/m^2). Maternal pre-pregnancy weight in pounds was reported on line 18 of the prenatal session screener (see Appendix A) converted to kilograms (kg) by using the formula kg=lb/2.2046. Height was measured in centimeters (cm; see Appendix B) by RAs using an adult standiometer (Shorr Productions, Olney MD; accuracy to 0.1 cm) at the prenatal session, and converted to meters (m) using the formula m=cm/100. Due to underrepresentation, participants in the underweight pre-pregnancy BMI range were excluded (n=4, M_{BMI}=17.5, SD_{BMI}=1.5). Of the remaining participants (n=92), pre-pregnancy BMI ranged from 18.7 to 55.5 (M_{BMI}=27.2, SD_{BMI}=6.46), with 45 participants (49%) within the normal category, 23 (25%) within the overweight category, and 24 (26%) in the obese category.

Gestational Weight Gain (GWG). GWG was determined via calculating the difference between measured weight at the prenatal session (i.e., 33-37 weeks gestation; see Appendix B) and the reported pre-pregnancy weight on the prenatal screener (see Appendix A). Maternal weight was taken in kilograms (kg), using a battery powered, calibrated scale (Seca 876; accuracy to 0.1 kg) with participants wearing as little outerwear as possible, including all external layers (e.g., coats, hats, scarves, etc.), with empty pockets and without shoes or jewelry.

Pre-pregnancy weight was converted from pounds to kg utilizing the formula kg=lb/2.2046, and rounded to the nearest tenth for continuity with maternal weight. GWG ranged from -8.64kg to 48.8 kg (M_{GWG}=12.85 kg, SD_{GWG}=8.28 kg) in this study.

Added sugar intake. The Dietary Screener Questionnaire (DSQ; see Appendix C) is a 26-item self-report dietary intake screener developed by the National Cancer Institute (NCI) for the National Health and Nutrition Survey (NHANES) 2009-2010 (NCI, 2018) for individuals aged 2–65 years. The DSQ records the frequency of consumption of 19 specific food items over the previous 30 days to infer intake of specific food groups and nutrients; namely fruits, vegetables, legumes, dairy/calcium, added sugars (as well as those from sugar-sweetened beverages), whole grains/fiber, red meat, and processed meat (NCI, 2018). Reported frequencies of consumption are converted to estimates of daily intake using scoring algorithms developed for NHANES 2009-2010 (NCI, 2018; Thompson, Midthune, Kahle, & Dodd, 2017), and generated using SAS software, University Edition. This study will utilize predicted daily added sugar intake, which will be converted from teaspoons (tsp) equivalents to grams (g) using the formula g=tsp*4.2 as suggested by the National Center for Health Statistics (Cioffi et al., 2018). Utilizing NHANES data, regression coefficient from added sugar intake on the DSQ in relation to 24-hour recall estimates (for example, EATS) was 0.77 among women (Thompson et al., 2017).

Depression symptoms. Depressive symptoms were measured by the EPDS (see Appendix D; Cox, Holden, & Sagovsky, 1987). The EPDS evaluates experiences and feelings over the previous 7 days, such as feeling sad or miserable, scared or panicky, unhappy to the extent of crying, or unable to cope, using the 10-item questionnaire on a 4-point Likert scale (i.e., 0=not at all, 1=not much, 2=sometimes, 3=quite a lot/often, or similar), with items 3 and 5-10 inversely scored (Cox et al., 1987). Originally designed the screen for postpartum depressive

symptoms, the EPDS was validated for use throughout pregnancy (Bergink et al., 2011; Cox et al., 1987). The EPDS was found to have high test-retest correlation coefficients from 12 to 24, weeks gestation (r=0.61), 12 to 36 weeks (r=0.55), and 24 to 36 weeks (r=0.55), with high concurrent validity when compared to the Symptom Checklist-90 items (SCL-90) anxiety and somatization subscales throughout pregnancy (r>0.50; p<0.001; Bergink et al., 2011). Postpartum, the EPDS was found to have high concurrent validity (r^2=0.80; p<0.0001) with the GHQ-12 (Navarro et al., 2007). Further, Reichenheim, Moraes, Oliveira, and Lobato (2011) found that the overall total score was well suited to represent postpartum depressive symptoms, as opposed to a multi-factor approach. For the present sample of 92 participants, the EPDS demonstrated good reliability (Cronbach's α=0.81).

Symptoms of anxiety. Symptoms of anxiety were measured by the Perinatal Anxiety Screening Scale (PASS; see Appendix E; Somerville et al., 2014). The PASS was developed to screen for problematic anxiety symptoms specific to the perinatal population, such as fear, worry, or dread in regard to the baby, controlling or perfectionist behaviors, fear of negative appraisal, and general difficulty with coping or adjustment (Somerville et al., 2014). The PASS consists of four subscales that can be combined for a total global anxiety score: general worry and specific fears; perfectionism, control and trauma; social anxiety; and acute anxiety and adjustment (Somerville et al., 2014). The PASS evaluates symptoms of anxiety over the past month on a 4-point Likert scale (i.e., 0=not at all, 1=sometimes, 2=often, 3=almost always), with items totaled and higher scores indicating increased levels of anxiety (Somerville et al., 2014). The PASS demonstrated high convergent validity with the 21-item Depression Anxiety and Stress Scale (DASS-21) Anxiety scale and the STAI State and Trait Anxiety subscales (Pearson r=0.75-0.83, p<.01), and adequate test-retest reliability (r=0.74) when women completed the measure in their

third trimester and again at two to six months postpartum (Somerville et al., 2014). For the participants in the present study, the PASS demonstrated high reliability (Cronbach's α=0.93).

Perceived stress. Perceived stress was measured by the PSS-14 (See appendix F; Cohen, Kamarck, & Mermelstein, 1983), which measures "the degree to which situations in one's life are appraised as stressful" (Cohen et al., 1983, p. 388). The PSS-14 evaluates thoughts, feelings, and coping behaviors in relation to life hassles, changes, and personal problems over the past month, with 7 positive and 7 negative items. Items were scored according to the Likert scale of the survey (i.e., never=0, almost never=1, only occasionally=2, fairly often=3 and 4=very often), with items 4-7, 9,10 and 13 inversely scored (Cohen et al., 1983). Originally validated with college students and a smoking cessation program, the PSS-14 demonstrated high reliability (Cronbach's α=0.84-0.86). While the PSS-14 has not been validated for pregnant women, the Arabic version of the PSS-10 (a 10-item version of the PSS) was validated among a sample of pregnant, postpartum, and college students, demonstrating adequate reliability (Cronbach's α=0.71-0.75), moderately high test-retest reliability after 2-3 weeks for (Spearman's ρ=0.63), and significant correlations with the GHQ-12 (Spearman's ρ=0.56-0.67) for pregnant and postpartum women (Chaaya, Osman, Naassan, & Mahfoud, 2010). Similarly, the PSS-10 was utilized in pregnant and postpartum women in Canada, in the second and third trimesters of pregnancy, and at 4 and 12 months postpartum, demonstrating high reliability (Cronbach's α=0.88-0.89) for all time periods, moderate test-retest reliability between the second and third trimesters (r=0.64), and significant correlations with the STAI State Anxiety subscale (r=0.75-0.77; Benediktsson, McDonald, & Tough, 2017). For the 92 participants of the current study, the PSS demonstrated good reliability (Cronbach's α=0.78).

Covariates

Age. Maternal age was established at the prenatal session on the Pregnancy Context Questionnaire (see Appendix G). Participants were asked to provide their birthdate and age. Literature suggests that maternal age at pregnancy has correlated with increased symptoms of perinatal depression (Ertel et al., 2017, 2015; Salehi-Pourmehr et al., 2018), anxiety (Hurley et al., 2005; Laraia et al., 2009; Mina et al., 2015; Paskulin et al., 2017), and perceived stress (Hurley et al., 2005; Laraia et al., 2009), and has been used as a covariate in those contexts. In this study, age at the prenatal session ranged from 18 to 36 (M_{AGE}=27.29, SD_{AGE}=3.85).

Household income. Household income was reported in the prenatal session as part of the sociodemographic interview (see Appendix H). Income was categorized, with 2% reported income between $5,000 and $9,999, 14% between $10,000 and $19,999, 18.5% between $20,000 and $29,999, 13% between $30,000 and $39,999, 9.8% between $40,000 and $49,999, 28.3% between $50,000 and $74,999, 7.6% between $75,000 and $99,999, and 6.5% earning $100,000 or greater (*Median*=$50,000-$75,000). Household income has been suggested in the literature to be correlated with increased symptoms of perinatal depression (Ertel et al., 2017; Paskulin et al., 2017), anxiety (Hurley et al., 2005; Laraia et al., 2009; Yannakoulia et al., 2008), and perceived stress (Hurley et al., 2005; Laraia et al., 2009).

Educational attainment. Educational attainment was established during the prenatal session as part of the sociodemographic interview (see Appendix H). Educational attainment was categorized as the greatest amount of education completed by participants, with 1% completing junior high school, 2% partial high school, 15% a high school degree (including GED), 33% partial college (minimum 1 year or other specialized or technical training), 39% standard college or university degree (i.e., BA/BS), and 10% completing graduate training with a degree. The

median educational attainment completed was partial college. Within existing studies, positive associations have been found between educational attainment and symptoms of depression (Baskin et al., 2017; Bodnar et al., 2009; Ertel et al., 2015), anxiety (Hurley et al., 2005; Laraia et al., 2009; Yannakoulia et al., 2008), and perceived stress (Hurley et al., 2005; Laraia et al., 2009). Therefore, it will be determined whether similar relationships exist in the current study.

Parity. Maternal parity was established at the prenatal session on the Pregnancy Context Questionnaire (see Appendix G). Participants were asked to record the number of children they had given birth to, live births specifically. Increased maternal parity was identified as significantly correlated with depressive symptoms (Chatzi et al., 2011; Ertel et al., 2017, 2015; Hurley et al., 2005; Salehi-Pourmehr et al., 2018), symptoms of anxiety (Hurley et al., 2005; Vilela et al., 2015), and perceived stress (Hurley et al., 2005; Laraia et al., 2009). In this study, maternal parity ranged from 0 to 8 live births (M_{PARITY}=1.27, SD_{PARITY}=1.62).

Ethnicity. Maternal ethnicity was established at the prenatal session during the sociodemographic interview (see Appendix I). Participants identified as White/Caucasian (92%), Hispanic/Latino (14%), Other (7%), Black or African American (2%,), Native Hawaiian or Other Pacific Islander (2%), American Indian/Alaska Native (1%), and Asian (1%). Categories were not mutually exclusive. In prior research, ethnicity has been identified as significantly correlated with depressive symptoms (Ertel et al., 2017), symptoms of anxiety (Laraia et al., 2009), and perceived stress (Laraia et al., 2009).

Proposed Analyses

In order to demonstrate the hypothesized relationships between pre-pregnancy BMI (X), GWG (M), and depressive symptoms, symptoms of anxiety, and/or perceived stress at 6 months postpartum (Y), a mediation model was hypothesized (see Hypothesis 1a, 2a, and 3a). Further, given the interaction between diet and weight, added sugar intake (W) was proposed to moderate

this mediation relationship on both the direct path (see Hypothesis 1b, 2b, and 3b), and the indirect path (see Hypothesis 1c, 2c, and 3c), therefore a conditional process model was hypothesized (see Figure 1).

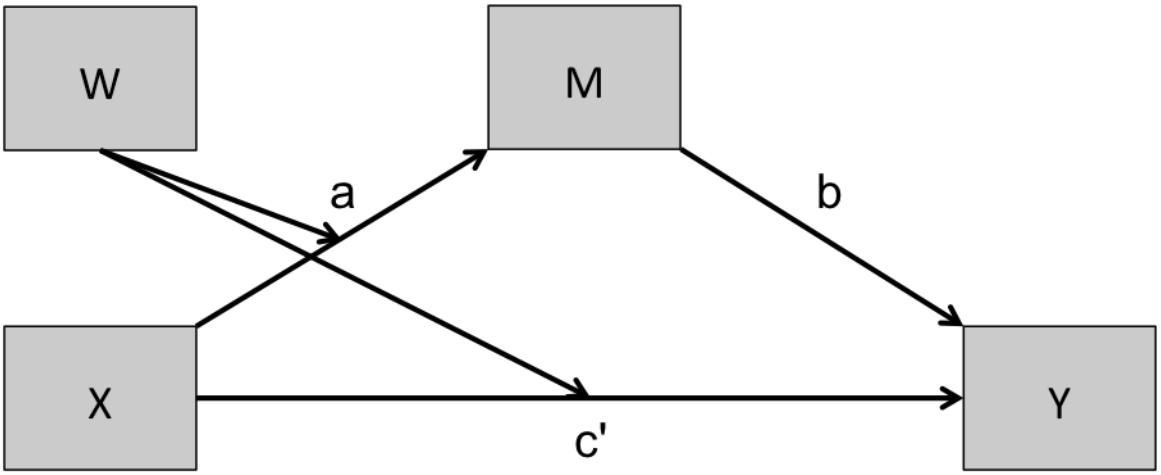

Figure 1. In this model, pre-pregnancy BMI is X, depressive symptoms, symptoms of anxiety, or perceived stress at 6 months postpartum is Y, and added sugar intake is W. The relationship between X and Y is the direct path, M is the mediator, and W is the moderator in this model.

All analyses were conducted using IBM SPSS Statistics for Macintosh, Version 25.0 (IBM Corp., 2017). Initial analyses included descriptive statistics for all variables, including potential covariates. Covariates were determined through Pearson correlation, in that those that significantly correlated with both predictor and outcome variables were added to the respective model outlined in Figure 1. Regression assumptions of normality, linearity, homoscedasticity, and multicollinearity were tested prior to running the models to determine whether data transformation would be needed. Specifically, distributions of scores were be tested for normality through inspection of frequency histograms, linearity was assessed through inspection of residuals scatterplots, multicollinearity was assessed through correlations of outcome variables, and homoscedasticity was assessed through plotting residuals. However, it should be

noted that the model testing software procedures are robust against these assumptions. Specifically, all models were tested using Hayes PROCESS macro v2.16 (Hayes, 2013).

A mediation model was tested for Hypotheses 1a, 2a, and 3a. Specifically, we estimated the direct effect of X on Y, or the c′ (c prime) path via the formula $c' = [\hat{Y} \mid (X=x, M=m)] - [\hat{Y} \mid (X=x-1, M=m)]$, which represents c′ as an estimated value of Y given two equal cases of m that differ by one unit on X (Hayes, 2013, p. 91). In other words, the c′ path represents the relationship between X and Y controlling for the contribution of M. We estimated the indirect effect of X on Y through M, or the product a and b paths, via the formulae $a = [\hat{M} \mid (X=x)] - [\hat{M} \mid (X=x-1)]$ and $b = [\hat{Y} \mid (M=m, X=x)] - [\hat{Y} \mid (M=m-1, X=x)]$, where the a path estimates how the values of M differ when the values of X differ by one unit, and the b path estimates the number of units that Y differs given equal units of X and M values that differ by one unit (Hayes, 2013, p. 92). To estimate the total effect (c) of X on Y, which represents the amount by which Y differs given X values that differ by one unit, we used the formula $c = c' + ab$ (Hayes, 2013, p.93). The significance of the direct effect was determined given a two-tailed *p*-value <.05, and a 95% confidence interval that did not include zero, indicating that the direct effect significantly differed from zero. The indirect effect was assessed using a bias-corrected bootstrap confidence interval, which calculated a confidence interval via bootstrapping with replacement, and corrected for bias by examining the distribution of the bootstrap estimates and removing the proportion of the estimates that were below the original value of *ab* from the original data, thereby creating a z-score, which was normally distributed in order to compare the original distribution and determine the upper and lower bounds of the confidence interval (Hayes, 2013, p. 112). Based on recommendations by Hayes (2013), 5,000 iterations were used for this study.

To estimate how W affects the relationship between X and M, and X and Y, a conditional process model was tested (see Figure 1). This model estimated the conditional direct effect of X on Y through moderation of W, and the conditional indirect effect of X on Y through M, as moderated by W. In this case, the conditional direct effect (Hypotheses 1b, 2b, 3b) was represented with the formula $\theta_{X\rightarrow Y}=c'_1 + c'_3W$, which quantified how changes in X map onto changes in Y as a function of W (Hayes, 2013, p.374). The conditional indirect effect (Hypotheses 1c, 2c, and 3c) was represented with the formula $\theta_{X\rightarrow M}b=(a_1 + a_3W)b$, which quantifies how changes in X map onto changes in Y (represented by b) indirectly through M, depending on the value of W (Hayes, 2013, p.373).

Results

Descriptive Statistics

Descriptive statistics of potential covariates indicated a mean participant age of 27.29 (*SD*=3.85). The majority of participants identified as European-American (88%), with 14% identifying as Hispanic or Latina. Most participants earned an annual income of $50,000-74,999 (28%), had earned a college or university degree (39%), were expecting their first child (40%), identified as members of the Church of Jesus Christ of Latter-day Saints (63%), and were living in an HPSA for Primary Care (79%) and Mental Health (100%).

Participant pre-pregnancy BMI ranged from 18.7-55.5 (*M*=27.22, *SD*=6.46), GWG from -8.64 kg–48.8 kg (*M*=12.86 kg, *SD*=8.28 kg), and added sugar intake from 44.43 g -175.3 g estimated daily intake based on scoring algorithms (*M*=70.13 g, *SD*=24.05 g; NCI, 2018; Thompson et al., 2017). The average score on the EPDS was 4.54 (*SD*=3.66) out of 30 possible points. The average score on the PASS was 14.84 (*SD*=10.51) out of 93 possible points, and the average score on the PSS was 19.99 (*SD*=6.02) out of a possible 56 points. As expected, scores

on the EPDS were significantly correlated with scores on the PASS (r=0.674, p<.001) and PSS scores (r=0.632, p<.001), and PASS scores were significantly correlated with PSS scores (r=0.571, p<.001).

Bivariate Pearson correlation tables (see Appendix J) indicated five statistically significant correlations between predictor and outcome variables. Pre-pregnancy BMI was negatively correlated with GWG (r=-0.25, p=0.016), and positively correlated with postpartum EPDS score (r=0.22, p=0.035). Prenatal added sugar intake was significantly correlated with postpartum EPDS score (r=0.234, p=0.025), postpartum PASS score (r=0.25, p=0.016), and postpartum PSS score (r=0.299, $p<.01$). Bivariate Pearson correlations between potential covariates and outcome measures indicated two significant correlations between both predictor and outcome variables. Maternal age was significantly negatively correlated with added sugar intake (r=-0.226, p=0.030), PASS score (r=-0.207, p=0.048), and PSS score (r=-0.256, p=0.014), and therefore was included as a covariate in models including added sugar intake with PASS and PSS as the outcome variable. Point-biserial correlations indicated a significant correlation between added sugar intake and identifying as Hispanic/Latina (r=0.27, p<.01).

Regression Assumptions

Frequency histograms were inspected for normality of variable distributions, and when skewness was visible (i.e., extended tails to the left or right or the normal curve), skewness z-scores were calculated. Transformations were performed on variables with skewness z-scores >3.29 or <-3.29 prior to primary analyses, depending on the perceived severity and direction of the skew, as recommended by Tabachnick & Fidell (2013). As such, EPDS and PASS scores were transformed via square root transformations, pre-pregnancy BMI via log transformation, and added sugar intake via inverse transformation, which was then multiplied by negative one

for ease of interpretation (Tabachnick & Fidell, 2013). Three outliers (± 3 SD) were identified, one participant in pre-pregnancy BMI, one in GWG, and one in added sugar intake. Following transformation, inclusion of the outliers did not prevent the data from being within appropriate skewness or kurtosis value limits (i.e., reduced *z*-score to ≤3.29 for $p<.001$, two-tailed test; Tabachnick & Fidell, 2013, *p*. 73). Therefore, none of the outliers were removed. Linearity and homoscedasticity were assessed via inspection of residuals scatterplots (i.e., symmetrical distributions, clustered around zero on the y-axis, with the overall shape as rectangular) and no other violations of regression assumptions were found.

Primary Analyses

Hypothesis 1: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Depression Symptoms

Hypothesis 1a: GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal depressive symptoms at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict increased maternal depressive symptoms at 6 months postpartum.

This overall mediation model was not significant (R^2=0.054, F[2,89]=2.54, p=0.085). Specifically, GWG did not predict maternal depressive symptoms at 6 months postpartum (b=0.007, t(90)=0.720, SE=0.010, p=0.473). However, greater pre-pregnancy BMI predicted lower GWG (b=-21.974, t(90)=-2.450, SE=8.968, p=0.016), indicating a significant *a*-path. Further, pre-pregnancy BMI significantly predicted maternal depressive symptoms at 6 months postpartum (b=1.919, t(89)=2.246, SE=0.854, p=0.027), indicating a significant c' path. However, the bias-corrected bootstrap confidence interval of the indirect effect included 0

(effect=-0.154, *SE*=0.258, 95% CI [-0.783, 0.253]), suggesting that the indirect effect was not statistically significant.

Hypothesis 1b: The relationship between elevated pre-pregnancy BMI and maternal postnatal depression will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to increased maternal depressive symptoms at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy.

Within the moderated mediation model, the interaction between pre-pregnancy BMI and added sugar intake in the third trimester did not significantly predict maternal depressive symptoms at 6 months postpartum (*b*=-91.092, *t*(87)=-0.480, *SE*=189.696, *p*=0.6323) and there was not a significant amount of explained variance in EPDS scores added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}=0.002, *F*[1,87]=0.231).

Hypothesis 1c: The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to greater GWG in women with greater added sugar intake, which will predict increased maternal depressive symptoms at 6 months postpartum.

The relationship between pre-pregnancy BMI and GWG was not moderated by added sugar intake in the third trimester in the moderated mediation model (*b*=-100.132, *t*(88)=-0.047, *SE*=2143.280, *p*=0.963) and there was not a significant amount of explained variance in GWG added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}<0.0001, *F*[1,88]=0.002). Similarly, the conditional indirect effect of pre-pregnancy BMI on maternal depressive symptoms at 6 months postpartum via GWG was not statistically

significant, suggesting that there was not statistically significant moderated mediation within the model (Index of moderated mediation=-0.733, *SE*=33.441, 95% CI [-78.720, 65.553]).

Hypothesis 2: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Anxiety Symptoms

Hypothesis 2a: GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal anxiety symptoms at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict increased maternal anxiety symptoms at 6 months postpartum.

This overall mediation model was not significant (R^2=0.026, F[2,89]=2.54, p=0.317). Specifically, GWG did not predict increased maternal anxiety symptoms at 6 months postpartum (*b*=0.001, *t*(89)=0.090, *SE*=0.016, *p*=0.929), and pre-pregnancy BMI did not predict maternal anxiety symptoms at 6 months postpartum (*b*=2.109, *t*(89)=0.090, *SE*=0.016, *p*=0.929). However, greater pre-pregnancy BMI predicted lower GWG (*b*=-21.974, *t*(90)=-2.450, *SE*=8.968, *p*=0.016), indicating a significant *a*-path. The bias-corrected bootstrap confidence interval of the indirect effect included 0 (effect=-0.032, *SE*=0.403, 95% CI [-1.028, .646]), suggesting that the indirect effect was not statistically significant.

Hypothesis 2b: The relationship between pre- pregnancy BMI and maternal anxiety symptoms at 6 months postpartum will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to increased maternal anxiety symptoms at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy.

Within the moderated mediation model, the interaction between pre-pregnancy BMI and added sugar intake in the third trimester did not significantly predict maternal anxiety symptoms

at 6 months postpartum (*b*=-341.394, *t*(86)=-1.100, *SE*=310.375, *p*=0.274) and there was not a significant amount of explained variance in PASS scores added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}=0.012, *F*[1,86]=1.210), while controlling for age.

Hypothesis 2c: The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to greater GWG in women with greater added sugar intake, which will predict increased maternal anxiety symptoms at 6 months postpartum.

The relationship between pre-pregnancy BMI and GWG was not moderated by added sugar intake in the third trimester in the moderated mediation model (*b*=-574.234, *t*(87)=-0.269, *SE*=2138.661, *p*=0.789) and there was not a significant amount of explained variance in GWG scores added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}=0.0008, *F*[1,87]=0.072). Similarly, the conditional indirect effect of pre-pregnancy BMI on maternal anxiety symptoms at 6 months postpartum via GWG as not statistically significant, suggesting that there was not statistically significant moderated mediation within the model (Index of moderated mediation=-3.505, *SE*=47.603, 95% CI [-132.106, 75.943]), while controlling for age.

Hypothesis 3: Pre-Pregnancy BMI, Prenatal Dietary Sugar Consumption, GWG, and Postnatal Perceived Stress

Hypothesis 3a: GWG up to the third trimester will mediate the relationship between pre-pregnancy BMI and maternal perceived stress at 6 months postpartum. Specifically, elevated pre-pregnancy BMI will be related to greater GWG, which will predict increased maternal perceived

stress at 6 months postpartum. Maternal age significantly correlated with added sugar intake in the third trimester and maternal perceived stress at 6 months postpartum, and as such was included as a covariate in this model.

This overall mediation model was not significant (R^2=0.027, F[2,89]=1.250, p=0.292). Specifically, GWG did not predict increased maternal anxiety symptoms at 6 months postpartum (b=-0.009, t(89)=-0.109, SE=0.078, p=0.913), and pre-pregnancy BMI did not predict maternal perceived stress at 6 months postpartum (b=10.335, t(89)=1.500, SE=6.891, p=0.137). However, greater pre-pregnancy BMI predicted lower GWG (b=-21.974, t(90)=-2.450, SE=8.968, p=0.016), indicating a significant a-path. The bias-corrected bootstrap confidence interval of the indirect effect included 0 (effect=0.188, SE=1.811, 95% CI [-4.073, 3.485]), suggesting that the indirect effect was not statistically significant.

Hypothesis 3b: The relationship between pre-pregnancy BMI and maternal postnatal stress will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to increased maternal perceived stress at 6 months postpartum for women with greater added sugar intake in the third trimester of pregnancy.

Within the moderated mediation model, the interaction between pre-pregnancy BMI and added sugar intake in the third trimester did not significantly predict maternal perceived stress at 6 months postpartum (b=-178.538, t(86)=-0.120, SE=1490.828, p=0.905) and there was not a significant amount of explained variance in PSS scores added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}=0.0001, F[1,86]=0.014), while controlling for age.

Hypothesis 3c: The relationship between pre-pregnancy BMI and GWG will be moderated by added sugar intake in the third trimester in the mediation model. Specifically, elevated pre-pregnancy BMI will be more robustly related to greater GWG in women with greater added sugar intake, which will predict increased maternal perceived stress at 6 months postpartum.

The relationship between pre-pregnancy BMI and GWG was not moderated by added sugar intake in the third trimester in the moderated mediation model (b=-574.234, t(87)=-0.269, SE=2138.661, p=0.789) and there was not a significant amount of explained variance in GWG added by the interaction term above and beyond the other predictors in the model (R^2_{CHANGE}=0.0008, F[1,87]=0.072). Similarly, the conditional indirect effect of pre-pregnancy BMI on maternal perceived stress at 6 months postpartum via GWG was not statistically significant, suggesting that there was not statistically significant moderated mediation within the model (Index of moderated mediation=-12.567, SE=195.384, 95% CI [-463.657, 396.722]), while controlling for age.

Discussion

Current Study Findings

Study population. Ninety-six participants completed the prenatal and postpartum sessions. Due to underrepresentation, participants who were underweight prior to pregnancy (n=4) were excluded from the current study analyses. Of the 92 participants remaining, 49% had a pre-pregnancy BMI in the normal category, 25% were in the overweight BMI category, and 26% were in the obese BMI category. This sample was comparative to the prevalence of pre-pregnancy BMI in Idaho from 2011-2015 reported by the CDC (Deputy et al., 2018). GWG ranged from -8.64 kg to 48.8 kg or -19.05 lbs to 107.59 lbs, with an average of 12.86 kg or 28.35

lbs (*SD*=8.28 kg or 18.25 lbs) of weight gain. This range was relatively restricted compared to Bogaerts et al. (2012), although the average GWG from that sample did not significantly differ from the current sample (Independent Samples $t(541120)=0.66$, $p=0.51$).

Added sugar intake ranged from 44.43 g to175.3 g estimated daily intake, which was comparable to the data collected from a subsample of pregnant women ($n=58$) from the NHANES 2009-10 study (range=41.95g-202.3g; CDC, 2018). Results of an independent samples *t*-test indicated no statistically significant difference in mean estimated daily added-sugar intake for NHANES participants ($M=77.95$, $SD=37.45$) and the current sample ($M=70.13$g, $SD=24.05$g; $t(148)=1.56$, $p=0.12$; CDC, 2018). Added sugar intake during the third trimester was significantly correlated with depressive ($r=0.227$, $p=0.029$), anxious ($r=0.237$, $p=0.023$), and perceived stress ($r=0.264$, $p=0.011$) symptoms at 6 months postpartum, indicating a small to medium effect size for each. Added sugar intake was negatively correlated with age ($r=-0.231$, $p=0.027$), such that increases in age was associated with lower added sugar intake, which was also in line with NHANES participants (CDC, 2018).

Point biserial correlation indicated that identification as Hispanic/Latina in ethnicity was positively correlated with added sugar intake ($r=0.270$, $p<.01$), indicating a medium effect size for the relationship. This finding is inconsistent with that of Coifi et al. (2018), who found no significant differences between added sugar intake among racial/ethnic groups. Coifi et al (2018), however, categorized race/ethnicity in mutually exclusive categories (i.e., Non-Hispanic White, Mexican American, Non-Hispanic Black, and Other), while this study did not limit racial/ethnic identity in such a way. Further, given the nationally representative nature of the data in the Coifi et al. study, and the small number of individuals who identified as Hispanic or Latina in the current study ($n=12$), this correlation may be due to factors outside of the scope of the current

study, such as regional, cultural differences among women in the sample. Therefore, despite the statistically significant findings, those limitations need to be considered when interpreting the relationship.

Mean EPDS scores for the current sample (4.54, *SD*=3.51) fell below the screener threshold for each measure's clinical cut score. This mean score did not significantly differ from the Somerville et al. (2014) control group (no psychiatric diagnosis) in their original validation study of the PASS (Independent Samples $t(317)=0.775$, $p=0.439$). For the current sample, 97% (*n*=89) of participants were below the 12-point threshold recommended by Cox, et al. (1987), with 73% (*n*=65) of participants scoring within the none to minimal level of depressive symptoms range, 30% (*n*=28) of participants scoring within the mild level of depressive symptoms range, 2% (*n*=2) scoring within the moderate levels of depressive symptom range, and no participants scoring within the severe level of depressive symptoms range at 6 months postpartum (McCabe-Beane, Segre, Perkhounkova, Stuart, & O'Hara, 2016). McCabe-Beane et al. (2016) determined severity rates for the EPDS by equipercentile linking EPDS scores to those of the BDI. This indicates that those with higher scores are more likely to be experiencing a greater number or more intense symptoms of depression. The rate at which participants in the current study exceed the threshold for elevated symptoms was similar to participants in the Benediktsson et al. (2017) sample, of which 5% exceeded threshold at 4-months postpartum, and lower than that of Ertel et al., (2017), who found that 9% of participants were above threshold at 6-months postpartum. However, the Ertel et al. (2017) sample included women who were underweight prior to pregnancy, who they found had higher odds of elevated postpartum symptoms (aOR = 1.36, 95% CI, 0.50-3.68; 2017). This may indicate that excluding women who were underweight prior to our sample may have impacted the mean EPDS score at 6-months

postpartum such that those who were less likely to exceed the elevated symptoms threshold were more likely to be included.

The average PASS score for this sample (*M*=14.84, *SD*=10.51) was below threshold for mild to moderate symptoms, with 75% (*n*=69) of participants scoring within the minimal level of anxiety symptoms range, 22% (*n*=20) of participants scoring within the mild to moderate level of anxiety symptoms range, and 3% (*n*=3) scoring within the severe levels of anxiety symptom range at 6 months postpartum (Somerville et al., 2015). Somerville et al. (2015) determined severity range by the absence or presence of a "primary or secondary anxiety disorder diagnosis" with the level of severity determined by increased symptoms of anxiety or depression as indicated by other screeners (pp. 20-21). Therefore, higher scores on the PASS are associated with increased likelihood of clinically elevated symptoms of anxiety, with those scoring in the "severe" range indicating possible clinically diagnosable levels of anxiety (Somerville et al., 2015). While there were no comparable studies found investigating normative prevalence rates for levels of PASS anxiety symptom severity among community samples of women at 6-months postpartum, mean scores for our sample did not significantly differ from that of Somerville's minimal anxiety symptoms group (*M*=13.37, *SD*=7.74; Independent Samples *t*(291)=-1.342, *p*=0.181; 2015). However, the Somerville sample combined pregnant and postpartum scores, and as such direct comparisons may be therefore limited.

The average PSS score for the current sample was 19.99 (*SD*=6.02), which was not significantly different from the average total score (*M*=20.5, *SD*=8.0) in Laria et al. (2009); Independent Samples *t*(1911)=0.60, *p*=0.55. While Laria et al. (2009) investigated women in their first trimester of pregnancy and not postpartum, Dipietro, Costigan, and Sipsma (2008) found prenatal and postnatal scores from the PSS-14 were stable from pregnancy to 24 months

postpartum (r=0.46, p<0.001), with no significant differences between time periods. Given this finding, it is likely that the current sample was comparable to the Laria et al. (2009) sample in early pregnancy and vice versa, although direct comparisons and conclusions may be limited. While we found a significant, negative correlation between postpartum PSS score and maternal age, such that an increase in maternal age was associated with a decrease in postpartum PSS score, neither Dipietro et al. (2008) nor Laria et al. (2009) reported such associations. Cohen and Janicki-Deverts (2012), however, reported that population level studies indicate that perceived stress (as measured by the PSS-10) declines with age, but did not report correlational data or the level of significance for the trend. Age in this study was significantly correlated with income and education such that increased age was associated with increased income and education (r=0.446, r=0.331, respectively, with ps<0.01), which were also associated with lower levels of stress in Cohen and Janicki-Deverts (2012). Therefore, it could be that relatively older women had more resources to buffer against stressors associated with the perinatal period.

Hypotheses 1a, 2a, and 3a: Mediation models. Prior research indicates a relationship between pre-pregnancy BMI and symptoms of depression, anxiety, and perceived stress during pregnancy and postpartum (Bodnar et al., 2009; Ertel et al., 2017; Laria et al., 2009; Mina et al., 2015; Molyneaux et al., 2014; Salehi-Pourmehr et al., 2018), as well as a similar relationship between GWG and postpartum maternal depressive symptoms (Bolton et al., 2017). Given that increased pre-pregnancy BMI was found to be associated with an increased likelihood of exceeding IOM guidelines for weight gain during pregnancy (Guilloty et al., 2015; Morisset et al. (2017), this study hypothesized that increased pre-pregnancy BMI may therefore be associated with greater GWG, which may contribute to further risk of elevated depressive, anxious, and perceived stress symptoms at 6 months postpartum. Thus, this study sought to add to the

literature by examining those relationships within an HPSA for primary care and mental health. Mediation models indicated that GWG did not mediate these relationship and Hypotheses 1a, 2a, and 3a were not supported.

Specifically, GWG did not predict postpartum depressive symptoms, therefore, this study failed to replicate prior literature linking increased GWG with increased postpartum depressive symptoms. In particular, Bolton et al. (2017) demonstrated a relationship between GWG and risk of postpartum depression at 1 month after delivery. The differences in findings here may suggest that the temporal relationship between GWG and postpartum mood diminishes over time. Ertel et al. (2014) found no association between GWG and elevated postpartum depressive symptoms. Similar to this study, they assessed depressive symptoms at 6 months postpartum, but contrary to this study, they used GWG up to 6 months gestational age (Ertel et al., 2017). Further, while Dayan et al. (2018) found that third-trimester GWG predicted depressive symptoms at 45-60 days postpartum, they failed to find a relationship between total GWG and depressive symptoms at 45-60 days postpartum. This may support the importance of distinguishing trimester-specific weight gain when investigating postpartum mood symptoms, rather than overall GWG or GWG up to 6 months gestational age.

The current study did find that pre-pregnancy BMI significantly predicted GWG, such that increased pre-pregnancy BMI predicted decreased GWG. While most of the literature regarding associations between pre-pregnancy BMI and GWG focus on pre-pregnancy BMI predicting risk of exceeding IOM recommendations, few published studies have focused on the relationship between pre-pregnancy BMI and GWG as continuous variables. Our finding replicated those of Babanezhad (2017), who found a significant inverse correlation between pre-pregnancy BMI and GWG in urban and rural pregnant women in Iran. This study extended the

literature in validating the findings in a US sample. Given that the total amount of weight gain during pregnancy recommended by IOM guidelines decreases for women of increasing pre-pregnancy BMI, it is possible that while women in overweight and obese pre-pregnancy BMI categories are more likely to exceed IOM guidelines (Guilloty et al., 2015; Morisset et al. (2017), they are still gaining less than those with a normal or underweight BMI (Babanezhad, 2017).

This study also found that pre-pregnancy BMI significantly predicted postpartum depressive symptoms, such that increased pre-pregnancy BMI predicted increased postpartum depressive symptoms. This finding replicates previous literature finding that women in the obese category and above (i.e., BMI $\geq$ 30 kg/m^2) prior to pregnancy had significantly more depressive symptoms, or were at greater risk of a positive screening for postpartum depressive symptoms, or had greater odds of postpartum depression up to 1 year postpartum, than women in the normal weight category (i.e., BMI from 18.5–24.9 kg/m^2) prior to pregnancy (Ertel et al., 2017; Mina et al., 2015; Molyneaux et al., 2014; Salehi-Pourmehr et al., 2018). This study found that increased pre-pregnancy BMI was predictive of increased depressive symptoms overall, even in a sample with few participants reaching the cutoff for elevated symptoms. This indicates that the relationship between increased pre-pregnancy BMI and postpartum depressive symptoms exists even in women with subclinical overall symptom levels. Further, this finding has been extended to women in HPSAs (i.e., for both primary care and mental health care).

Unlike depression symptoms, pre-pregnancy BMI did not predict postpartum symptoms of anxiety or perceived stress at 6 months postpartum, and therefore failed to replicate prior literature indicating a pre-pregnancy BMI category of obese or greater (e.g., pre-pregnancy BMI >29.0) was predictive of increased trait anxiety and perceived stress during pregnancy (Laria et al., 2009). Given the difference in statistical measurement (e.g., the use of significance testing by

weight status rather than weight as a continuous variable), a relationship may have been found in comparison to other weight groups rather than on a continuous level. Further, while Laria et al. (2009) utilized the STAI trait-anxiety scale as a measurement of anxiety symptoms, the current study utilized a perinatal anxiety scale. Therefore, future studies may want to utilize both types of scale to see whether one captures relations between perinatal weight and adjustment more effectively. Additionally, different findings across maternal psychological adjustment variables may be due to the fact that while depressive, anxious, and perceived stress symptoms at 6 months postpartum were correlated (*r* ranged from 0.57 to 0.67, $p<.01$), constructs are distinct. Our lack of findings may indicate that while pre-pregnancy BMI is predictive of postpartum symptoms unique to depression, it is not predictive of those unique to anxiety and perceived stress.

Hypotheses 1b, 2b, and 3b: Moderation of direct effect by added sugar intake. Prior research indicates a relationship between diets high in added sugar or sugar sweetened beverage intake and depressive symptoms (Chatzi et al., 2011; Hu et al., 2019; Knüppel et al., 2017). Further, pre-pregnancy BMI has been linked both with diets high in added sugar (Kornatowski & Comstock, 2018) and postpartum depressive symptoms (Ertel et al., 2017; Mina et al., 2015; Molyneaux et al., 2014; Salehi-Pourmehr et al., 2018). Therefore, it was hypothesized that the relationship between elevated pre-pregnancy BMI and increased maternal postnatal depressive symptoms would be moderated by added sugar intake in the third trimester in the mediation model. Given the literature relating increased pre-pregnancy BMI to increased trait anxiety during pregnancy (Laria et al., 2017), it was hypothesized that this relationship would extend to anxiety and stress symptoms at 6 months postpartum. However, null results across outcome variables did not support Hypotheses 1b, 2b, and 3b. While pre-pregnancy BMI and added sugar intake in the third trimester had significant, positive correlations with EPDS, PASS, and PSS

scores at 6 months postpartum, increased added sugar intake did not significantly interact with increased pre-pregnancy BMI to predict those scores at 6 months postpartum**.** These significant main effects replicate existing literature (Chatzi et al, 2017). For example, Chatzi et al. (2017) found a significant, positive association between added sugar intake at 14-18 weeks gestation and increased EPDS scores at 6-8 weeks postpartum, while this study assessed dietary intake at 33-37 weeks gestation and EPDS scores at 6 months postpartum. This novel finding within the current study may indicate a long-lasting effect of sugar intake over the course of pregnancy on postpartum depressive symptoms.

These significant main effects also add to the literature. Specifically, a relationship between added sugar intake in the third trimester and anxious and perceived stress symptoms at 6 months postpartum has not been investigated, nor found in the literature to date. Human studies have linked dietary patterns high in sugar and processed foods with psychological distress and anxiety, especially in combination with stressful life events (Jacka et al., 2010; Yazdi et al., 2018). However, none of those studies investigated a perinatal sample. Further, Animal models have suggested a relationship between increased refined carbohydrate consumption and symptoms of anxiety, with the effects of consumption being exacerbated following a stressful event (Décarie-Spain et al., 2018; Santos et al., 2018).

Moreover, while other studies have investigated the role of pre-pregnancy BMI and diets high in added sugar in relation to postpartum depressive symptoms, this was the first known study to investigate a potential interaction between pre-pregnancy BMI and prenatal sugar intake and postpartum depressive, anxious and perceived stress symptoms. As such, this study did not assess a longitudinal relationship between added sugar intake during the third trimester of pregnancy and depressive, anxious, and perceived stress symptoms at 6 months postpartum.

Thus, future studies should investigate the main effects of added sugar intake in the third trimester of pregnancy and postpartum on mental health directly.

Hypothesis 1c, 2c, and 3c: Moderated mediation. Empirical literature suggests that an interaction between increased pre-pregnancy BMI and prenatal dietary patterns high in added sugar was associated with higher GWG (Renault et al., 2015; Wrottesley et al., 2017). Therefore it was hypothesized that pre-pregnancy BMI and added sugar intake in the third trimester of pregnancy would interact to predict GWG in the mediation model. However, all of the indexes of moderated mediation across outcome variables were null and therefore Hypotheses 1c, 2c, and 3c were not supported. Thus, this study failed to replicate prior literature. Given that our study did not specifically investigate sugar from sugar-sweetened beverages (as did Renault et al., 2015), nor did it investigate pre-pregnancy BMI as a categorical variable (as did Wrottesley et al., 2017), this may explain differences in study findings. Thus, future research should look for associations between added sugar from foods and added sugar from sugar-sweetened beverages as separate variables, or pre-pregnancy BMI as a categorical variable.

Study Strengths

The current study has many strengths. The longitudinal nature of the IDAHO Mom Study design, along with the number of participants at 6 months postpartum, allowed for the investigation of predictive relationships among variables and the statistical power to detect medium effect sizes, when available. Measured variables (e.g., pre-pregnancy BMI, GWG, and added sugar intake) were well established in prior research, and measures used to assess mental health variables (e.g., EPDS, PASS, and PSS) were psychometrically strong and theoretically grounded. Participants were largely from an HPSA for primary care, and all participants were from an HPSA for mental health care. Further, the impact of perinatal health behaviors on

maternal postpartum mental health is largely understudied, particularly in reference to prenatal added sugar consumption, postpartum anxiety and perceived stress, and women in HPSAs. The current study contributes to this body of literature by replicating studies associating increased pre-pregnancy BMI with decreased GWG and increased depressive symptoms at 6 months postpartum. The current study is the first known to find an association between increased added sugar consumption in the third trimester of pregnancy and increased depressive, anxious, and perceived stress symptoms at 6 months postpartum.

Study Limitations

The IDAHO Mom Study sample was racially and religiously homogeneous, with the majority of participants earning greater than average income for the state of Idaho. While not significantly correlated with outcomes in the current study, those factors often buffer the impact of stressors on depressive, anxious, and perceived stress symptoms. Given the prevalence of those symptoms in the current, community sample, relationships between pre-pregnancy BMI and postpartum mental health, future studies should investigate these relations in a clinical sample. Further, a more sociodemographically diverse sample may lend better to investigating ethnic differences in added sugar intake in the third trimester. This study found a relationship between added sugar intake and postpartum mental health, but failed to replicate an interaction between pre-pregnancy BMI and added sugar intake on GWG. However, this may be due to the fact that the current study did not differentiate between the sources of added sugar (i.e., added sugar from foods or sugar sweetened beverages), nor pre-pregnancy BMI as a categorical variable.

While the current sample was representative of the population in the state of Idaho in pre-pregnancy BMI, women who were underweight prior to pregnancy were excluded due to

underrepresentation. Thus, studies should consider oversampling for underweight women in the future to gain a broader and more comprehensive understanding of how pre-pregnancy BMI impacts diet, gestational weight, and women's health outcomes. As GWG is frequently investigated as it pertains to meeting or gaining outside of IOM guidelines, this study may not have found a relationship among such weight gain, pre-pregnancy BMI and postpartum mental health since GWG was measured on a continuous scale. This suggests that it may be helpful for future studies to compare and contrast findings based upon the scale of measurement used for the GWG variable. Lastly, diet variables in early pregnancy have been indicated to influence GWG, and as the current study utilized diet information from the third trimester of pregnancy, we may not have captured a sensitive time window in which nutrition most robustly impacts gestational weight. In the future, longitudinal studies should consider measuring diet at multiple time points throughout pregnancy in relation to GWG and maternal adjustment to identify when prevention strategies may be most efficacious.

Implications and Future Directions

Replication of prior research indicating that pre-pregnancy BMI predicts increased symptoms of depression at 6 months postpartum indicates that efforts geared toward preventing postnatal distress should target women with elevated pre-pregnancy BMI, which is common among women of reproductive age. These programs could be preceded by identifying women with elevated BMI during family planning visits or early obstetrical care to enhance the efficiency with which they receive evidence-based weight management strategies (e.g., interventions that target diet, exercise, or both, early in pregnancy, and in a group format; Walker et al., 2018). The extension of these findings into a novel U.S. sample in an HPSA for primary care and mental health would further suggest the need for more research in those areas focused

on the dissemination of accessible prevention services in samples with barriers to accessing healthcare. Further, efforts to screen for depressive symptoms postpartum should remain in place greater than 2 years postpartum, as evidenced by this and other studies that found that the impact of pre-pregnancy BMI on depressive symptoms may last up to 24 months postpartum. Successful identification of women with elevated symptoms of depression would also result in better short- and long-term outcomes for women and their offspring, including the downstream negative effects of elevated postpartum symptoms of depression for mother and child.

Similarly, the novel finding of the association between increased added sugar consumption in the third trimester and increased symptoms of depressive, anxious, and perceived stress symptoms 6 months postpartum would suggest that research regarding postnatal mood, distress, and/or adjustment should also consider added sugar intake during pregnancy. Specifically, future research could seek to determine the main effects of added sugar intake during pregnancy on postpartum mood, examine the effects of timing of added sugar intake on postpartum mood and GWG, and/or examine potential other moderators established in the literature (e.g., maternal socioeconomic status and ethnicity) in more diverse sample of expecting mothers. These findings further suggest that prevention/intervention efforts toward decreasing added sugar intake during pregnancy should continue, including education efforts, healthy eating programs, and the dissemination of dietary guidelines for pregnancy to policymakers, providers, and at-risk communities (CDC & NCHS, 2017; HHS & USDA, 2015; USDA, 2018).

Prevention efforts aimed at reducing postpartum distress are important, as the documented impact of the effects of elevated postpartum symptoms of depression include persistent maternal depressive symptoms for up to 11 years, reduced maternal responsiveness to offspring, and increased likelihood of offspring behavioral problems in childhood and depressive

symptoms in adolescence (Murray, 2009; Netsi et al., 2018). Further, maternal perceived stress symptoms have been found to exacerbate postnatal depressive symptoms (Reid & Taylor, 2015), and negatively impact infant feeding style (Hurley, Black, Papas, & Caufield, 2008). Symptoms of maternal anxiety in the postnatal period have been linked to increased behavioral and emotional problems in offspring throughout childhood and adolescence (Rees, Channon, & Waters, 2019). Taken together, results support more research investigating perinatal weight and sugar intake as modifiable variables to prevent maternal maladjustment and associated health difficulties for women and their children.

Conclusion

Given support for the interrelated nature of maternal perinatal diet and weight, this study sought to investigate interactions between pre-pregnancy BMI and prenatal added sugar intake in predicting GWG and postpartum depression, anxiety, and perceived stress symptoms at 6 months postpartum. The current study was the first known study to examine these complex multivariate relationships in a longitudinal sample of U.S. women in HPSAs. The current study extended existing literature by replicating established relations between pre-pregnancy BMI and GWG, and pre-pregnancy BMI and depressive symptoms at 6 months postpartum in a novel U.S. sample in an HPSA for primary care and mental health. Additionally, the study is the first known to find significant associations between increased prenatal sugar intake in the third trimester and increased depressive, anxious, and perceived stress symptoms at 6 months postpartum. The current study failed to support statistically significant mediation of pre-pregnancy BMI and postpartum mood by GWG and an interaction between pre-pregnancy BMI and added sugar intake in the third trimester influencing GWG and postpartum mental health. When comparing and contrasting extant literature, it appears that null findings could be due to how and when pre-

pregnancy BMI and GWG were measured, the definition of added sugar (i.e., added sugar intake broadly as opposed to added sugar from sweetened beverages), or the sociodemographic heterogeneity of the current study sample. However, it may also be that relationships do not exist among these variables.

Strengths of the current study included the longitudinal nature of the study and the limited attrition rate, established measurements for variables and psychometric support for psychological measures, and the novelty of the sample and findings. Limitations included sociodemographic homogeneity, a limited number of underweight women and those with clinically significant psychopathology, lack of differentiation regarding the source (e.g., in sugar sweetened beverages or other sources) and timing of added sugar (e.g., when during pregnancy did sugar intake occur), and single definition/variable of GWG (i.e., measured and analyzed continuously instead of with regard to IOM Guidelines). The implications of this study involve prevention efforts for postpartum depression that include identifying women prior to pregnancy who could benefit from weight management strategies, screening for postpartum depressive symptoms at 6 months postpartum, and maintaining efforts to reduce added sugar consumption during pregnancy. Future directions for research include examining the direct relationship between added sugar intake during pregnancy and postpartum mood, timing effects, and potential moderators in more diverse samples.

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Appendices

Appendix A

Prenatal Session Screener

Prenatal Session Screener ID#: _____

STATUS: ____eligible ____ineligible

1. Date:_____

2. Administered By:_____

[redacted]

(To be separated from interview after completed)

First, I would just like to confirm your birth date and ensure that none of your contact information has changed since your phone screen:

3. Subject Name: _____

4. What is your birth date? _____ month _____ day _____ year

5. Subject Address: _____

6. Subject Day Phone #: _____ (Best time to call: _____)

7. Evening Phone #: _____ (Best time to call: _____)

8. Email: _____

9. How best to leave a message: _____

_____

10a. Permission to email message: _yes _____ no

10b. Text message: __yes _____ no

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Prenatal Session Screener ID#: _____

Since you were last contacted:

11. Has there been any change in your due date? ____ No ____ Yes

12. Expected Date of Delivery: _____

13. Current Gestation: _____

14. At which hospital are you planning to deliver your baby? _____

15. Do you know the sex of your baby? ____ No ____ Yes

    14a. **IF YES,** what is it? ____ Boy ____ Girl

16. Have you been told that you are having more than one baby? ____ yes ____ no

17. How are you planning to feed your baby? *(keep open-ended; let mother explain and then code.)*

    Explanation: _____

1=breast feed only 2=breast and bottle feed 3= bottle feed only 4=not sure 5=declined to answer

18. What was your approximate weight before you became pregnant? _____ lbs.

19. Diagnosed with Gestational Diabetes: ____ yes ____ no

20. Did you have Gestational Diabetes in previous pregnancy(ies)?
    ____ yes ____ no ____N/A

21. Told you were at risk for Gestational Diabetes: ____ yes ____ no

22. Diagnosed with High Blood Pressure, Pre-eclampsia, or Toxemia: ____ yes ____ no

23. Did you have High Blood Pressure, Pre-eclampsia, or Toxemia in previous pregnancy(ies)?
    ____ yes ____ no ____N/A

24. Diagnosed with Hyper/hypothyroidism or any other type of thyroid disorder :
    ____ yes ____ no

25. Other complications: (**"Has your doctor said that you are a 'high risk pregnancy'? Is he/she concerned about your baby being small?" or concerned about high blood pressure, excess fluid, low fluid, preterm labor**):
    ____ yes ____ no

    25a. If yes, explain:_____

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Prenatal Session Screener ID#: _____

26. Have you been hospitalized during this pregnancy? ____ yes ____ no
    26a. If yes, reason for hospitalization:_____

27. Have you been in any accidents during your pregnancy? ____ Yes ____ No
    (e.g., did you have a fall, car accident?)
    If yes, please explain_____

28. Have you **ever** been diagnosed with a physical illness, such as HIV, AIDS, Heart Disease, Herpes, Hepatitis, Asthma, Anemia, Seizures, or Group B Strep? ____ yes ____no
    28a. If yes, list physical illnesses:_____

29. During your pregnancy and the three months prior, have you taken **any** medications, **other than prenatal vitamins**?
    ____ yes ____ no

1. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

2. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

3. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

4. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

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Prenatal Session Screener ID#: _____

30. During your pregnancy and the three months prior, have you taken **prenatal vitamins or other vitamins**?

____ yes ____ no

If yes, List vitamins:

1. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

2. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

3. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

4. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

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31. During your pregnancy and the three months prior, have you taken **any supplements**? (e.g., Iron, Folic acid/folate, fish oil/Omega-3 fatty acids, etc.)
____ yes ____ no

1. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

2. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

3. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

4. Medication Name	Medication Information	
	Date Started:	Notes:
Medication Type	Date Stopped:	
1=Steroid		
2=Insulin	Dosage:	
3=Antidepressant		
4=Antibiotic	Reason Taken:	
5=Opiate or Pain Med		
6=Other		

32. Do you have any physical or learning disabilities? ____ Yes ____ No
Explanation: _____

33. Have you had any other health issues? _____ yes _____ no
If yes, describe: _____

34. Have you ever been diagnosed with a psychological disorder: _____ yes _____ no
If yes, describe: _____

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Prenatal Session Screener ID#: _____

34a. Check if one of the categories below:

Bipolar disorder	____ Yes	____ No
Schizophrenia	____ Yes	____ No
Schizoaffective disorder	____ Yes	____ No
Psychosis	____ Yes	____ No

General Information

35. What is your primary language?_____

23a. **(If English)** Do you have difficulty reading? ____ Yes ____ No

23b. **(IF NOT ENGLISH)** How well do you:
read, _____
write, and _____
understand English? _____

which country did your family come from? _____

36. Do all of your children live with you? ____ Yes ____ No

If no, why not? _____

37. Is the Department of Children, Youth and Families involved in this pregnancy or will they be involved at the baby's birth? ____ Yes ____ No

How will they be involved? _____

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Appendix B

Prenatal Maternal Anthropometry

Maternal Anthropometry

Subject ID_____ Session _____ Date_____

MATERNAL WEIGHT: _____ kg

MATERNAL HEIGHT: _____ cm

MATERNAL WAIST CIRCUMFERENCE: _____ cm

OTHER INFORMATION:

Appendix C

Dietary Screener Questionnaire

DIETARY SCREENER QUESTIONNAIRE

These questions are about foods you ate or drank during the past month, that is, the past 30 days. When answering, please include meals and snacks at home, at work or school, in restaurants, and anyplace else.

Mark an ☒ to indicate your answer. To change your answer, completely fill the box for the incorrectly marked answer (✒). Then mark an X in the correct one. Your answers are important.

How old are you (in years)?

☐☐☐ years

Are you male or female?

- ☐ Male
- ☐ Female

During the past month, how often did you eat **hot or cold cereals**? *Mark one* ☒.

- ☐ Never → **Go to question 4.**
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

During the past month, what kind of cereal did you usually eat? – *Print cereal.*

If there was another kind of cereal that you usually ate during the past month, what kind was it? – *Print cereal, if none leave blank.*

During the past month, how often did you have any **milk** (either to drink or on cereal)? Include regular milks, chocolate or other flavored milks, lactose-free milk, buttermilk. Please do **not** include soy milk or small amounts of milk in coffee or tea. *Mark one* ☒.

- ☐ Never → **Go to question 8.**
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2-3 times per day
- ☐ 4-5 times per day
- ☐ 6 or more times per day

During the past month, what kind of milk did you usually drink? *Mark one* ☒.

- ☐ Whole or regular milk
- ☐ 2% fat or reduced-fat milk
- ☐ 1%, ½%, or low-fat milk
- ☐ Fat-free, skim or nonfat milk
- ☐ Soy milk
- ☐ Other kind of milk – *Print milk.*

During the past month, how often did you drink **regular soda or pop** that contains sugar? Do **not** include diet soda. *Mark one* ☒.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2-3 times per day
- ☐ 4-5 times per day
- ☐ 6 or more times per day

1

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9 During the past month, how often did you drink **100% pure fruit juices** such as orange, mango, apple, grape and pineapple juices? Do **not** include fruit-flavored drinks with added sugar or fruit juice you made at home and added sugar to. *Mark one* ☒.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2-3 times per day
- ☐ 4-5 times per day
- ☐ 6 or more times per day

● During the past month, how often did you drink coffee or tea that had **sugar** or **honey** added to it? Include coffee and tea you sweetened yourself and presweetened tea and coffee drinks such as Arizona Iced Tea and Frappuccino. Do **not** include artificially sweetened coffee or diet tea.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2-3 times per day
- ☐ 4-5 times per day
- ☐ 6 or more times per day

● During the past month, how often did you drink **sweetened** fruit drinks, sports or energy drinks, such as Kool-Aid, lemonade, Hi-C, cranberry drink, Gatorade, Red Bull or Vitamin Water? Include fruit juices you made at home and added sugar to. Do **not** include diet drinks or artificially sweetened drinks.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2-3 times per day
- ☐ 4-5 times per day
- ☐ 6 or more times per day

● During the past month, how often did you eat **fruit**? Include fresh, frozen or canned fruit. Do **not** include juices.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat a green leafy or lettuce **salad**, with or without other vegetables?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

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14 During the past month, how often did you eat any kind of **fried potatoes**, including french fries, home fries, or hash brown potatoes?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat any **other kind of potatoes**, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat refried beans, baked beans, beans in soup, pork and beans or any other type of cooked dried beans? Do **not** include green beans.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat **brown rice** or other cooked whole grains, such as bulgur, cracked wheat, or millet? Do **not** include white rice.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, not including what you just told me about (green salads, potatoes, cooked dried beans), how often did you eat **other vegetables**?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you have Mexican-type **salsa** made with tomato?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

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20 During the past month, how often did you eat **pizza**? Include frozen pizza, fast food pizza, and homemade pizza.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

During the past month, how often did you have **tomato sauces** such as with spagetti or noodles or mixed into foods such as lasagna? Do not include tomato sauce on pizza.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

During the past month, how often did you eat any kind of **cheese**? Include cheese as a snack, cheese on burgers, sandwiches, and cheese in foods such as lasagna, quesadillas, or casseroles. Do **not** include cheese on pizza.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

During the past month, how often did you eat **red meat**, such as beef, pork, ham, or sausage? Do **not** include chicken, turkey or seafood. Include red meat you had in sandwiches, lasagna, stew, and other mixtures. Red meats may also include veal, lamb, and any lunch meats made with these meats.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

During the past month, how often did you eat any **processed meat**, such as bacon, lunch meats, or hot dogs? Include processed meats you had in sandwiches, soups, pizza, casseroles, and other mixtures.
Processed meats are those preserved by smoking, curing, or salting, or by the addition of preservatives. Examples are: ham, bacon, pastrami, salami, sausages, bratwursts, frankfurters, hot dogs, and spam.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

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25 During the past month, how often did you eat **whole grain bread** including toast, rolls and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do **not** include white bread.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

26 During the past month, how often did you eat **chocolate** or any other types of candy? Do **not** include sugar-free candy.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat **doughnuts**, sweet rolls, Danish, muffins, pan dulce, or pop-tarts? Do **not** include sugar-free items.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat **cookies, cake, pie or brownies**? Do **not** include sugar-free kinds.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat **ice cream or other frozen desserts**? Do **not** include sugar-free kinds.

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

● During the past month, how often did you eat **popcorn**?

- ☐ Never
- ☐ 1 time last month
- ☐ 2-3 times last month
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3-4 times per week
- ☐ 5-6 times per week
- ☐ 1 time per day
- ☐ 2 or more times per day

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Appendix D

Edinburgh Postnatal Depression Scale

Name: _____ Address: _____

Your Date of Birth: _____ _____

Baby's Date of Birth: _____ Phone: _____

As you are pregnant or have recently had a baby, we would like to know how you are feeling. Please check the answer that comes closest to how you have felt **IN THE PAST 7 DAYS**, not just how you feel today.

Here is an example, already completed.

I have felt happy:
- ☐ Yes, all the time
- ☒ Yes, most of the time — This would mean: "I have felt happy most of the time" during the past week.
- ☐ No, not very often — Please complete the other questions in the same way.
- ☐ No, not at all

In the past 7 days:

1. I have been able to laugh and see the funny side of things
   - ☐ As much as I always could
   - ☐ Not quite so much now
   - ☐ Definitely not so much now
   - ☐ Not at all

2. I have looked forward with enjoyment to things
   - ☐ As much as I ever did
   - ☐ Rather less than I used to
   - ☐ Definitely less than I used to
   - ☐ Hardly at all

*3. I have blamed myself unnecessarily when things went wrong
   - ☐ Yes, most of the time
   - ☐ Yes, some of the time
   - ☐ Not very often
   - ☐ No, never

4. I have been anxious or worried for no good reason
   - ☐ No, not at all
   - ☐ Hardly ever
   - ☐ Yes, sometimes
   - ☐ Yes, very often

*5 I have felt scared or panicky for no very good reason
   - ☐ Yes, quite a lot
   - ☐ Yes, sometimes
   - ☐ No, not much
   - ☐ No, not at all

*6. Things have been getting on top of me
   - ☐ Yes, most of the time I haven't been able to cope at all
   - ☐ Yes, sometimes I haven't been coping as well as usual
   - ☐ No, most of the time I have coped quite well
   - ☐ No, I have been coping as well as ever

*7 I have been so unhappy that I have had difficulty sleeping
   - ☐ Yes, most of the time
   - ☐ Yes, sometimes
   - ☐ Not very often
   - ☐ No, not at all

*8 I have felt sad or miserable
   - ☐ Yes, most of the time
   - ☐ Yes, quite often
   - ☐ Not very often
   - ☐ No, not at all

*9 I have been so unhappy that I have been crying
   - ☐ Yes, most of the time
   - ☐ Yes, quite often
   - ☐ Only occasionally
   - ☐ No, never

*10 The thought of harming myself has occurred to me
   - ☐ Yes, quite often
   - ☐ Sometimes
   - ☐ Hardly ever
   - ☐ Never

Administered/Reviewed by _____ Date _____

[1]Source: Cox, J.L., Holden, J.M., and Sagovsky, R. 1987. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry* 150:782-786 .

[2]Source: K. L. Wisner, B. L. Parry, C. M. Piontek, Postpartum Depression N Engl J Med vol. 347, No 3, July 18, 2002, 194-199

Appendix E

Perinatal Anxiety Screening Scale

ANTENATAL POSTNATAL DATE: ..... Weeks pregnant .....

Baby's age .....

	Not at all	Sometimes	Often	Almost Always
1. Worry about the baby/pregnancy	0	1	2	3
2. Fear that harm will come to the baby	0	1	2	3
3. A sense of dread that something bad is going to happen	0	1	2	3
4. Worry about many things	0	1	2	3
5. Worry about the future	0	1	2	3
6. Feeling overwhelmed	0	1	2	3
7. Really strong fears about things, eg needles, blood, birth, pain, etc	0	1	2	3
8. Sudden rushes of extreme fear or discomfort	0	1	2	3
9. Repetitive thoughts that are difficult to stop or control	0	1	2	3
10. Difficulty sleeping even when I have the chance to sleep	0	1	2	3
11. Having to do things in a certain way or order	0	1	2	3
12. Wanting things to be perfect	0	1	2	3
13. Needing to be in control of things	0	1	2	3
14. Difficulty stopping checking or doing things over and over	0	1	2	3
15. Feeling jumpy or easily startled	0	1	2	3
16. Concerns about repeated thoughts	0	1	2	3
17. Being 'on guard' or needing to watch out for things	0	1	2	3
18. Upset about repeated memories, dreams or nightmares	0	1	2	3
19. Worry that I will embarrass myself in front of others	0	1	2	3
20. Fear that others will judge me negatively	0	1	2	3
21. Feeling really uneasy in crowds	0	1	2	3
22. Avoiding social activities because I might be nervous	0	1	2	3
23. Avoiding things which concern me	0	1	2	3

24. Feeling detached like you're watching yourself in a movie	0	1	2	3
25. Losing track of time and can't remember what happened	0	1	2	3
26. Difficulty adjusting to recent changes	0	1	2	3
27. Anxiety getting in the way of being able to do things	0	1	2	3
28. Racing thoughts making it hard to concentrate	0	1	2	3
29. Fear of losing control	0	1	2	3
30. Feeling panicky	0	1	2	3
31. Feeling agitated	0	1	2	3

Global Score

Over the past month, how often have you experienced the following? Please tick the response that **most closely** describes your experience for **every** question.

Name: ....

DOB: .....

Women and Newborn Health Service
King Edward Memorial Hospital
Western Australia
Women's Health Care Clinical Care Unit (WHCCU) Department of Psychological Medicine

Reference:

Somerville, S., Dedman, K., Hagan, R., Oxnam, E., Wettinger, M., Byrne, S., Coo, S., Doherty, D., Page, A.C. (2014).

The Perinatal Anxiety Screening Scale: development and preliminary validation. *Archives of Women's Mental Health*, DOI: 10.1007/s00737-014-0425-8

Appendix F

Perceived Stress Scale 14-item

The questions in this scale ask you about your feelings and thoughts **DURING THE LAST MONTH.** In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

Be sure to circle just* ONE *number for each question.	**NEVER**	**ALMOST NEVER**	**SOMETIMES**	**FAIRLY OFTEN**	**VERY OFTEN**
1. In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3. In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
4. In the last month, how often have you dealt successfully with irritating life hassles?	0	1	2	3	4
5. In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?	0	1	2	3	4
6. In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
7. In the last month, how often have you felt things were going your way?	0	1	2	3	4
8. In the last month, how often have you found you could not cope with all the things that you had to do?	0	1	2	3	4
9. In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
10. In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
11. In the last month, how often have you been angered because of things that happened that were outside of your control?	0	1	2	3	4
12. In the last month, how often have you found yourself thinking about things that you have to accomplish?	0	1	2	3	4
13. In the last month, how often have you been able to control the way you spend your time?	0	1	2	3	4
14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix G

Pregnancy Context Questionnaire

Subject ID#: _____ Date: _____ Session: _____

PREGNANCY CONTEXT

SUBJECT DOB:_____ AGE:_____

I would also like to ask you some questions about your pregnancy and behaviors and feelings during your pregnancy.

How was your due date established?	By your Last Menstrual Period?	By 1st Trimester Ultrasound (up to 12 weeks)?	By 2nd Trimester Ultrasound (up to 28 weeks)?	Other
				Describe _____
	___Yes	**___Yes**	**___Yes**	_____
	___ No	**___ No**	**___ No**	_____

1. When was your last menstrual period? _____ (date)

2. How exact is that date? _____

   Were you keeping track or your menstrual period? _____ Yes ____ No

   Explanation: _____

3. When did you first find out that you were pregnant? _____ (date or weeks gestation)

4. How did you find out that you were pregnant? _____
   _____

5. Was your pregnancy planned? _____ Yes ____ No

6. Did you have any trouble conceiving?

   _____ No
   _____ Yes, but no treatment
   _____ Yes, received fertility treatment

7. If yes, how long were you trying to conceive? _____

8. If received fertility treatment, please describe: _____
   _____

9. When was your first prenatal exam? _____(if date, then calculate # weeks pregnant after interview and fill in here) _____

10. Is this your first pregnancy? _____ Yes _____ No

11. How many pregnancies have you had **(including this one)?** _____ (#)

Note: If this is mother's first pregnancy, Skip to Question 19

Of these previous pregnancies…

Subject ID#: _____ Date: _____ Session: _____

12. Did any result in full term deliveries?

___ Yes
___ No

If yes, how many? _____

13. Did any result in preterm deliveries?

___ Yes
___ No

If yes, how many? _____

14. Were any of these miscarriages or stillbirths?

___ Yes
___ No

If yes, how many? _____

15. Were any of these elective abortions?

___ Yes
___ No

If yes, how many? _____

16. So overall, you have given birth to how many children? _____ *N/A*
(# live births)

17. Approximately, how many weeks gestation were you for each of your previous pregnancies resulting in live births?

Pregnancy 1: _____
Pregnancy 2: _____
Pregnancy 3: _____
Pregnancy 4: _____
Pregnancy 5: _____
Pregnancy 6: _____

18. How old were you when your first child was born?_____ *(record Age)* *N/A*

(Fill In: How old will mother be when baby is born? _____ ***(Calculate from due date)***

19. Have you had any of the following symptoms during this pregnancy?

a. Severe morning sickness _____ Yes _____ No

b. Any morning sickness _____ Yes _____ No
If yes to a or b, for how many weeks? _____

When during pregnancy _____ (date) to _____ (date)

If yes to a or b, please describe _____
_____
_____

Subject ID#: _____ Date: _____ Session: _____

c. High blood pressure _____ Yes _____ No

d. Bleeding/spotting _____ Yes _____ No

If yes, please describe _____

e. Infection (Bacterial Vaginosis, Yeast Infection, Trichomoniasis, Urinary Tract Infection, or Chlamydia) _____ Yes _____ No

If yes, please describe _____

f. Anything else?

If yes, please describe _____

20. Has the pregnancy affected your eating habits? _____ Yes _____ No

If yes, please describe _____

21. Has the pregnancy affected your stress level? _____ Yes _____ No

If yes, please describe _____

22. Have any significant or important events or changes happened to you during this pregnancy or 3 months before this pregnancy? _____ Yes ____ No
If yes, what happened? _____

23. How did you feel when you found out you were pregnant with this baby?
(open-ended, write verbatim)

24. How are you feeling about the pregnancy now?
(open-ended, write verbatim)

25. Were you using birth control at the time you became pregnant?

_____ Yes, but not regularly (a:Type_____)
_____ Yes, must have failed (b:Type_____)
_____ No, but not trying to conceive
_____ No, trying to conceive

Subject ID#: _____ Date: _____ Session: _____

26. At any time during this pregnancy, did you consider abortion or adoption? **(Note: If mother has responded that she was pleased to be pregnant, say "I know you said you were pleased to be pregnant but…..")** _____ Yes _____ No

If yes, record verbatim _____

_____

27. Are you planning to have a C-section? ____ Yes ____ No

IF YES: What is the reason for the planned C-section? _____

_____

If pregnant previously: Have you ever had a C-section? ____ Yes ____ No

IF YES: What was the reason for the C-section? _____

28. *If pregnant previously:* Did you have any complications with your prior pregnancies or deliveries?
____ yes ____ no

If yes, explain: _____

_____

29. *If other children*: Were/are there any medical or developmental problems with any of your children?
____ yes ____ no

If yes, explain: _____

_____

30. What is your current marital status?
1. single
2. married
3. divorced
4. widowed
5. separated
6. committed relationship
7. engaged

31. What is your current relationship with this baby's father?

_____ We are married _____(how long—specify months or years)
_____ We are divorced/separated _____(how long married, how long divorced/separated—months/years)
_____ We are living together but not married _____(how long together—specify months/years)
_____ We are involved with each other but are not living together _____(how long together—months/years)
_____ We are no longer involved with each other romantically _____
Probe for reason--e.g broke up, _____
_____

When did relationship end? _____ months prior

Are you currently involved other than romantically (e.g., does he share responsibility for previous children?)

_____

Subject ID#: _____ Date: _____ Session: _____

_____ Not sure of father

32. **(If known)** How old is baby's father? _____ years

33. **(If known)** Does baby's father smoke currently? ____ Yes _____ No

Approximately how many cigarettes per day? _____

(If not smoking currently, ask next question; otherwise skip to Question 35)

34. **(If known)** Has baby's father ever smoked regularly? ____ Yes ____ No

(If yes) Approximately how many cigarettes per day? _____

35. **(If father is not current partner),** is there another man in your life right now?
___ Yes
___ No

If yes, how long have you been together? _____(months) **N/A**

36. ***Note: If first birth, skip this)*** Now, can you tell me about each of your children. I would like to know their ages and whether the child lives with you now.

(List children and include any deceased children).

Child's Age	Does Child Live with You? Y/N

Living Arrangements

Now I'd like to get to know something about your household.

37. What are your current living arrangements?

_____ rent an apt.

_____ live with relatives (***If Yes ask, "Do you pay rent?*** _____***Yes*** _____ ***No)***

_____ own condo

_____ own house

_____ rent house

_____ other_____

37a. If live with relatives, do you live in a:
_____apartment
_____house or condo

Subject ID#: _____ Date: _____ Session: _____

37b. **If living in an apartment,** How many units are in your apt building?
_____ (#units) or _____unsure

If unsure: Can you estimate the number of units?
____ ≤ to 5 units
____ 6-10 units
____ 11-15 units
____ 16-20 units
____ 21-25 units
____ >25

38. Have you moved at any time during this pregnancy? ____ No ____ Yes

If yes, how many times? _____ _____

If yes, explain? _____ _____
_____

39. Do you plan to move anytime in the near future (e.g., after baby comes)? ____ No ____ Yes

If yes, explain? _____ _____

40. Who lives in the house/apartment with you?
Number of adults: _____
Number of children: _____

41. Does anyone else in the household smoke? _____ Yes _____ No

42. Please list for me who smokes and how much they smoke per day? **N/A**

Who Smokes	How much do they smoke on average each day?

Appendix H

Socioeconomical Status Questionnaire

1. How many people live in your household? (Including you) | | |

2. Who supports or contributes to the household? **Check all that apply.**
(Ask separately for a to d. For b to d, individual need not be living in household.)

Individual	Check if contributing*
a) Subject	
b) Baby's Father	
c) Subject's Partner Who is Not Child's Father	
d) Other Adult (if more then one, choose the one making the largest contribution)	

*Write N/A for categories in which no such person exists.

3. Apart from you, who contributes the most money to the child's household? (Select only one)

Baby's Father	1
Subject's Partner Who is Not Child's Father	2
Other Adult	3
No Other Contributors	4

4. What is the total income in your household from all sources over the last year?

<$5,000	1
$5,000 to $9,999	2
$10,000 to $19,999	3
$20,000 to $29,999	4
$30,000 to $39,999	5
$40,000 to $49,999	6
$50,000 to $74,999	7
$75,000 to $99,999	8
≥ $100,000	9

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If baby's father does <u>not</u> contribute to household ask the following question.

5. What is the total income of the baby's father from all sources over the last year?

<$5,000	1
$5,000 to $9,999	2
$10,000 to $19,999	3
$20,000 to $29,999	4
$30,000 to $39,999	5
$40,000 to $49,999	6
$50,000 to $74,999	7
$75,000 to $99,999	8
≥ $100,000	9

6. Does the household income stay the same month to month? Yes [1] No [2]

Note: Complete questions 7, 8 and 9 for the subject, the baby's father, and the adult contributing the most money to the household (if this is not the baby's father). If there are no contributing adults (answer to question 3 is 4), complete only for the subject and baby's father.

Assign Educational Scale Score As Follows:	
1 = Less than seventh grade	5 = Partial college (minimum 1 year) or other specialized or technical training
2 = Junior high school (7th to 9th grade)	6 = Standard college or university degree
3 = Partial high school (10th to 12th grade)	7 = Graduate training with degree
4 = High school degree (including GED)	

7. What is the highest grade _____ has completed?
(Ask separately for a, b and c. Circle the answer below, and then assign Educational Scale Score.)

a) Subject 1-6 7 8 9 10 11 HS 1 2 3 4 BA/BS MA/MS PhD/MD ☐

b) Baby's Father 1-6 7 8 9 10 11 HS 1 2 3 4 BA/BS MA/MS PhD/MD ☐

c) Contributing Adult 1-6 7 8 9 10 11 HS 1 2 3 4 BA/BS MA/MS PhD/MD ☐

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Assign Occupational Scale Score as Follows

Refer to Full Occupational List if Needed. If unable to decide between 2 levels, score lowest level.
0 = Homemaker / housewife
1 = Welfare recipient; unemployed; farm laborer; menial service worker
2 = Unskilled workers
3 = Machine operators and semiskilled workers
4 = Smaller business owners; skilled manual workers, craftsmen; tenant farmers
5 = Clerical and sales workers, small farm and business owners (up to 2 employees)
6 = Technicians, semi-professionals, small business owners (up to 5 employees)
7 = Medium-small business owners (up to 20 employees), farm owners, managers, minor professionals
8 = Administrators, lesser professionals, proprietors of medium-sized businesses
9 = Higher executives, proprietors of large businesses, major professionals

8. What is _____'s usual occupation?
(Ask separately for a, b and c. Record in the space provided and then assign Occupational Scale Score.)

a) Subject _____ ☐

b) Baby's Father _____ ☐

c) Contributing adult _____ ☐

9. Is _____ currently working? (*Ask separately for a, b and c.*)

	Yes	No
a) Subject	1	2
b) Baby's Father	1	2
c) Contributing Adult	1	2

If subject is not currently working, ask the following question.

10. Have you ever held a job? ___ Yes (1) ___ No (2)

If yes, what kind of work? _____

_____

When did you last work? _____

If baby's father is not currently working, ask the following question.

11. Has he ever held a job? ___ Yes (1) ___ No (2)

ID#_____ Date: _____

If yes, what kind of work? _____

_____

When did he last work? _____

12. Is _____ currently in school? (*Ask separately for a and b.*)

	Yes	No
a) Subject	1	2
b) Baby's Father	1	2
c) Contributing Adult	1	2

Appendix I

Ethnicity and Race Questionnaire

ETHNICITY AND RACE

1. Your race and ethnicity

Are you Hispanic or Latino?

- ☐ Yes
- ☐ No
- ☐ Don't know

What is your race? (please check all that apply)

- ☐ American Indian/Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White
- ☐ Other (Please explain): _____

2. The baby's father's race and ethnicity

Is the **baby's father** Hispanic or Latino?

- ☐ Yes
- ☐ No
- ☐ Don't know

What is **the father's** race? (please check all that apply)

- ☐ American Indian/Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White
- ☐ Other (Please explain): _____

3. Your baby's race and ethnicity

Is **your baby** Hispanic or Latino?

- ☐ Yes
- ☐ No
- ☐ Don't know

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Subject #:_____ Session #:_____ Date:_____

What is **your baby's** race? (please check all that apply)

- ☐ American Indian/Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White
- ☐ Other (Please explain): _____

Appendix J

Table 1.
Correlations among Primary Study Variables

	1	2	3	4	5	6	7	8	9	10	11
1. Age	1										
2. Income	.446**	1									
3. Grade	.341**	.457**	1								
4. Parity	.533**	0.186	-0.163	1							
5. Ethnicity	-0.161	-.235*	-0.010	-0.114	1						
6. Hispanic_Latino	-0.015	-0.084	-0.178	0.164	.267*	1					
7. Sugar Intake†	-.226*	-0.071	-0.163	0.061	-0.094	.270**	1				
8. PPBMI†	0.065	-0.037	-0.079	-0.103	0.080	0.065	-0.146	1			
9. GWG	0.154	0.168	0.170	0.102	0.025	0.003	0.024	-.250*	1		
10. EPDS†	-0.184	-0.140	-0.151	-0.148	0.117	0.076	.234*	.220*	0.017	1	
11. PASS†	-.207*	-0.142	-0.088	-.210*	-0.013	-0.042	.250*	0.159	-0.031	.626**	1
12. PSS	-.256*	-0.144	-0.156	-0.118	0.007	-0.051	.299**	0.165	-0.052	.653**	.607**

Note. This table contains bivariate or point-biserial correlations between primary study variables and potential covariates. PPBMI=Pre-pregnancy body mass index; GWG=Gestational weight gain; Sugar=Added sugar intake in the third trimester; EPDS=Edinburgh Postnatal Depression Scale; PASS=Perinatal Anxiety Screening Scale; PSS=Perceived Stress Scale. †denotes a transformed variable, *p<0.05, **p<0.01.