THE EFFECTS OF MATERNAL PREPREGNANCY BODY MASS INDEX AND PSYCHOLOGICAL FACTORS ON INFANT FEEDING BEHAVIORS

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Nutrition, Gillings School of Global Public Health.

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ABSTRACT

USHMA J. MEHTA: The Effects of Maternal Prepregnancy Body Mass Index and Psychological Factors on Infant Feeding Behaviors
(Under the direction of Dr. Anna Maria Siega-Riz)

The American Academy of Pediatrics recommends exclusive breastfeeding for 6 months with continued breastfeeding until at least 1 year of age. Three-quarters of women in the U.S. initiate breastfeeding but rates decline considerably by 6 and 12 months postpartum; furthermore, many women introduce complementary foods before the recommended age. Low breastfeeding rates and early introduction of foods may be explained, in part, by the rise in obesity among women of childbearing age. There is some evidence that women who enter pregnancy overweight and obese are more likely to not breastfeed, to breastfeed for a shorter duration and to introduce complementary foods earlier than women of normal body mass index (BMI). It is unclear why this association exists but possible reasons include obesity-related biological changes, psychological changes and mechanical difficulties. The purpose of this research was to determine the association between pregravid BMI and infant feeding behaviors and explore whether the relationship was mediated by psychological factors present during pregnancy (depressive symptoms, stress, anxiety, and self-esteem).

Data came from the postpartum component of the Pregnancy, Infection, and Nutrition study. Pregnant women, recruited from the University of North Carolina hospitals between January 2001 and June 2005, were followed from pregnancy to postpartum. Using multivariable regression analysis, we found that women who entered pregnancy overweight or obese were less likely to adhere to current infant feeding recommendations. Specifically, overweight or obese women were less likely to initiate breastfeeding; more likely to breastfeed for shorter duration (any or exclusive); and more likely to introduce complementary foods before 4 months of age compared to women of normal BMI. We did not find evidence to support the hypothesis that the association between pregravid BMI and infant feeding was mediated by psychological factors.

Our results showed a strong association between maternal pregravid BMI and infant feeding behaviors but, contrary to our expectations, we did not find evidence for a mediatory psychological pathway. This suggests that other factors may be more important in explaining the pregravid BMI-infant feeding relationship. Future studies need to explore why overweight and obese women are less likely to adhere to infant feeding guidelines.

DEDICATION

To my family.

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LIST OF ABBREVIATIONS

AAP	American Academy of Pediatrics
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
PIN	Pregnancy, Infection, and Nutrition Study
PIN3	Pregnancy, Infection, and Nutrition Study, third cohort
PINPost	Pregnancy, Infection, and Nutrition Postpartum Study
RR	Risk Ratio
UNC	The University of North Carolina at Chapel Hill
WHO	World Health Organization

CHAPTER I

INTRODUCTION

In the U.S., adherence to infant feeding guidelines is low. Almost three-quarters of women initiate breastfeeding but rates decline considerably in the first few months postpartum[1] and many women introduce complementary foods before the recommended age.[2, 3] Low breastfeeding rates may be explained, in part, by the rise in obesity among women of childbearing age. More than half of all women of childbearing age are overweight or obese and recent studies associate entering pregnancy at this high body mass index (BMI) with being less likely to initiate breastfeeding, breastfeeding for a shorter duration, and introducing complementary foods at an earlier age.[4-7] The reason behind the increased rate of cessation among overweight/obese women is unclear although there is evidence of a biological, physical, and psychological basis for this relationship.[8, 9]

The overall goal of this dissertation was to determine the association between pregravid BMI and infant feeding behaviors and whether psychological reasons help to explain this relationship. Infant feeding practices include *breastfeeding initiation*, *breastfeeding duration* (*any* and *exclusive*), and *age of complementary food introduction*.

This dissertation was guided by two specific aims:

Aim 1: Determine the relationship between pregravid BMI and infant feeding outcomes.

Hypothesis: Women who are overweight or obese before pregnancy will be more likely to not breastfeed, to breastfeed for shorter duration, and to introduce complementary foods earlier than women of normal pregravid BMI.

Aim 2: Explore whether pregravid BMI is associated with infant feeding via a psychological pathway, represented by depressive symptoms, perceived stress, anxiety and self-esteem during pregnancy.

Hypothesis: That the psychological factors will explain part of the effect of pregravid BMI on infant feeding behaviors.

CHAPTER II

LITERATURE REVIEW

According to the World Health Organization (WHO), "inappropriate feeding practices and their consequences are major obstacles to sustainable socioeconomic development and poverty reduction."[10] The WHO and the American Academy of Pediatrics (AAP) promote breastfeeding as the ideal method of meeting the nutrient needs of infants.[10, 11] Breastfeeding provides short and long-term health benefits for both mother and child. Women who breastfeed their infants have lower risk of developing ovarian and premenopausal breast cancers, osteoporosis, and reduced risk of postpartum bleeding.[12, 13] Children benefit from breastfeeding through lower risk of ear and respiratory infections, gastrointestinal illness, type 2 diabetes, and sudden infant death syndrome.[14-16]

The WHO and AAP recommend exclusive breastfeeding (breast milk only) for the first 6 months of life.[10, 11] Despite these recommendations, a quarter of infants are supplemented with formula before they are 2 days old; 33.1% of infants are exclusively breastfed until 3 months and 13.6% until 6 months of age.[1]

Many mothers introduce formula or non-breast milk foods in the first 6 months of the infant's life. Studies have reported infants receiving solid foods or juices as early as 1 to 2 weeks postpartum.[3] Common introductory foods given before 6 months of age are cereal (alone or mixed in formula), juice, and fruit.[3, 17] These infants may have an increased risk of childhood obesity because infants who are formula or mixed-fed have a faster growth rate and weigh more than exclusively breastfed infants.[7, 18] Several meta-analyses have found conflicting evidence of the suggested protective effect of breastfeeding initiation and longer duration against childhood overweight [19-21] but this may be due to differences in sample size and population, follow-up time, reporting bias, confounders, and definitions of exposure and outcome.[22]

Maternal obesity may be a risk factor for poor infant feeding behaviors. Studies worldwide have found that women who are overweight or obese before pregnancy may be less likely to initiate breastfeeding and breastfeed for a shorter duration; there is some evidence that they may also be more likely to introduce complementary foods earlier.[6, 7, 23-25, 26] The reason behind the increased rate of cessation among overweight/obese women is unclear although there is evidence of a biological, physical, psychological and psychosocial basis for this relationship.[8, 9] The Pregnancy, Infection and Nutrition Postpartum study (PINPost), a longitudinal cohort study following women from pregnancy to postpartum, provided the unique opportunity to better understand the associations between maternal pregravid weight status, psychological factors during pregnancy and infant feeding practices.

Infant Feeding Definitions

This section provides a background of infant feeding definitions and current guidelines. *Exclusive breastfeeding* is feeding the infant only breast milk with the exception of drops or syrups consisting of vitamins, mineral supplements or medicines.[27] *Formula feeding* means feeding the infant only formula while *any breastfeeding* or *mixed* *feeding* refers to breastfeeding as well as feeding solid foods or other liquids (including formula).

The AAP recommends that women breastfeed until the infant is at least one year old and *complementary foods* should not be introduced before 4 months, preferably at 6 months of age.[11] These recommendations for the timing of complementary feeding are based on physiological readiness and nutrient needs of the infant.[28] The WHO global strategy for infant feeding outlines four important aspects of proper complementary food introduction: timeliness, adequacy, safety, and proper feeding style. [10] Timeliness means that foods should be introduced when exclusive breastfeeding no longer provides enough nutrition for the growing child.[29] Introduction of complementary foods before the infant is physiologically ready is associated with malnutrition, short stature, and delays in mental and motor development.[10, 29, 30] Adequacy refers to the food's ability to provide sufficient nutrients for the infant. Foods should also be stored, prepared and fed in a hygienic manner. The final requirement for complementary food introduction is that meal frequency and feeding method are suitable for the child's age and that the care provider practice responsive feeding, a type of infant feeding style. Responsive feeding is an active style of feeding that involves understanding the infant's cues of appetite and satiety, feeding the child with patience and encouragement and not forcing him/her to eat, and providing the child with a variety of high-quality foods. [29, 31] Other infant feeding styles include laissez-faire, indulgent, pressuring/controlling, and restrictive/controlling.[31, 32] Restrictive infant feeding styles have been implicated in increased risk of adverse health outcomes such as childhood obesity.[33]

Infant Feeding Determinants

A multitude of individual-, interpersonal-, societal-, community/environmental-, organizational-, and policy-level factors influence maternal decisions related to infant feeding. In this section, we briefly discuss these determinants of infant feeding utilizing a social ecological framework as created by Bentley, Dee and Jensen in 2003.[34] A visual representation of this framework can be seen in Figure1 below.

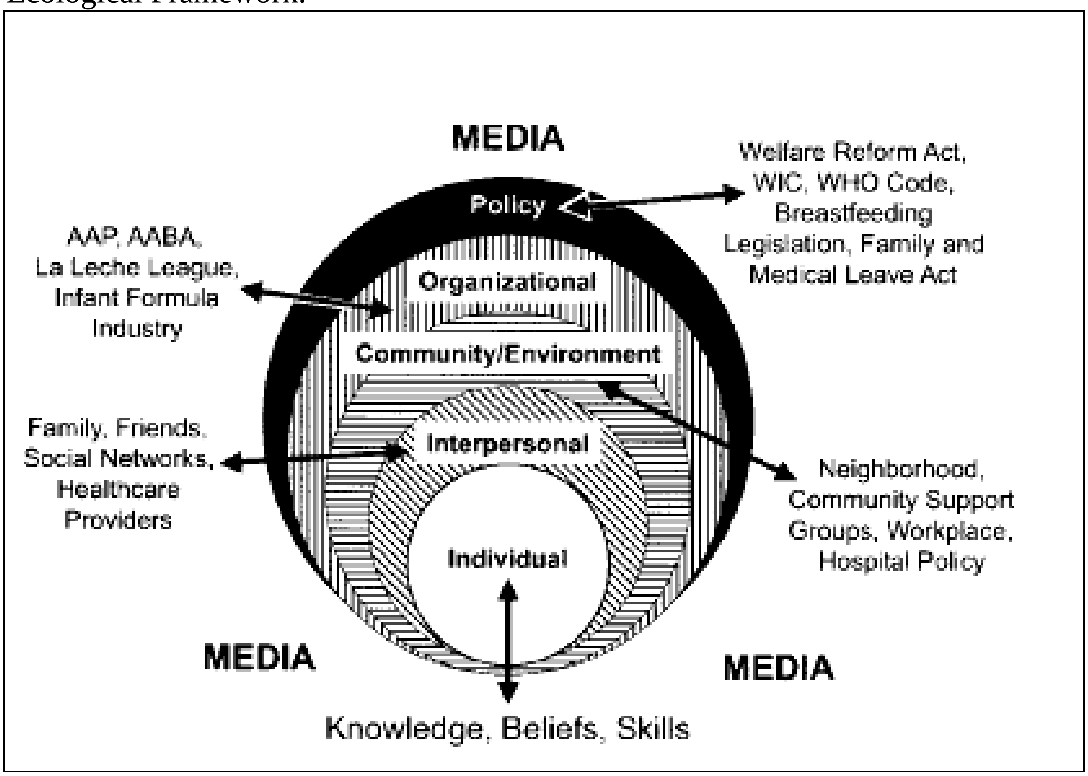
Determinants discussed here were chosen based on a literature review of infant feeding risk factors. Main exposures (maternal pregravid BMI, depressive symptoms, stress, anxiety and self-esteem) will be discussed in greater detail in upcoming sections. We start with policy-level risk factors and narrow down to the center of the sphere, placing particular emphasis on the individual-level determinants of infant feeding as these were the primary factors measured in the PIN study.

Policy

National and international policies affect environmental or community-level factors which, in turn, influence intrapersonal or individual-level determinants. In the U.S., laws addressing breastfeeding rights are both federal and state-specific. The most recent enacted breastfeeding legislation affirmed the right to breastfeed on federal property or in federal buildings. The Breastfeeding Promotion Act of 2009 was recently introduced in the House of Representatives; its objective is "to amend the Civil Rights Act of 1964 to protect breastfeeding by new mothers; to provide for a performance standard for breast pumps; and to provide tax incentives to encourage breastfeeding."[35] The US government also provides funding support for breastfeeding promotion through programs as WIC (Special Supplemental Nutrition Program for Women, Infants, and Children).[36] WIC infant feeding policies were recently improved to better promote breastfeeding based on recommendations of the Institute of Medicine (IOM).[37, 38]

Most US states have enacted breastfeeding laws but these vary considerably in the level of rights that are protected. For example, 39 states, the District of Columbia, and the Virgin Islands currently have laws specifically allowing women to breastfeed in any public or private location while only twenty states have addressed workplace breastfeeding.[39]

Figure 1. Influences of breastfeeding choices as represented by a Social Ecological Framework. [34]



Bentley et al, 2003

International policies relating to breastfeeding are established by organizations such as the WHO and UNICEF and these can greatly influence national policies. A prominent policy affecting the marketing of formula was the International Code of Marketing of Breast-Milk Substitutes, adopted by the World Health Assembly in 1981. This Code was created to protect and promote appropriate infant feeding by regulating the marketing of breast-milk substitutes, feeding bottles, and teats.[16]

Organizational

Organizations such as the American Academy of Pediatrics and La Leche League promote breastfeeding which influences policy-makers and health-care professionals; however, they do not create policy. Consequently, formula companies are able to aggressively market infant formula. Formula promotion activities occur through multiple paths; media is a potent marketing vehicle and includes television shows and advertisements for infant formula, bottles and other supplies. This creates an atmosphere where feeding formula is the norm and breastfeeding is unconventional.[34] Another method used by formula companies to establish formula as easier than breastfeeding and as nutritionally comprehensive as breast milk is through distribution of hospital discharge packs and provision of coupons for free or discounted formula.[11, 40]

Community/Environment

Working in the postpartum period is related to duration but not initiation of breastfeeding.[41-43] Workplace environment is a critical factor for breastfeeding decisions given that 55% of all women with an infant under 1 year of age were working in 2007.[44]

However, child care facilities, paid maternity leave, lack of long mother-infant separations, and the option to work part-time can promote successful breastfeeding.[41]

Hospital policies regarding rooming-in also impact the initiation of breastfeeding; keeping the infant in the mother's room after birth is shown to increase the chances of breastfeeding initiation because it is thought to promote demand feeding (feeding every 2-3 hours) and mother-infant contact.[11, 42] Lack of timely routine follow-up care and postpartum home health visits also result in reduced duration of breastfeeding.[11]

Interpersonal

At the interpersonal level, the woman's network of family, friends, and healthcare providers exert influence over infant feeding decisions.[42, 45] The woman's partner is often the most influential factor in feeding decisions; partners who are supportive of breastfeeding increase the likelihood of breastfeeding initiation.[46] Women are also more likely to initiate and continue breastfeeding if they find support from other members of their social network such as their mother and friends and guidance from healthcare providers.[42, 47, 48]

Individual

Sociodemographic

Breastfeeding initiation and duration share several sociodemographic risk factors. Women who are older, married, more educated, primiparous, and of a higher SES are more likely to both initiate breastfeeding and breastfeed for longer.[1]

CDC data on breastfeeding rates for children born during 2003-2006 show stark ethnic differences in the rates of breastfeeding. [49] Asian/Pacific Islander (80.9%) and Hispanic women (80.4%) have the highest rates of any breastfeeding, followed by non-Hispanic white (74.3%) and, lastly, non-Hispanic black women (54.4%).[49] Time spent in the US may also affect breastfeeding prevalence. A study of immigration status and ethnicity revealed US-born women of Hispanic descent had lower rates of breastfeeding compared with foreign-born Hispanic mothers.[50]

Psychological

Psychological factors associated with poor infant feeding practices include high levels of stress, anxiety, and pregnancy/ postpartum depression.[51-53] Mothers experiencing higher levels of stress, depression and anxiety may be at greater risk of following a nonresponsive feeding style.[53] High maternal breastfeeding self-efficacy, parental confidence in infant care, and confidence in breastfeeding and are also related to feeding decisions.[51, 52, 54]

Maternal health

Smoking and entering pregnancy overweight or obese is negatively associated with initiation and continuation of breastfeeding.[9, 55] Women who experience pregnancy or birth complications such as a cesarean section and lengthy duration of labor or are given labor medications may be less likely to initiate breastfeeding. [46, 56, 57]

Infant characteristics

Infants that are male, born with higher birth weight, and whose mothers perceived them as ready for food other than breast milk or formula are more likely to be fed solid foods early.[52, 58, 59] Infants born preterm and those admitted into the neonatal intensive care unit following birth have a greater risk of not being breastfed and of early weaning.[57]

Mechanisms Linking Maternal Obesity and Infant Feeding Behaviors

Currently, more than half of all women in the US are overweight or obese.[60] Maternal pregravid BMI appears to be a strong predictor of infant feeding practices but the number of observational studies in U.S. populations is limited and the ability to control for confounding has been suboptimal.

Using the Danish National Birth Cohort (DNBC), Baker and colleagues (N=37,459 mother-infant pairs) found that women classified as overweight and obese had increased odds of early breastfeeding cessation compared with women of normal pregravid BMI (12% and 39% increase in odds of early termination respectively).[7] Oddy et al (2006) found similar associations from prospective cohort data collected in an Australian population of 1803 women.[6] Cross-sectional data in the U.S. and Australia support these findings.[4, 24] A cohort study in a U.S. population[61] found gestational weight gain modified certain pregravid BMI categories but BMI before pregnancy remained the strongest predictor of breastfeeding practices; excessive weight gain raised already higher odds of poor breastfeeding practices for women overweight/obese before pregnancy. Overweight or obese women may also be more likely to introduce complementary foods when the infant is younger but the evidence is limited.[7]

Maternal obesity before pregnancy is thought to affect infant feeding behavior via several pathways.[62] Obesity may delay lactogenesis II by altering prolactin or progesterone levels in the body.[63, 64] Lactogenesis II is the stage of breastfeeding occurring one to three days postpartum in which production of abundant milk supply is stimulated.[64] Delayed lactogenesis II may affect a mother's perception of the adequacy of her milk supply which, in turn may influence her decision to discontinue breastfeeding early.[65] Maternal obesity before conception also places women at greater risk for adverse pregnancy outcomes such as preterm birth, cesarean section, or a large-for-gestational age baby which are all associated with reduced lactation success; possible reasons may be because of delayed lactogenesis II or resulting hospital practices that interfere with successful breastfeeding initiation.[8]

Researchers have also suggested a physical basis for breastfeeding decisions. Infants of obese women may have difficulty latching on to the breast, which is critical to the stimulation of breast milk.[66] Obese women may be more likely to have larger breasts which may make proper positioning of the infant problematic.[62, 66] They may also be more likely to have flattened areolas and nipples which would make latching on difficult.[62, 66]

Psychological pathway

The focus of this dissertation was the hypothesized psychological pathway, which proposes that psychological factors link maternal BMI to infant feeding outcomes. There is some evidence to support a mediatory pathway from pregravid BMI to infant feeding via psychological factors during pregnancy. Obesity is associated with mental health status, possibly in a bidirectional relationship.[67, 68] Evidence from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), the largest psychiatric epidemiology study conducted thus far showed that being obese predicted increased odds of any mood, anxiety, alcohol use disorders and personality disorders.[69] Being moderately overweight was also associated with anxiety and some substance disorders. There is some evidence that obesity disproportionately affects psychopathology in women[70] and that it affects psychological status during pregnancy. Prior analyses of PIN data revealed that higher pregravid BMI increased the risk of poor psychological status during pregnancy as characterized by higher perceived stress, trait anxiety, depressive symptoms, and lower self-esteem.[71] Another study found a dose-response relationship between pregravid BMI and Major Depressive Disorder occurrence during pregnancy.[68]

Research on the relationship between psychological factors and infant feeding has focused more on the protective role of breastfeeding on postpartum psychological status than the relationship between psychological factors in pregnancy and infant feeding. Researchers have found an association between depressive symptoms/stress/anxiety in postpartum and early cessation of breastfeeding.[48, 72-77] Most studies have not used clinically diagnosed depression or anxiety in their analysis but used questionnaires to assess symptoms of these psychological factors. However, a study among 1745 Australian women[72] did find that postpartum depression, assessed by a clinical interview, was associated with early breastfeeding cessation.

Fewer studies have examined the effect of psychological status in pregnancy on infant feeding behaviors. In a study of 1448 women, Pippins et al[78] used the Center for Epidemiologic Studies Scale (CES-D) to measure depressive symptoms experienced in the month prior to pregnancy and at three subsequent time points during pregnancy. Depressive symptoms prior to or during pregnancy were not associated with breastfeeding initiation but were related to breastfeeding less than 1 month. However, the presence of depressive symptoms in the month prior to pregnancy was measured around 15 gestational weeks and responses may have been affected by recall bias. Fairlie et al[79] reported that high levels of depressive symptoms and anxiety during pregnancy were not associated with breastfeeding initiation but were related to increased risk of planning to formula feed. There is less epidemiologic evidence for the associations between stress/self-esteem and infant feeding. In a cohort study of 2420 Australian women, Li et al. found that stressful life events during pregnancy predicted shorter duration of breastfeeding.[80] In addition, stress may result in hormonal changes that impede the onset of lactogenesis.[81] A recent qualitative study of 17 adolescent mothers in the U.K. identified self-esteem as being important to breastfeeding intention, especially as being protective against societal pressures to not breastfeed[82] . Further, self-esteem may be related to infant feeding through its association with self-efficacy, which significantly predicts breastfeeding duration.[54]

Evidence that psychological factors are associated with complementary food introduction is limited. McLearn et al[83] found no association between depressive symptoms reported between 2-4 months and introduction of cereal, water, or juice. However, their data were limited in that they assessed a small number of infant foods and did not estimate age of introduction. A more recent study among 37,919 mothers participating in the Norwegian Mother and Child Cohort Study found that maternal negative affectivity, conceptualized as the combination of anxiety and depression, predicted greater likelihood of introducing solid foods by 3 months of age and sweet drinks by month 6.[84]

It is difficult to compare across studies since they vary in their definitions of the psychological factors and breastfeeding, their method of assessment of both exposure and outcome, and the time span involved. Most of the information on the relationship between psychological factors and breastfeeding has come from observational studies. Consequently, it is difficult to determine causality. For example, breastfeeding and depression may be associated but the direction of the relationship is difficult to determine. There is evidence that women who are depressed are less likely to initiate breastfeeding and to breastfeed for a shorter duration than women who do not experience perinatal depression.[51, 74, 78, 85] On the other hand, studies have shown that breastfeeding may be protective of postpartum depression.[14, 75] There may, in actuality, be an interdependent relationship.

To our knowledge, only one epidemiologic study has accounted for the effect of psychological factors on pregravid BMI and infant feeding, specifically breastfeeding duration. In a cohort of 114 rural white women, Hilson et al[25] found that maternal obesity was associated with shorter duration after accounting for the following psychological and psychosocial variables: maternal confidence in breastfeeding, social support, body satisfaction, behavioral beliefs regarding breastfeeding and bottle-feeding, and social learning.

For this project, we concentrated on psychological factors such as depressive symptoms, perceived stress, anxiety and self-esteem measured during pregnancy. There is limited knowledge on the degree of their effect and their role in the pregravid BMI-infant feeding relationship. In this dissertation, we determined the association between maternal pregravid BMI and infant feeding and explored whether psychological factors helped to explain this association.

CHAPTER III

METHODS

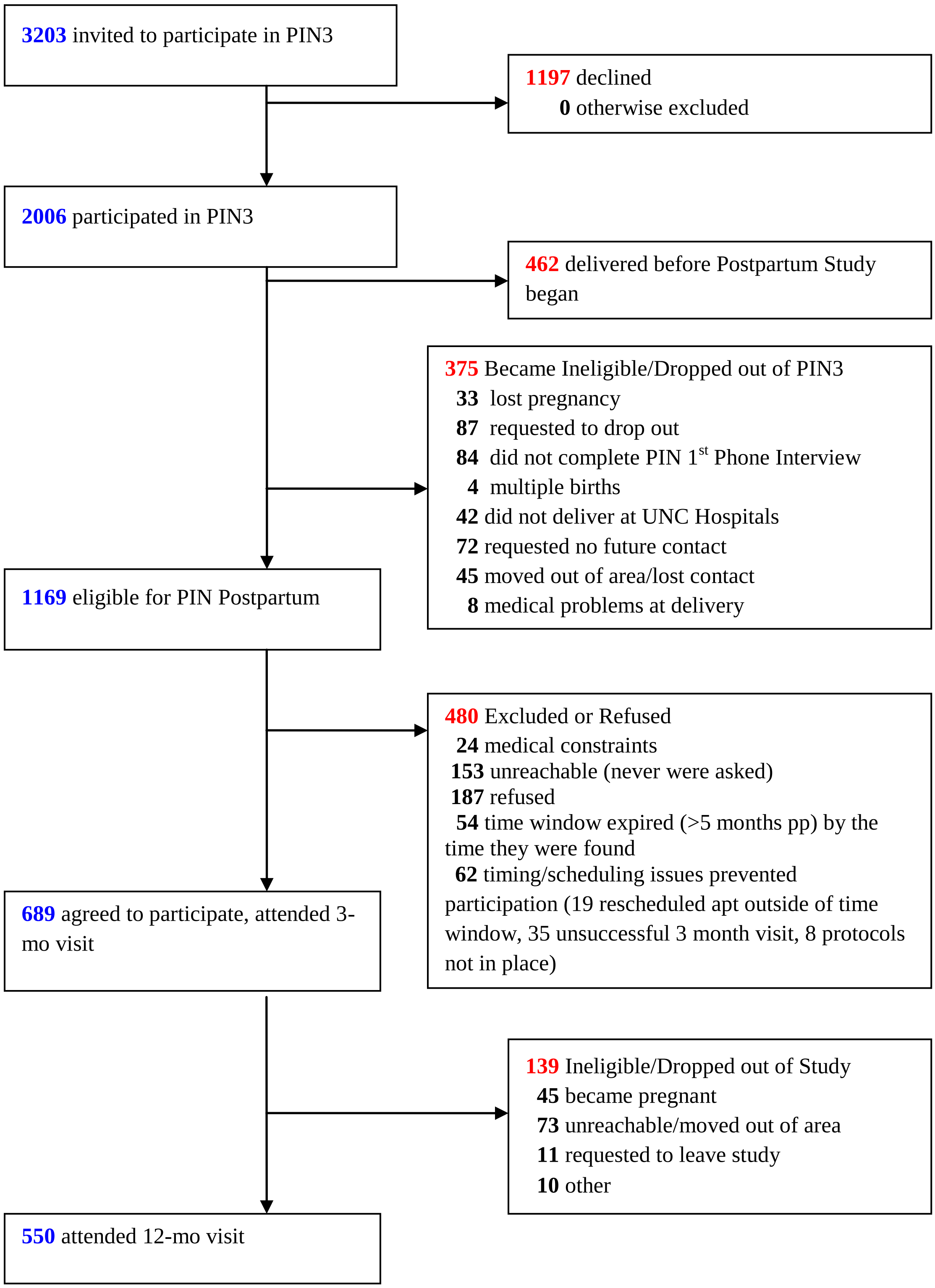
Study Design and Population

We used data from the postpartum component of the Pregnancy, Infection, and Nutrition study cohort 3 (PIN3), a longitudinal prospective cohort study identifying etiologic factors for preterm delivery. Of the 3203 women eligible to participate in the PIN3 study, 2,006 were followed through pregnancy. Pregnant women seeking prenatal services from University of North Carolina (UNC) hospitals between January 2001 and June 2005 were recruited for the pregnancy component. Exclusionary criteria included women younger than 16, non-English speaking, greater than or equal to 20 weeks' gestation on their second prenatal visit, not planning to continue care or deliver at the study site, and those carrying multiple gestations. Women were interviewed during pregnancy at 15-20 weeks (clinic visit 1), 17-22 weeks (telephone interview 1), 24-29 weeks (clinic visit 2), 27-30 weeks (telephone interview 2), and after delivery in the hospital. Participants for the postpartum component were those women followed through pregnancy and who gave birth after the postpartum study recruitment began; 1169 women were eligible to participate in the postpartum period. Exclusionary criteria included pregnancy loss, not completing PIN phone interview I, multiple births, and delivery at a hospital other than UNC. Of these 1169 women, participants who agreed to be contacted after delivery were phoned at 6 weeks postpartum; 480 refused or were ineligible, leaving 689 who participated in the 3 month interview. 550 completed both 3 and 12 month interviews. Reasons for attrition from 3 to 12 months postpartum included moving out of study area/being unreachable, request to drop out, and becoming pregnant. Attrition from pregnancy to postpartum is shown in Figure 2.

Study variables and statistical analyses

Data collection on covariates and methods specific to each analysis are discussed in detail in the following chapters.

Figure 2. Attrition in the Pregnancy, Infection and Nutrition study, from pregnancy to postpartum.



CHAPTER IV

MATERNAL OBESITY, PSYCHOLOGICAL FACTORS AND BREASTFEEDING INITIATION

Introduction

Leading health organizations world-wide recognize breastfeeding as the ideal method of meeting an infant's nutritional needs.[10, 11] Despite this, 25% of mothers in the United States (U.S.) do not initiate breastfeeding.[1] Recent studies suggest that women who enter pregnancy at a higher body mass index (BMI) are less likely to initiate breastfeeding.[4, 5, 25, 86] Reasons for this association are unclear although biological, physical, and psychological pathways are thought to be involved.[8, 9] Psychological factors during pregnancy may be modifiable with the appropriate interventions and, therefore, are an important avenue of research.

Currently, there is little research of a potential mediatory pathway between pregravid BMI and breastfeeding initiation by psychological factors. Prior research shows that maternal obesity is associated with women's psychological status during the perinatal period (pathway "a" in **Figure 3**)[68, 71] but there is less epidemiologic evidence relating psychological status to breastfeeding initiation (pathway "b" in Figure 3). We focus on four factors that may be indicative of women's overall mental health status during pregnancy: depressive symptoms, stress, anxiety, and self-esteem. Studies examining the association between prenatal depressive symptoms and breastfeeding initiation have found conflicting results, and the use of different measurement scales makes it difficult to compare results across studies.[78, 79, 87] One study that examined anxiety during pregnancy found no relationship to breastfeeding initiation although higher levels were related to a lower intent to breastfeed, which is known to predict initiation.[26, 79, 88] To our knowledge, the effects of prenatal perceived stress and self-esteem on breastfeeding initiation has not previously been studied.

In this paper, we present findings on the associations between pregravid BMI, psychological factors (prenatal depressive symptoms, stress, anxiety, self-esteem) and breastfeeding initiation. We hypothesize that women who are overweight or obese before pregnancy are less likely to initiate breastfeeding. Furthermore, we expect that part of the association between pregravid BMI and breastfeeding initiation is mediated by the presence of higher levels of depressive symptoms, stress, and anxiety and lower levels of self-esteem among overweight and obese women during pregnancy. Levels of these psychological factors during pregnancy may be indicative of a woman's overall mental health status during the prenatal period and are modifiable risk factors for future breastfeeding interventions.

Methods

Subjects

Data came from the postpartum component of the Pregnancy, Infection, and Nutrition (PIN) study, a prospective cohort study focusing on weight gain, psychosocial factors, physical activity, diet, and health behaviors during and following pregnancy.[89]

Women between 15 to 20 weeks' gestation were recruited at their second prenatal clinic visit at University of North Carolina hospitals between January 2001 and June 2005. Women younger than 16, non-English speaking, greater than or equal to 20 weeks' gestation on their second prenatal visit, not planning to continue care or deliver at the study site, and those carrying multiple gestations were not eligible to participate. Of the 2006 women who were followed through pregnancy, 1169 were eligible for the postpartum component (PINPost) of the study. To be eligible, they must have delivered live-born infants between October 2002 and December 2005 and have lived within a 2 hour radius of UNC (in order to facilitate home visits). We excluded 239 women: 24 due to medical constraints, 153 were unreachable, 54 were more than 5 months postpartum by the time they were contacted, and 8 for whom study protocols were not in place at the time of their eligibility window. The remaining 930 women were phoned at 6 weeks postpartum with a description of the postpartum component; 688 women consented and were interviewed in their homes by trained staff at approximately 3 months postpartum. Protocols for this study were approved by the University of North Carolina, School of Medicine Institutional Review Board.

Outcome

The dependent variable, breastfeeding initiation, was assessed at 3 months postpartum by the question "Did you ever breastfeed this baby?"

Exposure

Pregravid BMI, the main exposure, was calculated from self-reported weight (checked for implausible values) and height measured during screening at 15 to 20 weeks' gestation. For our analysis, pregravid BMI was dichotomized at 26 kg/m^2 based on Institute of Medicine cutpoints in use at the time participants attended prenatal care; women > 26 kg/m^2 before pregnancy were identified as overweight or obese and those ≤ 26 kg/m^2 as being of normal or underweight BMI (the referent category).[90]

Psychological variables

Depressive symptoms during pregnancy were assessed using the Center for Epidemiologic Studies-Depression scale (CES-D).[91] Participants were given questionnaires to return by mail at the first and second prenatal visits; 640 (93% of 688) completed the CES-D component of the questionnaire given between 15 to 20 weeks' gestation and 598 (87% of 688) completed the CES-D given between 24 to 29 weeks' gestation. The 20-item scale had Likert response categories that assessed the participant's feelings and activities in the previous week. A composite score was calculated and dichotomized at 17 for both time points measured; scores greater than or equal to 17 indicated the presence of a higher level of depressive symptoms. Though a cutpoint of 16 or higher is generally used to represent higher depressive symptoms, we used a slightly higher score to better distinguish between depressive and pregnancy symptoms, which are often similar.[92] To test the use of 17 as a cutpoint, we reexamined our population using the method proposed by Hoffman and Hatch[93], who used a cutpoint of 16 after removing items that overlapped with pregnancy and rescaling scores so that the range still lay between 0 and 60; no differences in results were found. Internal consistency as indicated by Cronbach's alpha ranged from 0.83 to 0.92.[94]

The Perceived Stress Scale [95] measured the degree to which respondents found situations to be stressful. 687 women completed the 14-item scale administered over the phone at 17 to 22 gestational weeks, and 652 (94.8%) completed a modified 10-item scale during a phone interview conducted between 27 to 30 gestational weeks. Questions were on a Likert scale, and higher overall scores indicated higher levels of perceived stress. After summing across items for each time period, the variables were categorized into three levels: 0 to < 17 (low stress; referent), 17 to < 23 (moderate), and ≥ 23 (high) for the 14-item scale; 0 to < 11 (low stress; referent), 11 to < 17 (moderate), and ≥ 17 (high) for the 10-item scale. Cronbach's alpha was 0.83 in three non-pregnant samples tested by Cohen.[96]

The State-Trait Anxiety Inventory was used to assess state and trait anxiety during pregnancy.[97] For this analysis, we used the state anxiety measurement because it assessed "immediate" feelings of anxiety, which better represented how women felt during pregnancy than the trait-anxiety scale, a stable measure of anxiety. The state-anxiety scale had 20 questions on a 4-point Likert scale. 636 (92.4%) participants completed the mail-in questionnaire given at screening (15 to 20 weeks) while 593 (86.2%) completed the questionnaire provided at the second prenatal visit (24 to 29 weeks). The variables were categorized into three levels: 0 to < 29 (low anxiety; referent), 29 to < 39 (moderate), and ≥ 39 (high). Cronbach's alpha ranged from 0.90 to 0.94 for the state scale.[97]

The Self-esteem Scale [98] was completed by 635 women (92.3%) during a phone interview between 15 to 20 gestational weeks. This variable was measured only once because we did not believe self-esteem was likely to change considerably during the course of the pregnancy. Ten questions on a 6-point Likert scale were used to determine the respondent's sense of self-worth and positive or negative orientation towards oneself. The variables were categorized into three levels that indicated low, moderate and high self-esteem: 0 to < 50, 50 to < 56, and ≥ 56 (referent). Test-retest correlations have been shown to be in the 0.82 to 0.88 range, and Cronbach's alpha ranged from 0.77 to 0.88.[99]

Both measurements for the CES-D, perceived stress, and state anxiety were separately assessed as mediators to determine which time point had a greater effect on the pregravid BMI-breastfeeding initiation relationship.

Covariates

We collected data on several covariates through self-reported questionnaires, telephone interviews and medical chart abstraction. The covariates reported here were examined for effect measure modification and confounding. They were selected based on construction of a directed acyclic graph, created after a review of the literature, which depicted the relationships between the exposure (pregravid BMI), outcome (breastfeeding initiation), and covariates.[100] Participants reported their race, age, parity, education, marital status, family income, household size, smoking status in the first two trimesters, and work/school status following the birth of the baby. Information on family income and household size was used to create a variable representing percent of the 2001 poverty index according to the U.S. Bureau of the Census.[101] We also collected information on weight gain during pregnancy, type of delivery (vaginal or cesarean) and whether the infant was hospitalized following delivery.

Statistical methods

Descriptive statistics were generated for the variables of interest. Student's t test and chi-squared tests were used to examine associations between study variables and breastfeeding initiation. Variables were assessed as both effect measure modifiers and confounders. Modification was tested using a likelihood ratio test to compare models with and without an interaction term between the potential modifier and pregravid BMI (a priori significance criterion of $p < 0.15$). If variables failed to meet the criteria for modification, they were tested for confounding. Covariates were kept as confounders in the final model if they changed the beta coefficient of the exposure by greater than 10%. Binomial regression produced risk ratios (RR) of the association between pregravid BMI and breastfeeding initiation..

Mediation was tested using a series of regression analyses.[102] To be considered a mediator, the exposure must be associated with the outcome (pathway "c" in Figure 3; Model 1); the mediator must be predicted by the exposure (pathway "a" in Figure 3; Model 2); the outcome must be predicted by the mediator while adjusting for the exposure (pathway "b" in Figure 3; Model 4); and the effect estimate of the exposure must be reduced while adjusting for the mediator (Model 4). A third step (Model 3) was added to explore the association between the psychological factors and breastfeeding initiation..The Sobel test for mediation determined whether the indirect effect of the exposure on outcome via the mediator was significantly different from zero. [103] Each psychological factor was tested in separate mediation analyses. All statistical analyses were conducted using Stata software (version 9.2; College Station, TX).

Results

The cohort was comprised primarily of women who were white (76.5%), married (80.4%), an average of 29 years old, had a college degree (65.5%), and were living above the poverty line (61.1%) (**Table 1**). Most women had a BMI of ≤ 26 kg/m^2 before pregnancy (68.1%) and gained above IOM-recommended weight gain guidelines during pregnancy (63.7%). Compared to women who started pregnancy underweight or normal weight, women who started their pregnancy overweight or obese were more likely to be non-white, less educated, unmarried, living below the poverty line, multiparous, and have gained excessively during pregnancy. Of the women who did not breastfeed, most were overweight or obese before pregnancy (72.1%), multiparous (72.6%), did not have a college degree (78.7%), and nearly half lived below the poverty line (47.5%).

Mean scores for depressive symptoms at 15 to 20 weeks and perceived stress at 17 to 22 weeks were significantly higher for those who did not breastfeed compared with those who breastfed ($p < 0.05$; **Table 2**). Compared with breastfeeders, non-breastfeeders had a greater proportion of women in the higher depressive symptoms category at 15 to 20 weeks but not at 24 to 29 weeks gestation ($p < 0.01$); however, there was no difference in stress, anxiety or self-esteem levels between breastfeeders and non-breastfeeders. Those with a BMI > 26 kg/m^2 prior to pregnancy had lower levels of self-esteem and higher levels of depressive symptoms, stress, and anxiety at both measurement times than those ≤ 26 kg/m^2 before pregnancy.

The majority of women who completed both CES-D assessments at 15 to 20 and 24 to 29 weeks gestation (*n* = 581) remained at a low level of depressive symptoms (72.1%) ; 9.3% increased to high and 6.2% decreased from high to low levels. Of the 652 women who completed both perceived stress measurements, 17.8% increased to a higher stress level during pregnancy while a quarter of women (24.8%) remained at a low level of stress. Almost a third (31.2%) of women who completed both anxiety measurements (*n* = 573) decreased to lower levels of anxiety as pregnancy progressed while 14.8% increased. A greater proportion of non-white participants reported higher levels of depressive symptoms, stress, and anxiety at both measurements during pregnancy ($p < 0.05$). Proportions of high and low self-esteem were not different between white and non-white participants.

Crude risk ratio estimates showed a positive association between pregravid BMI and breastfeeding initiation [RR = 5.52 (95% CI: 3.23, 9.45)]. This association was modified by age such that, as age increased, women entering pregnancy overweight or obese were less likely to breastfeed than those normal weight or underweight before pregnancy. After including confounders in the model, however, age was no longer a significant effect measure modifier. The crude association between pregravid BMI and breastfeeding was attenuated but remained strong after adjusting for race, education, marital status, and poverty status; women who started pregnancy overweight or obese were much more likely to not breastfeed compared to women of lower BMI [RR = 3.94 (95% CI: 2.17, 7.18)].

We then tested the hypothesis that the pathway between pregravid BMI and breastfeeding initiation was partially mediated by depressive symptoms, stress, anxiety, and self-esteem. Results from crude regression analyses are shown in **Table 3**, categorized by psychological factor. Model 1, the crude association between pregravid BMI and breastfeeding initiation, is the same for each psychological factor and is noted as a footnote in Table 3. Perceived stress and state anxiety were not related to breastfeeding initiation at either of the measured time points and, therefore, did not fit the definition of a mediator variable.[102] Self-esteem and depressive symptoms at 15 to 20 weeks (but not 24 to 29 weeks) were significantly related to both pregravid BMI and breastfeeding initiation (Models 2 and 3). In Model 4, depressive symptoms at 15 to 20 weeks slightly reduced the effect of pregravid BMI on breastfeeding initiation (8% change in estimate) and was, thus, considered to be a weak mediator in crude analyses. Self-esteem increased the magnitude of the relationship between the exposure on outcome, possibly acting as a suppressor variable as explained by McKinnon and colleagues.[104] However, the Sobel test found no significant reduction in the effect of the exposure on outcome via any of the hypothesized mediators (data not shown). In addition, once we accounted for race, education, marital status, and poverty status, pregravid BMI no longer predicted the psychological factors. Further, depressive symptoms and self-esteem were not associated with breastfeeding initiation.

Discussion

Our analysis provides support for an adverse association between pregravid BMI and breastfeeding initiation; similar to previous studies [4, 5, 25, 86], we found that women who entered pregnancy overweight or obese were much more likely to not breastfeed compared to normal or underweight women. We further explored whether this association could be explained in part by psychological factors present during pregnancy. Although we did not find evidence of mediation by depressive symptoms, stress, anxiety and self-esteem during pregnancy, our analysis contributes to the growing body of literature aiming to understand why overweight and obese women are less likely to breastfeed.

There are several possible reasons why we did not find evidence of mediation by the psychological factors. Of the psychological variables tested, only depressive symptoms at 15 to 20 weeks gestation and self-esteem predicted the outcome, breastfeeding initiation. The lack of association may be a consequence of the recruitment pool. Out of the 1169 women that were eligible to participate in the postpartum component, 480 were excluded or refused. We compared these 480 women to the 688 who attended the 3-month visit and found that those who refused to participate or were excluded had significantly higher levels of depressive symptoms and anxiety (data not shown). There was no difference in self-esteem or stress between the two groups. Thus, it is possible that we did not see a mediating effect of psychological factors on the pregravid BMI-breastfeeding initiation relationship because the women who chose to participate in PINPost had better overall mental health status during pregnancy than those who were excluded or refused, reducing the likelihood of finding an association. Furthermore, our measurement tools could not clinically diagnose depression or anxiety. It is possible that a more sensitive measurement tool is needed before we can see an effect on breastfeeding initiation.

Although we found that depressive symptoms, perceived stress, anxiety and self-esteem did not mediate the association between pregravid BMI and initiation of breastfeeding, it was important to explore their role given their potential as targets in breastfeeding interventions. Moreover, this is one of a few studies to examine how psychological factors in pregnancy can influence breastfeeding initiation. Previous studies have focused primarily on the postpartum period and the relationship between psychological factors and breastfeeding duration, excluding women who chose not to breastfeed. However, we wanted to look specifically at the effect of pregravid BMI on breastfeeders versus non-breastfeeders. Our results provide further support for the findings by Fairlie et al.[79] that perinatal anxiety levels are not associated with breastfeeding initiation. We did find that higher levels of depressive symptoms between 15 to 20 weeks' gestation significantly increased risk of not breastfeeding but this association attenuated and became non-significant after adjusting for confounders. To our knowledge, this is the first quantitative study to examine the effects of stress and self-esteem on breastfeeding initiation.

A further strength of this study includes its prospective cohort study design. This enabled measurement of the exposure and mediators prior to the outcome and, thus, allowed for the assessment of risk. In addition, previous work has failed to examine as many potential modifiers and confounders as comprehensively as we were able to do in the PINpost study.

While the PINPost study has been able to examine numerous risk factors related to maternal and child health status, the fact that most women were Caucasian, of a higher socioeconomic status and received prenatal care limits the generalizability of the findings. Our population is different from the general population of women who give birth in that 91% initiated breastfeeding, which is much higher than the national average of 73.8%.[1] We also have a much lower prevalence of overweight/obese women (31.9%) compared to the average for women of childbearing age in the U.S. (59.5%).[60] Furthermore, we did not have sufficient power to analyze racial or ethnic differences, although African American women in the U.S. have higher rates of obesity and lower rates of breastfeeding initiation than Caucasian women.[1, 40, 105]

An additional limitation of this analysis is in the assessment of the outcome variable. Breastfeeding initiation was determined by asking women, “Did you ever breastfeed this baby?” at the 3 month interview and it is possible that participants varied in their interpretation of the question. However, we found similar results when we compared our current definition of breastfeeding initiation to that of initiation defined as breastfeeding for one week or longer. This suggests that we are capturing women who persevered with breastfeeding rather than women who made a brief attempt to breastfeed.

In this paper, we found that prepregnancy obesity negatively influenced breastfeeding initiation and that higher levels of depressive symptoms, stress, anxiety and lower levels of self-esteem did not alter this adverse association. Studies examining the role of psychological factors should explore the possible mediating role of clinically diagnosed depression and anxiety. It may be that clinical levels of depressive symptoms and anxiety, not diagnosed by the CES-D or the STAI, may be associated with breastfeeding. Furthermore, a dataset with a larger sample size and, thus, greater statistical power than ours can provide the ability to examine differential effects by race. Given the prevalence of prepregancy obesity and the health benefits of breastfeeding, it is critical to elucidate the pathways between the two. As we advance our understanding of infant feeding decisions, we can better target interventions for improving breastfeeding initiation rates.

Table 1. Maternal characteristics of participants who completed the 3 month postpartum interview in the Pregnancy, Infection and Nutrition study (*n* = 688).

		Breastfeeding initiation			Pregravid BMI		
	Overall *n* [%]	% Breastfed (*n* = 626)	% Did not breastfeed (*n* = 62)	*p*[1] <	≤ 26 kg/m^2	> 26 kg/m^2	*p*[1] <
Age [mean in yrs]	688 [29.4]	29.7	26.7	0.01[2]	29.7	28.9	0.08[2]
Prepartum BMI							
≤ 26 kg/m^2	465 [68.1]	72.2	27.9		-	-	
> 26 kg/m^2	218 [31.9]	27.8	72.1	0.01	-	-	
Race							
White	526 [76.5]	78.9	51.6		83.7	61.5	
Non-white	162 [23.5]	21.1	48.4	0.01	16.3	38.5	0.01
Education status							
High School	118 [17.2]	14.2	47.5		11.9	28.0	
Some college	119 [17.3]	16.0	31.2		12.7	27.5	
College graduate & beyond	450 [65.5]	69.8	21.3	0.01	75.4	44.5	0.01
Marital Status							
married	553 [80.4]	82.6	58.1		87.1	66.5	
other (single, divorced, separated, widowed)	135 [19.6]	17.4	41.9	0.01	12.9	33.5	0.01
Percent of 2001 Poverty Line							
<185%	123 [18.5]	15.7	47.5		12.4	31.1	
185-350%	136 [20.4]	19.3	32.2		19.3	23.0	
≥350%	407 [61.1]	65.1	20.3	0.01	68.4	45.9	0.01
Parity (live births and still births)							
nulliparous	334 [48.6]	50.6	27.4		53.8	38.1	
1 or more	354 [51.5]	49.4	72.6	0.01	46.2	61.9	0.01
Maternal Smoking							
no	600 [87.2]	93.0	82.1		94.4	86.4	
yes	52 [7.6]	7.1	17.9	0.01	5.6	13.6	0.01

Gestational weight gain							
inadequate	96 [14.1]	13.3	21.3		14.6	12.8	
adequate	152 [22.3]	23.0	14.8		29.3	7.3	
excessive	435 [63.7]	63.7	63.9	0.12	56.1	79.8	0.01

[1]Pearson chi-square $p < 0.05$ unless otherwise stated. [2]Student's t test $p < 0.01$.

Table 2. Maternal psychological characteristics of participants who completed the 3 month postpartum interview in the Pregnancy, Infection and Nutrition study.

		Breastfeeding initiation			Pregravid BMI		
	Overall N [%][1]	% of those who breastfed	% Did not breastfeed	*p*	BMI ≤ 26 kg/m[2]	BMI > 26 kg/m[2]	*p*
Depressive symptoms at 15 to 20 wks' gestation	640	10.8 ± 8.6 [91.4][2]	14.7 ± 1.6 [8.6][2]	< 0.01[3]	10.2 ± 0.4 [68.4][2]	13.2 ± 0.7 [31.6][2]	< 0.01[3]
low level of depressive symptoms (scores < 17)	516 [80.63]	81.9	67.3	< 0.01[4]	83.22	75.12	0.02[4]
high level of depressive symptoms (scores ≥ 17)	124 [19.38]	18.1	32.7		16.78	24.88	
Depressive symptoms at 24 to 29 wks' gestation	598	11.1 ± 8.9 [92.3]	12.7 ± 9.8 [7.7]	0.26	10.6 ± 8.6 [69.7]	12.7 ± 9.7 [30.3]	< 0.01
low level of depressive symptoms (scores < 17)	465 [77.8]	78.4	69.6		80.2	71.7	
high level of depressive symptoms (scores ≥ 17)	133 [22.2]	21.6	30.4	0.16	19.8	28.3	0.02
Perceived stress at 17 to 22 wks' gestation	687	19.7 ± 7.5 [91.0]	21.7 ± 9.7 [9.0]	0.05	19.1 ± 7.4 [68.2]	21.4 ± 8.2 [31.8]	< 0.01
scores 0 to < 17	248 [36.1]	36.2	35.5	0.15	39.6	28.6	0.01
scores 17 to < 23	207 [30.1]	31.0	21.0		29.7	31.3	
scores ≥ 23	232[33.8]	32.8	43.6		30.8	40.1	

Perceived stress at 27 to 30 wks' gestation	652	13.2	14.1	0.28	12.8	14.2	< 0.01
scores 0 to < 11	237 [36.3]	36.4	35.7	0.45	38.3	31.7	0.01
scores 11 to <17	237 [36.4]	36.9	30.4		37.6	33.2	
scores ≥17	178 [27.3]	26.7	33.9		24.1	35.2	
State Anxiety (3-level categorical) at 15 to 20 wks' gestation	636	34.8 ± 10.3 [91.4]	36.6 ± 11.8 [8.6]	0.22	33.7 ± 10.1[68.4]	37.5 ± 10.9 [31.6]	< 0.01
scores 0 to < 29	213 [33.5]	33.6	32.7	0.93	37.7	24.5	< 0.01
scores 29 to <39	218 [34.3]	34.4	32.7		34.5	33.5	
scores ≥39	205 [32.2]	32.0	34.6		27.8	42.0	
State Anxiety(3-level categorical) at 24 to 29 wks' gestation	593	32.0 ± 10.6 [92.2]	33.6 ± 12.3 [7.8]	0.34	31.6 ± 10.2 [69.8]	33.2 ± 11.8 [30.2]	0.09
scores 0 to < 29	271 [45.7]	45.9	43.5	0.89	46.1	44.9	0.02
scores 29 to <39	184 [31.0]	31.2	30.4		33.5	25.3	
scores ≥ 39	138 [23.3]	23.0	26.1		20.4	29.8	
Self-esteem (3-level) at 15 to 20 wks' gestation	635	51.5 ± 7.3 [91.5]	50.2 ± 10.6 [8.5]	0.25	51.9 ±7.4 [68.5]	50.2 ± 8.1 [31.5]	0.01
scores 0 to <50	206 [32.4]	32.0	37	0.18	28.5	40.7	< 0.01
scores 50 to <56	213 [33.5]	34.6	22.2		35.7	29.2	
scores ≥ 56	216 [34.0]	33.4	40.7		35.9	30.2	

[1]Not all of the 688 women who completed the 3 month interview completed the assessments for depressive symptoms, stress, anxiety and self-esteem during pregnancy. [2]Mean ± standard deviation; percent of overall N in brackets. [3]Student's t-test p-value conducted to compare means of those who breastfed vs. did not breastfeed and those with BMI ≤ 26 kg/m^2 vs. BMI > 26 kg/m^2 (all such values). [4]Pearson's chi-squared test p-value comparing proportions between those who breastfed vs. did not breastfeed and those with BMI ≤ 26 kg/m^2 vs. BMI > 26 kg/m^2 (all such values).

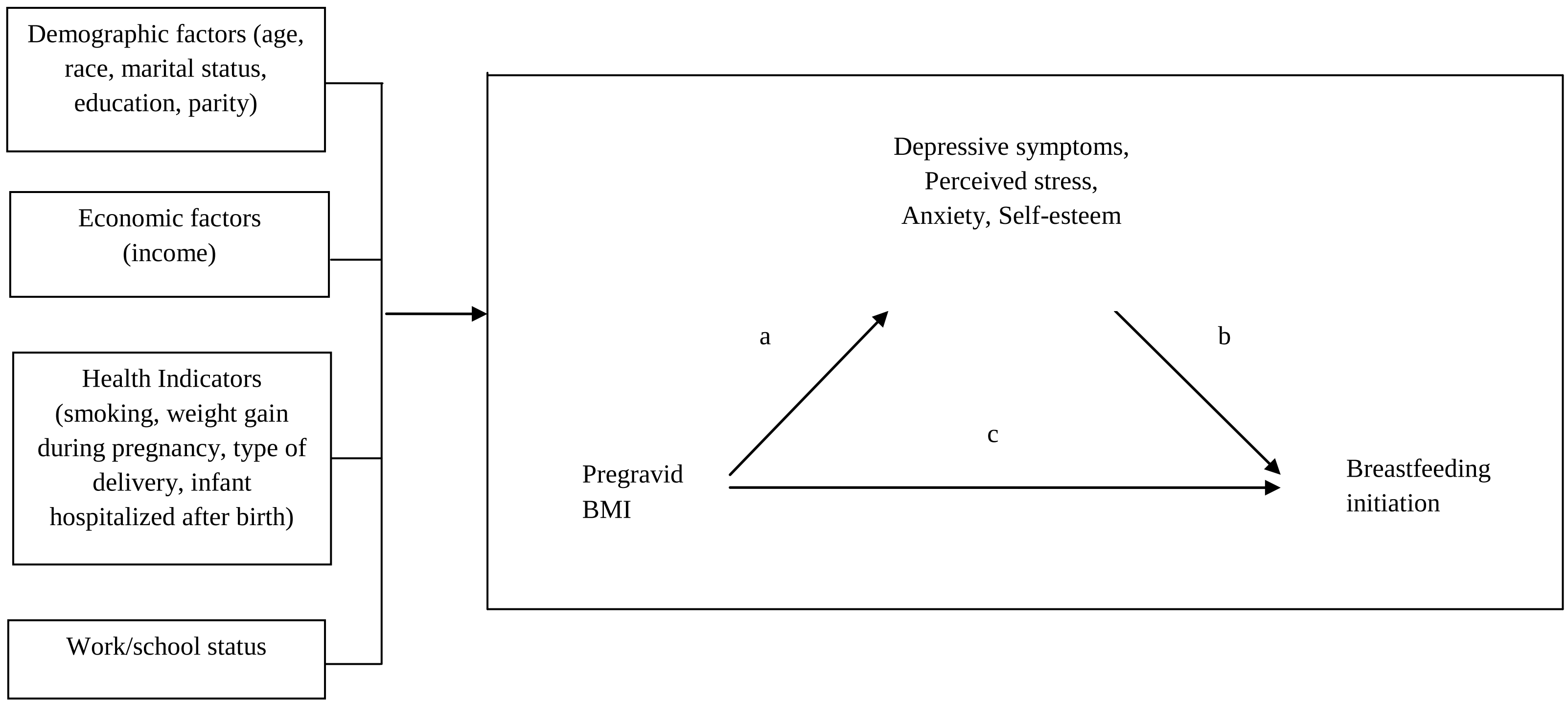
Table 3. Unadjusted regression analysis of possible mediation by psychological factors of the association between pregravid BMI and breastfeeding initiation in the Pregnancy, Infection and Nutrition Study[1].

	Effect of pregravid BMI on mediator (Model 2)[2]	Effect of mediator on not initiating breastfeeding (Model 3)	Effect of pregravid BMI on not initiating breastfeeding while controlling for the effect of mediator (Model 4)
Mediators	RR (95% CI)	RR (95% CI)[3]	RR (95% CI)[3]
Depressive symptoms at 15 to 20 wks gestation (continuous)	2.78 (1.15, 4.42)[4]	1.04 (1.02, 1.06)	5.51 (2.88, 10.57)
Depressive symptoms at 15 to 20 wks (dichotomous; scores ≥ 17 vs. < 17)	1.48 (1.02, 2.16)	2.40 (1.32, 4.39)	5.63 (2.95, 10.74)
Depressive symptoms at 24 to 29 wks (continuous)	1.86 (0.24, 3.49)[4]	1.02 (0.99, 1.05)	5.88 (3.08, 11.22)
Depressive symptoms at 24 to 29 wks (dichotomous; scores ≥ 17 vs. < 17)	1.46 (1.04, 2.04)	1.57 (0.83, 2.96)	5.85 (3.06, 11.16)
Perceived stress at 17 to 22 wks (continuous)	2.26 (0.84, 3.68)[4]	1.04 (1.00,1.07)	5.70 (2.98, 10.92)
Perceived stress at 17 to 22 wks (3-level)			5.97 (3.12, 11.40)
scores 11 to <17 vs. scores < 11	1.50 (0.95, 2.37)	0.84 (0.39, 1.80)	
scores ≥17 vs. scores < 11	1.85 (1.18, 2.89)	1.34 (0.69, 2.59)	
Perceived stress (continuous) at 27 to 30 wks	1.58 (0.50, 2.66)[4]	1.04 (0.99, 1.09)	5.80 (3.03, 11.10)
Perceived stress (3-level)			5.86 (3.06, 11.21)
scores 11 to <17 vs. scores < 11	1.13 (0.73, 1.75)	0.95 (0.46, 1.94)	
scores ≥17 vs. scores < 11	1.95 (1.23, 3.10)	1.50 (0.75, 3.00)	
State Anxiety (continuous) at 15 to 20 wks	2.90 (1.00, 4.80)[4]	1.02 (0.99, 1.04)	5.86 (3.06, 11.20)

State Anxiety (3-level categorical)			6.10 (3.19, 11.65)
scores 29 to <39 vs. scores < 29	1.35 (0.85, 2.13)	1.11 (0.55, 2.24)	
scores ≥39 vs. scores < 29	1.94 (1.23, 3.07)	1.07 (0.52, 2.22)	
State Anxiety at 24 to 29 wks (continuous)	1.79 (-0.19, 3.77)[4]	1.01 (0.99, 1.04)	5.93 (3.11, 11.31)
State Anxiety at 24 to 29 wks (3-level categorical)			6.15 (3.22, 11.73)
scores 29 to <39 vs. scores < 29	0.71 (0.45, 1.12)	1.09 (0.55, 2.14)	
scores ≥39 vs. scores < 29	1.47 (0.94, 2.31)	1.08 (0.52, 2.25)	
Self-esteem at 15 to 20 wks (continuous)	-1.98 (-3.40, -0.57)[4]	0.97 (0.94, 1.00)	5.75 (3.01, 10.99)
Self-esteem 15 to 20 wks (3-level categorical)			6.11 (3.21, 11.63)
scores 0 to <50 vs. scores ≥ 56	1.99 (1.27, 3.13)	1.00 (0.54, 1.87)	
scores 50 to <56 vs. scores ≥ 56	1.19 (0.74, 1.89)	0.34 (0.14, 0.82)	

[1]The sample size was restricted to those women who completed all the above-listed questionnaires and for whom we had information on pregravid BMI (*n* = 546). [2]Restricting the sample size to 546 (see footnote a) resulted in a crude RR of 5.98 (3.14, 11.38) for the association between pregravid BMI and breastfeeding initiation; this was considered Model 1. [3]Models 3 and 4 used binomial regression analysis to determine risk ratios (RR) unless otherwise stated; breastfeeding initiation was the dependent variable (not initiating breastfeeding was the index category). [4]Linear regression analysis was used because the mediator was continuous.

Figure 3. Relationship between pregravid BMI, breastfeeding initiation, psychological factors and covariates.



CHAPTER V

MATERNAL OBESITY, PSYCHOLOGICAL FACTORS, AND BREASTFEEDING DURATION: IS THERE A LINK?

Introduction

The American Academy of Pediatrics (AAP) promotes exclusive breastfeeding as the ideal method of meeting the nutrient needs of infants for the first six months of life followed by partial breastfeeding up to at least one year of age.[10, 11] However, in the U.S., adherence to these recommendations is low. Three-quarters of women initiate breastfeeding but by six and twelve months postpartum, the prevalence of *any* breastfeeding is 43.4% and 22.7%, respectively.[1] Further, although *exclusive* breastfeeding is recommended, only 33.1% of US women exclusively breastfeed for the first three months postpartum; by six months of age, the prevalence decreases to 13.6%.[1] Low breastfeeding rates may be explained, in part, by the rise in obesity among women of childbearing age. Women with higher pre-pregnancy body mass index (BMI) are less likely to initiate breastfeeding and more likely to breastfeed for a shorter duration.[4-7] Women who start pregnancy overweight and obese may face more biological, physical, psychosocial and psychological barriers to breastfeeding than women of lower BMI.[9, 62]

Maternal psychological well-being during pregnancy may influence the relationship between pregravid BMI and breastfeeding but there is little research on a possible psychological pathway. In this study, we explore whether depressive symptoms, perceived stress and anxiety during pregnancy explain part of the association between pregravid BMI and breastfeeding duration. There is some evidence to support the hypothesis of a mediatory pathway. Previous studies have shown that obesity may increase risk of poor mental health status in the perinatal period [68, 71] and, in turn, psychological factors have been associated with breastfeeding duration.[51, 74, 76, 106, 107] One epidemiologic study examined the influence of psychological and psychosocial factors on pregravid BMI and breastfeeding duration; Hilson and colleagues [25] adjusted for several psychosocial factors such as maternal confidence in breastfeeding, social support, and body satisfaction and found that they attenuated but did not eliminate the significant association between prepregnant BMI and breastfeeding duration. They also found no association with the onset of lactogenesis. To our knowledge, this is the first study to examine whether psychological factors such as depressive symptoms, perceived stress and anxiety help explain the association between pregravid BMI and breastfeeding duration.

We used data from the Pregnancy, Infection and Nutrition study to examine whether women who started pregnancy overweight or obese were more likely to breastfeed (any or exclusive) less than the recommended amount. Further, we explored whether depressive symptoms, perceived stress and anxiety during pregnancy mediated part of the effect of pregravid BMI on breastfeeding duration.

Methods

The Pregnancy, Infection and Nutrition study is a prospective cohort study following women from pregnancy to the postpartum period.[89, 108] Women between 15 to 20 gestational weeks attending their second prenatal visit at University of North Carolina (UNC) hospitals were recruited between January 2001 and June 2005 (N = 3203). Women younger than 16, non-English speaking, greater than or equal to 20 weeks' gestation on their second prenatal visit, not planning to continue care or deliver at the study site and those carrying multiple gestations were not eligible to participate. During pregnancy, 2006 women were interviewed in the clinic and by phone at 15 to 20 weeks' gestation, 17 to 22 weeks, 24 to 29 weeks, 27 to 30 weeks, and in the hospital.

For the postpartum component of the study (PINPost), participants must have delivered a live-born infant between October 2002 and December 2005 and resided within a 2-hour radius from UNC in order to facilitate home visits.[89] A total of 239 women were excluded from PINPost because of medical constraints (*n* = 24), they were unreachable (*n* = 153), they were more than 5 months postpartum by the time they were contacted (*n* =54), and for 8 women, study protocols were not in place at the time of their eligibility window. The remaining women (*n* = 930) were phoned at 6 weeks postpartum with a description of the postpartum component. 688 women agreed to participate in PINPost and were interviewed in their homes by trained staff at 3 months postpartum. Of these, 550 women were interviewed again at 12 months and 409 at 36 months. This analysis examines those who consented and participated in both the 3 and 12 months postpartum visits (*n* = 550); data from the 36 month interview was used to update time of breastfeeding cessation for those women who were still breastfeeding at the 12 month interview. Protocols for the prenatal and postpartum studies as well as this analysis were approved by the UNC School of Medicine Institutional Review Board.

The outcome variable for this study was breastfeeding duration, the length of time a child was breastfed. The breastfeeding duration variable was created using data collected at 3, 12 and 36 months postpartum. To establish initiation, women were asked “Did you ever breastfeed this baby?” at 3 months postpartum. Those who initiated were then asked at the 3 month interview and again at the 12 and 36 month interviews, “Are you still breastfeeding your baby?” If women reported having stopped breastfeeding at either interview, they were asked how old the infant was when they stopped (reported in days/weeks/months). For the purposes of this study, any breastfeeding included exclusive breastfeeding as well as mixed feeding with formula or complementary foods. We categorized duration of any breastfeeding as follows: none, those who breastfed less than 4 months, 4 to 6 months, 7 to 12 months, and more than 12 months (referent).

Exclusive breastfeeding included infants fed only breast milk with the exception of drops or syrups consisting of vitamins, mineral supplements or medicines.[27] Exclusive breastfeeding duration was determined by comparing duration with the age of introduction of formula and complementary foods. For each postpartum month, women reported whether they fed their infant breast milk, breast milk substitutes and other foods such as cereals, tea, juice, fruits or vegetables, meats. For this analysis, we categorized exclusive breastfeeding as follows: less than 1 month, 1 to less than 4 months, and 4 months or more (referent). The cutpoint of four months was based on current AAP guidelines; the AAP recommends that women should exclusively breastfeed for up to 6 months but they also state that complementary foods may be introduced as early as 4 months based on the "unique needs or feeding behaviors of the individual infants."[11]

The main exposure variable was pregravid BMI which was calculated by dividing self-reported pregravid weight by height measured during either a prenatal clinic visit between 15 to 20 weeks gestation or at the 3 month postpartum visit. Weight was checked for implausible values and 3 participants were excluded from analysis, leaving 547 women with complete information on breastfeeding duration and pregravid BMI. Pregravid BMI was categorized according to World Health Organization ranges for underweight (< 18.5), normal weight (18.5 to 24.9), and overweight/obese (≥ 25.0).[109]

Possible mediators

Depressive symptoms, perceived stress, and state anxiety were measured at two time points in pregnancy. This analysis used the second measure which was closer in time to the outcome of interest, breastfeeding duration. Measurements of depressive symptoms, perceived stress, and state anxiety for both time points were reasonably well-correlated (correlation coefficients = 0.66, 0.68, and 0.56, respectively).

Depressive symptoms during pregnancy were assessed using the Center for Epidemiologic Studies-Depression scale (CES-D).[91] Mail-in questionnaires given at the second prenatal visit between 24 to 29 weeks' gestation were completed by 490 (89% of 550) participants. The 20-item scale had Likert response categories that assessed the participant's feelings and activities in the previous week. A composite score was calculated and scores greater than or equal to 17 indicated the presence of a higher level of depressive symptoms. Although a cutpoint of 16 or higher has been associated with a significant level of depressive symptoms in the general population, we used a slightly higher cutpoint to distinguish between depressive and pregnancy symptoms, which are often similar.[92] We compared our method of a higher cutpoint with that proposed by Hoffman and Hatch[93] in which they used 16 as a cutpoint after removing items that overlapped with pregnancy and rescaling scores so that the range still lay between 0 and 60. There was no difference in how women were categorized between the two methods (data not shown). Internal consistency as indicated by Cronbach's alpha ranged from 0.83 to 0.92.[94]

The Perceived Stress Scale[95] measured the degree to which respondents found situations to be stressful. Of 550 participants, 527 (95.8% of 550) completed a modified 10-item scale administered during a phone interview conducted between 27 to 30 gestational weeks. Questions were on a Likert scale, and higher overall scores indicated higher levels of perceived stress. After summing across items, the variable was categorized into three levels: 0 to < 11 (referent), 11 to < 17, and ≥ 17. Cronbach's alpha was 0.83 in three non-pregnant samples tested by Cohen.[96]

The State-Trait Anxiety Inventory was used to assess state and trait anxiety during pregnancy.[97] For this analysis, we used the state anxiety measurement because it assessed "immediate" feelings of anxiety, which better represented how women felt during pregnancy than the trait-anxiety scale, a stable measure of anxiety. 487 (88.5% of 550) participants completed the mail-in questionnaire provided at the second prenatal visit (24 to 29 weeks). Scores from 20 questions on a 4-point Likert scale were summed and categorized into three levels: 0 to < 29 (referent), 29 to < 39, and ≥ 39. Cronbach's alpha ranged from 0.90 to 0.94 for the state scale.[97]

Covariates

Covariates tested for confounding in this analysis were chosen based on a directed acyclic graph, created from a review of the literature [100], and on the strength of their relationship with exposure and outcome. Data were collected at screening (15 to 20 weeks' gestation) and through self-reported questionnaires, telephone interviews and medical chart abstraction. Participants reported their race, age, parity, family income, household size, education, marital status, and smoking status in the first six months of pregnancy. Information on family income and household size was used to create a variable representing percent of the 2001 poverty index according to the U.S. Bureau of the Census.[101]

Statistical Analyses

The analysis of pregravid BMI and duration of any breastfeeding was restricted to participants for whom we had complete information on pregravid BMI (*n* = 547); the model for pregravid BMI and duration of exclusive breastfeeding was limited to those who initiated breastfeeding (*n* = 509). Multinomial logit models were utilized to determine the relative risk ratio (RR) between pregravid BMI and breastfeeding duration. We originally considered analyzing the data using a cumulative logit ordinal regression model which would have taken into account the natural order of the outcome categories and given an estimate of the effect of pregravid BMI on the odds of breastfeeding longer versus shorter duration/not initiating. However, the proportional odds assumption was violated for the majority of our explanatory variables. Furthermore, the multinomial logit model is easily interpretable and enabled us to compare back to a referent category based on current guidelines as well as to calculate separate effect estimates for each category of the outcome variables. The latter was especially important for duration of any breastfeeding in which the lowest duration category of "none" was comprised of non-breastfeeders. Combining any level of breastfeeding with non-breastfeeders would have provided an incorrect estimate of the association between pregravid BMI and breastfeeding duration because not all risk factors are the same for women who choose not to initiate breastfeeding and those who do initiate. Due to low power, we could not analyze effect measure modification. Backward elimination was used to build our adjusted model and covariates were kept as confounders in the model if they changed the beta coefficients of the exposure categories by greater than 10%.

Mediation was examined using a series of regression analyses.[102] Model 1 determined the association between the exposure (pregravid BMI) and the outcome (breastfeeding duration). Model 2 assessed the strength of the relationship between the exposure and mediator (depressive symptoms/perceived stress/state anxiety). Model 3 determined the association between the mediator and the outcome and, finally, Model 4 examined the reduction in effect of the exposure on the outcome while adjusting for the mediator. In order to satisfy requirements for mediation, the exposure must be associated with the outcome and the mediator in separate models (Models 1 and 2, respectively); the mediator must be associated with the outcome while adjusting for the exposure(Model 4);

and the effect estimate of the exposure fully or partially reduces while adjusting for the mediator (Model 4). Model 3 was added to determine the relationship between the potential mediator and breastfeeding duration when pregravid BMI was not accounted for because there is little research on this, specifically in regards to stress and anxiety. Each psychological factor was tested in separate mediation analyses. All statistical analyses were conducted using Stata software (version 9.2; College Station, TX).

Results

The majority of participants initiated breastfeeding (92.6% of 550 women). Duration of any breastfeeding ranged from 0 to 38.6 months with a median duration of 7.9 months. Prevalence at 3 and 6 months was 67.5% and 56.7 %, respectively. Women who did not initiate or who breastfed less than 4 months had a higher prevalence of pregravid obesity and overweight, respectively, while women who breastfed 4 months or longer were more likely to be in the normal weight category (Table 4). Compared to normal weight women, those who entered pregnancy overweight or obese were more likely to breastfeed for a shorter duration and introduce complementary foods earlier ($p < 0.01$; Table 4).

Of those who breastfed ($n = 509$), more than half (51.7%) did so exclusively for 4 months or more. Duration of exclusive breastfeeding ranged from 0 to 9 months with a median duration of 4.0 months. Women who exclusively breastfeed less than 1 month and 1 to < 4 months had mean BMIs of 26.7 kg/m^2 and 25.4 kg/m^2, respectively. Women who exclusively breastfed for 4 months or longer were more likely to be white (90.0%), married (94.3%), of higher income (mean = 492.3% ± 186.0 of the poverty line) and have more years of education completed (mean = 17.1 ± 2.1 years).

Women with low levels of depressive symptoms, stress and anxiety tended to be white, married, better educated, and of higher income. They were also more likely to enter pregnancy at a normal weight and to breastfeed (any or exclusively) longer than women with high levels of these factors (Table 5).

Crude multinomial regression showed a strong negative association between prepregnancy weight status and duration of any breastfeeding (Table 6 and Appendix – Tables 9 to 11, Model 1). After adjusting for race, education, marital status and smoking in the first 6 months of pregnancy, being underweight was no longer associated with duration of any breastfeeding and the effect estimate for overweight/obese was attenuated. However, overweight/obese women remained at higher risk of not breastfeeding [5.77 (2.45, 13.55)] and of breastfeeding less than 4 months [2.44 (1.36, 4.38)] compared to normal weight women.

Being overweight or obese before pregnancy, but not underweight, was negatively associated with exclusive breastfeeding (Table 6 and Appendix – Tables 12 to 14, Model 1). After adjusting for race, education, and poverty status the association of pregravid BMI on exclusive breastfeeding duration decreased. Being overweight/obese remained associated with exclusively breastfeeding less than 1 month [2.23 (1.32, 3.78)] but there was no longer an association with exclusive breastfeeding less than 4 months.

To ease in the interpretation of all the coefficients from the multiple equations estimated in the multinomial logit models, we used the model coefficients to predict the probability of being in each breastfeeding duration group, for each weight status group (underweight, normal weight, overweight/obese), holding all other variables in the model constant. Predicted probabilities are shown in Figures 4 and 5. Compared with normal weight women, overweight/obese women had significantly higher predicted probabilities for not initiating breastfeeding and for breastfeeding less than 4 months but lower predicted probabilities for breastfeeding 4 months or longer (Figure 4; t test $p < 0.01$ for all comparisons). Compared to normal weight women, overweight and obese women had a significantly higher predicted probability of exclusively breastfeeding less than 1 month and a lower probability of exclusively breastfeeding 1 to < 4 months and ≥ 4months (t test $p < 0.01$ for all comparisons; Figure 5).

Mediation

The association between pregravid BMI and any breastfeeding duration was not explained by depressive symptoms, perceived stress or state anxiety status during pregnancy. All three psychological factors were significantly predicted by pregravid BMI (Model 2, Appendix – Tables 9 to 11). Higher levels of depressive symptoms were related to breastfeeding less than 4 months (Model 3, Appendix – Table 9). However, it was not associated with the outcome once pregravid BMI was in the model (Model 4) and, thus, did not meet the criteria to be a mediator. Furthermore, once we adjusted for confounding (race, education, marital status and smoking in the first 6 months of pregnancy), pregravid BMI no longer predicted the psychological factors. As expected based on the crude results, the psychological factors were not significantly associated with any breastfeeding duration in the adjusted models.

When examining mediation of pregravid BMI-exclusive breastfeeding, once again, higher levels of all three psychological factors were predicted by pregravid BMI (Model 2, Appendix – Tables 12 to 14). The presence of high depressive symptoms and anxiety during pregnancy was associated with exclusive breastfeeding duration of less than 1 month and 1 to < 4 months; high stress predicted exclusive breastfeeding less than 1 month (Model 3, Appendix – Tables 12 to 14). Only depressive symptoms and stress remained associated with the outcome when pregravid BMI was in the model (Model 4) but they accounted for only a small part of the association between pregravid BMI and duration of exclusive breastfeeding (i.e. < 10%). However, adjusting for race, education, and poverty status greatly attenuated, and made non-significant, the association between depressive symptoms/stress and exclusive breastfeeding. The association between pregravid BMI and psychological factors also disappeared which was expected based on the mediation results for duration of any breastfeeding.

Discussion

In this study, we found that women who start pregnancy overweight or obese are at greater risk of not following AAP guidelines for breastfeeding. They are less likely to initiate breastfeeding and more likely to breastfeed for a shorter duration and exclusively breastfeed less than 1 month. The associations between pregravid BMI and durations of any and exclusive breastfeeding were not explained by depressive symptoms, stress, and anxiety during pregnancy. Despite differences in population and statistical methodology, we find that our results of a negative association between pregravid BMI and any breastfeeding duration are consistent with those of studies conducted worldwide. Studies in Danish and Australian populations found that overweight and obese women are at greater risk of shorter duration of any breastfeeding [5, 6, 26] while studies conducted among U.S. populations [4, 25] found that being obese, but not overweight, was related to shorter duration of any breastfeeding. Although we found that being overweight or obese before pregnancy was negatively related to exclusive breastfeeding, one study in the U.S. found no association of pregravid BMI with exclusive breastfeeding but this may have been due to small sample size (N = 151).[25] Another reported higher risk of cessation for overweight/obese up to 16 weeks postpartum.[5] We also found that underweight status was not associated with any or exclusive breastfeeding duration although our results were suggestive of an association. Lack of an association may have been a consequence of the small number of underweight women in our sample (n = 26) which led to less precise estimates, as can be seen in the large width of the confidence intervals.

This study is unique in that women who did not initiate breastfeeding were included in the analyses. Previous studies conducted analyses only among women who initiated which limits interpretation of the effects of obesity on breastfeeding duration to those who breastfeed and may be a source of selection bias.[4-6, 25, 26] From a prior analysis (unpublished manuscript), we know that being overweight or obese before pregnancy strongly predicts not initiating breastfeeding in our study population. Not including non-breastfeeders in our analyses would have produced an artificially attenuated effect estimate of the association between obesity and breastfeeding duration. As an example, an obese woman may choose not to initiate breastfeeding in this pregnancy because she experienced obesity-related mechanical difficulties breastfeeding a previous child. In our study, overweight and obese women were more likely to be multiparous ($p< 0.05$).

Although we found that depressive symptoms, perceived stress and anxiety did not mediate the association between pregravid BMI and breastfeeding duration, there existed differences in the relationships between these psychological factors and breastfeeding duration. In crude models, all three factors were predictive of exclusively breastfeeding less than 1month but only the presence of a high level of depressive symptoms was associated with duration of any breastfeeding, especially with a higher risk of breastfeeding less than 4 months. Previous studies support a greater risk of shorter duration of any breastfeeding for women with high levels of depressive symptoms.[51, 78, 85] Moreover, the association of all three factors with exclusive breastfeeding less than 1 month suggests that women with poor mental health status in pregnancy who choose to breastfeed are more likely to provide formula along with breast milk in early postpartum. Providing formula makes it possible for a partner or family member can bottle-feed the child, thus reducing the time that a woman experiencing depressive symptoms, stress and anxiety is forced to spend breastfeeding, an activity that requires a lot of active interaction with their child. This is supported by other studies which show that women with poor mental health status are less likely to engage in responsive feeding styles [53]and in parenting practices that require active interactions with their infant, such as breastfeeding.[83] In our study population, significantly greater proportions of women with high levels of depressive symptoms, stress and anxiety gave their infants formula in the first month compared to women with low levels of these factors ($p < 0.05$).

This study has several limitations that influence its interpretation and generalizability. Our study population is different from the U.S. population in that 92.6% initiated breastfeeding and almost 50% of those who initiated exclusively breastfed four months or more which is much higher than national rates[1]. We also have a much lower prevalence of overweight/obese women (35.7%) compared to the average for women of childbearing age in the U.S. (59.5%).[60] In addition, out of the 1169 that were eligible, 480 did not to participate in PINPost; we again experienced attrition from the 3 month to the 12 month interview (20% of 688). A comparison of the 480 to the 688 women who completed the 3 month visit revealed that women who did not participate had significantly higher levels of depressive symptoms and anxiety. Those who did not participate were more likely to be non-White, lower income, younger, less educated, and smoke during pregnancy. This was also true of the 138 women who did not participate in the 12 month postpartum interview.

Further limitations include our inability to examine potential effect measure modification by race due to our small sample size and our primarily Caucasian population; African American women have a higher proportion of overweight/obese and are less likely to breastfeed compared with Caucasian women.[1, 60] And although we have data collected prospectively, it is possible that there existed a reciprocal relationship between pregravid BMI and the psychological factors. For example, it is possible that women with higher levels of the psychological factors during pregnancy also had higher levels before pregnancy which placed them at risk of beginning pregnancy overweight or obese; this, in turn, increased their risk of continuing in or developing a poor mental health state during pregnancy. The literature supports evidence of bidirectionality between psychological factors and obesity, and, as an observational study, we cannot be certain that it does not exist in our data, thus limiting our ability to make causal inferences.[110] Finally, pregravid BMI was calculated from self-reported weight and measured height between 15 to 20 weeks in pregnancy. Women of childbearing age tend to underestimate their weight which would result in some BMI values being artificially low.[111] However, we checked pregravid BMI values for implausibility and used a categorized pregravid BMI variable, thus minimizing any potential misclassification.

The present study shows that being overweight or obese before pregnancy negatively influences breastfeeding behavior. To our knowledge, this is the first study to examine whether psychological factors such as depressive symptoms, perceived stress and anxiety help explain the association between pregravid BMI and breastfeeding duration. Although we found that depressive symptoms, perceived stress and state]anxiety did not explain this association, it may be that a more sensitive measurement tool is needed before we can see an effect on breastfeeding duration. Future studies should confirm the associations between pregravid BMI, psychological factors and breastfeeding duration in a larger and more diverse sample using clinically relevant assessment tools.

Table 4. Maternal characteristics by pregravid BMI and breastfeeding status among women in the Pregnancy, Infection and Nutrition postpartum study (*n* = 550).

	Pregravid BMI			Duration of *any* breastfeeding				
	Underweight (<18.5 kg/m^2)	Normal weight (≥ 18.5 to 24.9 kg/m^2)	Overweight/ obese (≥ 25.0 kg/m^2)	0 (did not initiate)	> 0 to < 4	4 to 6	> 6 to12	> 12
	n = 26	*n* = 326	*n* = 195	*n* = 41	*n* = 149	*n* = 48	*n* = 162	*n* =150
Pregravid BMI (mean)	17.6 ± 0.9[1]	21.7 ± 1.6	32.1 ± 6.8[1]	32.4 ± 10.0[2]	27.0 ± 7.7[2]	23.1 ± 4.2	24.1 ± 5.1	23.3 ± 4.6
Age(y)	27.8 ± 6.1	30.4 ± 5.1	29.4 ± 5.8	27.4 ± 5.7[1]	28.9 ± 6.1[1]	30.4 ± 5.1	29.9 ± 4.8	31.4 ± 5.0
Race: White (%)	84.6 [3]	86.8	64.1	61.0 [3]	67.8	70.8	84.6	90.7
Married (%)	80.8 [3]	91.7	70.8	70.7 [3]	68.5	87.5	88.9	95.3
Education (y)	15.5 ± 3.0	16.7 ± 2.5	14.9 ± 2.7	13.6 ± 2.4[2]	14.6 ± 2.7[2]	16.9 ± 2.5	16.6 ± 2.5	17.2 ± 2.1
Percent of the 2001 poverty level (mean)	389.4 ± 241.3	486.0 ± 200.1	351.3 ± 219.1[1]	257.1 ± 198.1[2]	342.9 ± 228.1[2]	532.7 ± 186.7	477.1 ± 206.2	490.7 ± 177.0
Primiparous (%)	50	51.5	42.1	26.8 [3]	44.3	56.3	50.6	52.7
Smoked during pregnancy (%)	16.0 [3]	3.8	13.6	13.2 [3]	17.3	2.1	3.9	3.4
Breastfeeding duration (mean in months)	7.1 ± 5.2	9.3 ± 6.2	5.8 ± 6.1[1]	-	1.5 ± 1.1	5.6 ± 0.5	9.8 ± 1.7	15.4 ± 4.9
Exclusive breastfeeding duration (mean in months)	2.8 ± 2.3	3.6 ± 2.2	2.5 ± 2.3[1]	-	0.8 ± 1.1[2]	2.8 ± 1.7[2]	4.0 ± 1.8[2]	4.8 ± 1.7
Age of complementary food introduction (mean in months)	4.5 ± 1.1	4.7 ± 1.3	4.1 ± 1.6[1]	3.1 ± 1.4[2]	3.8 ± 1.5[2]	4.9 ± 1.4	4.7 ± 1.1[2]	5.2 ± 1.1

[1]Significantly different from normal weight women: $p < 0.01$. [2]Significantly different from those who breastfed greater than 12 months: $p < 0.05$. [3]Pearson's chi-squared test p-value $p < 0.05$.

Table 5. Pregravid BMI and breastfeeding status by levels of depressive symptoms, stress and anxiety in the Pregnancy, Infection and Nutrition study.

	Depressive symptoms (n = 598)		Perceived stress (n = 527)			State anxiety (n = 487)		
	Low (%)	High (%)	Low (%)	Moderate (%)	High (%)	Low	Moderate	High
Pregravid BMI (mean)	24.5 ± 6.1[1]	26.9 ± 7.9	24.1 ± 5.1	24.4 ± 5.9[2]	27.5 ± 8.4[2]	24.7 ± 6.2	24.3 ± 6.1	26.7 ± 7.8[3]
Underweight	72.7[4]	27.3	36.0[4]	40.0	24.0	40.9[4]	40.9	18.2
Normal	83.2	16.8	38.1	41.0	21.0	47.3	34.8	17.9
Overweight/obese	70.8	29.2	32.1	33.7	34.2	42.8	27.1	30.1
Duration of any breastfeeding (mean in months)	37.1 ± 26.4	31.2 ± 32.5	37.8 ± 27.6	34.3 ± 23.3	33.0 ± 33.1	36.8 ± 27.5	38.4 ± 28.3	30.5 ± 27.6
No breastfeeding	67.7[4]	32.4	31.6[4]	31.6	36.8	41.2[4]	32.4	26.5
>0 to < 4 mo	68.5	31.5	30.9	36.0	33.1	42.9	24.6	32.5
4 to 6	86.1	14.0	37.5	39.6	22.9	34.9	48.8	16.3
> 6 to < 12	86.2	13.8	37.4	47.1	15.5	52.5	32.2	15.4
> 12	80.1	19.9	39.5	32.7	27.9	44.0	36.2	19.9
Exclusive breastfeeding (mean in months)	3.4 ± 2.2[1]	2.7 ± 2.3	3.5 ± 2.2	3.3 ± 2.2	2.7 ± 2.3[2]	3.3 ± 2.2	3.5 ± 2.3	2.8 ± 2.3
< 1mo	69.7[4]	30.3	30.8[4]	34.6	34.6	39.8	32.7	27.6
>0 to < 4	74.8	25.2	31.2	39.2	29.6	46.4	26.4	27.3
≥ 4	85.4	14.6	40.9	40.5	18.7	47.4	35.9	16.7

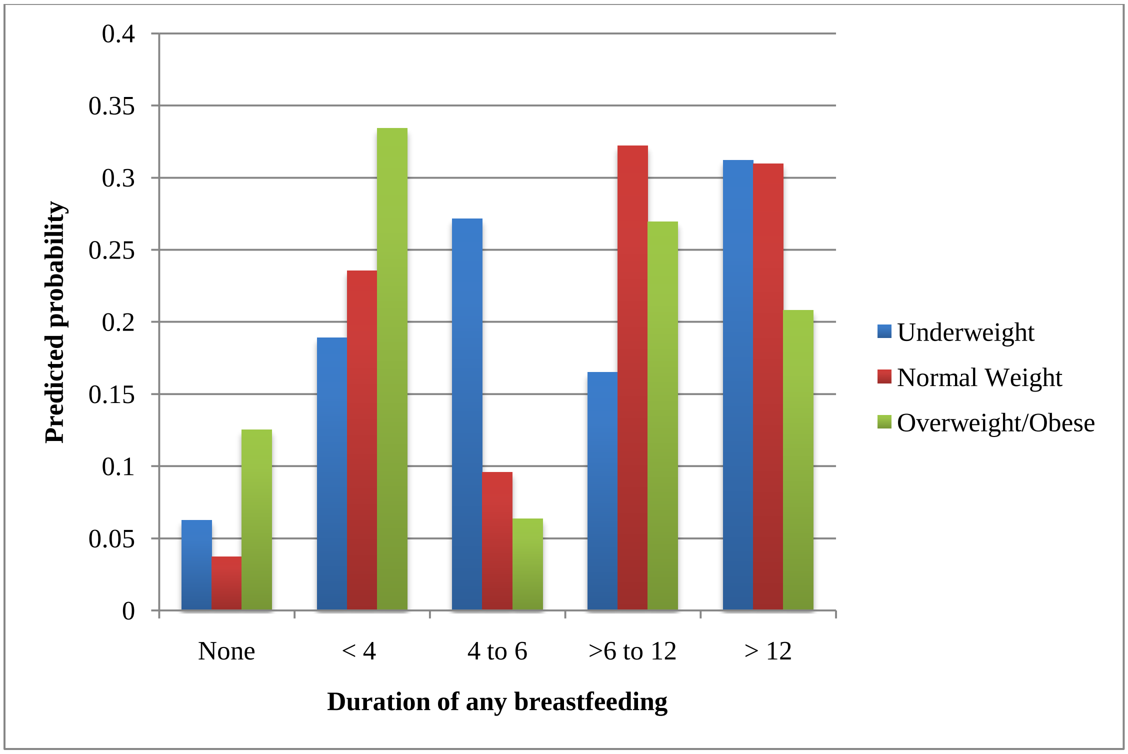
[1]t test $p < 0.01$. [2]Significantly different from women with low levels of perceived stress: $p < 0.01$. [3]Significantly different from women with low levels of anxiety: $p < 0.02$. [4]Pearson's chi-squared test p-value $p < 0.05$.

Table 6. Crude and adjusted results for multinomial logit regression models of the association between pregravid BMI and breastfeeding duration.

		Crude					Adjusted			
		Pregravid BMI					Pregravid BMI			
		Underweight		Overweight/Obese			Underweight		Overweight/Obese	
Breastfeeding Duration	*n*	RR (95% CI)	Robust SE	RR (95% CI)	Robust SE	*n*	RR (95% CI)	Robust SE	RR (95% CI)	Robust SE
Any breastfeeding[1]	547					524				
No breastfeeding		3.11 (0.57, 17.03)	2.70	9.58 (4.23, 21.71)	4.00		1.71 (0.31, 9.54)	1.50	5.77 (2.45, 13.55)	2.50
> 0 to <4 mo		1.37 (0.44, 4.25)	0.79	3.64 (2.18, 6.08)	0.95		0.81 (0.21, 3.10)	0.55	2.44 (1.36, 4.38)	0.73
4 to 6		3.22 (1.01, 10.30)	1.91	1.37 (0.63, 2.98)	0.54		2.95 (0.92, 9.47)	1.76	1.04 (0.44, 2.48)	0.46
> 6 to 12		0.71 (0.22, 2.29)	0.42	1.38 (0.82, 2.34)	0.37		0.51 (0.14, 1.92)	0.35	1.28 (0.74, 2.23)	0.36
>12		Reference	-	Reference	-		Reference	-	Reference	-
Exclusive breastfeeding[2]	506					493				
< 1mo		2.3 (0.85, 6.23)	1.17	3.14 (1.94, 5.08)	0.77		1.83 (0.59, 5.69)	1.06	2.23 (1.32, 3.78)	0.60
< 4		1.35 (0.48, 3.78)	0.71	2.11 (1.34, 3.32)	0.49		0.87 (0.30, 2.55)	0.48	1.46 (0.89, 2.41)	0.37
≥ 4		Reference	-	Reference	-		Reference	-	Reference	-

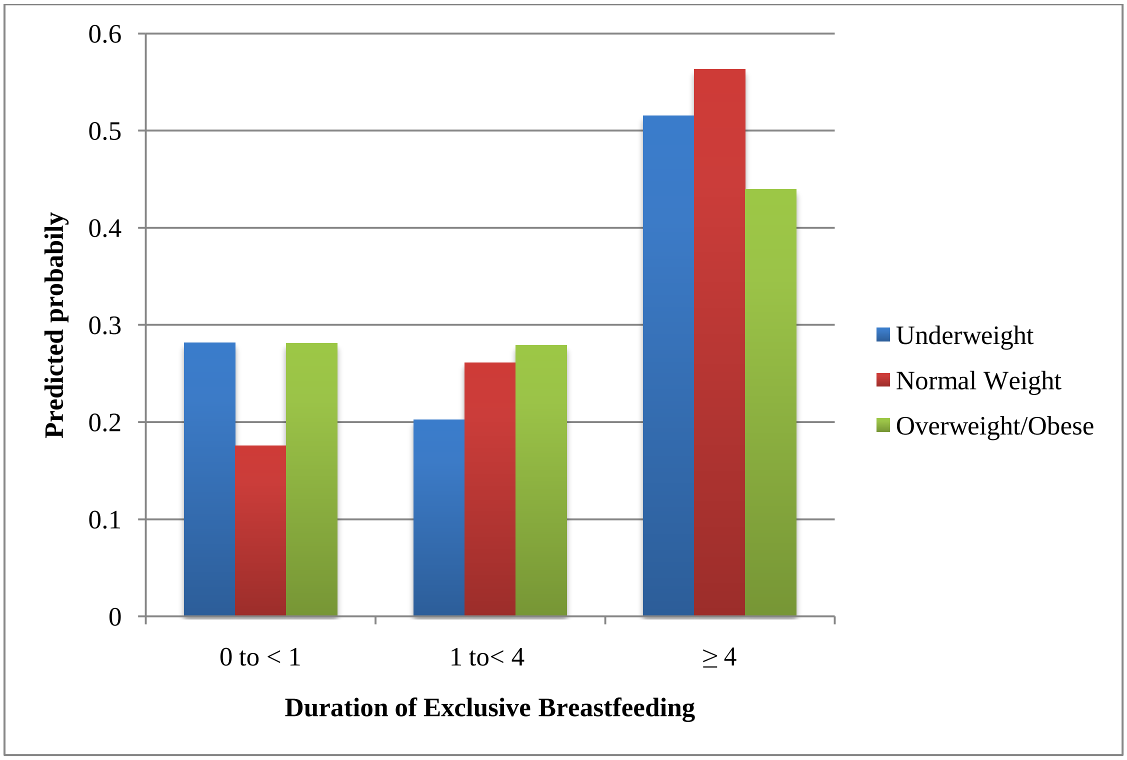
[1]Model of the association between pregravid BMI and ABF was adjusted for race, maternal education, marital status and smoking in the first 6 months of pregnancy. [2]Model of the association between pregravid BMI and EBF was adjusted for race, maternal education, and percent of the 2001 poverty index. [3]Does not include women who did not initiate breastfeeding (*n* = 41).

Figure 4. Predicted probability of any breastfeeding duration by pregravid BMI status[1] in the Pregnancy, Infection and Nutrition study.



[1]Adjusted for race, education, marital status and smoking in the first 6 months of pregnancy.

Figure 5. Predicted probability of exclusive breastfeeding duration by pregravid BMI status[1] in the Pregnancy, Infection and Nutrition study.



[1] Adjusted for race, education, and poverty status.

CHAPTER VI

PREGRAVID BMI IS ASSOCIATED WITH EARLY INTRODUCTION OF COMPLEMENTARY FOODS

Introduction

The American Academy of Pediatrics (AAP) recommends that infants be introduced to complementary foods after 4 months of age, preferably at 6 months [11], yet nearly 40% of infants in the U.S. are introduced to complementary foods too early.[2]. Recent studies suggest that maternal obesity is negatively associated with breastfeeding behavior; women who were overweight or obese at the onset of pregnancy were less likely to initiate breastfeeding and more likely to breastfeed for a shorter duration than women who began pregnancy at a normal body mass index (BMI).[4, 5, 25, 86] Less is known of the relationship between prepregnancy obesity and early introduction of complementary foods. Given that women who enter pregnancy overweight or obese are less likely to adhere to breastfeeding guidelines, it is possible that they are also less likely to follow complementary food introduction guidelines.

To date, there have been two studies that examined the association between pregravid BMI and age of complementary food introduction. However, these studies were conducted in European populations where the prevalence of obesity is lower and where racial/ethnic demographics do not reflect that of the U.S. population. In addition, the studies did not account for other factors, such as sociodemographics, that might be the actual drivers of this relationship.[7, 84]

The aims of this paper included examining the association between maternal obesity and the early introduction of complementary foods and exploring whether psychological factors present during pregnancy (depressive symptoms, perceived stress, and anxiety) help to explain the relationship between pregravid BMI and age of complementary food introduction. Although researchers have identified that women who enter pregnancy overweight or obese are less likely to follow breastfeeding guidelines, reasons behind this association remain unclear. In this paper, we explored whether modifiable psychological factors accounted for part of the association between pregravid BMI and early complementary food introduction.

Methods

Data came from the Pregnancy, Infection and Nutrition Postpartum Study (PINPost), a prospective cohort study focusing on risk factors for postpartum weight retention and a follow-up to the third cohort of the Pregnancy Infection and Nutrition Study (PIN3)[89]. Pregnant women were recruited from prenatal clinics at the University of North Carolina (UNC) hospitals between January 2001 and June 2005. Out of 3203 pregnant women eligible to participate in PIN3, 2006 were interviewed between 15 to 20 gestational weeks (screening), 17 to 22 weeks, 24 to 29 weeks, 27 to 30 weeks, and in the hospital. Those ineligible to participate in PIN3 included women greater than or equal to 20 gestational weeks on their second prenatal visit, those younger than 16, non-English speaking, not planning to continue care or deliver at the study site, and those carrying multiple gestations. Of the 2006 women followed through pregnancy, 1169 were eligible for the postpartum component which required women to have delivered a live-born infant between October 2002 and December 2005 and to reside within a 2-hour radius from UNC in order to facilitate home visits. A total of 239 women were excluded from participating in the study (see Siega-Riz et al 2009 for more detail). Of the remaining 930, 688 agreed to participate in PINPost and were interviewed in their homes by trained staff at 3 months postpartum; 550 participated in the 12 month interview. This study analyzed data from the 550 women who completed both the 3 and 12 month in-home visits. Protocols for the prenatal and postpartum studies as well as this analysis were approved by the UNC Medical Institutional Review Board.

The outcome variable, age of complementary food introduction was created based on a composite of questions asked at the 3 and 12 month interviews. For each month leading up to the 3 interview, women were asked, " How many times a day (24 hours) was your baby fed these foods during each of these months? " Women responded for each of the following foods: breast milk, infant formula, cow's milk, soy milk, cereals, tea, juice, fruits or vegetables, and meats for each month leading up to the time of interview. At the 12 month interview, women were asked, "At any time since the 3 month interview, have you fed your baby **______________** *[type of food]*?" for each month between the 3 and 12 month interviews. Women reported on the following foods: breast milk, infant formula, cow's milk, soy milk, cheese/yogurt, ice cream, infant cereals, cereals, breads, crackers, cookies (includes teething biscuits), tea, 100% fruit or vegetable juice, fruit drinks/Kool-Aid, fruits, vegetables, meats, fish, eggs, French fries, and soda. We categorized age of complementary food introduction as follows:

introduction of complementary foods < 4 months of age, 4 to < 6, and 6 months or later (referent). Cut points for the categories reflect the unclear guidelines set by the AAP.[11] Although the guidelines recommend that women should exclusively breastfeed until 6 months of age, they also state that complementary foods may be introduced as early as 4 months based on the "unique needs or feeding behaviors of the individual infants."[11]

The main exposure was pregravid BMI, calculated from self-reported weight and height measured during screening. We checked weight for implausible values and excluded 3 women from analysis. There remained 547 women with recorded pregravid BMI and age of complementary food introduction. Pregravid BMI was categorized according to criteria of the World Health Organization for underweight (< 18.5 kg/m^2), normal weight (18.5 kg/m^2 to 24.9 kg/m^2), and overweight/obese (≥ 25.0 kg/m^2).[109] Participants reported sociodemographic factors such as race, age, parity, family income, household size, education, and marital status. Information on family income and household size was used to create a variable representing percent of the 2001 poverty index according to the U.S. Bureau of the Census.[101]

Although psychological factors were measured at two time points during pregnancy, this analysis used the second measure which was closer in time to the outcome of interest, age of complementary food introduction. Measurements at both times were moderately correlated for depressive symptoms (correlation coefficient = 0.66), perceived stress (0.68), and state anxiety (0.56).

The Center for Epidemiologic Studies-Depression scale (CES-D) was used to measure the presence of depressive symptoms in pregnancy.[91] Participants (n = 490) completed a mail-in questionnaire provided at the second prenatal visit between 24 and 29 weeks' gestation. The scale was comprised of 20 questions with Likert response categories that assessed the participant's feelings and activities in the previous week. A composite score was calculated and scores of 17or higher indicated the presence of a significant level of depressive symptoms. A cutpoint of 16 or higher is generally used to represent a high (versus low) level of depressive symptoms but we felt that a slightly higher cutpoint would better distinguish between depressive and pregnancy symptoms, which can be similar.[92] Others have accounted for the similarity in symptoms of pregnancy and depression by using a cutpoint of 16 but removing items that overlapped with pregnancy and rescaling scores to keep the range between 0 and 60.[93] There was no difference in how women were categorized when we compared this method to our use of a higher cutpoint (data not shown). Internal consistency as indicated by Cronbach's alpha ranged from 0.83 to 0.92.[94]

The Perceived Stress Scale, administered during a phone interview conducted between 27 and 30 weeks gestation, measured the extent to which participants found situations in their lives to be stressful.[95] The majority (n = 527) of participants completed the scale consisting of 10 questions with Likert response categories. Scores were summed across items and categorized as follows: 0 to < 11 (low perceived stress, referent); 11 to < 17 (moderate), and ≥ 17 (high). Cronbach's alpha was 0.83 in three non-pregnant samples tested by Cohen.[96]

Participants (n = 487) completed the State-Trait Anxiety Inventory[97] as part of a mail-in questionnaire provided at the second prenatal visit between 24 and 29 weeks gestation. We used the state anxiety measurement for this analysis because it assessed "immediate" feelings of anxiety, which better represented how women felt during pregnancy than the trait-anxiety scale, a stable measure of anxiety. The scale consisted of 20 questions on a Likert scale that were summed and categorized into three levels: 0 to < 29 (low anxiety; referent), 29 to < 39 (moderate anxiety), and ≥ 39 (high anxiety). Cronbach's alpha ranged from 0.90 to 0.94 for the state scale.[97]

Statistical Analyses

The analysis of pregravid BMI and age of complementary food introduction was restricted to participants for whom we had complete information on pregravid BMI (n = 547); the mediation analyses were limited to those who completed all three psychological assessments (n = 470). We originally modeled the association between pregravid BMI and age of complementary food introduction using ordinal logistic regression but the proportional odds assumption was violated for all explanatory factors, including the main exposure. Hence, we used multinomial logit models to estimate relative risk ratios (RR) of the association between pregravid BMI and complementary food introduction. For mediation analysis, binomial regression models were used where the outcome was dichotomous and multinomial logit models were utilized where the outcome was polytomous. Potential confounders were chosen based on a directed acyclic graph created from a review of the literature [100] and on the strength of their relationship with exposure and outcome; however, we did not have a large enough sample size to test for effect measure modification. The adjusted model was built using backward elimination with confounders kept in the model if they changed the beta coefficients of the exposure categories by more than 10%.

Mediation analysis was comprised of a series of regression analyses.[102] To be considered a mediator, the exposure must be associated with the outcome (Model 1); the mediator must be predicted by the exposure (Model 2); the outcome must be predicted by the mediator while adjusting for the exposure (Model 4); and the effect estimate of the exposure must be reduced when adjusting for the mediator (Model 4). A third model (Model 3 in Appendix – Tables 15 to 17) was added in order to determine the relationship between the potential mediator and age of introduction when pregravid BMI was not accounted for because this has not been previously explored. Depressive symptoms, perceived stress and anxiety were examined in separate mediation analyses. All statistical analyses were conducted using Stata software (version 9.2; College Station, TX).

Results

The majority of our population (75.3% of 550) introduced complementary foods when the infant was 4 to 6 months old; 19.6% introduced before 4 months of age and 5.1% after 6 months. At 4 and 6 months postpartum, 65.5% and 56.7% of women were breastfeeding, respectively. Women who introduced complementary foods before 4 months of age were more likely to be non-White, overweight/obese before pregnancy, multiparous, unmarried, less educated, and of lower income (Table 7). They were also less likely to have initiated breastfeeding or to be breastfeeding at the 3 month interview.

Infant cereal was the most common food given to infants before they were 4 months old; 17.8% of infants were given infant cereal before 4 months of age and 61.8% by 6 months. In our study population, no infants were given cow's milk before 6 months of age but between 11 and 12 months of age, almost three-quarters (71.1%) were fed cow's milk . Few infants were introduced to fruits/vegetables (5.5%) before they were 4 months old but by 6 months, 75.5% had been fed fruits/vegetables.

Twenty-one percent of 490 who completed the CES-D had high levels of depressive symptoms, 25.8% (of 527) had high levels of perceived stress and 22.0% (of 487) high levels of state anxiety. The proportion of women with high depressive symptoms, stress and anxiety was significantly higher among those who introduced complementary foods before 4 months of age.

Results from an unadjusted model of pregravid BMI and age of complementary food introduction revealed that women who were overweight or obese before pregnancy were 4 times as likely [RR = 4.00 (95% CI: 2.37, 6.74)] to introduce complementary foods before the infant was 4 months old compared with normal weight women (Table 8). After adjusting for race, education, and poverty status, the risk estimate was attenuated but remained significant [RR = 2.22 (1.23, 4.01)].

Mediation

We ran a series of crude models to determine the presence of mediation by depressive symptoms, perceived stress and state anxiety (Appendix – Tables 15 to 17). All three psychological factors were found to be weak mediators. The association between pregravid BMI and age of complementary food introduction did not substantively attenuate when a psychological factor was included in the model. Being overweight or obese before pregnancy was associated with having higher levels of depressive symptoms, perceived stress, and anxiety during pregnancy (Model 2). High levels of depressive symptoms, stress and anxiety were related to the introduction of complementary foods before 4 months of age (Model 3). When included in the final model (Model 4), each of the mediators attenuated the association between pregravid BMI and age of introduction and remained significantly associated with the outcome. The effect of pregravid BMI on age of introduction was reduced 6.8% by depressive symptoms, 6.2% by anxiety, and 3.3% by stress.

After including race, education and poverty level in the mediation models, the psychological factors were no longer predicted by pregravid BMI status (Model 2) nor associated with the outcome (Model 3) (data not shown). In Model 4, the psychological factors slightly attenuated the association between being overweight or obese before pregnancy and introducing foods before 4 months of age. However, they did not significantly predict the outcome when adjusting for pregravid BMI and, thus, could not be considered mediators.

Discussion

In this paper, we examined the relationship between BMI before pregnancy and age of complementary food introduction. Our findings suggest that 1) women who enter pregnancy overweight or obese are more likely to introduce complementary foods to their infant before the recommended age and, 2) contrary to expectations, psychological factors did not explain this relationship. Although the AAP recommends introducing complementary foods after 4 months of age, ideally around 6 months, many mothers in the U.S. do not follow these guidelines.[2, 3, 112] Early introduction of complementary foods has been associated with increased risk of gastrointestinal illness, diarrhea, wheezing and childhood obesity among other adverse health outcomes.[11, 12, 15] Infants are not developmentally ready to consume solid foods until around 4 to 6 months of age. Moreover, early introduction replaces breast milk or breast milk substitutes with foods that are not as nutritionally adequate.[11]

We found that depressive symptoms, stress, and anxiety levels during pregnancy did not explain away the relationship between maternal overweight/obesity and early introduction. Although the psychological factors accounted for a small part of the pregravid BMI-age of introduction relationship in the crude analysis, this effect disappeared after adjusting for the sociodemographic variables of race, education and poverty level. There may be several reasons for why the psychological factors were not stronger mediators. First, we did not use clinically relevant assessment tools. It may be that clinically assessed depression and anxiety would be stronger mediators of the pregravid BMI-complementary food introduction association. Second, our study experienced attrition. Out of the 1169 women eligible for PINPost, 480 did not participate in the postpartum component; of the 688 that completed the 3 month interview, 138 did not participate in the 12 month interview. Women who did not participate in PINPost had significantly higher levels of depressive symptoms and anxiety ($p < 0.05$) which may have reduced our ability to find an association with complementary food introduction. Finally, because this is an observational study, causal inferences cannot be made and bidirectionality must be considered. For instance, our results show that women who started pregnancy overweight or obese were more likely to have higher levels of depressive symptoms, stress and anxiety during pregnancy. However, it is possible that these women had a more negative mental health status before pregnancy and that this, in turn, put them at higher risk of being overweight/obese at the start of pregnancy.

These findings are limited in their generalizeability to the general U.S. population because our study consisted primarily of women that were Caucasian, of higher socioeconomic status, and received prenatal care. Our population was representative of the racial demographics of North Carolina [113] but the small sample size restricted our ability to examine modification by race. This is an important point for future research given that non-whites, specifically African Americans, have a much higher rate of obesity and depression and have been found to introduce foods in early postpartum.[1, 3, 60]

Despite these limitations, this study has several strengths. The PINPost Study is a longitudinal prospective cohort which measured the explanatory variables before the occurrence of the outcome and, thus, allowed the assessment of risk. Furthermore, we add to the literature on pregravid BMI and infant feeding by examining the association between pregravid BMI and complementary food introduction. Research on maternal obesity and infant feeding has focused more on the relationship between pregravid BMI and breastfeeding rather than introduction of complementary foods.[4-6, 25, 26] Of the two studies we know of, the relationship between pregravid BMI and complementary food introduction was not the focus of their analyses.[7, 84]

We found a strong, inverse association between pregravid BMI and age of complementary food introduction and showed that this association was not explained by psychological factors. Our results suggest that overweight and obese women are less likely to meet the recommendations established by the AAP; specifically, they are more likely to introduce complementary foods before 4 months. Our findings highlight the importance of targeting overweight and obese women to delay the introduction of complementary foods until at least 4 months of age. However, in order to better target women, we need to have a more comprehensive understanding of why overweight and obese women are less likely to follow guidelines for the introduction of complementary foods. Future studies need to confirm the associations we found in a larger and more diverse sample population and explore reasons that may explain the pregravid BMI-infant feeding relationship.

Table 7. Maternal characteristics by pregravid BMI and age of complementary food introduction among women in the Pregnancy, Infection and Nutrition postpartum study (*n* = 550).

	Pregravid BMI			Age of complementary food introduction (mo)		
	Underweight (<18.5 kg/m²)	Normal weight (≥ 18.5 to 24.9 kg/m²)	Overweight/ obese (≥ 25.0 kg/m²)	< 4	4 to < 6	≥ 6
	n = 26	*n* = 326	*n* = 195	*n* = 108	*n* = 262	*n* = 177
Pregravid BMI (mean kg/m²)	17.6 ± 0.9[1]	21.7 ± 1.6	32.1 ± 6.8[1]	29.3 ± 9.0[2]	24.6 ± 6.2	23.5 ± 4.2
Age (mean in yrs)	27.8 ± 6.1	30.4 ± 5.1	29.4 ± 5.8	27.8 ± 6.3[2]	30.2 ± 4.8	30.8 ± 5.4
Race: White (%)	84.6[3]	86.8	64.1	55.6[3]	83.4	85.9
Married (%)	80.8[3]	91.7	70.8	63.0[3]	88.3	89.3
Education (mean in yrs)	15.5 ± 3.0	16.7 ± 2.5	14.9 ± 2.7	13.6 ± 2.4[2]	16.5 ± 2.5	16.8 ± 2.3
Percent of the 2001 poverty level (mean %)	389.4 ± 241.3	486.0 ± 200.1	351.3 ± 219.1[1]	278.1 ± 211.3[2]	458.2 ± 210.7	489.4 ± 190.3
Primiparous (%)	50	51.5	42.1	35.2[3]	50.2	53.1

Age of complementary food introduction (mean in mo)	4.5 ± 1.1	4.7 ± 1.3	4.1 ± 1.6[1]	2.4 ± 0.8[2]	4.3 ± 0.5[2]	6.0 ± 0.9
Breastfeeding initiation (%)	92.3[3]	96.9	85.1	75.0[3]	95,5	98.9
Breastfeeding at3 month interview	73.1[3]	77.3	50.3	26.0[3]	73.2	84.8
Exclusive breastfeeding duration (mean in mo)	2.8 ± 2.3	3.6 ± 2.2	2.5 ± 2.3[1]	1.1 ± 1.2[2]	2.9 ± 1.9[2]	4.6 ± 2.3
Depressive symptoms (% with high levels)	27.3[3]	16.8	29.2	38.5[3]	17.6	17.5
Perceived stress (% with high levels)	24.0[3]	21.0	34.2	36.7[3]	22.3	24.9
Anxiety (% with high levels)	18.2[3]	17.9	30.1	37.8[3]	17.3	20.1

[1]Significantly different from normal weight women: $p < 0.01$. [2]Significantly different from those who introduced complementary foods at 6 months of age or later: $p < 0.01$. [3]Pearson's chi-squared test p-value $p < 0.05$.

Table 8. Multinomial regression results of the association between pregravid BMI and age of complementary food introduction.

	Underweight		Overweight/Obese	
Age of complementary food introduction	RR (95% CI)	Robust SE	RR (95% CI)	Robust SE
Crude (*n* = 547)				
< 4 mos	2.00 (0.53, 7.46)	1.34	4.00 (2.37, 6.74)	1.07
4 to < 6	1.93 (0.73, 5.07)	0.95	1.25 (0.82, 1.91)	0.27
≥ 6	referent		referent	
Adjusted(*n* = 533)[1]				
< 4 mos	0.84 (0.20, 3.43)	0.60	2.22 (1.23, 4.01)	0.67
4 to < 6	1.63 (0.60, 4.40)	0.83	1.19 (0.76, 1.86)	0.27
≥ 6	referent		referent	

[1]Model of the association between pregravid BMI and age of complementary food introduction was adjusted for race, maternal education, and poverty status.

CHAPTER VII

CONCLUSION

The purpose of this research was to better understand the relationship between maternal pregravid BMI and infant feeding behaviors. Specifically, we wanted to determine the association between maternal pregravid BMI and (1) breastfeeding initiation, (2) breastfeeding duration (any and exclusive), and (3) age of complementary food introduction. Additionally, we explored whether psychological factors present during pregnancy (i.e. depressive symptoms, stress, anxiety and self-esteem) could explain these associations.

In this chapter, we review our findings and discuss the major strengths and limitations of the analyses that comprise this dissertation. We then discuss the public health implications and directions for future research.

Summary of Key Findings

The results of our analyses suggest that entering pregnancy overweight or obese is associated with less adherence to current infant feeding guidelines. Compared to normal weight women, those who were overweight or obese before pregnancy were more likely to not initiate breastfeeding, breastfeed for a shorter duration, and introduce complementary foods earlier than recommended. Furthermore, in our PINPost sample population, these associations were not explained by psychological factors present during pregnancy.

Review of Aims

In Chapter 3, we examined the relationship between maternal pregravid BMI and breastfeeding initiation. Our findings showed a strong association between being overweight or obese before pregnancy and not breastfeeding [RR = 3.94 (95% CI: 2.17, 7.18)] using normal weight women as the referent group. We adjusted for the effect of several covariates that confounded this association: race, education, marital status, and poverty status. In Chapter 4, we examined the association between pregravid BMI and breastfeeding duration and found that maternal overweight/obesity was associated with shorter duration of both *any* and *exclusive* breastfeeding compared to normal weight women. Overweight and obese women were more likely to: breastfeed less than four months [RR = 2.44 (1.36, 4.38)] after adjusting for race, maternal education, marital status and smoking in the first 6 months of pregnancy; and exclusively breastfeed less than one month [RR = 2.23 (1.32, 3.78)], accounting for race, maternal education, and poverty status. In Chapter 5, compared to normal weight women, overweight or obese women were more likely to introduce complementary foods before their infant was four months old [RR = 2.22 (1.23, 4.01)], adjusting for race, education and poverty status. Collectively, these findings suggest a strong negative association between maternal overweight/obesity and infant feeding behaviors.

Our results did not provide sufficient evidence to support the hypothesis that the association between pregravid BMI category and feeding practices can be mediated by psychological factors. However, we did find some interesting interrelationships between psychological factors, maternal pregravid BMI, and infant feeding behaviors. Entering pregnancy overweight or obese was associated with high levels of depressive symptoms, perceived stress, anxiety and low levels of self-esteem during pregnancy. The relationship between psychological factors and infant feeding was not as clear. We examined depressive symptoms, stress, anxiety and self-esteem in relation to breastfeeding initiation and found that high levels of depressive symptoms and low self-esteem were associated with not breastfeeding. For breastfeeding duration and age of complementary food introduction, we focused on depressive symptoms, stress, and anxiety. All three factors predicted shorter duration of *exclusive* breastfeeding and early introduction of complementary foods but only depressive symptoms were related to shorter duration of *any* breastfeeding. However, once we accounted for sociodemographic variables, these associations disappeared: pregravid BMI no longer predicted worse psychological profiles and the psychological factors were not related to infant feeding. This suggests that sociodemographic, rather than psychological factors, may explain more of the relationship between pregravid BMI and infant feeding.

Study Strengths

The Pregnancy, Infection and Nutrition study was a longitudinal prospective cohort study that followed women from pregnancy to postpartum. Data was collected on a multitude of pregnancy and postpartum-related factors, enabling us to comprehensively examine potential confounders. Due to the longitudinal nature of our study, we assessed the exposure before the mediators and the outcomes which facilitated the calculation of risk and the ability to conduct mediation analysis.

This study is more applicable to the U.S. population than many studies of pregravid BMI and infant feeding. Several studies have been conducted in other countries where the prevalence of obesity among women is much lower compared to the U.S.[5, 24, 84]

Our study contributes insight into why overweight or obese women are more likely to not follow infant feeding guidelines. Researchers have suggested that psychological reasons may partially explain why overweight/obese women have poor infant feeding outcomes [9] but few have examined whether there is evidence of mediation by psychological factors. Absence of evidence for a psychological pathway between pregravid BMI and infant feeding in our analyses suggests that the relationship may instead be explained by biological and physical pathways or some other mechanism.

Study Limitations

These findings must be interpreted in the context of our study's limitations. The generalizeability of our findings is limited for several reasons. The PIN3 study experienced attrition from the pregnancy to the postpartum cohort which resulted in a more homogenous PINPost population of women who were mostly Caucasian, married, highly educated, of high income and older. In addition, we recruited women from prenatal clinics when they were less than 20 weeks' gestation. Consequently, the results of our analyses may only be generalizable to women of similar sociodemographic characteristics and those who attend prenatal care early in pregnancy. The sample size (*n* = 550) restricted our ability to examine effect measure modification when examining breastfeeding duration and age of complementary food introduction as outcomes.

In this study, we did not find evidence of mediation of the pregravid BMI-infant feeding relationship by psychological factors in pregnancy. This may be due to attrition; women who refused to participate or were excluded from PINPost had significantly higher levels of depressive symptoms and anxiety than those who participated. It is possible that we did not see an effect of psychological factors on the pregravid BMI-breastfeeding initiation relationship because the women who chose to participate in PINPost had better overall mental health status during pregnancy than those who were excluded or refused, reducing the likelihood of finding an effect. In addition, we did not use clinically relevant assessment tools. It may be that clinically assessed depression and anxiety would be stronger mediators of the pregravid BMI-complementary food introduction association. Finally, it is possible that there existed a reciprocal relationship between pregravid BMI and the psychological factors despite having prospectively collected data. For example, if women with higher levels of the psychological factors during pregnancy also had higher levels before pregnancy, this would place them at risk of beginning pregnancy overweight or obese. Consequently, this would increase their risk of maintaining or developing high levels of the psychological factors during pregnancy. The literature supports evidence of bidirectionality between psychological factors and obesity, and, as an observational study, we cannot be certain that it does not exist in our data. Hence, our results are not meant to support causal inferences of causal of the associations studied.[110]

Public Health Implications

More than half of all women of childbearing age are either overweight or obese and many are entering pregnancy in this state.[60] We found that women who enter pregnancy overweight or obese are less likely to adhere to AAP infant feeding guidelines than women who enter at a normal weight status. Our studies are consistent with other research which shows a negative association between maternal overweight/obesity and infant feeding behaviors. However, there is little research on why the association between pregravid BMI and infant feeding exists. Possible reasons may be due to obesity-related biological changes, psychological changes, or mechanical difficulties. Contrary to our expectations, we did not find evidence for a mediatory psychological pathway explaining the association between overweight/obesity and infant feeding. This suggests that other factors may be more important at explaining this relationship. For instance, hormonal changes as a consequence of obesity may impair the onset of lactogenesis, thereby reducing the likelihood that a woman continues with breastfeeding.[62, 63, 114] Mechanical difficulties as a result of being obese may increase the difficulty of positioning infants or of latching on properly.[8] In addition, our results suggest that sociodemographic factors such as race, maternal education and poverty status are involved.

Feeding practices such as not breastfeeding, early cessation of breastfeeding, and early introduction of complementary foods may have lasting consequences for the health of the infant and mother. Not breastfeeding deprives the infant of the protective properties of breast milk.[11] Breastfeeding increases the mother-infant bond and is associated with better health outcomes such as lower risk of developing ovarian cancer, premenopausal breast cancers, and osteoporosis.[13] Early cessation of breastfeeding leads to early introduction of solids which is associated with childhood under- as well as over-nutrition, short stature, and delays in mental and motor development.[29, 30, 115] Complementary foods introduced earlier than recommended tend to displace breast milk and are not as nutritionally adequate to support infant growth.[116] Longer duration of breastfeeding, on the other hand, reduces risk of ear and respiratory infections, diarrhea, type 2 diabetes, gastroenteritis, atopic eczema and other adverse health outcomes for the infant.[11, 12, 15]

Although many women do not follow infant feeding guidelines in the U.S., this research identifies overweight and obese women as being particularly vulnerable. The first prenatal clinic visit is an important opportunity for public health professionals to promote breastfeeding since many women make decisions on breastfeeding initiation in early pregnancy.[45] However, simply knowing that overweight or obese women are less likely to adhere to infant feeding guidelines is not enough to guide interventions. We still do not know why being overweight or obese before pregnancy is related to poor infant feeding decisions. In this research, we tried to answer this question by exploring the role of psychological factors.

Directions for Future Research

There is a need for longitudinal data from a larger, more diverse sample, representative of the U.S. population. There are a wide range of races/ethnicities in the U.S. and each of these has specific cultural traditions that may influence infant feeding practices. Research on African American women, for example, shows that grandmothers and partners are strong influences in breastfeeding decisions.[45] Further, Asian Americans have one of the highest rates of breastfeeding initiation but there is little research on breastfeeding patterns and complementary food introduction in these populations. More information on this subject would help to better inform policy and improve interventions aimed at increasing adherence to infant feeding guidelines in the U.S.

This study, like others, found a negative association between maternal overweight/obesity and infant feeding. We found that depressive symptoms, perceived stress, anxiety and self-esteem did not mediate the effect of pregravid BMI on infant feeding. However, it is difficult to say this with any definitiveness because 1) our findings need to be supported by other studies, 2) the covariates are interrelated and 3) there was a low prevalence of high levels of psychological factors. Because this study is one of a few to explore the possibility of a psychological pathway between maternal pregravid BMI and infant feeding, our findings need to be replicated in future studies. Furthermore, in our analyses we found that once sociodemographic factors were in the model, the effect of psychological factors became non-significant. However, it is difficult to tease out the effect of each variable because sociodemographic factors influence psychological factors. In addition, reverse causality is involved in the relationship between pregravid BMI and psychological factors: pregravid BMI influences psychological status during pregnancy and may also be influenced by psychological factors prior to pregnancy. Future research on possible mediatory pathways explaining the maternal pregravid BMI–infant feeding relationship may benefit from a more comprehensive statistical method such as structural equation modeling. Finally, the low prevalence of high levels of the psychological factors may have made it difficult to detect an association. Research on clinically diagnosed depression and anxiety may yield a different relationship with pregravid BMI and infant feeding.

In order to improve interventions aimed at increasing adherence to infant feeding recommendations, we need to understand why women who enter pregnancy overweight or obese are less likely to follow guidelines. In this dissertation, I sought to better understand the relationship between pregravid BMI and infant feeding by examining mediation by depressive symptoms, stress, anxiety, and self-esteem. More research is needed on other possible pathways linking maternal pregravid BMI and infant feeding.

APPENDIX

Table 9. Mediation analysis of the association between pregravid BMI and duration of any breastfeeding by depressive symptoms in the Pregnancy, Infection and Nutrition study.[1]

Model 1: Effect of pregravid BMI on breastfeeding duration	Pregravid BMI[2]	
	Underweight	Overweight/obese
Breastfeeding duration	RR (95% CI)[3]	RR (95% CI)
none	3.81 (0.67, 21.69)	9.40 (3.91, 22.62)
> 0 to < 4 months	1.65 (0.48, 5.64)	4.46 (2.55, 7.80)
4 to 6	3.07 (0.87, 10.75)	1.18 (0.50, 2.80)
> 6 to 12	0.53 (0.13, 2.18)	1.40 (0.79, 2.48)
> 12	1.00	1.00

Model 2:Effect of pregravid BMI on mediator	Pregravid BMI	
	Underweight	Overweight/obese
Depressive symptoms[4,5]	1.80 (0.87, 3.71)	1.73 (1.20, 2.49)

Model 3: Effect of mediator on breastfeeding duration	Depressive symptoms
Breastfeeding duration	
none	2.04 (0.89, 4.71)
> 0 to < 4 months	1.83 (1.03, 3.26)
4 to 6	0.71 (0.27, 1.87)
> 6 to 12	0.60 (0.31, 1.17)
> 12	1.00

Model 4: Effect of pregravid BMI on breastfeeding duration with mediator in model	Pregravid BMI		Depressive symptoms
	Underweight	Overweight/obese	
Breastfeeding duration			
none	3.58 (0.63, 22.55)	9.00 (3.73, 21.72)	1.62 (0.68, 3.88)
> 0 to < 4 months	1.56 (0.45, 5.38)	4.28 (2.45, 7.49)	1.58 (0.86, 2.88)
4 to 6	3.19 (0.90, 11.31)	1.22 (0.51, 2.88)	0.67 (0.25, 1.77)
> 6 to 12	0.56 (0.13, 2.31)	1.45 (0.82, 2.56)	0.59 (0.30, 1.17)
> 12	1.00	1.00	1.00

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 470. [2]The referent is the normal BMI category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Center for Epidemiologic Studies-Depression scale measured depressive symptoms and was administered between 24 to 29 gestational weeks. [5]High vs. low depressive symptoms.

Table 10. Mediation analysis of the association between pregravid BMI and duration of any breastfeeding by perceived stress in the Pregnancy, Infection and Nutrition study.[1]

	Pregravid BMI[2]	
Model 1: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/Obese
Breastfeeding duration	RR (95% CI)[3]	RR (95% CI)
none	3.81 (0.67, 21.69)	9.40 (3.91, 22.62)
> 0 to < 4 months	1.65 (0.48, 5.64)	4.46 (2.55, 7.80)
4 to 6	3.07 (0.87, 10.75)	1.18 (0.50, 2.80)
> 6 to 12	0.53 (0.13, 2.18)	1.40 (0.79, 2.48)
> 12	1.00	1.00
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI	
Perceived stress[4]	Underweight	Overweight/Obese
Low stress	1.00	1.00
Moderate Stress	1.14(0.43, 3.06)	1.06 (0.66, 1.68)
High Stress	1.03(0.30, 3.56)	2.01 (1.22, 3.33)
Model 3: Effect of mediator on breastfeeding duration	Perceived stress	
Breastfeeding duration	Moderate Stress	High Stress
none	1.22 (0.48, 309)	1.62 (0.65, 4.07)
> 0 to < 4 months	1.25 (0.69, 2.28)	1.45(0.79, 2.67)
4 to 6	1.22 (0.56, 2.68)	0.70 (0.27, 1.79)
> 6 to 12	1.44(0.84, 2.49)	0.46 (0.23, 0.91)
> 12	1.00	1.00

	Pregravid BMI		Perceived stress	
Model 4: Effect of pregravid BMI on breastfeeding duration with mediator in model	Underweight	Overweight/obese	Moderate Stress	High Stress
Breastfeeding duration				
none	3.81 (0.66, 21.88)	9.25 (3.85, 22.21)	1.20 (0.46, 3.12)	1.25 (0.48, 3.24)
> 0 to < 4months	1.64 (0.48, 5.67)	4.41 (2.52, 7.70)	1.24 (0.67, 2.29)	1.21(0.65, 2.25)
4 to 6	3.01(0.85, 10.62)	1.24 (0.52, 2.94)	1.21 (0.55, 2.65)	0.70 (0.27, 1.80)
> 6 to 12	0.51 (0.12, 2.23)	1.53 (0.86, 2.72)	1.45 (0.84, 2.48)	0.44 (0.22, 0.88)
> 12	1.00	1.00		

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 470. [2]The referent is the normal BMI category according (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Perceived Stress Scale was administered between 27 to 30 gestational weeks.

Table 11. Mediation analysis of the association between pregravid BMI and duration of any breastfeeding by state anxiety in the Pregnancy, Infection and Nutrition study.[1]

	Pregravid BMI[2]	
Model 1: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/obese
Breastfeeding duration	RR (95% CI)[3]	RR (95% CI)
none	3.81 (0.67, 21.69)	9.40 (3.91, 22.62)
> 0 to < 4 months	1.65 (0.48, 5.64)	4.46 (2.55, 7.80)
4 to 6	3.07 (0.87, 10.75)	1.18 (0.50, 2.80)
> 6 to 12	0.53 (0.13, 2.18)	1.40 (0.79, 2.48)
> 12	1.00	1.00
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI	
State anxiety[4]	Underweight	Overweight/obese
Low anxiety	1.00	1.00
Moderate anxiety	1.54 (0.57, 4.15)	0.80 (0.50, 1.28)
High anxiety	1.32 (0.38, 4.57)	1.84 (1.13, 3.02)
Model 3: Effect of mediator on breastfeeding duration	State anxiety	
	Moderate anxiety	High anxiety
Breastfeeding duration		

	Underweight	Overweight/obese		
none	1.00 (0.42, 2.40)	1.40 (0.54, 3.64)		
> 0 to < 4 months	0.71 (0.39, 1.28)	1.63 (0.88, 3.04)		
4 to 6	1.69 (0.79, 3.65)	1.02 (0.37, 2.79)		
> 6 to 12	0.73 (0.43, 1.25)	0.66 (0.34, 1.27)		
> 12	1.00	1.00		
Model 4: Effect of pregravid BMI on breastfeeding duration with mediator in model	Pregravid BMI		State Anxiety	
	Underweight	Overweight/obese	Moderate anxiety	High anxiety
Breastfeeding duration				
none	3.80 (0.66, 21.67)	9.36 (3.91, 22.40)	1.08 (0.43, 2.69)	1.11 (0.42, 2.93)
> 0 to < 4 months	1.68 (0.49, 5.72)	4.20 (2.39, 7.40)	0.75 (0.41, 1.38)	1.40(0.74, 2.66)
4 to 6	2.97 (0.85, 10.37)	1.23(0.53, 2.89)	1.66 (0.77, 3.60)	1.00 (0.37, 2.72)
> 6 to 12	0.54 (0.13, 2.29)	1.43 (0.80, 2.55)	0.75 (0.44, 1.27)	0.63 (0.32, 1.24)
> 12	1.00	1.00		

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 470. [2]The referent is the normal BMI category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The State-Trait Anxiety Inventory was used to measure State anxiety between 27 to 30 gestational weeks.

Table 12. Mediation analysis of the association between pregravid BMI and exclusive breastfeeding duration by depressive symptoms in the Pregnancy, Infection and Nutrition study.[1]

Model 1: Effect of pregravid BMI on exclusive breastfeeding duration	Pregravid BMI[2]		
	Underweight	Overweight/obese	
Exclusive breastfeeding duration	RR (95% CI)[3]	RR (95% CI)	
< 1month	2.85 (1.03, 7.91)	3.44 (2.04, 5.81)	
1 to < 4	0.56 (0.12, 2.65)	2.23 (1.35, 3.67)	
≥ 4	1.00	1.00	
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI		
	Underweight	Overweight/obese	
Depressive symptoms[4,5]	1.67 (0.75, 3.73)	1.67 (1.13, 2.47)	
Model 3: Effect of mediator on breastfeeding duration	Depressive symptoms		
Exclusive breastfeeding duration			
< 1month	2.28 (1.28, 4.08)		
1 to < 4	1.87 (1.05, 3.33)		
≥ 4	1.00		
Model 4: Effect of pregravid BMI on breastfeeding duration with mediator in model	Pregravid BMI		Depressive symptoms
	Underweight	Overweight/obese	
Exclusive breastfeeding duration			
< 1month	2.67 (0.98, 7.28)	3.26 (1.93, 5.50)	1.99 (1.11, 3.56)
1 to < 4	0.54 (0.12, 2.47)	2.13 (1.28, 3.54)	1.74 (0.96, 3.16)
≥ 4	1.00	1.00	1.00

[1]Sample size restricted to those who breastfed, completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, $n = 436$. [2]The referent is the normal BMI category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Center for Epidemiologic Studies-Depression scale measured depressive symptoms and was administered between 24 to 29 gestational weeks. [5]High vs. low depressive symptoms.

Table 13. Mediation analysis of the association between pregravid BMI and exclusive breastfeeding duration by perceived stress in the Pregnancy, Infection and Nutrition study.[1]

	Pregravid BMI[2]			
Model 1: Effect of pregravid BMI on exclusive breastfeeding duration	Underweight	Overweight/ obese		
Exclusive breastfeeding duration	RR (95% CI)[3]	RR (95% CI)		
< 1month	2.85 (1.03, 7.91)	3.44 (2.04, 5.81)		
1 to < 4	0.56 (0.12, 2.65)	2.23 (1.35, 3.67)		
≥ 4	1.00	1.00		
Model 2: Effect of pregravid BMI on mediator	Pregravid BMI			
Perceived stress[4]	Underweight	Overweight/ obese		
Low stress	1.00	1.00		
Moderate stress	0.77 (0.28, 2.14)	0.99 (0.61, 1.62)		
High stress	0.68 (0.18, 2.60)	1.86 (1.10, 3.15)		
Model 3: Effect of mediator on exclusive breastfeeding duration	Perceived stress			
Exclusive breastfeeding duration	Moderate stress	High stress		
< 1month	1.18 (0.67, 2.08)	2.44 (1.31, 4.55)		
1 to < 4	1.07 (0.63, 1.81)	1.98 (1.08, 3.61)		
≥ 4	1.00	1.00		
Model 4: Effect of pregravid BMI on exclusive breastfeeding duration with mediator in model	Pregravid BMI		Perceived stress	
Exclusive breastfeeding duration	Underweight	Overweight /obese	Moderate stress	High stress
< 1month	2.94 (1.04, 8.30)	3.24 (1.91, 5.48)	1.17 (0.66, 2.10)	2.19 (1.15, 4.15)
1 to < 4	0.58 (0.13, 2.66)	2.12 (1.28, 3.52)	1.08 (0.64, 1.83)	1.82 (0.98, 3.37)
≥ 4	1.00	1.00	1.00	1.00

[1]Sample size restricted to those who breastfed, completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 436. [2]The referent is the normal BMI category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Perceived Stress Scale was administered between 27 to 30 gestational weeks.

Table 14. Mediation analysis of the association between pregravid BMI and exclusive breastfeeding duration by state anxiety in the Pregnancy, Infection and Nutrition study.[1]

	Pregravid BMI[2]	
Model 1: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/obese
Exclusive breastfeeding duration	RR (95% CI)[3]	RR (95% CI)
< 1month	2.85 (1.03, 7.91)	3.44 (2.04, 5.81)
1 to < 4	0.56 (0.12, 2.65)	2.23 (1.35, 3.67)
≥ 4	1.00	1.00
Model 2: Effect of pregravid BMI on mediator	Pregravid BMI	
State anxiety[4]	Underweight	Overweight/obese
Low anxiety	1.00	1.00
Moderate anxiety	1.58 (0.55, 4.54)	0.79 (0.48, 1.31)
High anxiety	1.49 (0.42, 5.32)	1.75 (1.04, 2.94)
Model 3: Effect of mediator on breastfeeding duration	State anxiety	
Exclusive breastfeeding duration	Moderate anxiety	High anxiety
< 1month	1.10 (0.63, 1.91)	1.90 (1.03, 3.53)
1 to < 4	0.77 (0.44, 1.33)	1.65 (0.91, 2.96)
≥ 4	1.00	1.00

Model 4: Effect of pregravid BMI on breastfeeding duration	Pregravid BMI		State Anxiety	
Exclusive breastfeeding duration with mediator in model	Underweight	Overweight/obese	Moderate anxiety	High anxiety
< 1month	2.79 (1.01, 7.70)	3.31(1.96, 5.59)	1.14 (0.64, 2.03)	1.68 (0.90, 3.15)
1 to < 4	0.57 (0.12, 2.63)	2.10 (1.26, 3.49)	0.80 (0.46, 1.40)	1.54 (0.85,2.78)
≥ 4	1.00	1.00	1.00	1.00

[1]Sample size restricted to those who breastfed, completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 436. [2]The referent is the normal BMI category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The State-Trait Anxiety Inventory was used to measure State anxiety between 27 to 30 gestational weeks.

Table 15. Mediation analysis of the association between pregravid BMI and age of complementary food introduction by depressive symptoms in the Pregnancy, Infection and Nutrition study.[1]

Outcome	Pregravid BMI[2]		
Model 1: Effect of pregravid BMI on Age of complementary food introduction	Underweight	Overweight/Obese	
Age of complementary food introduction	RR (95% CI)[3]	RR (95% CI)	
< 4 months	1.79 (0.31, 10.30)	4.87 (2.72, 8.74)	
4 to < 6	2.50 (0.81, 7.74)	1.16 (0.73, 1.85)	
≥ 6	1.00	1.00	
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI		
	Underweight	Overweight/Obese	
Depressive symptoms[4,5]	1.80 (0.87, 3.71)	1.73 (1.20, 2.49)	
Model 3: Effect of mediator on age of complementary food introduction	Depressive symptoms		
Age of complementary food introduction			
< 4 months	2.47 (1.34, 4.55)		
4 to < 6	0.87 (0.51, 1.49)		
≥ 6	1.00		
	Pregravid BMI		
Model 4 Effect of pregravid BMI on age of complementary food introduction with mediator in model	Underweight	Overweight/Obese	CES-D
Age of complementary food introduction			
< 4 months	1.59 (0.28, 9.17)	4.55 (2.52, 8.19)	2.09 (1.11, 3.91)
4 to < 6	2.56 (0.82, 7.98)	1.18 (0.74, 1.88)	0.83 (0.48, 1.43)
≥ 6	1.00	1.00	1.00

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, *n* = 470. [2]Normal BMI was the referent category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Center for Epidemiologic Studies-Depression scale measured depressive symptoms and was administered between 24 to 29 gestational weeks. [5]High vs. low depressive symptoms.

Table 16. Mediation analysis of the association between pregravid BMI and age of complementary food introduction by perceived stress in the Pregnancy, Infection and Nutrition study.[1]

Model 1: Effect of pregravid BMI on breastfeeding duration	Pregravid BMI[2]	
Age of complementary food introduction	Underweight	Overweight/Obese
	RR (95% CI)[3]	RR (95% CI)
< 4 months	1.79 (0.31, 10.30)	4.87 (2.72, 8.74)
4 to < 6	2.50 (0.81, 7.74)	1.16 (0.73, 1.85)
≥ 6	1.00	1.00
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI	
Perceived stress[4]	Underweight	Overweight/Obese
Low stress	1.00	1.00
Moderate Stress	1.14 (0.43, 3.06)	1.06 (0.66, 1.68)
High Stress	1.03(0.30, 3.56)	2.01 (1.22, 3.33)
Model 3: Effect of mediator on breastfeeding duration	Moderate Stress	High Stress
Age of complementary food introduction		
< 4 months	2.46 (1.24, 4.86)	3.36 (1.62, 7.01)
4 to < 6	0.99 (0.62, 1.59)	0.97 (0.56, 1.68)
≥ 6	1.00	1.00

	Pregravid BMI			
Model 4: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/Obese	Moderate Stress	High Stress
Age of complementary food introduction				
< 4 months	1.76 (0.29, 10.64)	4.71 (2.60, 8.53)	2.58 (1.28, 5.20)	2.83 (1.33, 6.00)
4 to < 6	2.50 (0.81, 7.73)	1.17 (0.73, 1.86)	0.99 (0.62, 1.59)	0.96 (0.55, 1.66)
≥ 6	1.00	1.00	1.00	1.00

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, n = 470. [2]Normal BMI was the referent category (18.5 to 24.9 kg/m2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The Perceived Stress Scale was administered between 27 to 30 gestational weeks.

Table 17. Analysis of mediation of the association between pregravid BMI and age of complementary food introduction by state anxiety in the Pregnancy, Infection and Nutrition study.[1]

Outcome	Pregravid BMI[2]	
Model 1: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/Obese
Age of complementary food introduction	RR (95% CI)[3]	RR (95% CI)
< 4 months	1.79 (0.31, 10.30)	4.87 (2.72, 8.74)
4 to < 6	2.50 (0.81, 7.74)	1.16 (0.73, 1.85)
≥ 6	1.00	1.00
Model 2:Effect of pregravid BMI on mediator	Pregravid BMI	
State Anxiety[4]	Underweight	Overweight/Obese
Low anxiety	1.00	1.00
Moderate anxiety	1.54 (0.57, 4.15)	0.80 (0.50, 1.28)
High anxiety	1.32 (0.38, 4.57)	1.84 (1.13, 3.02)
Model 3: Effect of mediator on breastfeeding duration	Moderate anxiety	High anxiety
Age of complementary food introduction		
< 4 months	1.04 (0.54, 2.02)	2.33 (1.22, 4.51)
4 to < 6	0.97 (0.61, 1.54)	0.79 (0.45, 1.37)
≥ 6	1.00	1.00

	Pregravid BMI			
Model 4: Effect of pregravid BMI on breastfeeding duration	Underweight	Overweight/Obese	Moderate anxiety	High anxiety
Age of complementary food introduction				
< 4 months	1.75 (0.31, 9.95)	4.57 (2.54, 8.24)	1.13 (0.57, 2.25)	2.02 (1.03, 3.97)
4 to < 6	2.52 (0.81, 7.86)	1.18 (0.74, 1.89)	0.96 (0.60, 1.53)	0.77 (0.44, 1.35)
≥ 6	1.00	1.00	1.00	1.00

[1]Sample size restricted to those who completed the CES-D, Perceived Stress and State Anxiety measurements and for whom we had pregravid BMI, n = 470. [2]Normal BMI was the referent category (18.5 to 24.9 kg/m^2). [3]Multinomial logit models were used to estimate relative risk ratios. [4]The State-Trait Anxiety Inventory was used to measure State anxiety between 27 to 30 gestational weeks.

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