

SOCIAL DETERMINANTS OF BREASTFEEDING: THE ROLE OF PRENATAL FOOD
INSECURITY

By

Chelsea Robinson

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ABSTRACT

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Background: Relatively little work has quantified associations between prenatal food insecurity and breastfeeding practices; however, understanding the implications of prenatal food insecurity may support food insecurity screening recommendations during prenatal care. Therefore, the purpose of this study was to investigate associations between prenatal food insecurity and breastfeeding initiation and duration.

Method: This study utilized data from a prospective Michigan pregnancy cohort. Women were recruited during their first prenatal visit. Prenatal food insecurity was assessed during pregnancy, and breastfeeding initiation and duration were assessed at the 3-month postpartum visit. Multiple logistic regression models were used to evaluate associations between prenatal food insecurity and two primary outcomes:

breastfeeding initiation and breastfeeding status at 3-months postpartum. Cox proportional hazard ratios were used to assess differences in the risk of breastfeeding cessation until 3 months postpartum by food insecurity status. An adversity index was created to stratify women into higher- and lower-risk groups for not breastfeeding. Associations between food insecurity and breastfeeding at 3 months postpartum were assessed via Fisher's Exact test within each group. **Results:** In the unadjusted models, women who

reported prenatal food insecurity were less likely to initiate breastfeeding (OR = 0.39; 95% CI: 0.21-0.69) and continue breastfeeding until 3 months postpartum (OR = 0.35; 95% CI: 0.20-0.61) compared to food secure women, but the associations were no longer significant after adjustment for sociodemographic and health-related factors. Prenatal food insecurity was not associated with breastfeeding at 3 months

postpartum in analyses stratified into high- and low-adversity groups. **Conclusions:** Prenatal food

insecurity is a strong predictor of breastfeeding practices. Though not significantly associated with breastfeeding practices after adjustment, screening for prenatal food insecurity may help clinicians identify women who may need more supports to initiate and maintain breastfeeding.

This thesis is dedicated to the families who participated in MARCH. Without your dedication, this work would not be possible. Thank you.

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KEY TO ABBREVIATIONS

aHR	Adjusted Hazard Ratio
aOR	Adjusted Odds Ratio
BF	Breastfed
BMI	Body Mass Index
HP	Health Plan
HR	Hazard Ratio
MARCH	Michigan Archive for Research on Child Health
OR	Odds Ratio
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children

CHAPTER 1: INTRODUCTION

1.1 Social Determinants of Health

The social determinants of health, or the conditions where people live, learn, work, and play, are now recognized as a significant contributor to health inequities.¹ Substantial evidence demonstrates that decreasing levels of income, education, social status, and social support are associated with increased illness and death throughout the lifespan.^{2,3} Such social determinants present in many ways, including discrimination, neighborhood safety, transportation, stress or allostatic load, limited access to quality care, housing insecurity, and food insecurity, and these factors often co-occur within individuals and communities. Some estimate that around 50% of one's health status can be determined by these socio-economic factors.^{4,5}

Despite growing evidence suggesting that social determinants are often root causes to medical problems, initiatives to address social determinants of health remain sparse, and are rarely integrated into standard medical care practices. A survey of primary care providers found that 85% believe that unmet social needs are leading directly to worse health outcomes among Americans, but 80% of physicians did not feel confident in their ability to meet their patients' social needs.^{2,6} However, there is also a growing field of front-line public health workers who advocate for evidence-based guidance on how to better address social determinants of health, and many agree that screening for social determinants of health should now be integrated into primary care practice.²

1.1.1 Food Insecurity

Food insecurity, defined as the lack of consistent access to enough food to sustain an active and healthy life, is just one social determinant of health.⁷ In 2020, Feeding America estimated that 1 in 8 Americans were food insecure, and households with children faced even higher prevalence of food insecurity.^{7,8} Though this high prevalence of food insecurity is alarming alone, it is of particular concern due to the myriad of physical and psychosocial health outcomes associated with food insecurity, including type 2 diabetes, obesity, and poor mental health. In fact, food insecurity is a stronger predictor of chronic disease than income.⁹ Though there is relatively limited research on the implications of food insecurity

during pregnancy, prenatal food insecurity has been shown to associate with decreased quality of life, poor psychosocial health, gestational weight gain, and pre-pregnancy body mass index (BMI).^{10–13} Food insecurity has a broad scope of impact at all stages of the life course, and given its high prevalence, more work addressing food insecurity is needed.

Because families with children face higher rates of food insecurity, one would hypothesize that the peripartum period would be a critical window for the development of food insecurity and assessing and intervening on food insecurity prenatally may improve health outcomes for families with children. Despite this theoretical hypothesis, relatively little work has attempted to even measure prevalence of food insecurity during pregnancy in the general population.¹⁴ Data from the Pregnancy, Infection, and Nutrition cohort of women in North Carolina from 2001-2005 found that 14% of pregnant women were marginally food insecure and 10% were food insecure, but more nationally representative estimates of food insecurity specific to the prenatal period are not available.¹¹ Though there is little recent research assessing the prevalence and impact of food insecurity in pregnancy, the American College of Obstetrics and Gynecology does suggest screening for food insecurity (among other social determinants of health) during pregnancy.¹⁵

Similar food insecurity screening recommendations have been provided by the American Academy of Pediatrics, who recommends universal food insecurity screening during pediatric care using a two-question screener called the Hunger Vital Sign. The two included questions are (1) “Within the past 12 months, we worried whether our food would run out before we got money to buy more” and (2) “Within the past 12 months, the food we bought just didn’t last and we didn’t have money to get more.” The goal of universal administration of the Hunger Vital Sign is to connect patients and their families to federal nutrition programs and food resources, document food insecurity status in medical records, and advocate for solutions to root causes of food insecurity all in an effort to promote child health.¹⁶ In addition to providing the Hunger Vital Sign screening resource, the American Academy of Pediatrics also provides extensive resources and education materials on how to implement food insecurity screening into

clinical care, which may also be helpful to prenatal care providers. Because prenatal visits are frequent and occur in a concentrated time, perinatal care may be an especially opportunistic time for screening.^{14,17}

Both theory and previous research suggest that the perception of limited resources (e.g., food insecurity) impacts both decision-making and health-related behaviors, which may explain mechanisms linking food insecurity to poor health.¹⁸ Such potential mechanisms include reduced access to healthy foods, reliance on cyclic eating patterns (likely due to intermittent insufficient income), and severe stress causing metabolic disturbances.^{13,18} These altered health-related behaviors and decision making may also contribute to unhealthy feeding patterns as early as infancy.¹⁸ Research on WIC-eligible mothers of young children found that during times when the families were food insecure, the mothers increased their own restrained eating, and the mothers restrained eating associated with more restrictive and less responsive child feeding practices.¹⁹ Another study among low-income Hispanic mothers found that food insecure mothers were more likely to exhibit obesogenic restrictive and pressuring infant feeding styles.²⁰ Because healthy infant feeding practices are integral to a child's lifelong development, more research regarding the potential impact of food insecurity on a mother's infant feeding practices is warranted.

1.2 Infant Feeding Practices: The Importance of Breastfeeding

The American Academy of Pediatrics recommends exclusive breastfeeding (i.e., infant receives no other foods or formula besides breast milk) through infant age 6 months, as breastfeeding has been shown to benefit many realms of child health and development, including reduced risk of asthma, obesity, and infections.^{21,22} In the United States, however, only about 1 in 4 infants meet this recommendation, and large disparities in breastfeeding practices persist by sociodemographic group.²² According to the Centers for Disease Control and Prevention, fewer than 75.5% of non-Hispanic Black infants are ever breastfed (i.e., infant received any breastmilk), while 85.3% of non-Hispanic White infants are ever breastfed. Infants receiving Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) benefits are also less likely to be breastfed than those eligible but not receiving WIC (76.9% vs 81.2%). Despite efforts to increase breastfeeding rates, prevalence of any breastfeeding and exclusive breastfeeding through 6 months have only increased marginally in recent years.²³

Causes of low adherence to breastfeeding recommendations and the persistence of breastfeeding disparities can begin to be understood when viewing breastfeeding through a socio-ecological lens. The socio-ecological model shifts the onus of health behavior decision making (e.g., decision to breastfeed) from the individual alone and includes intrapersonal, interpersonal, institutional, and community level factors that provide context for one's decision.²⁴ Qualitative work suggests that breastfeeding is a valued behavior and mothers desire to breastfeed, but multi-level barriers experienced by mothers often prevent them from being able to breastfeed as planned.²⁵ These barriers are summarized in Figure 1. At the individual level, barriers include exhaustion, time commitment of breastfeeding, and feelings of isolation, while interpersonal factors include lack of family or partner support for breastfeeding. Community level barriers involve social support (e.g., lack of community support groups), but also include social acceptability of breastfeeding in public spaces. Organizational barriers often begin at the hospital (e.g., lack of certified lactation counselors, formula advertising, provided formula samples),^{25,26} and policy level factors include inadequate maternity leave and inability to pump breastmilk at work.²⁵ In order to improve breastfeeding disparities, policy and interventions must consider the wide array of barriers experienced by mothers.

1.3 Conceptual Framework

Because of the multi-level social determinants of breastfeeding, and because of the impact food insecurity has on feeding practices more generally, we hypothesize that women with prenatal food insecurity may also endure more barriers to breastfeeding. Our hypothesis is consistent with qualitative findings, where low-income food insecure mothers reported actively limiting their portion sizes when eating and believed that their reliance on a poor diet combined with high stress levels would affect their breast milk quality.²⁷ Observational research on the topic is limited. Most studies assessing associations between food insecurity and breastfeeding are cross-sectional and have mixed results, making it uncertain if food insecurity is indeed predictive of breastfeeding outcomes.^{20,28–36} Two cohort studies prospectively measured prenatal food insecurity, but were conducted in limited samples (low-income Hispanic mothers and WIC participants), warranting replication in more diverse populations.^{37,38} Previous studies also

model associations with different covariates, making results difficult to interpret, given the multiple socio-demographic and health-related barriers faced by food insecure mothers.

To fill this gap in the literature, the present study assesses associations between prenatal food insecurity and breastfeeding behaviors in a diverse prospective cohort of pregnant women in Michigan. Because the prevalence of prenatal food insecurity is not well established, our first aim was to provide prenatal food insecurity prevalence estimates that may inform health policy in Michigan. Our second aim was to assess associations between prenatal food insecurity and (1) breastfeeding initiation, (2) percent breastfeeding at 3 months postpartum, and (3) breastfeeding duration until 3 months postpartum using sequential models that adjust for relevant covariates. Next, we created an adversity index to quantify the number of breastfeeding barriers mothers experienced to establish if the association between prenatal food insecurity and breastfeeding may differ in high-adversity facing and low-adversity facing groups. This approach is intended to describe prenatal food insecurity in the context of other factors disproportionately experienced by food-insecure mothers, which may help illustrate why screening for prenatal food insecurity may be beneficial.

CHAPTER 2: METHODS

2.1 Study Population

The study population consisted of women who participated in the Michigan Archive for Research on Child Health (MARCH), an ongoing prospective population-based pregnancy cohort representing all births in Michigan's lower peninsula. MARCH recruits women at their first prenatal visit at 22 Michigan clinics and includes follow-up of mother-infant dyads throughout early childhood. The goal of MARCH is to archive biospecimens and survey data for research on causes of adverse maternal and child outcomes. Eligibility criteria for MARCH include being age 18 years or older and being able to complete surveys in English. Recruitment began in 2017, and because recruitment is still ongoing, this study utilized data collected as of February 2022. Our analysis included mothers who provided informed consent, had singleton pregnancies, completed the food insecurity questions during the prenatal survey, and completed the three-month postpartum follow-up visit. This study was approved by the Michigan State University Institutional Review Board.

2.2 Data Collection

2.2.1 Food Insecurity

Food insecurity was assessed prenatally using the following three questions: (1) During the past month, did you ever eat less than you felt you should because there wasn't enough money to buy food? (2) During the past month, did you ever get emergency food from a church, food pantry, food bank or eat in a food kitchen? (3) During the past month, have you been concerned about having enough food for you or your family? These questions are similar to questions asked on the Current Population Survey Food Security Supplement (CPS-FSS), but our measure uses a 30 day timeframe (as opposed to a 12 month timeframe) in order to measure food insecurity specific to the prenatal period.³⁹ Mothers who answered yes to any of the three questions were categorized as food insecure, and mothers who said no to all three were categorized as food secure. Five participants who stated 'don't know' were excluded from the analysis.

2.2.2 Sociodemographic and Health-related Covariates

Several questionnaires were administered to mothers via telephone during pregnancy through 3 months postpartum. Mother's race, age, marital status, education, employment status, health plan type, household size, smoking status, and pregnancy intention were assessed during pregnancy around the mother's first prenatal visit. For descriptive and analytic purposes, race was categorized as non-Hispanic Black, non-Hispanic White, and other race. Mother's age at birth was categorized as ages 18-25 years, 26-33 years, and greater than 33 years. Marital status was categorized as married, living with a partner, and single (divorced/separated/widowed/never married). Mother's employment during the prenatal survey was categorized as working full time, part time, or not working for pay. Household size was assessed as the number of people relying on the household income, and was categorized as 1-2 people, 3-4 people, and 5 or more people. Health plan type was categorized as (1) having health insurance only through the government (e.g., Medicaid), (2) having health insurance from a job, spouse, or parent, and (3) having other, multiple, or no health insurance. Smoking was assessed around the first prenatal visit and categorized as non-smokers, those who quit since becoming pregnant, and those who still reported smoking. Pregnancy intention was assessed dichotomously as the response to "Was this pregnancy planned?". Maternal Body Mass Index (BMI) was assessed from self-reported height and pre-pregnancy weight. BMI was categorized as underweight ($< 18.5 \text{ kg/m}^2$), healthy weight ($18.5\text{-}24.99 \text{ kg/m}^2$), overweight ($25\text{-}29.99 \text{ kg/m}^2$) and obese ($\geq 30 \text{ kg/m}^2$).⁴⁰ Prenatal depression was also assessed at the prenatal survey using the validated Edinburgh Depression Scale, which was scored according the scale instructions.⁴¹ The Edinburgh Depression Scale has a potential score range of 0 to 30.⁴¹ A cut-off point of 11 or higher was used to indicate possible depression, as previous literature shows that this cut-off maximizes sensitivity and specificity in pregnant populations.⁴²

Additional sociodemographic and health-related variables were collected at the 3-month postpartum study survey. The mother's participation in the Women Infant and Children Supplemental Nutrition Program (WIC) was assessed as the mother's self-reported receipt of WIC vouchers for herself or the

baby in the prior month. Hospital length of stay at birth (in days) and birth sex were also self-reported by the mother at the 3-month survey.

Birth certificate data was also obtained for participants who consented to provide birth certificate data. Parity, birth sex, birth date, physician-estimated gestational age (in weeks), birth weight, and delivery route were abstracted from the birth certificates. Gestational age was dichotomized as those less than 37 weeks gestation to indicate preterm birth and those greater than or equal to 37 weeks gestation.⁴³ Birth weight was dichotomized as those with birth weights less than 2500 grams (i.e., low birth weight) and those with birth weights greater than or equal to 2500 grams.⁴⁴ For those in the analytic sample who did not provide birth certificate data (N = 35), gestational age was calculated (in weeks) as the time between the mother's last menstrual period (reported at the prenatal survey) and the birth date.

2.2.3 Breastfeeding Initiation and Duration

Information about breastfeeding practices were collected at the 3-month postpartum survey. The infant's age at the survey was calculated in days, and the first survey occurred at 89 days postpartum. The mother was first asked the following question "Did (baby) ever have breast milk, including directly at the breast or from a bottle, or mixed in cereal or other foods?". Mothers who said yes were categorized as breastfeeding initiators, and those who reported no were categorized as non-initiators. Mothers who initiated breastfeeding were then asked if they had completely stopped feeding the infant breastmilk both at the breast and via expressed milk in a bottle. Mothers who completely stopped breastfeeding reported the infant's age in days, weeks, or months when they completely stopped breastfeeding and pumping milk. This age was converted to days by multiplying weeks by 7 and months by 30. Breastfeeding at 3 months postpartum was dichotomized as those still breastfeeding at 89 days postpartum and those who were not breastfeeding at all at 89 days postpartum.

2.3 Statistical Analysis

Chi-square tests and Fisher's Exact tests (when expected number of cases in a cell was small) were utilized for covariate by exposure and outcome analyses. For all analyses, missing data was excluded in a

pairwise manner. All data analyses were performed using SAS software version 9.4 (SAS Institute, Cary NC).

2.3.1 Multiple Logistic Regression

Consistent with methodology used in prior literature, unadjusted and multivariate logistic regressions were used to assess associations between food insecurity and the two primary outcomes: (1) breastfeeding initiation and (2) breastfeeding at 3 months postpartum among those who initiated breastfeeding. Six sequential models were analyzed for each outcome analysis to accommodate covariates. Model 1 was unadjusted. Models two through four added in the most relevant confounders that play a causal role in breastfeeding behaviors. Model two adjusted for pregnancy intention, as previous literature suggests a close relationship between pregnancy intentions and breastfeeding intentions.^{45,46} Model 3 added cigarette smoking, as mothers who smoke have lower breastfeeding rates; reasons for which have been documented as through feelings that it is unhealthy to breastfeed when smoking and through physiologic decreases in milk production.^{47,48} Model 4 added in marital status as a proxy for social support. Previous literature has shown that social support is associated with the mother's ability to start and maintain breastfeeding.^{49,50} Model 5 added in maternal education, as maternal education may play a direct role in the mother's education about breastfeeding specifically.⁵¹ Model 6 added in mother race, age, and health plan type. These variables are less directly causally related to breastfeeding outcomes and may thus be proxies for other determinants of breastfeeding. Previous literature uses these variables, so model 6 serves to both replicate and ensure these results are comparable to prior literature.^{28,29,32,37,52}

2.3.2 Cox-Proportional Hazards Ratio

Cox-proportional hazard ratio methods were used to assess differences in time-to-breastfeeding cessation by food insecurity status in the entire analytic sample (i.e., breastfeeding initiators and never breast feeders). The same six iterative models were used as outlined in section 2.3.1. Log-log plots were used to assess proportionality of the hazards over time. Kaplan-Meier curves depicting time-to-breastfeeding cessation among all participants (breastfeeding initiators and never breast feeders) by food insecurity status were graphed.

2.3.3 Adversity Index

Previous research has shown that the many different adversities influence a women's ability to breastfeed, and these adversities most often do not occur in isolation.²⁵ To illustrate if these adversities operate in an additive fashion, we followed the methods used by Alaimo et al. to create a risk factor index by summing the factors associated with not breastfeeding or early breastfeeding cessation.⁵³ Participants with missing data in greater than one included category were excluded (N = 4). Each of the following factors were given one point and summed together to create an adversity score. These eight variables chosen for the adversity index were selected based on their availability in the data and the strength of the association between the factor and breastfeeding practices based on prior literature.

1. **Age at birth less than 20 years:** Previous research on adolescent parents has shown that parents less than age 20 endure lower breastfeeding rates compared to mothers aged 20 years or older (74% vs 82-84%). Many mechanisms have been proposed, including less social support, lack of school or work-based facilities to breastfeed, and lower breastfeeding education.^{26,54}
2. **Single marital status:** Mothers with single marital status have also been shown to breastfeed at lower rates than married and co-habituating mothers, presumably through social support mechanisms.^{49,50}
3. **Maternal education of high school completion or less:** Previous research suggests that there is a graded relationship between maternal education and breastfeeding initiation, with mothers with education of high-school or less having lower breastfeeding rates.⁵¹
4. **WIC recipient:** Though WIC provides additional incentives to women who choose to breastfeed, research consistently shows that WIC recipients experience lower ever-breastfeeding rates than WIC-eligible non-participants.⁵⁵
5. **Unplanned pregnancy:** Pregnancy intention is also strongly associated with breastfeeding initiation and duration, potentially because decisions about breastfeeding intentions are made during pregnancy, and women with planned pregnancies often have stronger social support.^{45,46}

6. **BMI greater than or equal to 30 kg/m²:** Women with obesity also have been shown to experience reduced breastfeeding rates. Proposed mechanisms include both physiologic factors (e.g., delayed lactogenesis, mechanical factors regarding additional body tissue, hormonal imbalance) and psychosocial factors (e.g., body image, depression, less control over breastfeeding due to having highly medicalized pregnancies).⁵⁶⁻⁵⁹
7. **Government health insurance:** Mothers on Medicaid (government) health plans also have been shown to experience lower odds of breastfeeding at 6-8 weeks postpartum than those with commercial insurance after accounting for other confounding factors.⁶⁰ Barriers to care among Medicaid recipients have been reported as including limited access to facilities that accept Medicaid plans, limited availability of culturally competent care, and limited appointment times that accommodate schedules of low-income workers.⁶¹
8. **Cigarette smoking during pregnancy:** Additional research suggests that women who smoke during pregnancy also experience lower breastfeeding rates potentially due to both physiologic (e.g., reduced milk volume, shorter lactation period) and psychosocial (e.g., mixed messages regarding the healthfulness of breastmilk of smokers) mechanisms.^{47,48}

To demonstrate if these factors indeed operate in an additive fashion, the percent breastfeeding at 3 months postpartum was plotted against the adversity score. A chi-square test was used to assess the association between the adversity score and breastfeeding status at 3 months postpartum. Then the analytic sample was divided into a high-adversity (score > 2) and low-adversity group (score ≤ 2). The cut point of 2 was selected based on both visual inspection of the plot outlined above and based on selecting a score that split the analytic sample most equally to avoid small subgroups. To assess for interactions between food insecurity and these other adversities, Fisher's Exact test was utilized to assess associations between food insecurity and breastfeeding at 3 months postpartum within the low-adversity and high-adversity groups.

CHAPTER 3: RESULTS

3.1 Study Participants

As of February 5, 2022, 1,113 pregnant women consented to participate in MARCH, 892 of which participated in initial data collection (i.e., completed prenatal survey). After exclusions were applied (multiple-gestation pregnancies, missing food insecurity questions, 3-month survey not completed either because of a missing data point or because the participants are not yet in the study visit time window in this ongoing cohort study), the final analytic sample was 495 (Figure 2). Maternal and infant characteristics by food insecurity status are listed in Table 1. Sixteen percent of women reported prenatal food insecurity, and most women (86%) initiated breastfeeding. Of those who initiated breastfeeding, 63% were still breastfeeding at 3 months postpartum. Most participants were non-Hispanic White (61%), age 26-33 years, married (54%), had a bachelor's degree or higher (43%) and worked full time during pregnancy (57%). Most women had health insurance through a job or family member (50%) and 42% were WIC recipients. Few participants reported smoking throughout pregnancy (11%) and slightly over half reported planned pregnancies (53%). Nineteen percent of women experienced prenatal symptoms consistent with possible depression, and over half of women were overweight or obese before pregnancy. Regarding birth outcomes, 90% of births occurred at 37 weeks or later, and 93% of infants had birth weights greater than or equal to 2500 grams.

As is evident in Table 1, differences were found in most sociodemographic characteristics between food insecurity groups. A larger proportion of participants experiencing food insecurity were non-Hispanic black, ages 18-25 years, single, had education of high school or less, were not working for pay, and had a household size with 5 or more people. A larger proportion of participants experiencing food insecurity also had government health insurance, received WIC, smoked, had unplanned pregnancies, and were multiparous. A higher proportion of participants experiencing food insecurity had possible depression and obesity. No significant differences by food insecurity status were observed for birth outcomes (i.e., gestational age, birth weight, delivery route, hospital length of stay).

Table 2 displays sociodemographic and health-related characteristics by breastfeeding initiation status. A larger percentage of those who never breastfed were non-Hispanic black, ages 18-25 years, single, had education of high school or less, and had a household size with 5 or more people. A larger percentage of those who never breastfed also had government health insurance, received WIC, smoked, had obesity, and had unplanned pregnancies. There were no notable differences in parity, prenatal depression, or birth outcomes (i.e., gestational age, birth weight, delivery route, hospital length of stay) among those who initiated versus never breastfed.

Table 3 shows sociodemographic and health-related characteristics by breastfeeding status at 3 months postpartum among those who initiated breastfeeding. A larger proportion of those who discontinued breastfeeding by 3 months postpartum were non-Hispanic black, ages 18-25 years, single, and had education of high school or less. A larger percentage of those who discontinued breastfeeding also had government health insurance, received WIC, smoked, had obesity, and had unplanned pregnancies. There were no notable differences in parity by breastfeeding status at 3 months postpartum, but a larger proportion of those who discontinued breastfeeding had possible depression (24% vs 15%). There were no differences in gestational age, birth weight, or delivery route between groups, but a larger proportion of those who discontinued breastfeeding by 3 months postpartum had hospital length of stays at delivery of 5 days or more (18% vs 9%).

3.2 Multiple Logistic Regression: Breastfeeding Initiation & Breastfeeding at 3 Months Postpartum

In the unadjusted model, women who reported food insecurity during pregnancy were less likely to initiate breastfeeding compared to food secure women (OR = 0.39; 95% CI: 0.21-0.69). The association remained significant when pregnancy intention was added to the model (aOR = 0.49; 95% CI: 0.27-0.91) but was no longer significant in model 3 when cigarette smoking was added. Similar results were seen for the association between prenatal food insecurity and breastfeeding at 3 months postpartum among those who initiated breastfeeding. In the unadjusted model, women who reported prenatal food insecurity had lower odds of breastfeeding at 3 months postpartum (OR = 0.35; 95% CI: 0.20-0.61). The association remained significant when pregnancy intention was added to the model (aOR = 0.48; 95% CI:

0.27-0.87), but when cigarette smoking was added to the model, the association was no longer significant (Table 4).

3.3 Cox-Proportional Hazards Ratio: Breastfeeding Duration

Using an unadjusted Cox-proportional hazards model of the analytic sample (breastfeeding initiators and never breast feeders), women who reported prenatal food insecurity experienced greater than twice the risk of breastfeeding cessation during the first three months postpartum when compared to food-secure women (HR = 2.29; 95% CI: 1.72-3.06). The association remained significant when pregnancy intention (aHR = 1.89; 95% CI: 1.33-2.43) and cigarette smoking (aHR = 1.62; 95% CI: 1.19-2.20) were added to the model. The association was no longer significant when marital status was added to the model (Table 4). Figure 3 shows the unadjusted Kaplan-Meier curve for breastfeeding duration by food insecurity status.

3.4 Adversity Index

Though the adversity index had a potential range from 0 to 8, the index score in our sample ranged from 0 to 7. Because only 9 participants had an index score equal to 7, scores of 6 and 7 were combined for descriptive and analytic purposes. Results from a chi-square test found the adversity score to be significantly associated with breastfeeding status at 3 months postpartum ($p < 0.001$). Twenty-eight percent of the sample had an adversity score of zero, and an additional 29% had an adversity score of 1-2 (Table 5). Those with an adversity score of 0 had the highest percentage breastfeeding at 3 months postpartum (78%) and the percentage breastfeeding at 3 months decreased with each additional adversity score point (Figure 4). Those with an adversity score of 6 or more had the lowest percentage breastfeeding at 3 months postpartum (16%).

The sample was dichotomized into a low-adversity (adversity score ≤ 2 ; $N = 283$) versus high-adversity (adversity score > 2 ; $N = 208$) groups. A larger proportion of the high-adversity group was food insecure (30.2% vs. 5.3%; $p < 0.0001$), non-Hispanic Black (59.1% vs. 6.7%; $p < 0.0001$) and were not breastfeeding at 3 months postpartum (70.7% vs. 27.2%; $p < 0.0001$) (Table 6). Fisher's Exact test

demonstrated that prenatal food insecurity was not associated with breastfeeding at age 3 months in either the low-adversity group or the high-adversity group (Table 7).

CHAPTER 4: DISCUSSION

4.1 Principal Findings

In this diverse sample of Michigan pregnant women, nearly one in six women experienced food insecurity during pregnancy, which is higher than the national average for U.S. adults (1 in 9) and comparable to average for children (1 in 7).^{7,8} Breastfeeding initiation rates (86%) in our sample were also comparable to the national average (84%).²² Prenatal food insecurity was strongly associated with both breastfeeding initiation and breastfeeding duration until 3 months postpartum in unadjusted analyses, but results were attenuated when important covariates were considered. Though these results suggest that prenatal food insecurity alone is not causally related to breastfeeding behaviors, the adversity index analysis demonstrated that a larger proportion of women facing many other barriers to breastfeeding endure food insecurity when compared to mothers with few breastfeeding barriers. Thus, food insecurity does not occur independently from other barriers, and screening for prenatal food insecurity may still be a useful tool in predicting the totality of the barriers endured by women and the impact that those multiple barriers may have on breastfeeding behaviors.

4.2 Results in the Context of What is Known

Previous literature assessing associations between food insecurity and breastfeeding behaviors has been mixed. Most prior work has been cross-sectional during infancy, and most studies found significant associations between food insecurity and breastfeeding initiation before adjustment, but not after adjustment, which is consistent with our findings.^{28–30,33} However, prior studies included many covariates in adjusted models without theoretical explanations for their modeling choices, and we believe that some covariates used may be only proxies of potential confounders (e.g., race and income may be proxies for groups who experience more exhaustion and time constraints) and other covariates used may be mediators between food insecurity and breastfeeding (e.g., maternal depression, maternal BMI). Because of this possibility for overadjustment, our sequential addition of covariates and theoretical explanations for our model building strategy provides more information on which key covariates may be explaining the association.

Both food insecurity and breastfeeding behaviors are culturally specific, thus associations between them may operate differently in different populations. For example, studies in the Canadian Inuit population found that food insecurity was not associated with breastfeeding initiation or exclusivity even before adjusting for any covariates.^{33,35} Similarly, a study of low-income Hispanic mothers who were WIC participants found no association between food insecurity during pregnancy or infancy and breastfeeding duration, exclusivity, or breastfeeding status at 9 months postpartum.^{20,38} A U.S. cross-sectional study of primarily low-income minority families also found no differences in percent breastfeeding at 2 months postpartum between food secure and food insecure mothers in unadjusted analyses,³⁶ further demonstrating the inconsistent and possibly sample-specific results of prior studies.

Few previous studies found significant associations between food insecurity and breastfeeding behaviors after adjustments. The Canadian community survey found that those with household food insecurity had no differences in breastfeeding initiation compared to food secure households but did have significantly lower odds of exclusive breastfeeding at age 4 months after adjustment.³¹ They also found that those mothers with severe food insecurity breastfed for a significantly shorter time period (1.2 months, $p = 0.04$) than food secure mothers, but there was no difference for mothers with marginal or moderate food security.³¹ A small study of low-income patients at two Medicaid pediatric clinics found that food insecure mothers had a lower likelihood of breastfeeding at 2 months postpartum after adjustments.³² Another study of WIC participants found that low prenatal food security was associated with lower likelihood of initiating breastfeeding, but not breastfeeding duration.³⁷ These results differed from our present study likely due to having more specific food insecurity measures, studying different populations, and having breastfeeding measures (e.g., exclusivity) that were not assessed in our analysis.

Our study builds upon these prior studies by attempting to view food insecurity in the context of other adversities, instead of merely adjusting for these factors. Moreover, the adversity index creates a summation score that represents the totality of breastfeeding barriers endured by mothers, which helps illustrate breastfeeding differences in accord with the socio-ecological model. Our results suggest that mothers who face larger number of adversities have lower breastfeeding rates at 3 months postpartum.

This finding alludes to the difficulty we as researchers face when trying to parse out the effect of one social determinant of health from others, because these factors often co-occur. Furthermore, this leads us to question the practicality of adjusting for many covariates, as doing so may create a result that will not apply to real life scenarios and may mis-inform public health policy.

Previous research in pediatric populations demonstrates that screening for food insecurity, using measures like the Hunger Vital Sign, during clinical care is feasible and effective at connecting families to resources. The Hunger Vital Sign has been shown to have high sensitivity (96.7%) and specificity (86.2%) when administered to low-income urban families with children in emergency departments and primary care settings.⁶² A cluster randomized controlled trial of mothers with infants at eight urban community health centers found that an intervention that involved screening for social determinants of health (including food insecurity) and providing information on community resources was associated with increased enrollment in community resources in the intervention group compared to the usual care group, suggesting the potential effectiveness of screening.⁶³ Some preliminary research using a convenience sample of adults at emergency departments found that the Hunger Vital Sign was also highly sensitive (94%) in adult populations.⁶⁴ Though minimal research has used the Hunger Vital Sign in prenatal populations, one study among pregnant women taking opioid agonist treatment for opioid use disorder found that prenatal food insecurity (measured using the Hunger Vital Sign) associated with increased risk of severe neonatal abstinence syndrome.⁶⁵ Given that the Hunger Vital Sign is shorter and easier to administer compared to longer validated food insecurity measures, implementing similar screening policies into prenatal care may be feasible and effective at reducing poor health outcomes by connecting women and families to resources.

4.3 Strengths and Limitations

There are several strengths to this study. First, this study includes a diverse sample recruited from 22 prenatal clinics in Michigan, enhancing the generalizability of the results. The prospective nature of the study is also a considerable strength, given that only two prior studies assessed prenatal food insecurity prospectively. Prospective collection of food insecurity may be more accurate than mothers'

retrospective recall of prenatal food insecurity during infancy. Additionally, our food insecurity questions measured food insecurity during the prior 30 days, which gives a very acute picture of prenatal food insecurity compared to other studies which may assess food insecurity over 12 months. Lastly, our detailed descriptions of our covariate selection techniques and the inclusion of the adversity index provide more context to the association between prenatal food insecurity and breastfeeding behaviors.

Our study also has several limitations. First, we did not have a measure of food insecurity during infancy. Because mother's food insecurity status may change after acquiring WIC benefits, it would have been beneficial to describe relationships between both prenatal and postnatal food insecurity and breastfeeding behaviors. Additionally, the food insecurity measure used was not able to differentiate between very low, low, and marginal levels of food insecurity, which may have differing impacts on breastfeeding. Second, our analysis only includes breastfeeding duration data until 3 months postpartum, and it does not account for breastfeeding exclusivity or intensity. Third, we did not have data on several factors that would have been important to consider, including other material hardships (e.g., housing insecurity, difficulty paying bills), mothers' access to maternity leave, and the mothers' employment status after birth. Additionally, the adversity index weights all included factors equally, which may not accurately portray the impact each factor has on breastfeeding. Lastly, while our sample size was moderate, this study should be replicated with larger sample sizes.

4.4 Conclusions

These results should inform future intervention studies that seek to improve breastfeeding outcomes by addressing social determinants. As is shown in our results, breastfeeding barriers that exist on multiple socio-ecological levels often co-exist within individuals and addressing any one barrier may not make a substantial impact on the outcome without considering the full context of barriers faced. This may also explain why programs like WIC, which seeks to enhance mother and child outcomes with food insecurity by providing food vouchers, have been shown to be ineffective at increasing breastfeeding rates.⁶⁶ Moreover, WIC is designed to primarily address food insecurity, without addressing the various other stressors that women with food insecurity face.

Because prenatal food insecurity is predictive of both breastfeeding initiation and duration, screening for food insecurity during prenatal care may be an effective strategy for identifying women who likely face multiple barriers to breastfeeding. In our study, our three-item food insecurity questionnaire was well-accepted by participants, as only 5 women had to be excluded due to selecting “don’t know” as an answer. This shows that most women are aware of their food insecurity status and feel comfortable providing that information, which makes food insecurity a potentially better screener than some other socioeconomic indicators that women may feel less comfortable sharing (e.g., income). By using a simple food insecurity screener, like the two-question Hunger Vital Sign screener recommended by the American Academy of Pediatrics, clinicians trained in social determinants of health will be able to connect food insecure women with supports that may better enable mothers to meet their breastfeeding goals.

APPENDICES

APPENDIX A

Tables

Table 1. Sociodemographic and health-related characteristics in the analytic sample and by food insecurity status.

Category	All (N = 495)		Food Secure (N = 416)		Food Insecure (N = 79)		P
	N	(%)	N	(%)	N	(%)	
Race/ethnicity							
Non-Hispanic Black	142	(29)	98	(24)	44	(56)	<.0001
Non-Hispanic White	299	(61)	273	(66)	26	(33)	
Other	52	(11)	44	(11)	8	(10)	
Mother Age (years)							
18-<26	118	(24)	86	(21)	32	(41)	0.0006
26-<34	251	(51)	222	(53)	29	(37)	
≥34	126	(25)	108	(26)	18	(23)	
Marital Status							
Married	264	(54)	250	(60)	14	(18)	<.0001
Living with Partner	101	(20)	82	(20)	19	(24)	
Divorced, Separated, Widowed, Never Married	128	(26)	83	(20)	45	(58)	
Education							
< High School	41	(8)	22	(5)	19	(25)	<.0001
High school graduate, diploma, or GED	90	(18)	65	(16)	25	(32)	
Some college/technical/Associate's	147	(30)	119	(29)	28	(36)	
Bachelor's or Higher	213	(43)	208	(50)	5	(6)	
Mother Employment							
Full time	279	(57)	254	(61)	25	(32)	<.0001
Part time	88	(18)	68	(16)	20	(26)	
Not working for pay	126	(26)	93	(22)	33	(42)	
Household Size (Number of people)							
1-2	210	(45)	179	(45)	31	(46)	0.0159
3-4	199	(43)	177	(44)	22	(32)	
5 or more	57	(12)	42	(11)	15	(22)	
Health plan (HP) Type							
HP from Job, Spouse, or Parent	248	(50)	240	(58)	8	(10)	<.0001
Government	197	(40)	137	(33)	60	(77)	
Other, Multiple, None	48	(10)	38	(9)	10	(13)	
WIC Status							
Yes	209	(42)	144	(35)	65	(82)	<.0001
No	283	(58)	269	(65)	14	(18)	
Smoking status							
Non-Smoker	384	(78)	342	(83)	42	(54)	<.0001
Quit since becoming pregnant	55	(11)	38	(9)	17	(22)	
Smoker	53	(11)	34	(8)	19	(24)	

Table 1 (cont'd)

Category	All (N = 495)		Food Secure (N = 416)		Food Insecure (N = 79)		P
	N	(%)	N	(%)	N	(%)	
Planned Pregnancy							
Yes	255	(53)	233	(57)	22	(28)	<.0001
No	229	(47)	173	(43)	56	(72)	
Parity							
Nulliparous	141	(31)	122	(32)	19	(25)	0.3689
Primiparous	133	(29)	111	(29)	22	(29)	
Multiparous	186	(40)	150	(39)	36	(47)	
Prenatal Depression							
Depression not likely	395	(81)	353	(86)	42	(55)	<.0001
Possible Depression	94	(19)	59	(14)	35	(45)	
Body Mass Index (BMI) kg/m ²							
Underweight (<18.5)	19	(4)	14	(3)	5	(7)	0.0248
Healthy (18.5-<25)	188	(39)	168	(41)	20	(26)	
Overweight (25-<30)	110	(23)	95	(23)	15	(20)	
Obese (≥30)	171	(35)	135	(33)	36	(47)	
Birth Sex							
Male	233	(47)	199	(48)	34	(43)	0.4334
Female	262	(53)	217	(52)	45	(57)	
Gestational Age (Weeks)							
<37 weeks	49	(10)	42	(10)	7	(9)	0.7372
≥37 weeks	440	(90)	369	(90)	71	(91)	
Birth weight (g)							
< 2500 g	30	(7)	24	(6)	6	(8)	0.6207
≥2500 g	430	(93)	359	(94)	71	(92)	
Delivery Route							
Cesarean	155	(34)	128	(33)	27	(35)	0.7806
Vaginal	305	(66)	255	(67)	50	(65)	
Hospital Length of Stay at Delivery (days)							
1-2	280	(57)	240	(58)	40	(51)	0.1383
3-4	147	(30)	124	(30)	23	(29)	
≥5	66	(13)	50	(12)	16	(20)	

Missing data: Race/ethnicity (N = 2); Marital Status (N = 2); Education (N = 4); Mother employment (N = 2); Household Size (N = 29); Health Plan Type (N = 2); WIC Status (N = 3); Smoking Status (N = 3); Planned Pregnancy (N = 11); Parity (N = 35); BMI (N = 7); Gestational age (N = 6); Birth weight (N = 35); Delivery Route (N = 35); Hospital Length of Stay at Delivery (N = 2)

Table 2. Sociodemographic and health-related characteristics in the analytic sample and by breastfeeding initiation status.

Category	All (N = 495)		Ever BF (N = 427)		Never BF (N = 68)		P
	N	(%)	N	(%)	N	(%)	
Race/ethnicity							
Non-Hispanic Black	142	(29)	100	(23)	42	(63)	<.0001
Non-Hispanic White	299	(61)	280	(66)	19	(28)	
Other	52	(11)	46	(11)	6	(9)	
Mother Age (years)							
18-<26	118	(24)	94	(22)	24	(35)	0.019
26-<34	251	(51)	217	(51)	34	(50)	
≥34	126	(25)	116	(27)	10	(15)	
Marital Status							
Married	264	(54)	256	(60)	8	(12)	<.0001
Living with Partner	101	(20)	84	(20)	17	(25)	
Divorced, Separated, Widowed, Never Married	128	(26)	86	(20)	42	(63)	
Education							
< High School	41	(8)	25	(6)	16	(24)	<.0001
High school graduate, diploma, or GED	90	(18)	63	(15)	27	(41)	
Some college/technical/Associate's	147	(30)	126	(30)	21	(32)	
Bachelor's or Higher	213	(43)	211	(50)	2	(3)	
Mother Employment							
Full time	279	(57)	250	(59)	29	(43)	0.0604
Part time	88	(18)	72	(17)	16	(24)	
Not working for pay	126	(26)	104	(24)	22	(33)	
Household Size (Number of people)							
1-2	210	(45)	181	(45)	29	(46)	0.0573
3-4	199	(43)	178	(44)	21	(33)	
5 or more	57	(12)	44	(11)	13	(21)	
Health plan (HP) Type							
HP from Job, Spouse, or Parent	248	(50)	238	(56)	10	(15)	<.0001
Government	197	(40)	144	(34)	53	(79)	
Other, Multiple, None	48	(10)	44	(10)	4	(6)	
WIC Status							
Yes	209	(42)	155	(36)	54	(82)	<.0001
No	283	(58)	271	(64)	12	(18)	
Smoking status							
Non-Smoker	384	(78)	344	(81)	40	(60)	0.0003
Quit since becoming pregnant	55	(11)	43	(10)	12	(18)	
Smoker	53	(11)	38	(9)	15	(22)	

Table 2 (cont'd)

Category	All (N = 495)		Ever BF (N = 427)		Never BF (N = 68)		P
	N	(%)	N	(%)	N	(%)	
Planned Pregnancy							
Yes	255	(53)	236	(57)	19	(28)	<.0001
No	229	(47)	181	(43)	48	(72)	
Parity							
Nulliparous	141	(31)	121	(30)	20	(32)	0.6138
Primiparous	133	(29)	118	(30)	15	(24)	
Multiparous	186	(40)	158	(40)	28	(44)	
Prenatal Depression							
Depression not likely	395	(81)	346	(82)	49	(74)	0.1475
Possible Depression	94	(19)	77	(18)	17	(26)	
Body Mass Index (BMI) kg/m ²							
Underweight (<18.5)	19	(4)	18	(4)	1	(2)	0.0084
Healthy (18.5-<25)	188	(39)	167	(40)	21	(32)	
Overweight (25-<30)	110	(23)	101	(24)	9	(14)	
Obese (≥30)	171	(35)	136	(32)	35	(53)	
Birth Sex							
Male	233	(47)	208	(49)	25	(37)	0.0668
Female	262	(53)	219	(51)	43	(63)	
Gestational Age (Weeks)							
<37 weeks	49	(10)	42	(10)	7	(10)	0.9002
≥37 weeks	440	(90)	380	(90)	60	(90)	
Birth weight (g)							
< 2500 g	30	(7)	25	(6)	5	(8)	0.6244
≥2500 g	430	(93)	372	(94)	58	(92)	
Delivery Route							
Cesarean	155	(34)	129	(32)	26	(41)	0.171
Vaginal	305	(66)	268	(68)	37	(59)	
Hospital Length of Stay at Delivery (days)							
1-2	280	(57)	248	(58)	32	(48)	0.1925
3-4	147	(30)	126	(30)	21	(32)	
≥5	66	(13)	53	(12)	13	(20)	

Missing data: Race/ethnicity (N = 2); Marital Status (N = 2); Education (N = 4); Mother employment (N = 2); Household Size (N = 29); Health Plan Type (N = 2); WIC Status (N = 3); Smoking Status (N = 3); Planned Pregnancy (N = 11; Parity (N = 35); BMI (N = 7); Gestational age (N = 6); Birth weight (N = 35); Delivery Route (N = 35); Hospital Length of Stay at Delivery (N = 2)

Abbreviations: BF = Breastfed

Table 3. Sociodemographic and health-related characteristics in the analytic sample and by breastfeeding status at 89 days postpartum among those who initiated breastfeeding.

Category	All (N = 495)		Still BF at 89 days (N = 268)		Discont' BF before 89 days (N = 159)		P
	N	(%)	N	(%)	N	(%)	
Race/ethnicity							
Non-Hispanic Black	142	(29)	42	(16)	58	(37)	<.0001
Non-Hispanic White	299	(61)	195	(73)	85	(54)	
Other	52	(11)	31	(12)	15	(9)	
Mother Age (years)							
18-<26	118	(24)	43	(16)	51	(32)	0.0005
26-<34	251	(51)	144	(54)	73	(46)	
≥34	126	(25)	81	(30)	35	(22)	
Marital Status							
Married	264	(54)	194	(72)	62	(39)	<.0001
Living with Partner	101	(20)	45	(17)	39	(25)	
Divorced, Separated, Widowed, Never Married	128	(26)	29	(11)	57	(36)	
Education							
< High School	41	(8)	9	(3)	16	(10)	<.0001
High school graduate, diploma, or GED	90	(18)	30	(11)	33	(21)	
Some college/technical/Associate's	147	(30)	71	(26)	55	(35)	
Bachelor's or Higher	213	(43)	158	(59)	53	(34)	
Mother Employment							
Full time	279	(57)	166	(62)	84	(53)	0.0144
Part time	88	(18)	49	(18)	23	(15)	
Not working for pay	126	(26)	53	(20)	51	(32)	
Household Size (Number of people)							
1-2	210	(45)	109	(42)	72	(49)	0.2064
3-4	199	(43)	122	(47)	56	(38)	
5 or more	57	(12)	26	(10)	18	(12)	
Health plan (HP) Type							
HP from Job, Spouse, or Parent	248	(50)	171	(64)	67	(42)	<.0001
Government	197	(40)	73	(27)	71	(45)	
Other, Multiple, None	48	(10)	24	(9)	20	(13)	
WIC Status							
Yes	209	(42)	69	(26)	86	(54)	<.0001
No	283	(58)	198	(74)	73	(46)	
Smoking status							
Non-Smoker	384	(78)	232	(87)	112	(71)	<.0001
Quit since becoming pregnant	55	(11)	24	(9)	19	(12)	
Smoker	53	(11)	11	(4)	27	(17)	

Table 3 (cont'd)

Category	All (N = 495)		Still BF at 89 days (N = 268)		Discont' BF before 89 days (N = 159)		P
	N	(%)	N	(%)	N	(%)	
Planned Pregnancy							
Yes	255	(53)	175	(67)	61	(39)	<.0001
No	229	(47)	87	(33)	94	(61)	
Parity							
Nulliparous	141	(31)	75	(30)	46	(32)	0.6028
Primiparous	133	(29)	79	(31)	39	(27)	
Multiparous	186	(40)	97	(39)	61	(42)	
Prenatal Depression							
Depression not likely	395	(81)	226	(85)	120	(76)	0.0281
Possible Depression	94	(19)	40	(15)	37	(24)	
Body Mass Index (BMI) kg/m ²							
Underweight (<18.5)	19	(4)	13	(5)	5	(3)	0.004
Healthy (18.5-<25)	188	(39)	120	(45)	47	(30)	
Overweight (25-<30)	110	(23)	61	(23)	40	(25)	
Obese (≥30)	171	(35)	71	(27)	65	(41)	
Birth Sex							
Male	233	(47)	129	(48)	79	(50)	0.7565
Female	262	(53)	139	(52)	80	(50)	
Gestational Age (Weeks)							
<37 weeks	49	(10)	23	(9)	19	(12)	0.2712
≥37 weeks	440	(90)	241	(91)	139	(88)	
Birth weight (g)							
< 2500 g	30	(7)	13	(5)	12	(8)	0.2292
≥2500 g	430	(93)	238	(95)	134	(92)	
Delivery Route							
Cesarean	155	(34)	75	(30)	54	(37)	0.1449
Vaginal	305	(66)	176	(70)	92	(63)	
Hospital Length of Stay at Delivery (days)							
1-2	280	(57)	176	(66)	72	(45)	0.0001
3-4	147	(30)	67	(25)	59	(37)	
≥5	66	(13)	25	(9)	28	(18)	

Missing data: Race/ethnicity (N = 2); Marital Status (N = 2); Education (N = 4); Mother employment (N = 2); Household Size (N = 29); Health Plan Type (N = 2); WIC Status (N = 3); Smoking Status (N = 3); Planned Pregnancy (N = 11; Parity (N = 35); BMI (N = 7); Gestational age (N = 6); Birth weight (N = 35); Delivery Route (N = 35); Hospital Length of Stay at Delivery (N = 2)

Abbreviations: BF = Breastfed

Table 4. Unadjusted and adjusted associations between prenatal food insecurity and breastfeeding outcomes.

	Breastfeeding Initiation ^a (Yes vs No)	Still Breastfeeding at 3 Months ^b (Yes vs No)	Breastfeeding Duration ^c
	OR (95% CI)	OR (95% CI)	HR (95%CI)
Model 1: Food Insecurity Status (Unadjusted) ^d	0.39 (0.21, 0.69)*	0.35 (0.20, 0.61)*	2.29 (1.72, 3.06)*
Model 2: Model 1 + Pregnancy Intention	0.49 (0.27, 0.91)*	0.48 (0.27, 0.87)*	1.80 (1.33, 2.43)*
Model 3: Model 2 + Cigarette Smoking	0.58 (0.31, 1.09)	0.56 (0.30, 1.02)	1.62 (1.19, 2.20)*
Model 4: Model 3 + Marital Status	0.88 (0.46, 1.67)	0.69 (0.36, 1.31)	1.31 (0.96, 1.78)
Model 5: Model 4 + Maternal Education	1.09 (0.56, 2.13)	0.74 (0.38, 1.42)	1.19 (0.87, 1.64)
Model 6: Model 5 + Maternal Race + Maternal Age + Health Plan Type	1.20 (0.60, 2.50)	0.72 (0.37, 1.41)	1.18 (0.85, 1.62)

^a Logistic Regression of breastfeeding initiation among all participants (N = 495)

^b Logistic regression of breastfeeding at 3 months postpartum among those who ever initiated breastfeeding (N = 427)

^c Cox proportional hazards model for the hazard of stopping breastfeeding from birth until 3 months postpartum among all participants (N = 495)

^d Food Insecurity is measured dichotomous as food secure vs food insecure. Referent = Food Secure

* p < 0.05

Table 5. Percent breastfeeding at 3 months postpartum by adversity score (N = 491).*

Adversity Score	All Participants		Still breastfeeding at 3 months postpartum among the analytic sample		
	N	(%)	N	(%)	P ^a
0	139	(28)	108	(78)	<.0001
1	83	(17)	57	(69)	
2	61	(12)	41	(67)	
3	49	(10)	22	(45)	
4	66	(13)	22	(33)	
5	50	(10)	10	(20)	
≥6	43	(9)	7	(16)	

* The analytic sample consisted of N = 495, but N = 4 were deleted from the adversity score analysis due to missing data on greater than 1 factor included in the score composite. Each of the following factors were given a point of one each and summed together to create an adversity score: age at birth less than 20, single marital status, maternal education of high school completion or less, WIC recipient, unplanned pregnancy, BMI greater than or equal to 30 kg/m², government health insurance, and cigarette smoking during pregnancy.

^a Chi-square test

Table 6. Descriptive characteristics of low-adversity (adversity score ≤ 2) and high-adversity (adversity score > 2) groups.

	Low-Adversity Group (N = 283)		High-Adversity Group (N = 208)		P ^a
	N	(%)	N	(%)	
Food Insecurity					
Food Insecure	15	(5.3)	63	(30.2)	<.0001
Food Secure	268	(95.6)	145	(69.7)	
Still BF at 3 Months					
No	77	(27.2)	147	(70.7)	<.0001
Yes	206	(72.8)	61	(29.3)	
Race					
Non-Hispanic Black	19	(6.7)	123	(59.1)	<.0001
Non-Hispanic White	234	(82.7)	65	(31.3)	
Other	30	(10.6)	20	(9.6)	

^a Chi-square test

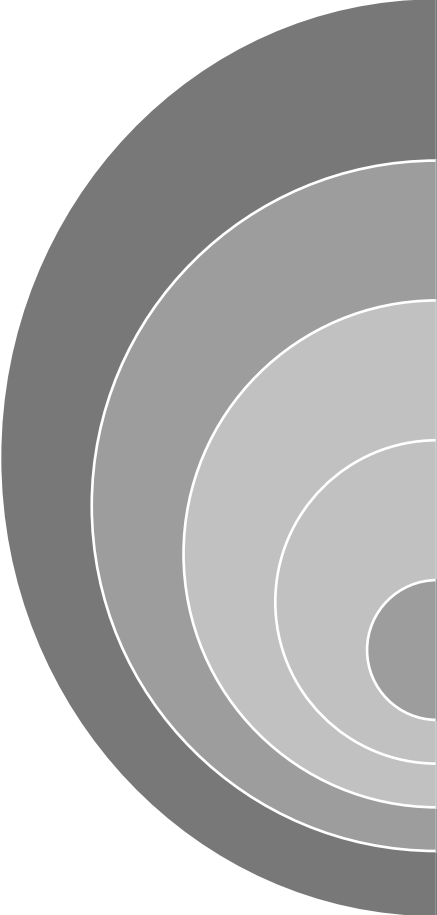
Table 7. Associations between food insecurity and breastfeeding at 3 months postpartum within the high-adversity and low-adversity groups using Fisher's Exact Test.

Still Breastfeeding at 3 Months Postpartum						
	Low-Adversity Group (N = 283)			High-Adversity Group (N = 208)		
	Still BF: Yes	Still BF: No		Still BF: Yes	Still BF: No	
	N	N	P	N	N	P
Food Insecurity						
Food Insecure	9	6	0.2473	15	48	0.3201
Food Secure	197	71		46	99	

APPENDIX B

Figures

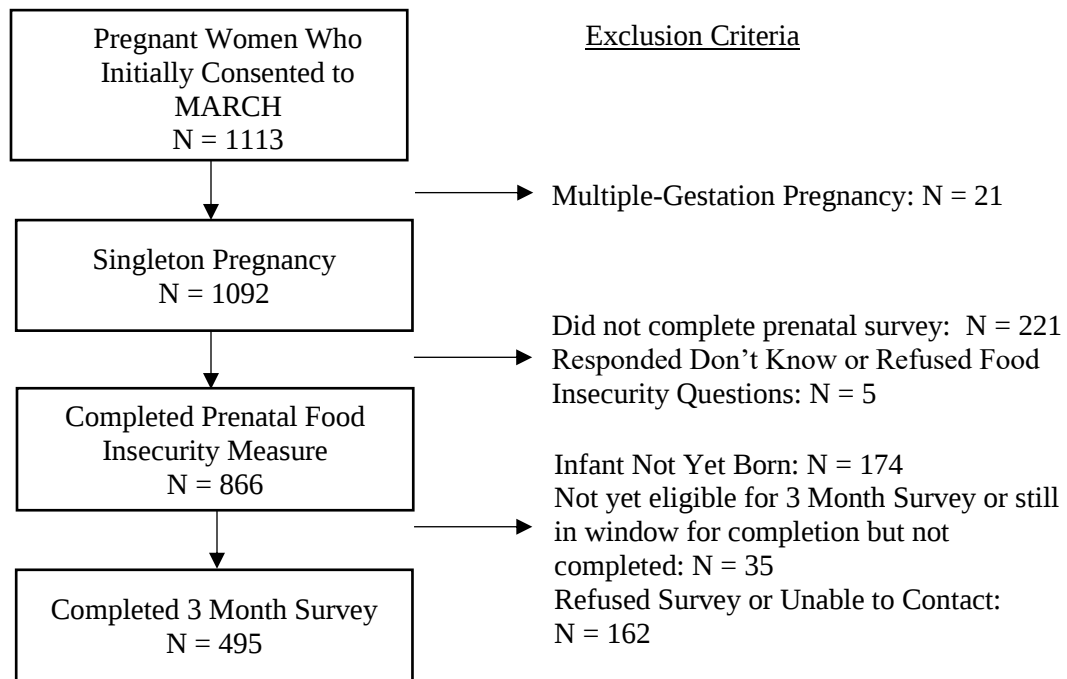
Figure 1. Summary of socio-ecological barriers to breastfeeding.*



Policy Barriers	•Inadequate maternity leave •Limited ability to pump breastmilk at work
Organizational Barriers	•Hospital resources (e.g., lack of certified lactation counselors, formula advertising, provided formula samples)
Community Barriers	•Lack of normalization of breastfeeding in public •Lack of resource access (e.g., community support groups)
Interpersonal Barriers	•Lack of partner or family support
Individual Barriers	•Isolation •Exhaustion •Time commitment of breastfeeding

* This figure summarizes results from Bookhart et al. (2021), Snyder et al. (2021), and the American College of Obstetrics and Gynecology Breastfeeding Expert Work Group (2021).^{24–26}

Figure 2. Derivation of the Analytic Sample



*MARCH data as of 02/05/2022

Figure 3: Unadjusted Kaplan-Meier curve for breastfeeding duration in days by food insecurity status in the analytic sample (N = 495). Breastfeeding duration is censored at the infant's age at the 3-month survey for those still breastfeeding at the time of the survey.

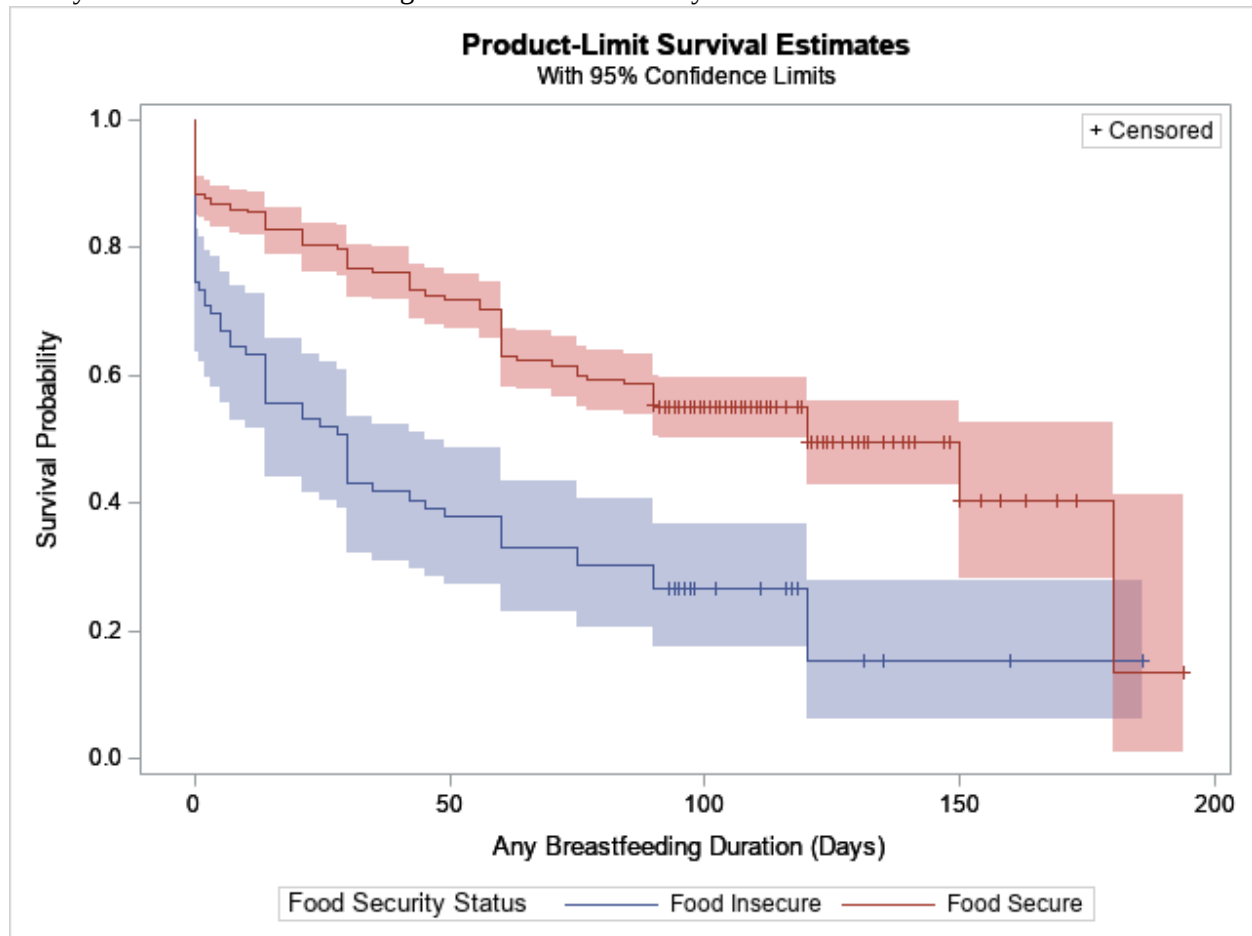
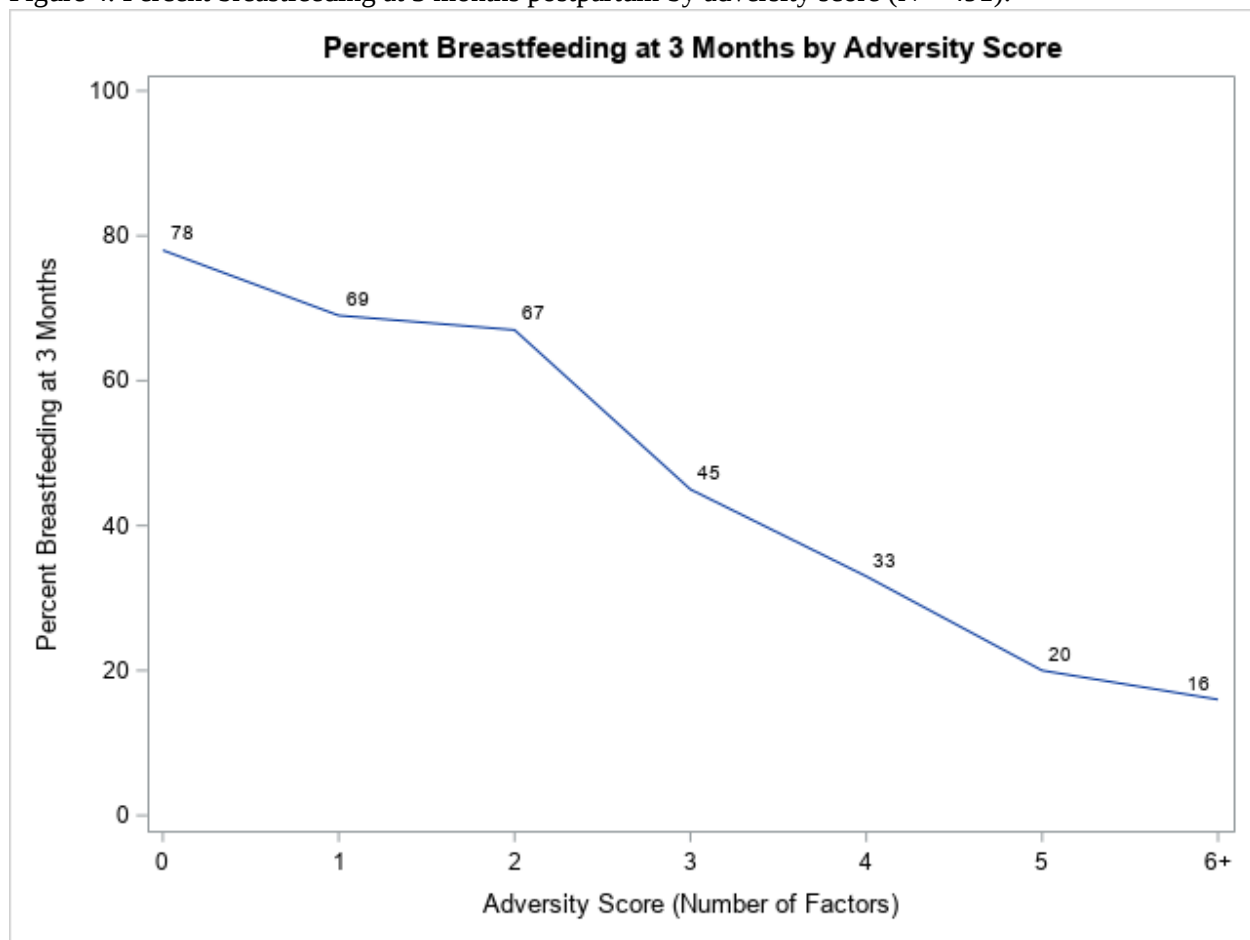


Figure 4. Percent breastfeeding at 3 months postpartum by adversity score (N = 491).*



* The analytic sample consisted of N = 495, but N = 4 were deleted from the adversity score analysis due to missing data on greater than 1 factor included in the score composite. Each of the following factors were given a point of one each and summed together to create an adversity score: age at birth less than 20, single marital status, maternal education of high school completion or less, WIC recipient, unplanned pregnancy, BMI greater than or equal to 30 kg/m², government health insurance, and cigarette smoking during pregnancy.

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