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Los Angeles

An Examination of Place-Based Structural and Social Determinants of Breastfeeding Among Low-Income Women in Los Angeles County

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Community Health Sciences

by

Skye Shodahl

2026

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ABSTRACT OF THE DISSERTATION

An Examination of Place-Based Structural and Social Determinants of Breastfeeding Among Low-Income Women in Los Angeles County

by

Skye Shodahl

Doctor of Philosophy in Community Health Sciences

University of California, Los Angeles, 2026

Professor Michael L. Prelip, Chair

Background: Despite ongoing public health efforts, racial/ethnic disparities in breastfeeding remain a major barrier to maternal and child health equity. Minority women (e.g., Black and Hispanic) continue to experience lower breastfeeding rates than White women. Place-based SDOH, such as neighborhood conditions, are well-established determinants of health and may also be relevant to breastfeeding. Although research on their role in breastfeeding remains limited, existing studies have indicated an association that warrants further investigation.

This dissertation attempts to address this gap by examining the association between structural and social determinants of health and breastfeeding (initiation, duration, and exclusivity) among low-income women, specifically participants in the Supplemental Nutrition Assistance Program for Woman, Infant, and Children (WIC) living in Los Angeles County.

Three interconnected studies were conducted, each focusing on a distinct and understudied aspect of the neighborhood environment. *Study 1* provides the most comprehensive assessment by examining how a multidimensional measure of place-based SDOH may help explain individual-level differences in breastfeeding practices. This measure reflects overall neighborhood quality as well as conditions across eight domains: economic, education, social, housing, transportation, neighborhood-built environment, clean environment, and healthcare access. *Study 2* is an exploratory examination of how a broad measure of neighborhood racial/ethnic concentration, operationalized as the percentage of Hispanic residents in a neighborhood, may help explain individual-level differences in breastfeeding practices. Lastly, *Study 3* examines the association between a neighborhood's food environment, specifically access to healthy foods, and individual-level breastfeeding practices.

Methods: Multilevel data were used throughout each study. The primary datasets include individual-level data from the Los Angeles County WIC Survey (Studies 1-3) and neighborhood-level data from the Healthy Places Index (Study 1), United States Department of Agriculture's Food Access Research Atlas (Study 3), and the United States Census Bureau's Decennial Census and Geographic Relationship files (Study 2 and 3, respectively). These datasets were merged across the three studies, in different combinations, to create the multilevel datasets used to examine neighborhood effects on breastfeeding. Given the multilevel nature of the data, all three studies employed multilevel analyses, using mixed models, to account for the nesting of individuals within ZIP codes.

Results: *Study 1* found that overall neighborhood quality is not associated with breastfeeding outcomes, however domain-specific analyses of neighborhood conditions revealed that the education domain is positively and independently associated with increased initiation,

duration (at 3 and 6 months) and exclusivity (at 3 and 6 months) beyond maternal covariates. Additionally, exclusive breastfeeding is the only outcome independently associated with multiple domains (i.e., education, income, and healthcare), with better neighborhood conditions linked to increased initiation, duration (at 3 and 6 months), and exclusivity (at 3 and 6 months) even after adjusting for maternal covariates. *Study 2* found that higher neighborhood Hispanic concentration is associated with lower odds of exclusive breastfeeding at 3 and 6 months, even after adjusting for maternal covariates. *Study 3* found that the neighborhood food environment, as measured by the percentage of residents in a ZIP-code living in a food desert tract, is not independently associated with breastfeeding beyond maternal covariates.

Conclusion: Overall, the findings of this dissertation provide evidence that breastfeeding behaviors are shaped not only by individual-level factors but also by some broader neighborhood contexts. By adopting a place-based approach, this dissertation integrated a contextual dimension to the understanding of breastfeeding inequities that has been largely overlooked in the existing body of research. The dominant individualistic framing of breastfeeding as a personal choice has narrowly placed responsibility on mothers while ignoring the structural inequities that limit their choice to breastfeed. Overlooking these structural forces allows systems that fail mothers to persist and reinforce inequities. Therefore, continuing to grow this body of research is critical to advancing maternal and child health equity by shifting the framing of breastfeeding from an individual choice to one shaped by broader structural conditions.

The dissertation of Skye Shodahl is approved.

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2026

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INTRODUCTION

Breastfeeding is considered the gold standard for infant feeding as it provides significant benefits for both maternal and child health. Despite these advantages, racial disparities in breastfeeding rates persist. Racial/ethnic minorities, particularly Black and Hispanic mothers continue to have disproportionately lower rates compared to White mothers. Social and environmental factors, including those related to the social determinants of health (SDOH), play a critical role in a woman's ability to initiate and maintain breastfeeding. SDOH are defined as the conditions in which people are born, grow, work, and live. These determinants operate across multiple levels, including both individual-level (e.g., income, education) and group-level (e.g., neighborhood environments).

While individual-level factors have received more attention in health research, scholars have identified a need to better examine place-based determinants in health equity work. The role of place, which encompasses an individual's physical, social, and economic environments, in shaping health is well-established. Individuals living in low-opportunity neighborhoods have been shown to lack the necessary conditions (i.e., limited access to resources such as healthcare, green spaces, transportation, and educational opportunities) for health, wealth, and overall well-being. Because these place-based factors are modifiable, they present critical opportunities for targeted interventions and policy changes to reduce health disparities and improve population health.

Research has shown that adverse SDOH related to education, employment, neighborhood conditions, and housing instability significantly contribute to disparities in breastfeeding practices in the United States (U.S). However, much of this research has focused on individual-level factors, with limited attention to neighborhood-level determinants of breastfeeding. Adverse social and physical environments may influence breastfeeding through multiple

pathways, including limited access to healthy foods, healthcare, lactation support as well as unsafe housing, environmental pollutants, inadequate transportation, and chronic neighborhood stressors. Although place-based factors represent a potentially important avenue for SDOH research, the influence of place on disparities in breastfeeding remains underexplored.

To address this gap, the overarching goal of this dissertation is to deepen the currently limited understanding of how a neighborhood's social and physical environment shapes individual-level differences in breastfeeding practices. This dissertation examines both structural and social determinants of health. Structural determinants represent the broader social, political, and economic systems that produce inequities in social determinants that can manifest through neighborhood social and physical environments. The primary research question is: How do place-based structural and social determinants of health, measured through the neighborhood social and physical environment, influence individual-level racial differences in breastfeeding practices among low-income women? To address this question, a series of three distinct but interrelated studies were conducted.

- **Study 1 Aim:** To examine how place-based SDOH, measured by a multidimensional index of community conditions known as the Healthy Places Index (HPI), help explain individual-level differences in breastfeeding practices (initiation, duration, and exclusivity).
- **Study 2 Aim:** To examine how neighborhood racial/ethnic concentration help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

- **Study 3 Aim:** To examine how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

The dissertation is organized as follows. Chapter 1 provides an overview of breastfeeding, including its benefits, national goals and recommendations, current trends in the U.S., and key determinants. Chapter 2 narrows the focus to examine the relationship between SDOH and breastfeeding, with particular emphasis on how these factors operate at the neighborhood level. It also highlights critical gaps in the literature and how this dissertation aims to address them. Chapter 3 presents the theories and conceptual frameworks guiding this work. Chapter 4 outlines the research aims, questions, and hypotheses. Chapter 5 describes the data sources, methods, and analytic approaches used in each study. Chapters 6, 7, and 8 present and discuss the results of Studies 1, 2, and 3, respectively. Finally, Chapter 9 summarizes the findings across studies, discusses limitations, and outlines the significance of this dissertation and future research directions.

CHAPTER 1: Background and Significance

Chapter Overview

This chapter provides an overview of breastfeeding and highlights its significance. It begins by exploring the benefits of breastfeeding for maternal and child health, environmental sustainability, and economic stability. Next, I will outline the current goals and recommendations for breastfeeding established by health organizations. I will then present current breastfeeding trends in the United States (U.S.), including disparities across different populations. Finally, I will examine the key determinants influencing breastfeeding practices, ranging from individual to structural factors.

The Public Health Importance of Breastfeeding

Breastfeeding is considered the gold standard for infant feeding, with numerous benefits for promoting maternal and child physical and psychological health, supporting environmental sustainability, and contributing to economic well-being.

Physical Health Benefits

Maternal and Infant Mortality Reduction

Breastfeeding has been found to have a significant impact on infant and maternal mortality rates. Breastfeeding initiation is associated with a 33% reduction in the likelihood of post-perinatal infant mortality between 1 week and 1 year of age in the U.S. (Ware et al., 2023) . Global evidence further underscores the life-saving potential of breastfeeding. The Lives Saved Tool is a mathematical modeling tool which estimates the impact of coverage changes of maternal and child health interventions on mortality in low- and middle-income countries. According to this tool, breastfeeding is an effective intervention to reduce infant and child mortality. Increasing breastfeeding rates to meet the World Health Organization (WHO) 2030 goals (i.e., early initiation within 1 hour of birth in 70% of infants, exclusive breastfeeding to 6

months in 70% of infants, continued breastfeeding to 12 months in 80% of infants, and continued breastfeeding to 24 months in 60% of infants) could potentially save nearly 200,000 lives of children under 5 years old globally between 2020 to 2030. If rates exceed these goals, over 820,000 lives per year could be potentially saved (North et al., 2022). Similarly, the Cost of Not Breastfeeding tool suggests that adherence to the WHO breastfeeding recommendations could prevent 595,379 childhood deaths from diarrhea and pneumonia and 974,956 cases of childhood obesity per year (Walters et al., 2019). Moreover, it has the potential to impact maternal health by preventing 98,243 deaths from breast and ovarian cancers as well as type II diabetes in women annually (Walters et al., 2019).

Infant Physical Health Benefits

The benefits of breastfeeding to infant health are well-established, with several studies in both global and U.S. settings supporting its positive impact. A systematic review demonstrates that breastfeeding can reduce the risk of necrotizing enterocolitis, late-onset sepsis, upper and lower respiratory illness (e.g., pneumonia), diarrheal infections, ear infections, and Sudden Infant Death Syndrome (Masi & Stewart, 2024). Additionally, children who are breastfed are less likely to be overweight or obese up to five years of age compared to those who were not breastfed (Nianogo et al., 2017; Pattison et al., 2019). These health benefits have been shown to extend beyond infancy and childhood into adulthood (North et al., 2022).

Maternal Physical Health Benefits

Several studies suggests that breastfeeding has significant short- and long-term benefits on maternal health outcomes. Systematic reviews have found that breastfeeding is associated with a reduced risk of type 2 diabetes, coronary heart disease, osteoporosis, hypertension, cardiovascular disease, and ovarian and breast cancer (Masi & Stewart, 2024; Muro-Valdez et

al., 2023; Prentice, 2022). These benefits follow a dose-response pattern, with longer breastfeeding duration associated with lower risk. In addition to reducing disease risk, breastfeeding is also associated with lower mortality from these conditions, especially cardiovascular causes.

Psychological and Developmental Benefits

Infant Brain and Cognitive Development

A systematic review highlights the positive impact of breastfeeding on infants' brain and cognitive development (Krol & Grossmann, 2018). In terms of cognitive development, longitudinal prospective studies have demonstrated that an increased duration of breastfeeding during the first year of life is associated with better cognitive performance, including memory, language, and motor skills at 14 (Guxens et al., 2011) and 18 months (Leventakou et al., 2015).

These cognitive benefits have been shown to extend beyond infancy into childhood and adolescence (Krol & Grossmann, 2018). Initiation of breastfeeding immediately after birth has been linked to a reduced risk of cognitive impairment (i.e., specific language impairment) in children four to 11 years old (Diepeveen et al., 2017). Children who were breastfed for longer durations during infancy also showed higher verbal intelligence scores at five years of age and demonstrated increased cognitive performance as adults (Mortensen, 2002; Quinn et al., 2001). Additionally, children who were exclusively breastfed for longer periods demonstrated improved cognitive development and problem-solving abilities at two and three years old (Bernard et al., 2013), improved executive function (i.e., cognitive control) at four years old (Julvez et al., 2014), and higher intelligence scores at 6.5 years old (Kramer, 2008), and increased verbal abilities at 16 years old (Yang et al., 2018). In adulthood, increased duration of exclusive breastfeeding was

associated with increased intelligence, educational attainment, and income at 30 years old (Victora et al., 2015) as well as a higher reading ability at 53 years old (Richards et al., 2002).

Breastfeeding has also been shown to have positive effects on infant brain development (Krol & Grossmann, 2018). Research using electroencephalography (EEG) and magnetic resonance imaging (MRI) has shown that breastfeeding prolongs the peak of myelination processes in the developing brain to a later age and increases whole brain volume, cortical thickness, and white matter volume (Deoni et al., 2018; Deoni, S.C.L. et al., 2013; Jing et al., 2010). Together, these findings suggest that breastfeeding, especially exclusive breastfeeding, has a positive and enduring impact on infants' cognitive and brain development (Krol & Grossmann, 2018).

Infant Socio-emotional Development

Several studies have linked breastfeeding to social and emotional development in children, though the research is mixed (Krol & Grossmann, 2018). While some studies have shown that breastfed infants display greater negative affect and negative temperament (i.e., fussiness) in infancy, others have found that they exhibit more "vigor" (i.e., eagerness to approach and engage with their environment) compared to formula-fed infants (De Lauzon-Guillain et al., 2012; Kielbratowska et al., 2015; Taut et al., 2016). Additionally, longer duration of breastfeeding in infancy has been associated with reduced parent-reported antisocial and aggressive behavior in children aged 4 to 11 years, with benefits that extend into adulthood (Merjonen et al., 2011; Shelton et al., 2011). Research also suggests that breastfeeding may influence infants' responses to social cues, such as enhanced attention to positive emotions (e.g., happy expressions and happy eyes) and reduced attention to negative emotions (e.g., fearful expressions and angry eyes) (Krol, Monakhov, et al., 2015; Krol, Rajhans, et al., 2015). Studies

have also found a link between breastfeeding and reduced risk of autism spectrum disorder diagnosis (Tseng et al., 2019).

Maternal Mental Health Benefits

Several studies show that breastfeeding positively impacts maternal mood, affect, and stress levels (Krol & Grossmann, 2018). Compared to formula-feeding mothers, those who breastfeed have lower anxiety, negative mood, and stress, and cortisol response to social stress (Groër, 2005; Heinrichs et al., 2002). Breastfeeding has also been shown to improve mothers' sleep patterns, with breastfeeding mothers experiencing longer and higher quality sleep than formula-feeding mothers (Doan et al., 2007). Another line of research suggests a connection between breastfeeding and postpartum depression in mothers (Krol & Grossmann, 2018). Prospective studies have shown that breastfeeding mothers tend to have lower scores on depression scales and are less likely to be diagnosed with postpartum depression compared to formula-feeding mothers (Krol & Grossmann, 2018). At the same time, studies suggest that mothers who experience difficulties with breastfeeding (e.g., physical discomfort or pain) are more likely to have poorer maternal mood and higher depression scores (Krol & Grossmann, 2018).

Environmental Health Benefits

In addition to the potential benefits for maternal and child health, a systematic review highlighted the considerable environmental impact of breastfeeding, including reductions in carbon footprint and water usage (Bai & Alsaidi, 2024). Infant formula has a carbon footprint twice as large and a blue water footprint of 699 liters per kilogram compared to breastfeeding (Pope et al., 2021). Exclusive breastfeeding for the first 6 months can reduce carbon dioxide emissions by 95–153 kilograms per infant, compared to feeding infants exclusively with artificial

milk formula. (Joffe et al., 2019). Additionally, breastfeeding for six months conserves around 488 kilograms of carbon dioxide equivalents of greenhouse gases and 105,280 liters of water (Davidove & Dorsey, 2019).

Artificial milk production requires significant water and energy for sterilization, powder conversion, rehydration, and supporting the operations related to cow grazing and feed (Davidove & Dorsey, 2019). To produce one liter of cow's milk, which serves as the raw material for artificial milk formula, an estimated 800 liters of water is needed (Davidove & Dorsey, 2019). The mass production of artificial milk formulas significantly contributes to water degradation and pollution, which has significant ramifications on planetary health (Andresen et al., 2022). Andresen et al. (2022) found that using 1 kg of ready-to-feed infant formula has a 24–60% higher environmental impact than using 1 kg of human milk. This study also found that feeding with infant formula for four months resulted in 28% higher global warming potential (Andresen et al., 2022). These findings highlight the environmental benefits of breastfeeding over formula feeding and highlight its critical role in developing sustainable first-food systems.

Economic Well-Being

In addition to the positive health and environmental impact, breastfeeding also has economic implications. As previously mentioned, breastfeeding, according to global recommendations, could prevent significant morbidity and mortality, including childhood deaths from diarrhea and pneumonia, childhood obesity cases, and maternal deaths from breast and ovarian cancers and type 2 diabetes (Walters et al., 2019). In the U.S., the resulting economic impact of premature child and women's mortality attributed to not breastfeeding according to recommendations is approximately $55 billion in future lost earnings annually (Walters et al., 2019). Even more significant are the economic losses due to child cognitive losses attributed to

suboptimal breastfeeding, which is estimated to be $285.4 billion annually in the U.S. (Walters et al., 2019). The total annual global economic losses due to not breastfeeding according to recommendations are estimated to be between $257 billion (0.37%) and $341 billion (0.70%) of global gross national income (Walters et al., 2019). Together, these data underscore the economic advantages of breastfeeding to society.

Breastfeeding Recommendations and Goals

Considering the numerous health, environmental, and economic benefits of breastfeeding, many health organizations recommend it as the standard method of infant feeding. Since the 1940s, the American Academy of Pediatrics (AAP) has continuously promoted breastfeeding as the foundation of good feeding practices (Meek et al., 2022; Section on Breastfeeding, 2005; Section on Breastfeeding et al., 2012; Work Group on Breastfeeding, 1997). Historically, the AAP has consistently recommended exclusive breastfeeding for the first six months of life, followed by continued breastfeeding alongside complementary foods for up to one year of age or longer, as mutually desired by mother and infant (Section on Breastfeeding, 2005; Section on Breastfeeding et al., 2012; Work Group on Breastfeeding, 1997). However, the most recent update to these recommendations reflects a slight change.

As of 2022, the AAP now recommends exclusive breastfeeding for the first 6 months, followed by continued breastfeeding alongside complementary foods for as long as mutually desired by mother and child, extending to two years of age and beyond (Meek et al., 2022). These recommendations are now more closely aligned with those set forth by the WHO (Meek et al., 2022). In line with these recommendations, the Healthy People 2030 goals, set by the U.S. Office of Disease Prevention and Health Promotion, aim for 42.4% of infants to breastfeed

through 6 months exclusively, and 54.1% of infants to breastfeed through 12 months (*Infants*, n.d.).

U.S. National Breastfeeding Rates and Trends

Despite progress over the past few decades and breastfeeding recommendations, the U.S. continues to face challenges in meeting the Healthy People 2030 goals and addressing persistent disparities in breastfeeding. Nationally, a high percentage of infants start life receiving some human milk (83.2%), but this rate significantly declines over time (Breastfeeding Report Card United States, 2022, 2023). By three months, 69.1% of infants are still receiving any human milk and only 45.3% are exclusively breastfed. At six months, the rates drop even further, with 55.8% receiving any human milk and just 24.9% exclusively breastfed. By 12 months, only 35.2% of infants continue receiving human milk (Breastfeeding Report Card United States, 2022, 2023). These rates indicate that while many women initiate breastfeeding, there are significant drops over time, which suggests ongoing challenges in sustaining breastfeeding duration and exclusivity in the U.S.

Current rates indicate that as a nation, we still have progress to make in meeting the Healthy People 2030 goals. Raju (2023) estimated the national and state-specific gaps in breastfeeding rates in the U.S. for achieving the Healthy People 2030 targets. He found that relative to baseline rates in the 2022 National Immunization Survey, the U.S. needs an 18% increase to achieve the Healthy People 2030 exclusivity at six months target and a 16% increase to achieve any breastfeeding at 12 months target (Raju, 2023).

However, these trends mask significant racial and ethnic as well as socioeconomic disparities in breastfeeding practices. Disparities are particularly pronounced among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). WIC is

a federal assistance program administered by the USDA that provides supplemental foods, nutrition education, breastfeeding support, and referrals to health and social services for low-income (household incomes at or below185 percent of the federal poverty income guidelines) and nutritionally at-risk (has at least one medical-based or dietary-based health condition) pregnant, postpartum, and breastfeeding women, as well as infants and children up to age five (*WIC Eligibility Requirements*, 2025). WIC participants consistently have lower rates of breastfeeding initiation, duration, and exclusivity compared to the general population. For example, WIC participants are less likely to ever breastfeed (79.2%) compared to eligible non-WIC (87.5%) and ineligible women (92.2%) (*About Breastfeeding Data*, 2025). Additionally, breastfeeding rates at six months is significantly lower among WIC mothers (19.2%) compared to non-WIC mothers (29.5%) (Bunik et al., 2009). These patterns highlight low-income women, specifically WIC participants, as a particularly vulnerable population for suboptimal breastfeeding.

While national data indicate widespread variation in breastfeeding rates across states, California has shown steady progress toward meeting the Healthy People 2030 targets and has even surpassed national rates. California needs a 15% increase to reach the target of 42.4% exclusive breastfeeding at 6 months and an 11% increase to reach the 54.1% target for breastfeeding at 12 months (Raju, 2023). These gaps are notably smaller than the national averages of 18% and 16%, respectively (Raju, 2023). These overall trends provide a broad understanding of breastfeeding trends at the national and state levels.

At the state level, California's diverse population offers a useful context for further examining breastfeeding disparities. In California, breastfeeding initiation, duration, and exclusivity vary across several socio-demographic characteristics including race/ethnicity,

neighborhood poverty, household income, and education (Table 1) (California Department of Public Health, 2026).

White mothers have the highest rates across all breastfeeding practices, while Hispanic and Black mothers consistently have the lowest rates. Household income shows similar trends, with mothers earning above 200% of the poverty line exhibiting the highest breastfeeding rates and mothers living at or below 100% of the poverty line showing the lowest rates. Additionally, mothers with higher educational attainment have better breastfeeding practices, with college graduates showing the highest rates and mothers with less than high school showing the lowest rates. At the community level, higher neighborhood poverty (i.e., percentage of residents living below the federal poverty threshold) is associated with lower rates of breastfeeding. Mothers in neighborhoods with 10% of the residents living in poverty have the highest rates while mothers in neighborhoods with 30% or more of the residents living in poverty have the lowest rates.

These disparities reflect broader social, economic, neighborhood, and healthcare inequities that disproportionately impact racial/ethnic minorities and lower socioeconomic groups, with the largest disparities observed in any breastfeeding at three months. To address these disparities, it is critical to examine the underlying determinants of breastfeeding, which contribute to lower outcomes. Understanding these factors is essential for developing targeted interventions to improve breastfeeding rates and achieve national health goals.

Table 1. Breastfeeding outcomes in California by sociodemographic characteristics, 2020-2022

	Initiation N (%)	Any breastfeeding at 3 months N (%)	Exclusive breastfeeding at 3 months N (%)
Overall	382,400 (94.5)	210,700 (71.7)	88,500 (30.8)
Race/ethnicity			
Asian	53,900 (95.9)	31,800 (81.8)	10,300 (27.0)
Black	19,300 (89.8)	10,600 (62.9)	5,000 (30.3)
Hispanic	179,500 (94.1)	95,900 (66.0)	35,200 (24.9)
Pacific Islander	1,600 (85.2)	700 (46.5)	400 (25.7)
White	109,700 (95.7)	61,000 (79.1)	33,500 (44.1)
Neighborhood Poverty			
<10%	175,200 (96.1)	100,900 (77.9)	46,100 (36.2)
10-19%	125,300(94.3)	67,500 (69.4)	26,300 (27.7)
20-29%	55,600 (92.1)	28,300 (62.7)	10,700 (24.2)
30%+	24,500 (90.6)	13,100 (63.5)	5,000 (25.1)
Household Income			
0-100% of poverty	101,000 (91.5)	52,000 (61.3)	20,600 (24.9)
101-200% of poverty	72,800 (93.9)	38,700 (68.0)	14,900 (26.9)
200%+ of poverty	173,600 (97.0)	98,200 (81.6)	45,200 (37.8)
Education			
Less than high school	44,900 (91.1)	24,900 (64.2)	7,100 (19.1)
High school graduate	65,400 (90.3)	32,000 (57.4)	12,300 (22.6)
Some college	114,600 (95.2)	61,400 (69.0)	28,300 (32.3)
College graduate	154,400 (97.0)	90,500 (84.1)	40,300 (37.9)

Source: California Department of Public Health, Center for Family Health, Maternal, Child and Adolescent Health Division, Breastfeeding Intention and Duration Dashboard, Last Modified April 2026. go.cdph.ca.gov/Breastfeeding-Intention-and-Duration-Dashboard

Determinants of Breastfeeding

Breastfeeding is influenced by a complex interplay of factors across multiple levels. To better understand these influences, I will use a conceptual model (Figure 1) that outlines components of an enabling environment for breastfeeding (Rollins et al., 2016). This model offers a systematic approach to examining how historical, socioeconomic, cultural, and individual factors contribute to breastfeeding practices.

At the structural level, societal factors influencing breastfeeding include social trends, advertising, media, and the availability of infant feeding products in stores. These factors shape

the interactions, policies, practices, and information related to breastfeeding within three primary settings: health systems and services, family and community, workplace, and employment. At the individual level, characteristics of the mother (e.g., income, health status, age, education), infant (e.g., health status), and their relationship affect the mother's ability, confidence, and self-efficacy to breastfeed. These individual-level factors do not exist in isolation. Rather, they are embedded within and shaped by the structural and community contexts in which a mother lives. In other words, a mother's personal beliefs and decisions about breastfeeding are informed by how she experiences, interprets, and internalizes societal norms and systemic conditions. Together, these factors shape a woman's approach, beliefs, and decisions regarding breastfeeding. In the following sections, I will explore each of these levels in more detail and highlight the key factors within each.

In the following sections, I will explore each of these levels in more detail and highlight the key factors within each. Although each level will be discussed in separate sections, it is important to remember that these levels are not mutually exclusive. Meaning, they are interconnected and continuously interact with one another to shape breastfeeding behaviors.

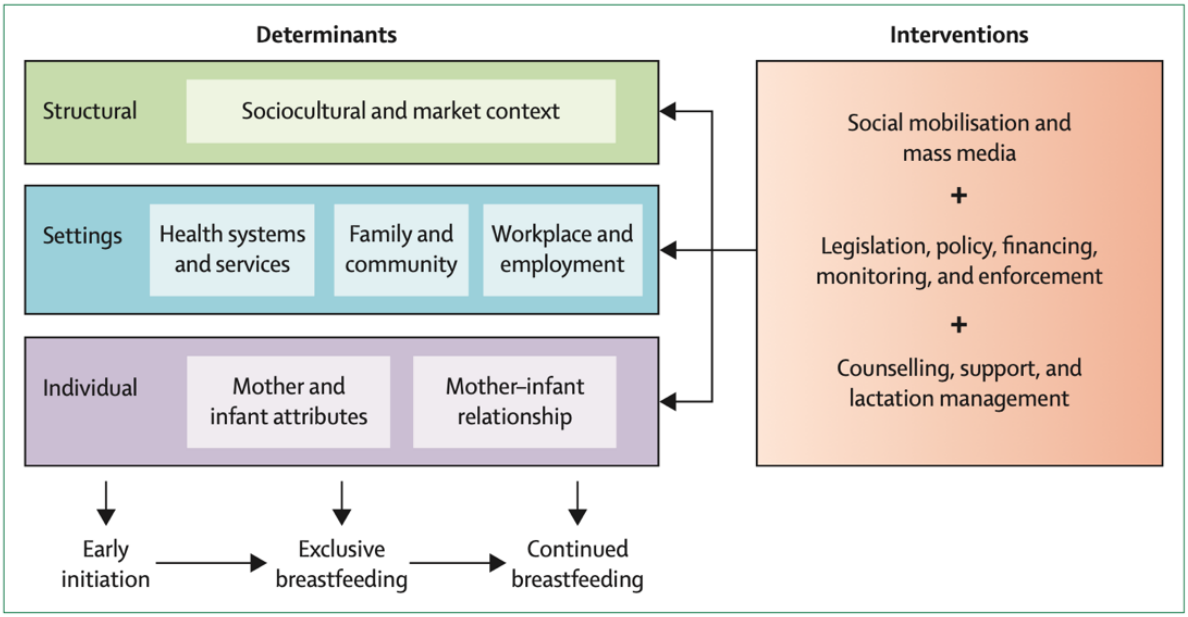


Figure 1. A conceptual model of the components of an enabling environment for breastfeeding developed by Rollins et al. (2016).

Individual

Maternal Attributes

Maternal sociodemographic characteristics like parity, age, income, and education are associated with breastfeeding. Women who are younger in age, lower income, less educated, who smoke, lower parity, and foreign-born have a lower likelihood of breastfeeding initiation and continuation (Cohen et al., 2018; Jones et al., 2011; Martínez-Vázquez et al., 2022). Adverse pregnancy and birth outcomes also play an important role in breastfeeding. Medically complex pregnancies, including conditions like gestational diabetes, pre-eclampsia, and obesity, are associated with poor breastfeeding practices, such as a 30% reduced likelihood of intending to breastfeed and a 30% reduced likelihood of breastfeeding at one week postpartum (Kozhimannil et al., 2014) compared to those without complex pregnancies. Additionally, women with medically complex pregnancies are less likely to receive supportive maternity care practices, including holding their baby in the first hour after birth in their arms and receiving help from

hospital staff to start breastfeeding (Kozhimannil et al., 2014). This is concerning because high levels of hospital support among women with medically complex pregnancies are associated with nearly three times the odds of exclusive breastfeeding one week postpartum (Kozhimannil et al., 2014).

Birth complications, including cesarean delivery, fetal distress, failure to progress (i.e., labor not progressing as expected), and postpartum hemorrhage, are associated with a lower likelihood of breastfeeding initiation as well as shorter breastfeeding durations (Brown & Jordan, 2013; Cohen et al., 2018). This is largely due to the increased pain and difficulties experienced by women with birth complications compared to those who did not have such issues (Brown & Jordan, 2013).

Maternal health status is also a crucial factor in breastfeeding practices. Several studies have shown that chronic diseases, such as autoimmune conditions (e.g., rheumatoid arthritis, inflammatory bowel disease, multiple sclerosis), epilepsy, asthma, congenital heart disease, thyroid disorders, and infectious diseases (e.g., HIV, hepatitis B) are associated with reduced breastfeeding initiation and duration (Sokou et al., 2023). Likewise, women experiencing poor mental and emotional health are less likely to exclusively breastfeed at 6 months (Jones et al., 2011). For example, research has consistently demonstrated a negative association between perinatal depressive symptoms and breastfeeding exclusivity and duration (Butler et al., 2021).

Furthermore, maternal knowledge and attitudes related to breastfeeding influence breastfeeding practices. Knowledge of infant health benefits and comfort with breastfeeding in social settings are associated with increased intentions to exclusively breastfeed (Stuebe & Bonuck, 2011). For instance, women who disagree that infant formula is as good as breastmilk are over three times more likely to intend exclusive breastfeeding versus exclusive formula

feeding (Stuebe & Bonuck, 2011). Additionally, awareness of the health benefits of breastfeeding is positively associated with intentions to exclusively breastfeed (Stuebe & Bonuck, 2011). These benefits are crucial for the promotion of breastfeeding, as prenatal intentions are a key determinant of longer breastfeeding durations (Lau et al., 2018).

Infant Attributes

Beyond maternal attributes, the infant's health status plays a critical role in breastfeeding. Preterm infants (born before 37 weeks of gestation) have lower rates of receiving breastmilk than term infants (Chiang et al., 2019). In the U.S., nearly 84% of term infants receive breastmilk, whereas the percentage is lower in extremely preterm (71.3%), early preterm (76%), and late preterm infants (77.3%) (Chiang et al., 2019). Pre-term infants born to mothers with lower socio-economic status, receiving federal assistance, or using Medicaid insurance are at an even greater risk of not receiving breastmilk (Carpay et al., 2021). Low-birth weight infants (less than 2,500 grams) also have a 28% lower odds of ever breastfeeding and 52% lower odds of breastfeeding for at least 6 months, compared to infants with normal birthweight (Campbell & Miranda, 2018).

As a result, mothers of infants experiencing adverse health outcomes face distinct practical and psychological challenges to breastfeeding. These include concerns about adequate milk intake by the infant, maternal quality of milk composition, problems with the mechanics of breastfeeding, delayed lactation onset, reduced milk production, and extended separation from their babies (Kavanaugh et al., 1995; Parker et al., 2021). The psychological toll of an infant's hospitalization often leads to feelings of exhaustion, anxiety, depression, and inadequacy, which can significantly hinder breastfeeding (Hookway et al., 2021).

Mother-Infant Relationship

In addition to the individual attributes of the mother and infant, the mother-infant relationship is also crucial to breastfeeding. The quality of latch (i.e., how the baby attaches to the mother's breast during nursing) has been found to impact breastfeeding practices. A proper latch during breastfeeding is important for facilitating milk production and supports longer-term breastfeeding success and exclusivity (Sowjanya & Venugopalan, 2018; Tornese et al., 2012; Westerfield et al., 2018). Whereas an improper latch can cause nipple pain, which can often lead to breastfeeding cessation (Westerfield et al., 2018). Skin-to-skin contact, also referred to as kangaroo care, is “the practice where a baby is dried and laid directly on the mother’s bare chest after birth, both of them covered in a warm blanket and left for at least an hour or until after the first feed” (*Skin-To-Skin Contact*, n.d.). Skin-to-skin contact enhances the bond between mother and infant and increases the neonate's responsiveness to maternal stimulation, which promotes breastfeeding (Karimi et al., 2020). This practice is associated with increased breastfeeding duration and exclusivity (Karimi et al., 2020).

Responsive feeding, defined as feeding in response to hunger cues, is associated with breastfeeding. Although research on responsive feeding is still emerging, existing studies suggest its importance to breastfeeding (Ventura, 2017). Mothers who reported responsive feeding were more likely to exclusively breastfeed for the first 6 months, breastfeed more frequently throughout the day, and intend to breastfeed for longer than mothers who did not responsively feed (Ventura, 2017).

Settings

Health Systems and Services

Within the health systems and services setting, maternity care practices and professional lactation support are important for promoting breastfeeding. The Baby-Friendly Hospital Initiative is a critical set of guidelines promoting breastfeeding-friendly maternity care practices through its Ten Steps to Successful Breastfeeding. (Appendix A; Baby Friendly USA, n.d.). These practices have been shown to improve breastfeeding practices, including higher in-hospital exclusivity and longer breastfeeding duration (Abrahams & Labbok, 2009; Fauziah & Riono, 2021; Pérez-Escamilla et al., 2016). Research suggests a dose-response relationship between exposure to the Ten Steps and breastfeeding, with exposure to more steps leading to better outcomes (Pérez-Escamilla et al., 2016). Step 10 which describes fostering breastfeeding support groups and referring mothers to them on discharge, has been identified as the most important for the long-term sustainability of breastfeeding improvements (Pérez-Escamilla et al., 2016).

One key example of this is peer support groups, which involve guidance from individuals with lived breastfeeding experience in a variety of formats (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019). One such model is Baby Cafés, which integrates peer support with guidance from healthcare professionals in a community-based setting. These informal, drop-in spaces provide free breastfeeding support that improves breastfeeding by helping mothers navigate challenges with peer and professional guidance (Jenkins et al., 2020).

WIC is another critical source of community-based lactation support. Foundational to WIC's breastfeeding efforts are provision of supplemental food assistance and peer support programs such as the Breastfeeding Peer Counseling Program (BFPC) (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019; *WIC Food Packages*,

2026).Through these supports, WIC participation has been shown to improve breastfeeding, with women who enroll in the first trimester more likely to initiate and sustain breastfeeding for at least 3, 6, and 12 months compared to those who enroll later (Metallinos-Katsaras et al., 2015)

WIC's supplemental food assistance uses a tiered incentive structure, providing larger food packages to participants who exclusively or partially breastfeed compared to those who formula feed (*WIC Food Packages*, 2026). This approach has been shown to improve initiation and nearly double exclusive breastfeeding at 3 and 6 months (Langellier et al., 2014). In addition, WIC's BFPC, which connects participants with trained peer counselors, has been shown to improve breastfeeding initiation, duration, and exclusivity (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019). Other lactation-related services include provision of breast pumps and supplies and developing social marketing campaigns to normalize breastfeeding (Increasing Access to Breastfeeding Support through Local WIC Agencies Services Expansion, 2017).

Healthcare providers, including physicians and nurses, also play a pivotal role in educating and encouraging mothers to initiate and continue breastfeeding (Burgio et al., 2016). More specifically, lactation professionals, which are individuals with specialized training in supporting breastfeeding, are especially crucial for increasing initiation, duration, and exclusivity (Patel & Patel, 2016). They are also critical in community-based settings, such as WIC, where ongoing support is essential for sustaining breastfeeding practices beyond discharge (Increasing Access to Breastfeeding Support through Local WIC Agencies Services Expansion, 2017; Patel & Patel, 2016).

Family and Community

Within the family and community setting, social factors including partner, family, and peer support as well as family circumstances, influence a woman's self-efficacy, confidence,

time, and ability to breastfeed. Partner support is vital for providing knowledge, offering help with household duties and breastfeeding challenges as well as giving encouragement (Davidson & Ollerton, 2020; Jiang, 2021). These supportive behaviors have been shown to promote breastfeeding by increasing mothers' confidence and ability to breastfeed and are especially critical when women return to work (Mannion et al., 2013; Ogbo et al., 2020; Tsai, S.Y., 2014). Partner support is a strong predictor of continued breastfeeding, with women who feel supported or encouraged by their partner substantially more likely to continue after hospital discharge (Ingram et al., 2002; Martínez-Vázquez et al., 2022).

The cultural and social norms upheld by family members are also critical in shaping parental beliefs and practices around infant feeding (Dattilo et al., 2020). Familial support, especially from babies' grandmother, is important in infant feeding decisions (Aubel et al., 2021; Cisco, 2017; Snyder et al., 2021; Wasser et al., 2013). While grandmothers are a primary source of emotional and informational support, other family members, such as maternal grandfathers, siblings, and in-laws, also contribute valuable support that improves breastfeeding (Cisco, 2017; Concha & Jovchelovitch, 2021).

Beyond the family system, peers (i.e., friends) have been identified as a critical source of breastfeeding support. Mothers who report receiving emotional support from friends have a lower risk of early cessation by nearly 31%, compared with mothers who do not receive such support (Cisco, 2017). Although this form of support is often less prioritized than that from partners and families, peers still offer valuable emotional and informational support for breastfeeding (Cisco, 2017).

Family circumstances, including family structure and household composition, significantly influence breastfeeding practices. Children from single-parent or stepfamily

households are 29% and 32% less likely to be exclusively breastfed for 6 months, respectively (Odar Stough et al., 2019). Likewise, women in non-cohabiting situations are 33% less likely to initiate breastfeeding and are 43% less likely to continue breastfeeding for 2 years or more (Corsack et al., 2022; McGovern, 2022). Additionally, three-generation households, particularly in lower-income families, are linked to lower breastfeeding initiation and continuation, potentially due to economic or emotional strain (Pilkauskas, 2014).

Workplace and employment

The workplace and employment setting includes policies, practices, and facilities that support breastfeeding within workplaces and educational institutions. These factors significantly impact a mother's ability to balance work and breastfeeding, especially since returning to work is a significant barrier to breastfeeding (Kozhimannil et al., 2016). To prepare for return to work, some women report introducing formula early or stopping breastfeeding due to concerns about their breastmilk stock and a lack of confidence in their ability to continue breastfeeding during the transition (Febrianingtyas et al., 2019). Supportive lactation accommodations in the workplace are, therefore, crucial for breastfeeding exclusivity and duration (Franzoi et al., 2024).

Paid family leave, which provides paid time off to care for a newborn, can help increase breastfeeding duration and exclusivity (Rosenberg, J. et al., 2024). The length of leave is critical to the effectiveness of leave policies in promoting breastfeeding, with longer leave associated with improved breastfeeding practices, with longer leave associated with better breastfeeding practices . For example, full-time employment at three months postpartum is associated with reduced breastfeeding duration, averaging 8.6 weeks shorter compared to those not working and 15 weeks shorter than those working part-time (Fein & Roe, 1998; Lubold, 2016). Studies have shown that women with access to both adequate breaktime and private spaces to pump are 2.3

times as likely to breastfeed exclusively at 6 months and 1.5 times as likely to continue breastfeeding exclusively with each passing month (Kozhimannil et al., 2016).

Beyond policy, the social and cultural environment of the workplace plays a critical role in the decision to continue breastfeeding (Franzoi et al., 2024). Despite support from employers, women may still face discrimination and inappropriate comments related to breastfeeding from colleagues (Franzoi et al., 2024). This social stigma can lead individuals to feel ashamed or isolated, which can contribute to early breastfeeding cessation (Franzoi et al., 2024).

Structural

Social and cultural attitudes as well as market factors, play a significant role in shaping attitudes, beliefs, and behaviors related to breastfeeding. Despite human milk and breastfeeding being recognized by health organizations as the normative way to feed infants, aggressive marketing of commercial milk formula (CMF) companies presents significant challenges to this (Baker et al., 2023; Rollins et al., 2023). Today, the aggressive promotion of CMF continues to portray its use as widespread, modern, and comparable to or even better than breastmilk (Rollins et al., 2023). This marketing influences social norms by positioning CMF feeding as the societal standard and undermining breastfeeding.

Unfortunately, the U.S. has been slow to adopt policies regulating formula marketing, such as the International Code of Marketing of Breastmilk Substitutes (Marketing of Breast-Milk Substitutes: National Implementation of the International Code, Status Report 2020., 2020). This has allowed exploitative practices, such as the distribution of free formula in hospitals, to persist (Rollins et al., 2023; Rosenberg et al., 2008). This is concerning because these marketing strategies have been shown to negatively impact breastfeeding. For example, women who receive commercial hospital discharge packs are more likely to exclusively breastfeed for an

average of 10 weeks shorter than those who do not receive the packs (Rosenberg et al., 2008). These marketing strategies are harmful because they create an environment that undermines breastfeeding by normalizing formula feeding, making it more socially acceptable and accessible.

The WIC population is particularly vulnerable to exploitative infant formula marketing. WIC is the largest purchaser and distributor of infant formula in the United States, providing formula to nearly 40% of all infants (*Infants in USDA's WIC Program Consumed an Estimated 56 Percent of U.S. Infant Formula in 2018*, 2025). Additionally, WIC participants account for an estimated 56% of all infant formula consumed nationwide (*Infants in USDA's WIC Program Consumed an Estimated 56 Percent of U.S. Infant Formula in 2018*, 2025). These influences extend beyond WIC participants and also impact the purchasing behaviors of non-WIC populations. This phenomenon, referred to as the spillover effect, can increase non-WIC sales of infant formula by as much as 80% to 130% (Choi et al., 2020).

As the infant formula marketing industry continues to grow rapidly, its impact will increasingly challenge breastfeeding as the societal norm while reinforcing formula feeding in society (Global Market Inishts, Inc., 2019). The perception that breastfeeding is not the societal norm creates an environment where women may feel uncomfortable breastfeeding in public. Although women have the legal right to breastfeed in public, many report challenges such as drawing unwanted attention, the sexualization of breasts, awareness of others' discomfort, and efforts to avoid being seen (Hauck et al., 2021). These experiences often lead to judgment, criticism, and discrimination, which can discourage women from breastfeeding and cause emotional distress. (Hauck et al., 2021). Together, exploitative marketing tactics and the societal stigma surrounding breastfeeding contribute to a culture of shame and embarrassment, which

undermines breastfeeding as the preferred choice and perpetuates the normalization of formula feeding.

Chapter Summary

This chapter provided a comprehensive overview of breastfeeding, including its significance, current national trends, goals and recommendations, and a broad discussion of the factors influencing its practice. Breastfeeding offers significant and well-established benefits for maternal and infant health as well as the environment and society at large. Given the substantial benefits, health organizations universally recommend exclusive breastfeeding for 6 months, followed by 12 months of supplemental breastfeeding as complementary foods are introduced. Nevertheless, disparities persist among racial/ethnic minorities and lower income populations and progress toward national health goals is still needed. These challenges are largely due to a complex interplay of factors at the individual, community, and structural level, to create barriers to breastfeeding.

Building on this foundation, Chapter 2 will continue to explore key factors influencing breastfeeding by narrowing the focus to the social determinants of health (SDOH). SDOH are the non-medical conditions in which people work, play, and live that influence health (*Social Determinants of Health*, n.d.). They include various social, economic, environmental, and political factors that are closely aligned with and embedded within the multilevel model introduced earlier in this chapter (*Social Determinants of Health*, n.d.). SDOH have been identified as critical factors to breastfeeding, including education, employment, neighborhood conditions, food access, and housing. Considering their importance, the SDOH provide a useful lens for understanding how factors across the individual, setting, and structural levels shape breastfeeding practices.

In Chapter 2, I build on the discussion from Chapter 1 by focusing on specific SDOH and their role in influencing breastfeeding across the different levels identified in this chapter: individual, setting, and structural. While many SDOH may affect breastfeeding, Chapter 2 highlights the social determinants most relevant to this dissertation and examines their impact at the neighborhood level, including income, education, employment, healthcare access, urban greenspace, transportation, environmental pollution, food access, and social connection.

Chapter 2 also highlights the critical role of structural factors, specifically neighborhood racial/ethnic concentration, in shaping these place-based SDOH. Chapter 2 will not only summarize existing literature but will also highlight areas where further research is needed, which will be used to inform and guide the aims of this dissertation. By examining these determinants, the next chapter will provide a deeper understanding of how SDOH, particularly at the neighborhood-level, directly impacts breastfeeding practices, which is central to the aims of this dissertation.

CHAPTER 2: Literature Review

Chapter Overview

This chapter provides a review of the social determinants of health (SDOH) that significantly influence breastfeeding. The SDOH and related literature presented here are not intended to be exhaustive and does not cover all SDOH impacting breastfeeding. Instead, this chapter focuses on the specific SDOH that are central to the research objectives of this dissertation, including employment, income, education, food access, transportation, clean environments, housing, social connections, and urban green spaces. Some domain sections are more extensive due to a more developed body of literature. While SDOH are conceptualized to operate at the individual-level and the group-level (e.g., neighborhood environments), this chapter will emphasize place-based determinants as they are the focus of this dissertation.

I will begin by defining SDOH and demonstrating their relevance to health, including breastfeeding. Next, I present a framework developed by Healthy People 2030, which outlines various domains of social determinants that impact health. This framework is used to guide the organization of the literature in the following sections. Throughout these sections, I explore the relationship between breastfeeding and each SDOH relevant to this dissertation. I present current literature on how these factors influence breastfeeding, outline the pathways connecting them, and highlight existing gaps and future directions for research. Finally, I conclude by identifying the gaps in the broader literature on SDOH and breastfeeding and explaining how this dissertation addresses these gaps.

Defining Social Determinants of Health (SDOH)

SDOH are defined as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life" (*Social*

Determinants of Health, n.d.). These determinants are non-medical and include various social, economic, environmental, and political factors (*Social Determinants of Health*, n.d.). Research has shown that these social and environmental factors account for approximately 50% of the variation in health outcomes, whereas medical care is responsible for only 34% (Hood et al., 2016). This suggests that SDOH, more than medical care, are critical in shaping both individual and community health.

SDOH include both individual determinants of health (e.g., biology and behavior) and group-level determinants (e.g., neighborhood and community) (Bensken et al., 2023; Charlson et al., 2024). Each is important and provides distinct measures that capture different dimensions of risk. While individual-level factors have received more attention in health research, scholars have identified a need to better examine place-based determinants in health equity work (Palmer et al., 2019; Scribner et al., 2017). Considering their significant impact, SDOH have been identified as key drivers of health inequities and addressing these factors have become a central strategy in public health efforts to improve population health (Gómez et al., 2021; Palmer et al., 2019).

Healthy People 2030 Framework

A key way SDOH are being integrated into current efforts to address health disparities is through their incorporation in national health goals such as Healthy People 2030 (Gómez et al., 2021). One of the five overarching goals of this initiative is directly related to addressing SDOH: "Create social, physical, and economic environments that promote attaining the full potential for health and well-being for all" (Healthy People 2030, n.d.). To guide this effort, Healthy People 2030 established a framework that categorizes SDOH into five key domains (Figure 2): 1) economic stability, 2) education access and quality, 3) health care access and quality, 4)

neighborhood and built environment, and 5) social and community context (Healthy People 2030, n.d.).

A modified version of this framework is used to guide the literature review in the following sections. The five domains from the original model will be used to organize the relevant SDOH for this dissertation, including both those identified by the original model and additional factors not included, such as green spaces, food access, and transportation. The first domain, economic stability, explores the link between people's financial resources and their health (Centers for Disease Control, n.d.). Key SDOH included under this domain relate to income (e.g., socio-economic status, poverty, cost of living) and employment. The second domain, education, examines the link between education access, quality, and health. Key factors related to this SDOH include educational attainment, graduation rates, and literacy. The third domain, healthcare access and quality, examines how people's access to health services impacts their health. Key factors related to this SDOH include healthcare access and health insurance coverage. The fourth domain, neighborhood and built environment, explores the relationship between where people live and their health. Key SDOH included under this domain are transportation, the food environment, housing, exposure to environmental toxins (i.e., clean air and safe drinking water), and access to urban green spaces. The fifth domain, social and community context, explores the link between characteristics of people’s environments and their health. Key factors related to this SDOH include civic participation, social cohesion, social capital, and social connection (Centers for Disease Control, n.d.). This framework provides a comprehensive way to understand and explore the connection between SDOH and breastfeeding.



Figure 2. The five key domains of social determinants of health as outlined in the Healthy People 2030 framework (U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion, n.d.).

Shifting Toward Place-Based Approaches

To better understand the role of SDOH in shaping health disparities, researchers and health organizations have emphasized the need to integrate more place-based approaches (Palmer et al., 2019; Scribner et al., 2017). The role of place, which encompasses an individual's physical and social environments, in shaping health is well-established (Acevedo-Garcia et al., 2008; Diez Roux & Mair, 2010; Northridge, 2003). The physical environment encompasses the tangible characteristics, both natural and man-made, of a neighborhood including transportation, green spaces, sidewalks, environmental pollution, as well as access to healthy food and health facilities. Whereas the social environment encompasses the social relationships, norms, and structures that exist within a neighborhood including social cohesion, social capital, social connection, as well as economic and employment opportunities.

Together, the social and physical environments of neighborhoods shape a 'geography of opportunity' that significantly influences the health and well-being of individuals and

communities (Acevedo-Garcia et al., 2008). An opportunity neighborhood is a residential area that provides neighborhood-based opportunities that support health, such as access to sustainable employment, high-performing schools, health care, adequate transportation, and neighborhood safety (Acevedo-Garcia et al., 2008). In contrast, low-opportunity neighborhoods have been shown to lack the necessary conditions (i.e., limited access to resources such as healthcare, green spaces, transportation, and educational opportunities) for health, wealth, and overall well-being (Community Health and Economic Prosperity: Engaging Businesses as Stewards and Stakeholders—A Report of the Surgeon General, 2021).

The creation of an opportunity neighborhood and the distribution of resources is shaped by broader structural forces, including neighborhood racial/ethnic concentration. These mechanisms are theorized to create conditions that influence exposure to both neighborhood-level risks and resources, such as poverty, access to quality education, transportation, healthy food outlets, and employment opportunities. (Acevedo-Garcia et al., 2008). As a result, neighborhood racial/ethnic concentration are thought to operate through pathways of structural disadvantage that adversely affect health, as well as through potential protective pathways of enhanced sociocultural processes that may benefit health. These dual pathways provide critical ways of understanding how neighborhood context may shape breastfeeding outcomes through both structural and social mechanisms. Chapter 3 provides a more detailed discussion of the theoretical frameworks underlying these pathways.

SDOH and Breastfeeding

Research has shown that adverse SDOH, at the individual-level, related to education, income, employment, food, and housing instability, significantly contribute to racial disparities in breastfeeding practices in the U.S. (Standish & Parker, 2022). For example, a lack of

maternity leave, inadequate workplace lactation accommodations, lower educational attainment, and housing insecurity are associated with a lower likelihood of breastfeeding initiation and shorter breastfeeding duration (Standish & Parker, 2022). While these individual-level factors are critical, they do not fully capture how these factors operate at the setting and structural levels to shape the broader ecological contexts that impact breastfeeding. This shortcoming is especially concerning because breastfeeding, as outlined in the multilevel model discussed in Chapter 1 (see Figure 1), is shaped by a complex interplay of factors operating across individual, setting, and structural levels.

Given the increasing emphasis on place-based approaches in SDOH research, it is important to note that, although limited, existing studies suggest that the neighborhood environment plays a significant role in breastfeeding. These studies have begun to shift the focus away from the individual level to the structural and community levels. For example, neighborhoods with greater affluence, higher socioeconomic status, higher levels of educational attainment, and increased resources (e.g., green spaces, walking paths, and access to quality early childhood education and healthy food) are generally associated with higher breastfeeding rates. This association has been found to persist even after accounting for individual-level factors. These limited findings highlight the potential role of place, at the structural and community level, in shaping breastfeeding practices. Yet, the influence of place-based SDOH remains understudied in the breastfeeding literature. As I will discuss in more detail later in this chapter, this is a critical gap in the literature that this dissertation attempts to address.

In the following sections, I explore the relationship between breastfeeding and nine SDOH: employment (Domain 1), income (Domain 1), education (Domain 2), healthcare access (Domain 3), transportation (Domain 4), environmental pollution, (Domain 4), housing (Domain

4), food access (Domain 4), urban green spaces (Domain 4), and social connections (Domain 5). These SDOH were selected based on their inclusion in the Healthy Places Index (HPI), which is the primary indicator that will be used to measure SDOH in this dissertation (Study 1). The HPI is an online, publicly accessible tool for assessing community well-being and includes eight SDOH-related components: economic, education, social, housing, transportation, neighborhood built-environment, clean environment, and healthcare access. More details on the HPI are provided in Chapter 4, where the study methods are discussed. Food access will be examined separately from the HPI, as it is not comprehensively captured within the HPI but remains a critical and understudied factor in breastfeeding research (Study 3).

While the focus of the following sections is on the SDOH identified in the previous paragraph, it is important to recognize that their distribution and manifestation within neighborhoods are shaped by broader structural factors, including patterns of racial/ethnic concentration. Specifically, neighborhood racial/ethnic concentration is conceptualized as an upstream structural factor that influences how these SDOH operate within local environments. These dynamics are not discussed in detail in this chapter but are examined more fully in Chapter 3.

Below, I present current literature on how SDOH influence breastfeeding, outline the pathways connecting them, and highlight existing gaps and future directions for research. Throughout the discussion, particular emphasis is placed on how these factors operate at the neighborhood level, given the central focus of place-based determinants in this dissertation. By understanding these connections, the critical role of individual-level and place-based SDOH in shaping breastfeeding practices will become clear.

Domain 1: Economic Stability

The first domain, economic stability, explores the link between people's financial resources and their health (Centers for Disease Control, n.d.). Key SDOH included under this domain relate to income (e.g., socio-economic status, poverty, cost of living) and employment (Centers for Disease Control, n.d.).

Income

Income and Health: An Overview

Income is a well-established SDOH, with substantial evidence linking both lower absolute income and income inequality to poorer health (Ecob & Davey Smith, 1999; Matthew & Brodersen, 2018; Pickett & Wilkinson, 2015). Absolute income refers to household or disposable income and reflects an individual's material resources and purchasing power. Higher incomes are associated with greater longevity, with research indicating a nearly 15-year gap in life expectancy between the richest 1% and poorest 1% of individuals (Chetty et al., 2016). In contrast, income inequality refers to the distribution of income within a population. Income inequality has been linked to higher rates of chronic conditions and negative health behaviors, such as heavy drinking, obesity, heart disease, and diabetes, as well as lower levels of physical activity and mental health (Matthew & Brodersen, 2018). These income-related disparities may be attributed to the fact that higher incomes provide greater access to healthcare, healthier living conditions, and resources that promote behavioral, physical, and mental health outcomes (Matthew & Brodersen, 2018). Overall, existing research highlights the significant impact of income on overall health and well-being.

Income and Breastfeeding: Exploring the Connection

Income is a critical SDOH for breastfeeding, with studies in international and U.S. settings supporting its significance. Research has consistently shown that higher levels of family

and household income are associated with a greater likelihood of breastfeeding intention, initiation, as well as an increase in duration of any and exclusive breastfeeding up to 2 years (Heck et al., 2006; Shofiya et al., 2020). Studies measuring income levels using indexes of individual-level SES have shown that women with higher SES are more likely to initiate breastfeeding and have increased durations of any and exclusive breastfeeding up to 6 months (Ajami et al., 2018; Flacking et al., 2007; Foster et al., 2023).

Low income can limit access to resources that support healthy maternal behaviors, such as increased stress levels, smoking, food insecurity, and poor diet, which they may perceive as inhibiting their ability to breastfeed (Matthew & Brodersen, 2018; Weston et al., 2023). These factors may be perceived as barriers to breastfeeding and can also increase the risk of adverse birth outcomes. Compared to high-SES women, low-SES women are more likely to experience medicalized births (e.g., being induced), which can delay the time between birth and the first latch-on (Wallace & Chason, 2007). This delay results in a lower likelihood of breastfeeding initiation and duration in low-income women (Wallace & Chason, 2007).

Access to various forms of support (e.g., familial, healthcare, workplace, and community) is another critical pathway through which income influences breastfeeding. Studies have found that higher-income women have increased family support for breastfeeding (Wallace & Chason, 2007; Weston et al., 2023). Even when support is available, low-income women report that family members lack the necessary knowledge needed to provide the necessary support to facilitate breastfeeding (Weston et al., 2023). Additionally, low-income women report that grandparents encourage the use formula for family convenience and efficiency (Weston et al., 2023). Inadequate support from family is especially concerning for low-income women, as they

rely more on experiential knowledge of their family and peers rather than scientific knowledge when deciding to breastfeed (Groleau et al., 2013).

Likewise, research indicates a positive association between income and support within the healthcare setting. Low-income women have identified inadequate support from healthcare providers as a critical barrier to breastfeeding (Weston et al., 2023). For example, low-income women may receive educational materials but are not provided with any discussion or guidance from the healthcare providers, leaving them to interpret the information on their own. The lack of support from healthcare providers can be attributed to their biases and assumptions about low-income women, including that breastfeeding attempts would be unsuccessful. Despite their desire to exclusively breastfeed, low-income women are often discouraged in their breastfeeding efforts due to overwhelming pressure to use formula by hospital staff. Even when they successfully initiate, low-income mothers still report receiving limited coaching, support, and follow-up once they return home (Weston et al., 2023).

A similar trend has been observed between income and access to lactation accommodations in the workplace, where women of higher SES are more likely to have supportive workplace environments (i.e., paid maternity leave and designated spaces and break time to pump while at work) (Navarro-Rosenblatt & Garmendia, 2018; Wallace & Chason, 2007). Nationally, more than half of all lower-income and minority women still lack adequate maternity protection. For example, when low-income women are provided designated pumping spaces, they often report discomfort in these spaces (Weston et al., 2023). The lack of supportive work environments create additional barriers to breastfeeding for low-income women that negatively impact their ability to continue once they return to work (Holmes et al., 2023).

Within the community context, income-related measures are often included in indices of neighborhood disadvantage to study neighborhood effects on breastfeeding. A limited number of studies using neighborhood-level measures of income, though mixed, provide support for the importance of are-level income as a critical factor influencing breastfeeding. Previous research shows that area-level income indicators (e.g., the percentage of households living below poverty level and the percentage of households receiving public assistance), as part of broader indices of neighborhood socioeconomic status, disadvantage, and deprivation, are associated with breastfeeding from hospital discharge through six months (Burdette, 2013; Galante et al., 2022; Griswold et al., 2025; LoCasale-Crouch et al., 2024; Yourkavitch et al., 2018) . However, the strength of these associations varies across breastfeeding practices and populations.

In general, greater neighborhood disadvantage (i.e., higher proportions of families living in poverty and receiving income-related benefits) is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to six months (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). These associations often attenuate but remain statistically significant after adjusting for maternal socio-demographic characteristics (Galante et al., 2022; Griswold et al., 2018a; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018), though some studies report non-significant findings post-adjustment (Galante et al., 2022; Riley et al., 2016; Yourkavitch et al., 2018). Only one study has found no association between neighborhood disadvantage, which includes area-level income indicators, and breastfeeding initiation (Cubbin et al., 2008). Overall, the existing research indicates neighborhood disadvantage, including income-based measures, as a significant factor that may independently influence breastfeeding initiation beyond individual-level characteristics.

Additionally, these associations have been shown to vary by race and ethnicity. For example, some studies found that increasing neighborhood disadvantage was associated with lower odds of exclusive breastfeeding for all groups except White women, suggesting that the impact of neighborhood conditions may differ across racial and ethnic groups (Yourkavitch et al., 2018). In contrast, Griswold (2025) found that the associations between neighborhood socio-economic status and breastfeeding initiation were similar across maternal education, occupation, marital status, and region, indicating no effect modification by these socio-demographic characteristics.

One study that focused solely on income-related neighborhood measures independently, rather than as part of broader indices, provides a different understanding of this relationship. Burdette (2013) examined the association between neighborhood economic deprivation and breastfeeding initiation and any breastfeeding for six months or more. Neighborhood economic deprivation was measured using two income-related variables: the percentage of households living below poverty level and the percentage of households receiving public assistance. Results showed that neighborhood economic deprivation was significantly associated with lower odds of breastfeeding initiation and any breastfeeding at six months or more. However, these associations became statistically non-significant after adjusting for maternal socio-demographic characteristics. This finding suggests that neighborhood economic deprivation, based on income-related measures alone, may not fully capture the complexity of neighborhood disadvantage. Therefore, it could be a stronger predictor when considered alongside other indicators as part of a multidimensional index, such as employment and education.

These studies highlight neighborhood socioeconomic status (NSES), more generally, as an important place-based factor shaping breastfeeding practices. Several pathways may explain

this relationship. In particular, lower NSES has been shown to negatively impact the availability and quality of healthcare infrastructure and lactation-related support within neighborhoods. Compared to women in high-income neighborhoods, those in low-income neighborhoods lack access to critical community-based lactation support, such as mother-to-mother support groups, breastfeeding peer counselors, and board-certified lactation consultants (Grubesic & Durbin, 2021). Proximity to these sources of support, specifically board-certified lactation consultants, are associated with improved breastfeeding. One study found that counties with a higher density of International Board Certified Lactation Consultant (IBCLC) had higher six-week breastfeeding prevalence rates (Ray et al., 2019). Mothers in in higher-income neighborhoods also report living in communities with greater access to breastfeeding-friendly public spaces such as cafés and coffeeshops as well as access to large parks with benches (Isherwood et al., 2019). In contrast, women in lower-income neighborhoods often lack access to these resources within their communities and report needing to travel elsewhere to obtain them (Isherwood et al., 2019).

NSES also shapes the availability of healthcare services within neighborhoods. This relationship has become particularly evident with the widespread closure of obstetric units across the U.S., which has disproportionately reduced access to maternity and postpartum care in lower-income neighborhoods. Between 2021 and 2022, approximately one in 25 obstetric units nationwide closed (Nowhere to Go: Maternity Care Deserts Across the US, 2024). Consequently, in 2022, nearly half of rural hospitals and over one-third of urban hospitals did not offer obstetric care (Kozhimannil et al., 2025). Similar trends have occurred in California, where more than 46 labor and delivery units closed since 2012 (Hwang et al., 2023). Los Angeles County has been especially hit hard, accounting for approximately 30% (n = 17) of these closures (McHugh, 2025). These closures are concerning because they have contributed to the emergence of

maternity care deserts in the U.S., with over 35% of counties nationwide lacking access to maternity services (Nowhere to Go: Maternity Care Deserts Across the US, 2024).

Several factors contribute to these closures, including workforce shortages (e.g., physicians and nurses) and rising operational costs. These challenges are especially pronounced in hospitals located in low-income communities, where physicians are often scarcer and facilities serve a high proportion of Medicaid patients (*Poor Health: Poverty and Scarce Resources in U.S. Cities*, n.d.). As a result, closures have disproportionately occurred in community hospitals in low-income communities of color. Hospitals located in areas with greater socioeconomic disadvantage are more than twice as likely to close (Tung et al., 2024). These closures raise concerns about the growing prevalence of maternity care deserts in low-income communities and the potential consequences it may have for breastfeeding.

Women living in a maternity care desert are more likely to receive inadequate prenatal care (i.e., fifth month of pregnancy or later) or no prenatal care at all (Nowhere to Go: Maternity Care Deserts Across the US, 2024). Prenatal care visits are a critical setting for delivering breastfeeding education to pregnant women. Such education has been shown to increase breastfeeding knowledge, positive attitudes, and family support, which are associated with higher rates of initiation, longer duration, and greater exclusivity up to six months (Ahlers-Schmidt et al., 2020; Kehinde et al., 2023; Rosen et al., 2008; Ugurlu & Yavan, 2016). Additionally, the increase in closures of obstetric units have led more women to give birth in less appropriate settings, including emergency departments. This pattern is evident in LAC, where approximately 64% of individuals who gave birth in an emergency room were Hispanic (*As LA Maternity Wards Close, Patients Are Giving Birth in ERs: 'There's No System to Care for These Women,'*

2026). Because emergency departments are not equipped to provide comprehensive obstetric or lactation support, giving birth in these settings may compromise breastfeeding.

Even when healthcare services are available within neighborhoods, the quality of care varies by NSES. Hospitals in more disadvantaged areas are rated more poorly overall, with lower safety, patient experience, and effectiveness of care scores than those in less advantaged areas (Nwana et al., 2022). Regarding maternity care, women who give birth at hospitals in socioeconomically disadvantaged areas are more likely to receive formula in the hospital without a medical reason compared to those giving birth in wealthier areas (Mildon et al., 2026). This is problematic as in-hospital formula feeding is associated with a higher risk for early weaning (McCoy & Heggie, 2020).

Additionally, safety-net hospitals, which are often located in low-income communities, face increased challenges in implementing initiatives to improve maternity care (e.g., Baby-Friendly Hospital Initiative) (Eganhouse et al., 2016). These challenges include staffing constraints and limited financial resources. While the presence of Baby Friendly hospitals are emerging across socioeconomically disadvantaged areas, many have not received accreditation (Benjamin-Neelon et al., 2019). This suggests that structural and organizational constraints may be hindering progress toward full implementation, particularly in under-resourced settings.

Overall, the existing evidence shows that increases in neighborhood disadvantage, including higher percentage of households living below poverty level, are associated with worse breastfeeding practices. While the number of studies is limited and findings are somewhat mixed, these studies highlight the potential yet critical role of income as a significant neighborhood-level factor to breastfeeding that warrants further research.

Income and Breastfeeding: Current Gaps and Future Directions

Income is a well-established SDOH that impacts breastfeeding, with research consistently showing a positive association between income and better breastfeeding practices. However, measures of income have predominantly been operationalized at the individual-level rather than the neighborhood-level. This has left critical gap in our understanding of how neighborhood-level income, such as NSES, impacts breastfeeding. **Although limited, studies indicate that income is an important neighborhood-level factor for breastfeeding that warrants further research on its independent association and its role as an indicator of deprivation. This is a critical gap that this dissertation seeks to address.**

Additionally, more research is needed to clarify the pathways through which neighborhood-level measures of income impact breastfeeding to better understand the underlying mechanisms driving this connection. As discussed in the previous paragraphs, existing literature has identified several potential pathways explaining this relationship, however few studies have explicitly tested the factors that mediate or moderate this relationship. Addressing these critical gaps could provide important insights into how income, operating at an ecological level, influences breastfeeding practices. While examining these relationships is beyond the scope of this dissertation, it represents important directions for future research.

Employment

Employment and Health: An Overview

The importance of employment to health is well-established. Research has identified a protective effect of employment on an individual's quality of physical and mental health (Dean et al., 2018; Van Der Noordt et al., 2014). In contrast, unemployment or precarious employment is associated with poor health outcomes, including mental health disorders, suicide ideation, health risk behaviors, poor quality of life, and occupational injuries (Vancea & Utzet, 2017).

Precarious employment has also been found to have negative consequences on maternal and child health, including higher odds of being low-birth weight and stunting (Aronsson et al., 2023). A significant pathway linking unemployment and precarious employment to worse health outcomes is the lack of economic and social benefits associated with this type of work (Vancea & Utzet, 2017). Overall, existing research highlights employment as a critical SDOH, with important implications for maternal and child health.

Employment and Breastfeeding: Exploring the Connection

Research conducted in international and national settings has shown that work-related factors influence breastfeeding practices. Although employment positively impacts general health and well-being, most of the literature linking employment and breastfeeding suggests an inverse relationship. Returning to work is a significant barrier to breastfeeding (Franzoi et al., 2024; Wolf et al., 2023). In a U.S.-based national survey of women, approximately 50% reported that their employment impacted their decision to breastfeed and 33% reported that their employment posed a challenge to breastfeeding (Kozhimannil et al., 2016). To prepare for their return to work, some mothers report introducing formula early or stopping breastfeeding due to concerns about their breastmilk stock and a lack of confidence in their ability to continue breastfeeding during the transition (Febrianingtyas et al., 2019).

These challenges contribute to the well-established negative impact of postpartum employment on breastfeeding initiation, duration, and exclusivity (Amer & Kateeb, 2023; Attanasio et al., 2013; Dagher et al., 2016; De Lauzon-Guillain et al., 2019; Febrianingtyas et al., 2019; Fein & Roe, 1998; Franzoi et al., 2024; Hawkins et al., 2007; Kozhimannil et al., 2016; McCarter-Spaulding et al., 2011; Ryan et al., 2006; Wolf et al., 2023). Women who are employed full-time by six months are less likely to initiate breastfeeding (De Lauzon-Guillain et

al., 2019; Hawkins et al., 2007). Specifically, employment within the first six weeks postpartum is associated with lower odds of breastfeeding initiation, compared to those who are not employed (Hawkins et al., 2007). Additionally, women who are planning to work full-time postpartum have a lower likelihood of initiation, compared to those not intending to work postpartum (Fein & Roe, 1998; Noble, 2001).

Similar trends have been identified for breastfeeding duration and exclusivity. Full-time employment is consistently associated with shorter breastfeeding duration and lower likelihood of exclusivity. Mothers working full-time are less likely to continue breastfeeding at six months and are at increased risk of early cessation, particularly if they return to work within the first six months postpartum (Amer & Kateeb, 2023; Dagher et al., 2016; Fein & Roe, 1998; Lubold, 2016; McCarter-Spaulding et al., 2011; Ryan et al., 2006). In contrast, mothers who are not employed or who work part-time are more likely to sustain breastfeeding, with stay-at-home mothers being up to twice as likely to exclusively breastfeed for six months (Amer & Kateeb, 2023). These disparities can emerge as early as the prenatal period, as full-time employment during pregnancy has been linked to a lower likelihood of breastfeeding initiation and shorter overall duration (Attanasio et al., 2013).

In contrast to these studies, mixed associations have been identified in research examining breastfeeding and informal employment, which encompasses unregistered employment arrangements without protections (e.g., sick leave, pensions or annual leave) such as domestic work, street vending, and agricultural labor (Aronsson et al., 2023). While some studies suggest that informal employment is associated with fewer interruptions in breastfeeding and increased exclusivity rates, others indicate that such employment leads to lower odds of breastfeeding initiation, duration, and exclusivity (Aronsson et al., 2023). These inconsistencies

have been attributed to differences in the policy contexts of the countries where the studies were conducted (Aronsson et al., 2023). For instance, a protective factor of formal employment was found in studies conducted in countries where formally employed women have access to workplace lactation accommodations, such as designated spaces and time for breastfeeding or pumping (Aronsson et al., 2023). Conversely, a negative impact of formal employment was identified in studies conducted in countries where formally employed women lacked these accommodations (Aronsson et al., 2023). This underscores the importance of supportive lactation accommodations in the workplace for breastfeeding in working mothers (Franzoi et al., 2024).

Paid family leave is a U.S. policy that provides employees time off from work while still receiving pay to care for a newborn (*State Paid Family Leave Laws Across the U.S.*, 2024). It serves as a crucial resource for new parents by offering financial stability for families during this period. States with paid family leave policies have been shown to have higher rates of breastfeeding duration and exclusivity compared to states without such policies (Rosenberg, J. et al., 2024). While access to paid family leave is essential, length of leave is equally important to a woman's decision to stop breastfeeding or to start integrating formula (Franzoi et al., 2024). Women with less than 12 weeks of leave report breastfeeding for an average of five weeks fewer than those with 12 or more weeks of leave, while leave for 15 weeks is associated with a higher prevalence of breastfeeding up to six months (De Lauzon-Guillain et al., 2019; Lubold, 2016).

Upon returning to work, workplace lactation accommodations play a crucial role in supporting breastfeeding mothers. The Affordable Care Act (ACA), enacted in 2010, amended the Fair Labor Standards Act to require employers to provide reasonable unpaid break time and a private, non-bathroom space for employees to express breastmilk for one year after the child's birth (*Fact Sheet #73: FLSA Protections for Employees to Pump Breast Milk at Work*, 2023).

These additional provisions are known as the Break Time for Nursing Mothers law (*Fact Sheet #73: FLSA Protections for Employees to Pump Breast Milk at Work*, 2023).

The positive impact that these accommodations have on supporting breastfeeding is well-established (Franzoi et al., 2024). Women with both adequate break time and private space are more than twice as likely to breastfeed exclusively at six months compared to women without these accommodations (Kozhimannil et al., 2016). Additionally, the policy change has led to increases in national rates of breastfeeding, including a 10% increase in breastfeeding duration and a 21% increase in the duration of exclusive breastfeeding (Gurley-Calvez et al., 2018). Beyond these provisions, other workplace conditions that support breastfeeding include shorter working hours, on-site child care, telecommuting, and having a breastfeeding workplace policy (Bettinelli, 2012).

The social and cultural environment of the workplace also plays a critical role in the decision to continue breastfeeding (Franzoi et al., 2024). Despite support from employers, women may still face discrimination and inappropriate comments related to breastfeeding from colleagues (Franzoi et al., 2024). This social stigma can lead individuals to feel ashamed or isolated, which can contribute to early breastfeeding cessation (Franzoi et al., 2024). With the well-established benefits of supportive lactation accommodations in the workplace, as well as the growing number of working moms, national policies and practices must ensure that women's lactation needs are met when they return to work.

Beyond individual-level employment, neighborhood-level employment indicators also shape breastfeeding outcomes. Employment-related measures are often used to create indices of neighborhood disadvantage that have been used to study neighborhood effects on breastfeeding. A limited number of studies, though mixed, provide support for the importance of neighborhood-

level employment to breastfeeding. Studies using area-level employment rates, as part of broader indices of NSES, have found associations between breastfeeding at hospital discharge through six months (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). However, the strength of these associations varied across breastfeeding practices and populations.

International and national studies using composite indices of NSES, which include area-level employment indicators (e.g., the percentage of white-collar employed persons and percentage of unemployed persons), have shown significant associations with breastfeeding practices, even beyond individual-level factors (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). In general, greater neighborhood disadvantage (e.g., higher proportions of unemployed persons) is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to six months (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). These associations often attenuate but remain statistically significant after adjusting for maternal socio-demographic characteristics (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018), though some studies report non-significant findings post-adjustment (Galante et al., 2022; Riley et al., 2016; Yourkavitch et al., 2018).

While most studies using multidimensional indices report a significant relationship between neighborhood disadvantage and breastfeeding, one study did not. Cubbin et al. (2008) found no association between neighborhood-level deprivation, as measured by the Townsend Index (which includes an employment-related indicator), and breastfeeding initiation among

mothers living in Washington and Florida. This finding held in both unadjusted and adjusted analyses.

In contrast with studies using broader indices of NSES, Bonet et al. (2013) examined the distinct association between area-level unemployment rates and breastfeeding at hospital discharge in the U.K. and France. In fully adjusted models, accounting for maternal sociodemographic characteristics, mothers living in neighborhoods in the highest unemployment quartile had lower odds of initiating breastfeeding. Although unadjusted results were not reported, these findings suggest that area-level unemployment on, its own, may have an independent effect on breastfeeding initiation and underscores the need to examine this factor in isolation.

Employment and Breastfeeding: Current Gaps and Future Directions

The importance of employment-related factors, such as employment status and workplace lactation accommodations, to breastfeeding is well-established. Employment can negatively impact breastfeeding, particularly when proper accommodations are not in place to promote and support breastfeeding. In contrast, unemployment and part-time employment have been found to improve breastfeeding practices. While not within the scope of this dissertation, future research needs to identify how unemployment or underemployment influences breastfeeding practices, such as exploring factors like time available for breastfeeding, financial stress, or social support.

Additionally, measures of employment have predominately been operationalized at the individual-level rather than the neighborhood-level. This has left critical gap in our understanding of how neighborhood-level employment impacts breastfeeding. **Although limited, studies indicate that area-level employment is an important neighborhood-level factor for breastfeeding that warrants further research on its independent association and**

its role as an indicator of deprivation. This is a critical gap that this dissertation seeks to address.

Lastly, more research is needed to clarify the pathways through which neighborhood-level measures of employment impact breastfeeding to better understand the underlying mechanisms driving this connection. While the literature has identified several potential pathways explaining this relationship, few studies have explicitly tested the factors that mediate or moderate this relationship. Although these relationships are not explicitly examined in this dissertation, future research is needed to clarify the underlying mechanisms driving this relationship. Addressing these critical gaps could provide important insights into how employment, operating at an ecological level, influences breastfeeding practices.

Domain 2: Education Access and Quality

The second domain, education, examines the link between education access and quality, and health. Key factors related to this SDOH include educational attainment, graduation rates, and literacy (Centers for Disease Control, n.d.).

Education and Health: An Overview

The relationship between educational attainment and health is well-documented, with substantial research showing that lower educational attainment is associated with worse physical and mental health outcomes. For example, lower educational attainment is linked to higher risks of both chronic and acute conditions including heart disease, stroke, hypertension, high cholesterol, diabetes, asthma, and ulcers, as well as greater morbidity from these illnesses (Telfair & Shelton, 2012). One reason for this relationship is that higher educational attainment leads to better access to and understanding of health information and resources that support health. These advantages help promote healthier lifestyles and better health outcomes in

individuals with higher education. For example, individuals with lower educational attainment are more likely to engage in health-harming behaviors such as smoking, drinking, and substance use (Telfair & Shelton, 2012). Those with less education are also more likely to be uninsured (Kaplan et al., 2017). Overall, there is substantial support for the important role of educational-related factors as a SDOH.

Education and Breastfeeding: Exploring the Connection

Maternal education is a critical SDOH for breastfeeding, with studies in international and U.S. settings supporting its significance. Research has overwhelmingly showed that higher maternal education levels are associated with a greater likelihood of breastfeeding initiation, duration, and exclusivity (Cohen et al., 2018; Laksono et al., 2021; Neves et al., 2021; Sarki et al., 2019; Skafida, 2009; Tang et al., 2019). Higher maternal education is also linked to a lower likelihood of early breastfeeding cessation (Tang et al., 2019). Maternal education has been found to be a stronger predictor of breastfeeding practices than occupation-related social class and household income (Neves et al., 2021; Skafida, 2009).

Beyond individual-level educational attainment, neighborhood-level education indicators also shape breastfeeding outcomes. Education-related measures are often included in indices of neighborhood disadvantage to study neighborhood effects on breastfeeding. A limited number of studies using these measures, though mixed, provide support for the relationship between area-level education and breastfeeding. Studies which use area-level education indicators, as part of broader indices of NSES have been linked to breastfeeding at hospital discharge to six months (Galante et al., 2022; Griswold et al., 2025; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018). However, the strength of these associations varied across breastfeeding practices and populations.

International and national studies using composite indices of NSES, which include area-level education indicators (e.g., percentage of adults who completed college and access and quality of early childhood education), have shown significant associations with breastfeeding practices, even beyond individual-level factors. In general, greater neighborhood disadvantage is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to six months (Galante et al., 2022; Griswold et al., 2025; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018). These associations often attenuate but remain statistically significant after adjusting for maternal socio-demographic characteristics (Galante et al., 2022; Griswold et al., 2025; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018), though some studies report non-significant findings post-adjustment. (Galante et al., 2022; Yourkavitch et al., 2018).

One study that focused specifically on neighborhood-level education measures independently rather than as part of broader indices, provides a different understanding of this relationship. Burdette (2013) examined the association between the percentage college-educated individuals within a neighborhood and breastfeeding initiation and any breastfeeding for six months or more. In unadjusted models, a higher percentage of college-educated individuals in a neighborhood was significantly associated with higher odds of initiating breastfeeding and any breastfeeding for six months or more. After adjusting for maternal socio-demographic characteristics, these associations remained statistically significant. Overall, the existing evidence highlights the importance of education-related measures, whether included as part of a broader index or examined on its own, as a significant factor that independently influences breastfeeding practices beyond individual-level characteristics.

A key pathway through which maternal education for breastfeeding is health literacy. Higher educational attainment is associated with increased health literacy (Long et al., 2022). Health literacy refers to an individual's capacity to obtain, process, and understand health information, which is crucial for making informed health decisions (Rudd et al., 2007). Individuals with stronger literacy skills are more likely to engage in health-promoting behaviors, understand health risks, and follow treatment protocols, which contribute to better health outcomes (Rudd et al., 2007). This is particularly evident in pregnant women, where studies have shown that higher maternal education is associated with reduced alcohol consumption and increased use of folic acid supplements (Górniaczyk et al., 2017). Additionally, women with higher education and stronger literacy skills are better able to understand and process health information related to breastfeeding to inform their feeding choices (Groleau et al., 2013). This advantage can lead to increases in maternal breastfeeding knowledge, attitude, self-efficacy, and confidence, which can positively impact her decision and ability to breastfeed.

Likewise, neighborhoods with higher educational attainment may foster environments that support breastfeeding through greater knowledge, norms, and resources. Prior research suggests that more educated areas tend to hold stronger health-promoting beliefs, which in turn have led to better health outcomes (e.g., lower rates of obesity and smoking) (Bor et al., 2024). Breastfeeding represents an important health behavior that these mechanisms may also apply to.

Social networks are critical aspects of neighborhoods that shape norms, knowledge, and support. When supportive messages are shared through these networks, it has the ability to strengthen a women's confidence and ability to breastfeed (Carlin et al., 2019). Additionally, in communities where breastfeeding is normalized and visible in public spaces (e.g., parks or local cafés), it has been shown to foster supportive community networks for breastfeeding families and

to increase breastfeeding initiation as well as exclusivity. In this way, neighborhood-level beliefs are an important mechanism through which area-level educational attainment can influence individual attitudes and behaviors around breastfeeding.

Another major pathway linking maternal education to breastfeeding is through financial stability. Higher educational attainment can lead to higher incomes and increased job security. As discussed in the previous sections, these financial advantages can facilitate breastfeeding by increasing access to healthcare, lactation resources and support, breastfeeding-friendly workplaces, and improving mental well-being.

Having greater financial resources can also increase your likelihood of living in a higher-income neighborhood with better access to resources to support healthy behaviors (Hawthorne & Kwan, 2013; Moore et al., 2008). These financial advantages and increased access to resources can help women overcome barriers to breastfeeding and increase their breastfeeding knowledge, self-efficacy, and confidence. Overall, maternal education plays a critical role in breastfeeding by equipping women with the knowledge to make informed choices about breastfeeding and the financial stability needed to support those choices.

Education and Breastfeeding Current Gaps and Future Directions

The literature supporting the association between maternal education and breastfeeding is well-established. Studies consistently find that higher maternal education is linked to increased breastfeeding initiation, duration, and exclusivity. However, education-related measures have predominately been operationalized at the individual-level rather than the neighborhood-level. This has left critical gap in our understanding of how neighborhood-level education impacts breastfeeding. **Although limited, studies indicate that education is an important neighborhood-level factor for breastfeeding that warrants further research on its**

independent association and its role as an indicator of deprivation. This is a critical gap that this dissertation seeks to address.

Additionally, more research is needed to clarify the pathways through which neighborhood-level measures of education impact breastfeeding to better understand the underlying mechanisms driving this connection. While the literature has identified several potential pathways explaining this relationship, few studies have explicitly tested the factors that mediate or moderate this relationship. Addressing these critical gaps is beyond the scope of this dissertation but represents an important area for future research to better understand how education, operating at the ecological level, influences breastfeeding practices.

Domain 3: Healthcare Access and Quality

The third domain, healthcare access and quality, examines how people's access to health services impacts their health (Centers for Disease Control, n.d.). Key factors related to this SDOH include healthcare access and health insurance coverage (Centers for Disease Control, n.d.).

Healthcare and Health: An Overview

Access to healthcare is an important SDOH that plays a crucial role in promoting healthy behaviors and improving health outcomes. Access to healthcare has a significant impact on an individual's ability to receive medical care when needed and on a consistent basis. Research has shown that adults without health insurance are less likely to see a physician when needed, receive a routine check-up within the past two years, or use preventative health services such as cancer screenings and mammograms (Ayanian, 2000). As a result, uninsured adults are more likely to report poorer health statuses and are at a greater risk of mortality, compared to those with insurance (Ayanian, 2000). Lack of access to healthcare remains a critical SDOH, with

consequences resulting in greater unmet health needs and poorer health outcomes among uninsured individuals.

Healthcare and Breastfeeding: Exploring the Connection

Healthcare access is critical to ensuring pregnant and lactating women receive prenatal care services as well as coverage for breastfeeding support and supplies. Prenatal care services are essential to the promotion of breastfeeding. During prenatal care visits, qualified healthcare professionals provide breastfeeding education to pregnant women. This is important because prenatal breastfeeding education has been shown to improve breastfeeding practices. Women report that receiving this type of education reinforced their decision to breastfeed and increased their intention to breastfeed exclusively for six months (Kehinde et al., 2023). Additionally, provision of this type of education is associated with higher rates of breastfeeding initiation, duration, and exclusivity up to six months (Ahlers-Schmidt et al., 2020; Kehinde et al., 2023; Rosen et al., 2008; Ugurlu & Yavan, 2016).

Breastfeeding self-efficacy plays an important role in a mother's confidence in her ability to initiate and maintain breastfeeding. Providing prenatal breastfeeding education has been shown to increase breastfeeding self-efficacy in women up to six months postpartum (Kehinde et al., 2023). This support is especially valuable for mothers with previous unsuccessful breastfeeding experiences. Prenatal breastfeeding education has also been shown to foster positive attitudes towards breastfeeding and increase negative attitudes towards formula feeding. This has led to increases in women's intentions to initiate and exclusively breastfeed for longer. Additionally, improvements in breastfeeding knowledge, such as awareness of correct breastfeeding practices, have been observed in women up to six months postpartum. Lastly, prenatal breastfeeding education is associated with increases in family support. This is because

educating family members about breastfeeding has shown to increase their likelihood of offering their support (Kehinde et al., 2023).

These findings highlight the importance of providing ongoing breastfeeding education and support, throughout the perinatal period, to ensure women have the necessary knowledge, skills, and support to breastfeed. Prenatal care visits play a vital role in this process, therefore access to healthcare is an essential step in ensuring women are provided education and support during critical points in their pregnancy journey.

Insurance coverage is an important indicator of healthcare access and has important implications for breastfeeding. Since the 2012 Affordable Care Act (ACA) policy change, most health insurance plans are required to cover breastfeeding services and supplies without cost-sharing, including lactation counseling, education, and breast pumps (Gurley-Calvez et al., 2018). This coverage is critical to increasing access to support and supplies needed to breastfeed, especially for those who face financial barriers. Between 2012 and 2014, there was an 11-fold increase in breast pump claims among women covered by private insurance (70 to 803 claims) (Hawkins et al., 2017). However, disparities persisted among Medicaid recipients, with a total of only 11 claims during this period (Hawkins et al., 2017). This discrepancy may be due to state-level variations in Medicaid coverage under ACA mandate (Hawkins et al., 2017). While these gaps in insurance coverage are concerning, they highlight the critical role of the ACA breastfeeding provisions in expanding access to breastfeeding support (Hawkins et al., 2017).

By improving access to breastfeeding services and supplies, the ACA has had a positive impact on breastfeeding practices. This policy change has resulted in a 10% (0.57 months) increase in breastfeeding duration and a 21% (0.74 months) increase in duration of exclusive breastfeeding (Gurley-Calvez et al., 2018). Additionally, the policy change has been shown to

increase the likelihood of breastfeeding initiation by 2.5 percentage points, which translates to about 47,000 more infants being breastfed (Gurley-Calvez et al., 2018). These benefits are even greater for Black, less educated, and unmarried mothers, who are typically at-risk of poorer breastfeeding practices (Kapinos et al., 2017).

As discussed in Chapter 1, an important aspect of a neighborhood's healthcare infrastructure includes access to and availability of healthcare and community-based services. Peer support programs, such as peer counseling groups and Baby Cafés, provide community-based lactation support that improves breastfeeding by fostering confidence, sharing knowledge, and building supportive networks (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019; Jenkins et al., 2020). Additionally, WIC clinics are an important community-based support that provide food assistance, financial incentives for breastfeeding, and peer counseling services, all of which have been shown to increase breastfeeding rates (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019; Langellier et al., 2014).

Healthcare and Breastfeeding: Current Gaps and Future Directions

The importance of healthcare access in ensuring women receive the necessary education, support, and resources to initiate and continue breastfeeding is well-documented. However, disparities in health insurance coverage, due to state-variations in Medicaid coverage, create gaps in access to this essential support. To address this, research is needed to explore women's experiences of accessing coverage for breastfeeding services and equipment to better understand how the ACA's breastfeeding provisions are being implemented. This research will provide insights into how current ACA policies can be improved to ensure better coverage.

Additionally, most of the research examining healthcare access and breastfeeding has focused on individual-level measures of healthcare access. This has resulted in a major gap in our understanding of how neighborhood-level measures of healthcare access may impact breastfeeding. This is concerning because area-level insurance coverage may reflect broader environmental barriers to accessing healthcare. Research shows that the percentage of uninsured women is twice as high in maternity care deserts, where access to maternity care services is limited or nonexistent, compared to areas with full access (Nowhere to Go: Maternity Care Deserts Across the US, 2024). This suggests that neighborhood-level measures of healthcare access are important to breastfeeding, as they can serve as an important indicator of overall care availability. Therefore, **neighborhood-level measures need to be included in future research to better understand how healthcare access, operating at an ecological level, influences breastfeeding. This is a critical gap that this dissertation seeks to address.**

Additionally, more research is needed to clarify the pathways through which neighborhood-level measures of healthcare access impact breastfeeding to better understand the underlying mechanisms driving this connection. While the literature has identified several potential pathways explaining this relationship, few studies have explicitly tested the factors that mediate or moderate this relationship. While not the focus of this dissertation, addressing these critical gaps could provide important insights into how healthcare access, operating at an ecological level, influences breastfeeding practices.

Domain 4: Neighborhood and Built Environment

The fourth domain, neighborhood and built environment, explores the relationship between where people live and their health (Centers for Disease Control, n.d.). Key SDOH included under this domain are transportation, the food environment, housing, exposure to

environmental toxins (i.e., clean air and safe drinking water), and access to urban green spaces (Centers for Disease Control, n.d.).

Transportation

Transportation and Health: An Overview

Transportation is an important SDOH that can be both beneficial and detrimental to health (Glazener et al., 2021). Transportation is beneficial to health when it serves as pathways for increased social connectivity, engagement in physical activity, and improved access to jobs, education, and services (i.e., health facilities) (Glazener et al., 2021). It is considered detrimental to health when it leads to increases in air pollution, road travel injuries, noise, stress, environmental contamination, climate change, social exclusion, and restricted green space (Glazener et al., 2021). Transportation can also be harmful to health when it creates barriers to accessing healthcare, which increases the likelihood missing clinical appointments and poor medication adherence (Syed et al., 2013). While transportation has the potential to promote health, it can also pose significant risks that exacerbate health inequities.

Transportation and Breastfeeding: Exploring the Connection

Transportation is an understudied SDOH in the breastfeeding literature. To my knowledge, only one study has examined the association between a transportation-related indicator and breastfeeding. Specifically, Cubbin et al. (2008) used the Townsend Index, which includes the proportion of occupied housing units without a motor vehicle, to examine the association between neighborhood-level socioeconomic deprivation and breastfeeding initiation. For both unadjusted and adjusted analyses, they found no association between neighborhood-level deprivation and breastfeeding initiation among mothers living in Washington and Florida.

Despite this finding and the very limited research examining the association between transportation and breastfeeding practices, studies have identified potential pathways linking the

two. For example, transportation plays a critical role in a woman's ability to access the necessary resources, support, and healthcare for successful breastfeeding. This is especially important for women living in maternity care deserts, where there is no access to birthing hospitals, birth centers, or obstetric providers (Nowhere to Go: Maternity Care Deserts Across the US, 2024). In these areas, women, on average, travel 38 minutes to receive care, which is 2.6 times longer than those living in non-maternity care deserts. As a result, these women are at an increased risk of receiving inadequate or no prenatal care, compared to those not living in maternity care deserts (Nowhere to Go: Maternity Care Deserts Across the US, 2024). Prenatal care is essential for connecting mothers to breastfeeding education and support services, therefore this lack of access can have negative consequences for breastfeeding (see prior section). Without access to reliable transportation, women face additional barriers to receiving prenatal care and are at an increased risk for poor breastfeeding practices, especially those living in maternity care deserts.

Other potential pathways through which transportation may either promote or hinder breastfeeding include its impact on access to resources, quality of environmental conditions, and neighborhood infrastructure. The availability of residential green space is influenced by a neighborhood's transportation infrastructure (Nieuwenhuijsen & Khreis, 2016). While the expansion of urban growth (e.g., highways) results in the loss of greenspace, cities that are shifting to non-motorized travel have increased opportunities for more green space (Nieuwenhuijsen & Khreis, 2016). This is important because access to greenspace can improve breastfeeding practices through increased well-being and physical activity levels (McEachan et al., 2016; Nguemeni Tiako et al., 2021; Nguyen et al., 2019; Sun et al., 2023). In contrast, built environments with car-centric infrastructures where there is a reliance on motor vehicle use, are characterized by limited access to green spaces and safe walking paths (Bozovic, 2025). This is

concerning because urban walkability is associated with improved physical activity, mental well-being, and social connectivity, which can positively impact breastfeeding (Westenhöfer et al., 2023). Additionally, car-centric infrastructures can increase levels of environmental contaminants, such as oils, heavy metals, and particulate matter, through motor vehicle traffic (Nieuwenhuijsen & Khreis, 2016). These pollutants contribute to water and air pollution, which can have a detrimental impact on a mother's decision and ability to breastfeed (Brown, L.J. & Sear, 2019; Criswell et al., 2020; Nielsen et al., 2022).

Transportation and Breastfeeding: Current Gaps and Future Directions

Transportation is a potentially important, yet underexplored, SDOH for breastfeeding. While research suggests different pathways through which transportation may either promote or hinder breastfeeding, no study has directly examined this association. Beyond establishing a relationship, future research is also needed to clarify the pathways through which individual- and neighborhood-level measures of transportation impact breastfeeding to better understand the underlying mechanisms driving this connection.

This gap in the literature is concerning, especially given the prevalence of maternity care deserts and the increasing challenges these women face in accessing maternity care (Nowhere to Go: Maternity Care Deserts Across the US, 2024). These widespread closures underscore the growing importance of transportation in ensuring women can not only access the maternity care they need but also the necessary education, resources, and support services to successfully breastfeed. **Overall, research suggests that transportation is an important, yet understudied, factor for breastfeeding that warrants further research. This is a critical gap that this dissertation seeks to address.**

Environmental Exposures

Environmental Exposures and Health: An Overview

Exposure to environmental pollutants, such as heavy metals, particulate matter, pesticides, and plastic, are harmful to human health (Shetty et al., 2023). Research has shown that environmental pollution can adversely impact reproductive, prenatal, neural, and cardiovascular health as well as increase the risk for various types of cancers (Shetty et al., 2023). Air pollution and water supply are key pathways through which pollutants are emitted and contribute to environmental health hazards (Xu et al., 2022). Therefore, poor air quality and unsafe drinking water are critical SDOH that have important implications for health outcomes.

Environmental Exposures and Breastfeeding: Exploring the Connection

A clean environment, where people can breathe fresh air and access safe drinking water, is an important, yet understudied, SDOH with significant implications for breastfeeding. To my knowledge, only one study has examined the association between a pollution-related indicator and breastfeeding practices. Specifically, LoCasale-Crouch et al. (2024) used the Childhood Opportunity Index 2.0, which includes measures of exposure to environmental toxins, to examine the association between neighborhood resources and breastfeeding up to 6 months. The Childhood Opportunity Index includes five indicators related to toxic exposures: hazardous waste dump sites, airborne microparticles, ozone concentration, extreme heat, and industrial pollutants in air, water, or soil. They found that mothers living in highly resourced neighborhoods (e.g., lower toxic exposures) had significantly higher odds of any and exclusive breastfeeding at the two- to six-month postpartum follow-up, even after adjusting for child and maternal socio-demographic characteristics. Their findings suggest that environmental pollution measures are a significant factor that may influence breastfeeding initiation beyond individual-level characteristics.

Despite the limited research examining the association between environmental pollution and breastfeeding practices, studies have identified potential pathways linking the two. Environmental pollution has been shown to comprise the quality and quantity of breastmilk, which can influence a woman's decision and ability to initiate and sustain breastfeeding. Regarding quality, maternal exposure to environmental pollutants has been shown to adversely impact breastmilk composition. Studies have shown that higher concentrations of endocrine-disrupting chemicals (EDCs) are associated with shorter durations of any and exclusive breastfeeding (Criswell et al., 2020). Studies have found EDCs in breastmilk at varying concentrations, with higher levels often released during energy-intensive periods like pregnancy and breastfeeding, regardless of maternal exposure (Bernasconi et al., 2022; Serreau et al., 2024). (Chemek & Nevoral, 2019) Even at low dosages, the presence of EDCs in breastmilk can be harmful to infant health, including complications in nervous system function, reproductive health, and gut microbiome development (Chemek & Nevoral, 2019; Street et al., 2023). Concerns about the potential transmission of harmful chemicals to the infant through breastmilk may cause some women to hesitate to breastfeed (Larrea-Killinger et al., 2020).

Regarding quantity, maternal exposure to environmental pollutants, particularly EDCs, can also affect lactation capacity. Animal studies, primarily involving rodents, suggest that perinatal exposure to EDCs can disrupt breast development and alter milk production and secretion (Criswell et al., 2020; Vandenberg, 2021). Even if a mother wishes to breastfeed, these disruptions to milk production can hinder her ability to do so.

The harmful consequences of environmental pollution on the quality and quantity of breastmilk may adversely impact breastfeeding practices. On a broader scale, studies have linked poor physical environmental quality to adverse breastfeeding practices. While limited in number

and primarily conducted in international settings, these studies provide further support that environmental quality can impact breastfeeding. For example, a study conducted in the United Kingdom examined the association between an individual's physical environmental quality and breastfeeding initiation and cessation among White British and Pakistani-origin mothers (Brown, L.J. & Sear, 2019). Physical environmental quality indicators included measures of water safety (i.e., water disinfectant by-products), air pollution (nitric oxide and nitrogen dioxide levels in the air), passive cigarette smoke (exposure to cigarette smoke at home or at work), and household condition (damp and/or mold and lack of central heating) (Brown, L.J. & Sear, 2019).

While results identified mixed associations across physical environmental quality indicators, they broadly suggest a link between poor physical environmental quality and adverse breastfeeding practices (i.e., lower odds of initiation and higher odds of cessation). Among the physical environmental indicators that were included, air pollution and water safety measures were significant predictors of breastfeeding (Brown, L.J. & Sear, 2019). Specifically, the air pollution measures were identified as negative predictors of breastfeeding initiation for both ethnic groups, while the water safety measures were significant negative predictors of both breastfeeding practices for Pakistani-origin mothers only (Brown, L.J. & Sear, 2019). These results suggest that lower physical environmental quality, related to air pollution and water safety, is associated with poor breastfeeding practices (Brown, L.J. & Sear, 2019).

A study conducted in Sweden provides further support for the association between access to safe drinking water and breastfeeding practices (Nielsen et al., 2022). Researchers examined the association between exposure to heavily contaminated water containing perfluoroalkyl substances and breastfeeding initiation, duration, and cessation (Nielsen et al., 2022). Exposure was assessed using the residential addresses of mothers during the five-year period before

delivery (Nielsen et al., 2022). These addresses were linked to municipal water supply records to determine the source of drinking water (i.e., highly contaminated waterworks, other municipal waterworks, or a private well) (Nielsen et al., 2022). Mothers were classified as having high exposure if they lived at an address with contaminated water for at least one year, whereas mothers were classified with low exposure if their water came from other municipal sources or private wells (Nielsen et al., 2022). Results showed that mothers who received contaminated water were twice as likely to not initiate breastfeeding, 1.2 times more likely to not exclusively breastfeed at three months, and 1.6 times more likely to stop breastfeeding by six months (Nielsen et al., 2022). These findings support access to unsafe drinking water as an important risk factor for poor breastfeeding practices, including failure to initiate and shorter duration.

In contrast, a limited number of studies suggest that poor physical environmental quality may be associated with better breastfeeding practices. For example, a study conducted in Bangladesh found that mothers living in areas with arsenic-contaminated waters had longer durations of breastfeeding and were more likely to exclusively breastfeed compared to those in areas with cleaner water sources (Keskin et al., 2017). Similarly, findings from the previously mentioned United Kingdom based study showed that White British mothers who were exposed to higher levels of air pollution were more likely to breastfeed for longer (Brown, L.J. & Sear, 2019).

One potential explanation for this is that breastfeeding may protect infants from the harmful effects of environmental pollution (Brown, L.J. & Sear, 2019). Studies have shown that breastfeeding can protect infants from adverse effects of both indoor and outdoor air pollution exposure including respiratory issues (e.g., infections, impaired lung function, asthma symptoms) and immune system complications (e.g., allergies, nervous system disorders, and

cardiovascular issues) (C. Zhang et al., 2019; Zielinska & Hamulka, 2019). Though these studies are limited, they do suggest that mothers in polluted environments may use breastfeeding as a protective strategy to mitigate the negative health effects of their environment.

In conclusion, research suggests a complex link between environmental quality and breastfeeding. Exposure to environmental pollutants, such as EDCs, can negatively affect both the quality and quantity of breastmilk, which may have ramifications on her ability or decision to breastfeed. While poorer environmental quality, characterized by exposure to EDCs, air pollution, and unsafe drinking water, is associated with worse breastfeeding practices, some studies suggest that mothers in polluted environments may use breastfeeding as a protective strategy against environmental toxins. Despite inconsistent findings, the literature highlights the importance of environmental quality, particularly access to clean water and air, as critical factors to breastfeeding.

Environmental Exposures and Breastfeeding: Current Gaps and Future Directions

Research examining the association between environmental quality and breastfeeding is limited, especially in the U.S. To date, most of the research has focused primarily on the impact of individual pollutants, such as EDCs, on breastfeeding practices. This has led to the insufficient exploration of the association between broader environmental quality measures, such as air pollution and water safety, and breastfeeding practices. These aggregate measures of environmental quality, accounting for air and water pollutants, can more accurately capture the combined impact of various environmental conditions on breastfeeding. This approach can provide clarity to our understanding of how multiple factors interact and potentially contribute to inconsistent results across studies. By examining the aggregate effects of various environmental conditions, rather than individual pollutants, we can better understand the nuanced relationship between environmental quality and breastfeeding.

Although limited, existing evidence suggests that environmental pollution is a key neighborhood-level factor that warrants further investigation, both as an independent influence and as an indicator of neighborhood quality. **This has left critical gap in our understanding of how environmental pollution impacts breastfeeding, which is a gap that this dissertation seeks to address.**

Additionally, more research is needed to clarify the pathways through which environmental pollution impacts breastfeeding to better understand the underlying mechanisms driving this connection. While the literature has identified several potential pathways explaining this relationship, few studies have explicitly tested the factors that mediate or moderate this relationship. Addressing these critical gaps are beyond the scope of this dissertation but represents important areas for future research to better understand how environmental pollution, operating at an ecological level, influences breastfeeding practices.

Urban Greenspaces

Urban Green Space and Health: An Overview

Urban green spaces, defined as an open land with some form of vegetation cover, are an important SDOH that positively impacts health in various ways. Examples of urban green spaces include city parks and gardens, green roofs, domestic gardens, and urban agriculture (Hunter & Luck, 2015). Characteristics of urban green spaces include: biodiversity (e.g., number of plant species, origin of species, and diversity of species), structure (e.g., form of trees, vegetation cover, distance and connectivity between urban green spaces) naturalness (e.g., extent of man-made elements), and other (Reyes-Riveros et al., 2021). These spaces impact health through various pathways including increases in physical activity, sense of community and belonging, perceived social support, mental well-being, and air quality (Dadvand et al., 2016; Reyes-

Riveros et al., 2021). Research shows a positive association of the number of green spaces and their percentage of vegetation cover and size (structure) with improved mental and physical health (Reyes-Riveros et al., 2021). Additionally, biodiversity and naturalness of green spaces are associated with better mental health and good social relations. Urban greenspaces have also been found to be an important SDOH to maternal and child health, with research consistently finding that exposure to urban greenspaces has a positive effect on birth outcomes (Aktan et al., 2024; Banay et al., 2017; Villeneuve et al., 2022; Ye et al., 2024).

Urban Green Space and Breastfeeding: Exploring the Connection

Urban green spaces are an important, yet understudied, SDOH with important implications for breastfeeding. In the U.S., LoCasale-Crouch et al. (2024) used the Childhood Opportunity Index 2.0, which includes measures related to greenspace and walkability, to examine the association between neighborhood resources and breastfeeding up to six months. They found that mothers living in highly resourced neighborhoods (e.g., increased walkability and access to greenspaces) had significantly higher odds of any and exclusive breastfeeding at the two- to six-month postpartum follow-up, even after adjusting for child and maternal socio-demographic characteristics.

Similarly, Kummer et al. (2020) examined the association between neighborhood amenities and breastfeeding initiation and exclusivity at six months in a sample of women living in the United States. Neighborhood amenities were measured using four indicators that included access to parks/playgrounds, sidewalks/walking paths, community/recreation centers, and libraries/bookmobiles. In unadjusted analyses, they found that children living in a neighborhood with four amenities was associated with higher odds of breastfeeding initiation. After adjusting for maternal socio-demographic characteristics, the association weakened but remained

statistically significant. The associations for exclusive breastfeeding were not significant in both unadjusted and adjusted analyses. This suggests that, in general, neighborhood amenities, including access to greenspace, is a significant factor that may influence breastfeeding practices beyond individual-level characteristics, especially for any breastfeeding.

A study conducted in Finland by Galante et al. (2002) examined the association between neighborhood greenness, based on the Normalized Difference Vegetation Index, and breastfeeding initiation and any breastfeeding at six months. Contrary to their initial hypotheses, they found that low neighborhood greenness was significantly associated with a higher likelihood of breastfeeding initiation and any breastfeeding at six months. This finding suggests that neighborhood greenness alone may not have a direct effect but could be a stronger predictor when considered alongside other factors as part of a multidimensional index.

Although this relationship remains underexplored and findings are somewhat mixed, emerging research has identified key mechanisms through which access to urban green spaces could positively impact breastfeeding practices. One major pathway is mental health. Studies have identified a link between greater exposure to residential urban green space and positive mental health outcomes in women, including a lower likelihood of prenatal and postpartum depression as well as reductions in physiological and emotional stress (McEachan et al., 2016; Nguemeni Tiako et al., 2021; Sun et al., 2023). This is concerning as poor mental health adversely affects breastfeeding practices.

Women with perinatal mental health conditions (e.g., depression, anxiety, eating disorders) face several barriers to breastfeeding, which significantly affect their decision to initiate and continue breastfeeding (Billings et al., 2024). These challenges include a desire to regain control of their body, inconsistent advice and lack of support from healthcare

professionals, concerns over medication safety and breastfeeding, and negative impact on the quality and quantity of their breastmilk (Billings et al., 2024). Additionally, women experiencing prenatal or postpartum depression have been found to report more breastfeeding difficulties, negative breastfeeding attitudes, and lower breastfeeding confidence (Dias & Figueiredo, 2015). On a physiological level, maternal distress can negatively impact lactation capacity by increasing the risk of delayed lactogenesis and insufficient milk supply, even after milk production has been fully established (Nagel et al., 2022). This inability to produce milk is a major contributor to breastfeeding cessation and the need for supplementation (Nagel et al., 2022).

These challenges have contributed to poorer breastfeeding practices among women experiencing perinatal mental health conditions. High prenatal and postpartum anxiety (from delivery to 6 months) is linked to a lower likelihood of initiation, duration, and exclusivity, as well as an increased risk of early formula supplementation and breastfeeding cessation (Hoff et al., 2019) Similarly, prenatal and postpartum depression are associated with lower odds of intention and shorter durations of any and exclusive breastfeeding (Dias & Figueiredo, 2015).

Another key mechanism through which urban greenspaces impact breastfeeding is physical activity. Higher levels of physical activity in pregnant women are associated with better breastfeeding practices at 12 months postpartum, including higher rates of any breastfeeding and a lower risk of breastfeeding cessation (Nguyen et al., 2019). The positive impact of physical activity on breastfeeding can be attributed to the potential benefit of exercise on the quality and quantity of breastmilk. For example, a study found a two-to four-fold increase of lactate, a compound that helps promote healthy gut bacteria development in infants, in the breastmilk of women who just finished exercising (Wallace, J.P. et al., 1994). Additionally, women with

higher levels of physical activity, compared to sedentary women, have been shown to have a higher breastmilk volume and breastmilk energy output (Lovelady et al., 1990).

Urban greenspaces play an important role in increasing engagement in physical activity. Greater exposure to and closer access to green spaces are associated with higher physical activity levels in adults, with emerging research suggesting similar associations among pregnant and postpartum women (Hillsdon et al., 2006; Richardson et al., 2013; Shen et al., 2021). A study found that daily visits to natural open spaces, such as urban parks, increased the duration of moderate to vigorous physical activity by eight minutes and the likelihood of meeting the WHO daily physical activity guidelines in pregnant women (Vich et al., 2024). Greater distance to a park has been linked to lower odds of physical activity at three months postpartum and a smaller increase in physical activity from pregnancy to three months postpartum (Porter et al., 2019). Additionally, previous research suggests that physical activity partially mediates the relationship between green space and mental health among pregnant and postpartum women (Sun et al., 2023). Overall, these studies demonstrate the positive impact of urban green spaces on increased physical activity levels and underscore their importance in promoting lactation and breastfeeding.

Lastly, maternal exposure to green spaces has also been shown to improve milk quality. One study showed that increased maternal exposure to greener environments led to increased diversity and concentrations of human milk oligosaccharides, which are complex carbohydrates that offer several infant-promoting health benefits (Lahdenperä et al., 2023). Given milk quality is a crucial factor in a woman's decision to breastfeed (Gross et al., 2019), these changes in milk composition could have a positive impact on breastfeeding practices.

Urban Greenspaces and Breastfeeding: Current Gaps and Future Directions

Although the literature examining the association between urban greenspace and birth outcomes is well established, its importance to breastfeeding has yet to be explored (Aktan et al., 2024; Banay et al., 2017; Villeneuve et al., 2022; Ye et al., 2024). While research suggests different pathways through which urban greenspaces may impact breastfeeding, a limited number of studies have directly examined the association between urban greenspace and breastfeeding. **These studies suggest that urban greenspace is an important SDOH for breastfeeding that warrants further research on its independent association and its role as an indicator of deprivation. This is a critical gap that this dissertation seeks to address.**

Housing

Housing and Health: An Overview

Housing is a key social determinant which impacts health in both direct and indirect ways (Braveman et al., 2011; D'Alessandro & Appolloni, 2020). Research has identified four ways that housing impacts health: 1) residential instability, 2) affordability (i.e., financial burdens of high-cost housing), 3) housing safety and quality, and 4) neighborhood (i.e., environmental and social characteristics of where people live) (D'Alessandro & Appolloni, 2020).

Individuals experiencing housing instability are more likely to have inadequate access to healthcare, poorer self-rated health, and worse mental health outcomes. Similar adverse health outcomes can be seen in individuals living in unaffordable housing and those struggling to pay their rent or mortgage. These individuals are more likely to have poorer self-rated health, worse mental health outcomes, and a higher risk of hypertension, and arthritis. Additionally, they often do not have a usual source of medical care and are less likely to access this care when needed. Poor physical characteristics of homes, such as outdated infrastructure and damaged housing, can

lead to in-home exposures to toxins that can cause neurological damage as well as development of chronic diseases and cancers. (D'Alessandro & Appolloni, 2020).

Housing and Breastfeeding: Exploring the Connection

Housing insecurity and household conditions are recognized as important SDOH to breastfeeding. In a scoping review which examined the impact of housing and living conditions on breastfeeding practices, researchers identified key housing-related factors that negatively impact breastfeeding, including type of housing, housing conditions, safe space to breastfeed, and homelessness (Hirani, S.A. & Ahmadi, 2023). These factors align with those found in the broader literature on health and housing (D'Alessandro & Appolloni, 2020). Regarding the type of housing, women who had stable housing, such as official housing, private housing, or owned their own home, had a higher likelihood of breastfeeding intention, initiation, and exclusivity (Hirani, S.A. & Ahmadi, 2023). Whereas women who had unstable housing or were living in public housing or informal settlements had a reduced likelihood of breastfeeding initiation, duration, and exclusivity (Hirani, S.A. & Ahmadi, 2023). Specifically, women facing housing insecurity may initiate breastfeeding but are likely to discontinue before the infant is four months of age. One reason for this is that women experiencing unstable housing invest a lot of time and energy in securing stable housing, which leaves little left to focus on breastfeeding. Another reason is the lack of social support provided to women living in homeless or emergency shelters (Hirani, S.A. & Ahmadi, 2023).

Regarding stress related to housing, studies have shown that living conditions can impact the mental health of breastfeeding women. Women facing unfavorable living situations often worry about high rent, personal safety, and the threat of eviction (Dharod et al., 2024). These stressors can lead to increases in anxiety, mental agony, inadequate sleep, and overall stress

(Dharod et al., 2024). This is concerning as stress-related high cortisol levels may cause delays in the milk ejection reflex, which can contribute to an inadequate milk supply (Dharod et al., 2024). Together, these factors can contribute to the early cessation of breastfeeding by increasing breastfeeding challenges and decreasing women's self-efficacy to breastfeed (Hirani, S.A. & Ahmadi, 2023).

Regarding housing conditions, unsanitary living conditions, characterized by insufficient ventilation, filthy carpets, pest infestations, and safety hazards, can negatively affect breastfeeding (Hirani, S.A. & Ahmadi, 2023). Additionally, living in a small, cramped, and unpleasant space with no private area to breastfeed poses a significant challenge to breastfeeding (Hirani et al., 2021). These living conditions are also associated with heightened maternal stress, which has led to women experiencing suicidal thoughts (Hirani, S.A. & Ahmadi, 2023). Therefore, a safe and secure home environment is crucial to support a positive breastfeeding experience (Hirani, S.A. & Ahmadi, 2023).

Accessing a safe, private space for breastfeeding is critical, yet continues to be a significant challenge among women who are living in homeless shelters or disaster relief camps (Hirani, S.A. & Ahmadi, 2023). Homeless shelters often do not provide private areas for nursing, pumping, or storing milk (Reilly et al., 2019; Standish & Parker, 2022). Women living in emergency shelters also indicate the absence of a private space to breastfeed as well as a lack of space for mothers to connect and share their experiences and breastfeeding practices with one another (Giusti et al., 2022).

A limited number of studies using neighborhood-level measures of housing, though mixed, provide further support for the importance of housing. Studies which use area-level housing indicators (e.g., median housing value and proportion of vacant housing units), as part of

broader indices of neighborhood socioeconomic status, disadvantage, and deprivation, have been linked to breastfeeding from hospital discharge through six months (Galante et al., 2022; Griswold et al., 2018a; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). However, the strength of these associations varied across breastfeeding practices and populations.

International and national studies using composite indices of neighborhood deprivation and socioeconomic status, which include area-level housing indicators (e.g., median housing value and proportion of vacant housing units), have shown significant associations with breastfeeding practices, even beyond individual-level factors (Galante et al., 2022; Griswold et al., 2018a; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). In general, greater neighborhood disadvantage (i.e., lower median housing value and higher vacancy rates) is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to six months (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018). These associations often attenuate but remain statistically significant after adjusting for maternal socio-demographic characteristics (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018), though some studies report non-significant findings post-adjustment. (Galante et al., 2022; Riley et al., 2016; Yourkavitch et al., 2018).

Additionally, these associations have been shown to vary by race and ethnicity. For example, some studies found that increasing neighborhood disadvantage was associated with lower odds of exclusive breastfeeding for all groups except White women, suggesting that the impact of neighborhood conditions may differ across racial and ethnic groups (Yourkavitch et

al., 2018). In contrast, few studies have found no association between neighborhood disadvantage, which include area-level housing indicators, and breastfeeding initiation (Cubbin et al., 2008; Riley et al., 2016). Overall, these studies suggest the importance of neighborhood disadvantage, including housing-based measures, as a significant factor that may independently influence breastfeeding initiation beyond individual-level characteristics.

Housing and Breastfeeding: Current Gaps and Future Directions

Housing is an important, yet underexplored, SDOH for breastfeeding. While research suggests different pathways through which housing may impact breastfeeding, limited research has directly examined this association. **Although limited, existing evidence suggests that housing is a key neighborhood-level factor that warrants further investigation, both as an independent influence and as an indicator of broader neighborhood quality. This is a critical gap that this dissertation seeks to address.**

Additionally, more research is needed to clarify the pathways through which housing impacts breastfeeding to better understand the underlying mechanisms driving this connection. Although the literature has identified several potential pathways explaining this relationship, few studies have explicitly tested the factors that mediate or moderate this relationship. Addressing these critical gaps could provide important insights into how housing, operating at an ecological level, influences breastfeeding practices.

Food Environment

Food Environment and Health: An Overview

A neighborhood's food environment is a critical determinant of an individual's access to, healthy, nutritious foods. One commonly used indicator of limited food access is residence in a food desert, which is defined as a low-income census tract where a substantial number or share of residents have limited access to retail outlets selling healthy and affordable food (Ver Ploeg,

M. et al., 2011). Food desert residence has been linked to poorer health behaviors, such as unhealthy dietary patterns (Gray et al., 2018), and worse health outcomes, including increased risk for cardiovascular disease and higher body mass indexes (Testa et al., 2021; Woodruff et al., 2020). As such, limited access to healthy foods, which is shaped by an individual's neighborhood environment, is a critical SDOH that has important implications for health behaviors and outcomes.

Food Environment and Breastfeeding: Exploring the Connection

A neighborhood's food environment is an important, yet understudied, SDOH within the breastfeeding literature. To my knowledge, only one study has directly examined the association between food access, measured by food desert residence, and breastfeeding. Ajoseh et al. (2025) used birth data from the Florida Department of Public Health and linked it with the USDA Food Access Research Atlas to obtain food desert residence, defined as census tracts where at least 20% of residents have incomes below 80% of the statewide median and where at least 500 people or 33% of the population live more than one mile (urban) or 10 miles (rural) from the nearest supermarket. The study found that mothers living in food deserts had 60% higher odds of not initiating breastfeeding, compared to those who do not. This association attenuated but remained significant after adjusting for maternal sociodemographic factors, with 23% higher odds of not initiating among food desert residents. Stratified analyses further revealed that the association was strongest among non-Hispanic Black women, followed by Hispanic and White women.

In another study, researchers examined the impact of food desert residence by including it as one of several indicators in a broader index of community resources. LoCasale-Crouch et al. (2024) used the Childhood Opportunity Index 2.0, which includes a measure of food access, to

examine the association between neighborhood resources and breastfeeding up to 6 months. The Childhood Opportunity Index food access using the percent of households without a car located further than a half mile from the nearest supermarket. They found that mothers living in highly resourced neighborhoods had significantly higher odds of any and exclusive breastfeeding at the two- to six-month postpartum follow-up, even after adjusting for child and maternal socio-demographic characteristics.

Although research on the neighborhood food environment and breastfeeding is limited, existing studies suggest that food access plays an important role in shaping breastfeeding practices, even beyond individual-level factors, and may contribute to breastfeeding disparities. Despite the limited research, studies have identified potential pathways linking the neighborhood food environment and breastfeeding. Limited access to affordable, healthy foods (associated with food desert residence) may have an adverse impact on a mother's ability and choice to breastfeed.

Nutrient deficiencies can lead to failed secretory activation and negatively impact milk production, secretion, and composition (Lee & Kelleher, 2016). This is concerning as these adverse effects may hinder a person's ability to breastfeed or influence their decision to do so. Maternal intake of fruits and vegetables has been found to be associated with breastfeeding duration, with the odds of breastfeeding for 6 months increasing by 2.5 times as daily intake increased from one to six servings (Amir & Donath, 2012). Additionally, mothers who perceive their diet to be poor (e.g., did not eat enough fruits and vegetables) often avoid breastfeeding due to beliefs that their breastmilk was inadequate and unable to provide their child with the necessary nutrients (Gross et al., 2019). These concerns often contributed to decisions to supplement with formula and stop breastfeeding (Gross et al., 2019).

Another major pathway through which limited access to affordable, healthy foods can impact breastfeeding is mental health. Studies have identified a link between unhealthy diet patterns and an increased risk of prenatal depression (Khan et al., 2020). This is concerning as poor mental health adversely affects breastfeeding practices. Women with perinatal mental health conditions (i.e., depression, anxiety, eating disorders, etc.) face several barriers to breastfeeding, which significantly affect their decision to initiate and continue breastfeeding (Billings et al., 2024). These include increased breastfeeding difficulties, negative breastfeeding attitudes, and lower breastfeeding confidence (Dias & Figueiredo, 2015). These challenges have contributed to poorer breastfeeding practices among women experiencing perinatal mental health conditions. High prenatal and postpartum anxiety (from delivery to six months) is linked to a lower likelihood of initiation, duration, and exclusivity, as well as an increased risk of early formula supplementation and breastfeeding cessation (Hoff et al., 2019) Similarly, prenatal and postpartum depression are associated with lower odds of intention and shorter durations of any and exclusive breastfeeding (Dias & Figueiredo, 2015).

Additionally, research has shown that areas identified as food deserts often overlap with hospital deserts (i.e., areas with limited access to healthcare facilities) and are more common in low-income communities (Y. Zhang et al., 2025). Food deserts may therefore serve as indicators of broader neighborhood deprivation and resource constraints important to breastfeeding. As discussed in previous sections, limited access to hospitals and lower NSES may have negative implications for breastfeeding outcomes.

Food Environment and Breastfeeding: Current Gaps and Future Directions

The neighborhood food environment is a critical determinant of access to affordable, healthy foods, which can influence both the decision to breastfeed and the ability to do so. Despite this, it remains an understudied SDOH within the breastfeeding literature. While research suggests different pathways through which the food environment may impact breastfeeding, limited research has directly examined this association. **Existing evidence suggests that food desert residence is a key neighborhood-level factor that warrants further investigation, both as an independent influence and as an indicator of broader socioeconomic deprivation. This is a critical gap that this dissertation seeks to address.** Although not within the scope of this dissertation, more research is also needed to clarify the pathways through which the food environment impacts breastfeeding to better understand the underlying mechanisms driving this connection.

Domain 5: Social and Community Context

Social and Community Context and Health: An Overview

The social and community context is a relatively newer and broader determinant of health that includes aspects of social connection such as social cohesion, social capital, social networks, and social support. Social cohesion broadly refers to the degree of solidarity and connectedness within a community or society (Ichiro Kawachi & Lisa Berkman, 2000). Two defining characteristics of social cohesion are the absence of latent social conflict and the presence of strong social bonds (Ichiro Kawachi & Lisa Berkman, 2000). Although there is no single, universally accepted definition, social cohesion is widely recognized as a multidimensional concept (Schiefer & Van Der Noll, 2017). Depending on the definition, it can encompass dimensions such as social relations, shared identity, orientation toward the common good, shared

values, quality of life, and (in)equality (Schiefer & Van Der Noll, 2017). These characteristics are key to minimizing social division and inequity and promoting social unity and collective action (Ichiro Kawachi & Lisa Berkman, 2000).

An important indicator of social cohesion is social capital, which is defined as "features of social structures-such as levels of interpersonal trust and norms of reciprocity and mutual aid-which act as resources for individuals and facilitate collective action" (Ichiro Kawachi & Lisa Berkman, 2000). Other forms of social capital include appropriable social organizations, which are formal or informal groups (e.g., neighborhood associations, online forums, local groups) that offer individuals a potential network for accessing resources and information, receiving support, or collaborating on common goals to improve the quality of life for community members (Ichiro Kawachi & Lisa Berkman, 2000). Social support (i.e., direct assistance received or perceived to be available through a social relationship) and social networks are key dimensions of social capital and can serve as a pathway through which social cohesion is observed and maintained (Duh-Leong et al., 2021).

Social cohesion and social capital impact health behaviors in many ways (Eriksson, 2011; Ferlander, 2007; Ichiro Kawachi & Lisa Berkman, 2000). Social capital aids in the diffusion of health information and, as a result, increases the adoption of health-promoting behaviors. Social capital also increases social control over deviant behaviors (i.e., underage drinking and smoking) and minimizes delinquency and crime, which help to create safer and healthier neighborhoods for all. Furthermore, social capital fosters a sense of collective responsibility, trust, and reciprocity, which are essential for providing both emotional and practical support to cope with daily stressors (e.g., child-rearing) (Ichiro Kawachi & Lisa Berkman, 2000).

Socially cohesive neighborhoods are better able to mobilize collective action to enact social change and transformation. Social cohesion increases levels of civic participation, which lead to stronger community engagement and the development of local initiatives that benefit residents. One way this is achieved is through the establishment of appropriable social organizations that can secure access to health-promoting services, such as community health clinics (Ichiro Kawachi & Lisa Berkman, 2000). As a result, socially cohesive communities are able to address both individual and collective needs to improve the health and quality of life for all residents.

Despite its potential significance to public health, social connection has often been overlooked (Holt-Lunstad et al., 2017). However, emerging research is recognizing it as a critical determinant of health (Holt-Lunstad et al., 2017). The presence of social connection is a strong predictor of longevity and improved overall health (Holt-Lunstad, 2024). Whereas a lack of social connection is associated with increased risks of suicide, premature death, and poorer physical health (e.g., malnutrition, cardiovascular diseases such as coronary heart disease, stroke, and heart failure), mental health (e.g., social anxiety, depression, psychosis, and suicidal ideation), and cognitive health (e.g., dementia) (Holt-Lunstad, 2024).

Social and Community Context and Breastfeeding: Exploring the Connection

The literature on social connection and breastfeeding is emerging and has primarily focused on individual-level measures such as social networks and social support, with little to no research on community-level measures such as social cohesion and social capital. Even when social capital is assessed, it is typically measured at the individual rather than neighborhood level.

For example, one study examined the association between social capital and breastfeeding initiation among low-income Puerto Rican women in the U.S., including those participating in WIC (Anderson et al., 2004). In this study, social capital was measured at the individual level by assessing respondents' access to personal relationships and the exchange of resources within their social networks. Specifically, respondents were asked whether they had family or friends who were most important to them living in the U.S. and whether they engaged in the following behaviors within their networks: 1) lending or borrowing money, 2) lending or borrowing goods (e.g., food, household items), and 3) exchanging services (e.g., errands, babysitting, cooking). Women with more social capital had twice the odds of initiating breastfeeding than those with less. The social capital dimension of exchanging services and support within their networks was a significant predictor of breastfeeding initiation, whereas lending and borrowing money or goods were not (Anderson et al., 2004). These findings suggest that social capital, in the form of practical support and reciprocity, is an important predictor of breastfeeding initiation.

Another study, though not looking at breastfeeding practices directly, used qualitative methods to explore whether social capital can be built through a voluntary model of breastfeeding peer support in North-West England (Thomson et al., 2015). Thematic analyses revealed peer support groups were able to successfully build three forms of social capital in the context of breastfeeding promotion: bonding (i.e., close connections and strong bonds between individuals in closed networks), bridging (i.e., distant connections between people, especially those from different interests or backgrounds), and linking (i.e., vertical interactions between individuals and people in positions of power).

Through bonding and bridging, peer support groups expanded mothers' social networks across ethnic, economic, and professional lines, which helped to facilitate the spread of breastfeeding knowledge, resources, and support. Mothers reported that these forms of support increased their confidence and motivation to breastfeed, which were associated with increased confidence and motivation to continue breastfeeding. Linking social capital enabled connections with healthcare providers, policymakers, and community organizations. These connections were useful in helping to promote breastfeeding and integrate support into community settings. These relationships supported initiatives such as breastfeeding-friendly public spaces, which helped address barriers like discomfort with breastfeeding in public. Together, these findings highlight the role of social capital in strengthening support networks, increasing access to resources, and fostering a more supportive environment for breastfeeding (Thomson et al., 2015).

Participation in federal assistance programs, specifically WIC, can help build social capital by connecting participants to supportive resources. This is particularly evident through WIC's Breastfeeding Peer Counselor Program, which pairs participants with staff members who are often from their own communities and have successfully breastfed themselves (Breastfeeding Peer Counselors: A Successful Program That Should Be Expanded, 2019). Additionally, WIC offers breastfeeding group classes that provide opportunities for parents to connect with one another and build supportive networks.

Although the literature on social cohesion and social capital is limited, the few studies available highlight the potential role they play in promoting breastfeeding. These studies identify key mechanisms through which social capital can improve breastfeeding practices, such as fostering supportive relationships, providing access to resources, diffusing information, and promoting a culture of breastfeeding. By strengthening networks and facilitating trust and

reciprocity, social capital and social cohesion help to overcome barriers to breastfeeding, such as societal stigma and lack of support.

The literature on social networks and social support is somewhat more developed and highlights the significance of these forms of social capital in promoting breastfeeding. These studies provide further justification for the relevance of social cohesion and social capital in promoting breastfeeding. Social networks are crucial sources of support and serve as key pathways through which breastfeeding knowledge and behaviors are disseminated. Within these networks, social support such as partner, family, and peer support, influence a woman's self-efficacy, confidence, time, and ability to breastfeed.

Supportive partner behaviors are categorized in four ways: knowledge (i.e., learning and applying breastfeeding knowledge), help (i.e., tangible assistance with household chores, breastfeeding, and caring for mother, newborn, or other children), encouragement (i.e., expressing appreciation for the mother breastfeeding and wishing her to continue), and responsiveness (i.e., attentiveness to the mother's needs, respect for her choices, promoting autonomy, co-parenting, and providing knowledge, help, and encouragement in a manner that is deemed acceptable by the woman (Davidson & Ollerton, 2020). These forms of active and positive support promote breastfeeding by helping women feel more capable and confident in their ability to breastfeed (Mannion et al., 2013).

In addition to support from partners, familial support is important in infant feeding decisions (Aubel et al., 2021). Globally, the role of familial support in improving breastfeeding practices, particularly in promoting exclusivity, is well established (Aubel et al., 2021; Masruroh & Istianah, 2019; Negin et al., 2016). Within the family support systems, grandmothers are recognized as highly active and influential figures due to their proximity, experience, and

commitment to the dyad (Aubel et al., 2021; Negin et al., 2016) . Grandmothers offer both emotional and informational support that encompasses nutrition advice, breastfeeding, cultural practices, caregiving and maternal mental health (Concha & Jovchelovitch, 2021). Furthermore, the cultural and social norms upheld by family members shape parental beliefs and practices related to the introduction of complementary foods (Dattilo et al., 2020).

Although limited, studies conducted within the U.S. have also recognized family support, especially from the grandmother, as a crucial factor in infant feeding decisions (Cisco, 2017; Snyder et al., 2021). Women who receive encouragement from their mother (i.e., maternal grandmother) are 12.4 times more likely to intend to breastfeed compared to those who do not receive such encouragement (Mahoney & James, 2000). While grandmothers are a primary source of emotional and informational support, other family members, such as maternal grandfathers, siblings, and in-laws, also contribute valuable support (Cisco, 2017). For example, more frequent discussions about breastfeeding with maternal grandfathers is associated with increased duration (Cisco, 2017).

Beyond the family system, peers (i.e., friends) have been identified as a critical source of breastfeeding support (Cisco, 2017). Research shows that mothers who receive emotional support from friends are 31% less likely to wean at any given time compared to those who do not receive such support (Cisco, 2017). Although this form of support is often less prioritized than that from partners and families, peers still offer valuable emotional and informational support for breastfeeding (Cisco, 2017).

The existing literature on social networks and social support, highlight the critical role they play in building social capital and strengthening social cohesion. The social capital built within a mother's network provides her with the necessary support, resources, and information

needed to overcome barriers to breastfeeding. When communities are rich in social capital and are more cohesive, they are more likely to create environments that support breastfeeding, through both informal (i.e., family and friends) and formal (i.e., healthcare systems and public policies) networks. Therefore, fostering social cohesion and leveraging social capital need to be integrated in public health efforts to create supportive environments for breastfeeding.

Social and Community Context and Breastfeeding: Current Gaps and Future Directions

The concept of social connection remains an understudied SDOH within the social and community context. Despite the importance of social connection to health, it remains largely absent from current national health objectives and health surveys in the U.S. There is an increasing call for greater inclusion of social connection in public health efforts at the local, state, and national level. One area of public health where the role of social connection is crucial yet underexplored is breastfeeding.

To date, the majority of research examining social connection and breastfeeding has focused on the role of social support and social networks, while less attention has been given to social capital and social cohesion. As a result, much of the literature focuses on the importance of individual-level measures of social connection and fails to capture the influence of social connection at the ecological level. Even when measures of social capital have been included in studies, they often focus on individual-level assessments rather than collective measures at the neighborhood-level.

The reliance on individual-level measures to assess aspects of social capital and social cohesion reflects a major measurement issue in the field (Ichiro Kawachi & Lisa Berkman, 2000). Since social cohesion and social capital are considered collective or ecological concepts, they should be measured at these levels (Ichiro Kawachi & Lisa Berkman, 2000). This

shortcoming inhibits our ability to draw accurate insights about the role of social capital in shaping breastfeeding practices. **To gain a more comprehensive understanding of the impact of social connection on breastfeeding, it is crucial that future research include ecological and collective measures of social cohesion and social capital. This is a critical gap that this dissertation seeks to address.**

Current Gaps in Research and Dissertation Focus

Research has highlighted SDOH, including income, education, employment, healthcare access, urban greenspace, transportation, food access, environmental pollution, and social connections, as critical factors for breastfeeding. However, the literature specifically examining these factors at a neighborhood-level remains limited, with some determinants being studied more extensively than others. Overall, the literature on neighborhood effects and breastfeeding remains underdeveloped and is still in its early stages. This dissertation contributes to the growing literature by addressing three major gaps:

- *Gap #1:* Limited understanding of how place-based SDOH shape breastfeeding practices
- *Gap #2:* Limited utilization and understanding of aggregate, place-based measures of SDOH and breastfeeding practices
- G*ap #3:* Limited understanding of how structural determinants, such as neighborhood racial/ethnic concentration, shape breastfeeding practices

To address these gaps, this dissertation aims to examine how place-based structural and social determinants of health influence individual-level breastfeeding practices. The aims of the three proposed studies are:

- *Study 1:* To examine how place-based SDOH, as measured through the neighborhood social and physical environment, help explain individual-level differences in

breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

- *Study 2:* To examine how neighborhood racial/ethnic concentration help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.
- *Study 3:* To examine how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

By integrating a place-based approach to study the impact of SDOH on breastfeeding, this dissertation expands the limited literature exploring how a neighborhood's social and physical environment influences differences in breastfeeding. In the following sections, I discuss the current gaps in the literature and how this dissertation attempts to address them.

Gap #1: Limited understanding of how place-based SDOH shape breastfeeding practices

This dissertation seeks to deepen the current understanding of how neighborhood environments influence breastfeeding practices, which remains a critical gap in the literature. Addressing this gap is especially important given the growing importance of place-based approaches in SDOH research (Liang et al., 2024; Ozieh et al., 2021; Palmer et al., 2019; Scribner et al., 2017). Despite this, the impact of neighborhood-level factors on breastfeeding remains largely underexamined. Although limited, the existing research suggests that the physical and social environments of neighborhoods can influence breastfeeding practices, even beyond individual-level factors. However, findings to date are mixed and vary depending on the population studied, the measures used, and the geographic context. This inconsistency underscores the need for further research that examines these relationships, especially in the U.S.

The current reliance on individual-level measures of SDOH in breastfeeding research has limited our understanding of how broader environmental and social conditions shape breastfeeding practices. While individual-level measures of SDOH provide important insights into how personal attributes and circumstances impact breastfeeding, they do not account for how the physical, social, and economic environment of a neighborhood impacts individual breastfeeding practices. This dissertation addresses this critical gap across all three studies, with each exploring a different dimension of how place-based SDOH affect breastfeeding. These dimensions include income, education, social connection, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access (*Study 1*, as well as the food environment (*Study 3*).

Gap #2: Limited utilization and understanding of aggregate, place-based measures of SDOH and breastfeeding practices

Beyond the general lack of understanding of how place-based factors impact breastfeeding, the use of aggregate, place-based measures of SDOH are even more limited. This shortcoming has led to an inadequate understanding of how different aspects of neighborhoods collectively impact breastfeeding practices. SDOH do not operate in isolation, rather they are interconnected and influence each other in ways that collectively shape health outcomes as described in this chapter. Emerging studies have shown that individuals exposed to multiple adverse SDOH are more likely to develop poor health outcomes, including depression and all-cause mortality (Liang et al., 2024; Ozieh et al., 2021). To better understand how neighborhoods impact breastfeeding, it is important to consider the complex ways in which different SDOH interact.

To date, research has predominantly focused on the independent associations of various SDOH to breastfeeding, typically examining each one separately rather than considering their cumulative impact. Few studies have explored the cumulative effects of various SDOH on breastfeeding using multi-dimensional approaches that account for multiple factors at one time. One study in the U.S. examined the association between breastfeeding duration and the Childhood Opportunity Index 2.0, which is a composite index comprising 29 indicators of SDOH across three weighted domains (LoCasale-Crouch et al., 2024). In the U.K., two studies examined the association between breastfeeding practices and neighborhood deprivation using the Index of Multiple Deprivation, a composite measure that includes 37 indicators of SDOH across seven weighted domains (Oakley et al., 2013; Peregrino et al., 2018).

Other studies have tried to capture cumulative risk by using less comprehensive measures of neighborhood disadvantage, affluence, or deprivation (Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Griswold et al., 2025; Kummer et al., 2020; Riley et al., 2016; Yourkavitch et al., 2018). These measures include far fewer SDOH compared to more comprehensive approaches, such as the Childhood Opportunity Index and Index of Multiple Deprivation, and are limited to socio-economic indicators (i.e., income, employment, and education). These measures, while important, do not account for other critical SDOH that shape breastfeeding practices, such as access to transportation, environmental quality, and social connections. Although limited, existing evidence research suggests the importance of considering the cumulative effect of adverse SDOH on breastfeeding practices.

To address these gaps, *Study 1* of this dissertation will explore both the cumulative and individual relationships between place-based measures of SDOH and breastfeeding practices. To do this, a multidimensional, place-based index of community health, grounded in SDOH, will be

used. By adopting a place-based approach, this dissertation will provide insights into the often-overlooked intersection of place, SDOH, and breastfeeding.

Gap #3: Limited understanding of how structural determinants, such as neighborhood racial/ethnic concentration, shape breastfeeding practices

In addition to the limited research on how place-based SDOH shape breastfeeding, only two studies have examined the structural forces that produce and sustain these neighborhood conditions. In particular, neighborhood racial/ethnic concentration is a critical, yet understudied, structural mechanism that influences the distribution of resources (e.g., place-based SDOH) within the neighborhood environment. The influence of neighborhood racial/ethnic concentration has been primarily understood through two distinct but complementary bodies of literature: the segregation literature and the ethnic density literature.

According to the segregation literature, racial residential segregation (e.g., high concentrations of a racial/ethnic minority population) is a key mechanism that produces concentrated disadvantage and unequal geographies of opportunity (Acevedo-Garcia et al., 2008). In contrast, the ethnic density perspective suggests that living among individuals of similar racial/ethnic backgrounds (e.g., high neighborhood Hispanic concentration) may confer protective benefits through shared norms, social support, and cultural cohesion. Together, these frameworks highlight that neighborhood racial/ethnic concentration may operate through both structural disadvantage and potential protective pathways.

Consistent with the segregation literature, existing research, while limited, suggests that higher neighborhood concentration of minority populations may have potentially harmful effects on breastfeeding. One study assessed neighborhood concentration using several measures, including the percentage of Hispanic residents, African American residents, and immigrants

within a census tract (Burdette, 2013). Although no statistically significant associations with breastfeeding were found, the consistently below-one odds ratios that were observed suggest that higher neighborhood concentration of minority populations may be associated with lower odds of breastfeeding (Burdette, 2013). Another study examined the association between perceived neighborhood racial concentration during childhood and breastfeeding outcomes (Griswold et al., 2018a). The findings indicated that living in a predominantly Black neighborhood up to age 18, compared to a predominantly White neighborhood, was associated with lower odds of breastfeeding. Based on the emerging evidence, neighborhood racial/ethnic concentration may be impacting breastfeeding through structural pathways of disadvantage that are more consistent with the segregation literature. However, this area of research is extremely limited and the relationship remains unclear.

To address this critical gap, *Study 2* of this dissertation examines how neighborhood racial/ethnic concentration, specifically neighborhood Hispanic concentration, shapes breastfeeding practices. Given the limited literature and the potential for both harmful and protective effects, an exploratory approach was taken. By examining concentration more broadly, this study aims to understand how the spatial distribution of populations influences breastfeeding and serves as a foundational starting point for further investigation in this area.

Chapter Summary

This chapter provided a comprehensive overview of the nine SDOH relative to this dissertation and their impact on breastfeeding: 1) income, 2) education, 3) employment, 4) healthcare access, 5) urban greenspace, 6) transportation, 7) food access, 8) environmental pollution, and 9) social connections. The chapter outlined existing connections and potential pathways through which these SDOH impact breastfeeding practices. Current gaps in the

literature were also identified, including the limited research examining the relationship between neighborhood-level structural and social determinants of health and breastfeeding practices. Chapter 3 builds on this foundation by introducing the theoretical frameworks guiding this dissertation to help understand the mechanisms through which neighborhood social and physical environments influence breastfeeding.

CHAPTER 3: Theory

Chapter Overview

This chapter provides an overview of the theories and frameworks that form the theoretical foundation for this dissertation including the Socioecological Model, the SDOH framework, and the neighborhood effects literature. As outlined in Chapters 1 and 2, breastfeeding is influenced by various multi-level factors, including those at the individual-level to the societal-level. Therefore, the theories and frameworks presented in this chapter were selected because they highlight the importance of both individual and contextual factors in understanding health behaviors.

Socioecological Model (SEM)

The SEM, developed by Urie Bronfenbrenner, takes an ecological approach to understanding human development (Bronfenbrenner, 1977). The SEM explains how individual behavior and development are shaped by multiple levels of influence, from personal characteristics to broader social, community, and policy environments. He proposed that individuals develop within a nested set of five subsystems: 1) microsystem, 2) mesosystem, 3) ecosystem, 4) macrosystem, and 5) chronosystem. Together, these nested subsystems form the larger ecological framework that explains how context shapes human growth and development (Bronfenbrenner, 1977).

At the most granular level is the microsystem. This subsystem describes the proximal processes (e.g., activities, social roles, and relationships) that occur between an individual and their immediate environments (e.g., home, school, workplace, etc.). These are settings where direct, face-to face interactions take place and influence development and behavior. The mesosystem is the second level and describes the connections and interactions between different

microsystems (e.g., the relationship between home and school). The exosystem is the third level and describes environments, outside of an individual's microsystems and mesosystems, that indirectly influence the individual (e.g., parent's workplace). The fourth level is the macrosystem which describes broader societal and cultural influences (e.g., social norms). Finally, the fifth level and most distal is the chronosystem. This subsystem accounts for the dimension of time (e.g., life transitions and sociohistorical contexts) (Bronfenbrenner, 1977).

While the conception of Bronfenbrenner's SEM is rooted in Developmental Psychology, his framework has been applied to and adapted for the field of public health. An important concept introduced by Bronfenbrenner is that human growth and development are influenced by multiple levels. Building on this foundational concept, McLeroy and colleagues (1988) expanded Bronfenbrenner's framework to a public health context by proposing five levels of influence on health outcomes and behaviors:1) intrapersonal factors, 2) interpersonal factors, 3) institutional or organizational factors, 4) community factors, and 5) public policy factors.

The first level consists of intrapersonal factors and includes individual-level characteristics (e.g., knowledge, attitudes and skills). The second level consists of interpersonal factors and includes formal and informal social networks, including family, friends, and coworkers. The third level consists of institutional factors and includes social institutions and the organizational characteristics of these institutions (e.g., rules and policies). The fourth level consists of community factors and includes relationships among organizations, institutions, and informal network. Finally, the firth level consists of public policy factors and includes laws and policies at the local, state and national level (McLeroy et al., 1988).

Since the adaptation of the SEM to public health, its use in health research has become widespread. The SEM has been widely applied in public health research to better understand a

broad range of topics, including physical activity, healthy eating, mental health, and COVID-19 vaccination uptake and hesitancy (Al-Jayyousi et al., 2021; Fenta et al., 2023; Kousoulis & Goldie, 2021; Tehrani et al., 2016; Townsend & Foster, 2013). One example of how the foundational concepts of the SEM have been used to better understand the multilevel influences on breastfeeding was introduced in Chapter 1 (see Figure 1). This model offers a systematic approach to examining how historical, socioeconomic, cultural, and individual factors contribute to breastfeeding practices (Rollins et al., 2016).

At the structural level, societal factors shape the interactions, policies, practices, and information related to breastfeeding within three primary settings: 1) health systems and services, 2) family and community, and 3) workplace and employment. At the individual level, characteristics of the mother (e.g., income, health status, age, education), infant (e.g., health status), and their relationship affect the mother's ability, confidence, and self-efficacy to breastfeed. Additionally, how the mother experiences, interprets, and internalizes the broader societal norms and systemic conditions also impact her ability, confidence, and self-efficacy to breastfeed. Together, these multilevel factors interact with each other to shape a woman's approach, beliefs, and decisions regarding breastfeeding (Rollins et al., 2016).

A major strength of the SEM is that it provides a way to understand the complex and dynamic interplay of health-related factors across multiple levels. At the same time, the multilevel nature of SEMs poses important practical limitations. For example, socioecological interventions have been found to be too resource- and time intensive-to implement because it requires close coordination of individuals across various sectors and the use of multi-level, multi-method assessments of program outcomes (Stokols, 1996). Furthermore, the breadth of SEMs has been identified as potentially over-inclusive of all health-relevant factors, which can make it

challenging to target specific variables for study or intervention (Stokols, 1996). Despite these limitations, SEMs still provide a valuable way to move beyond the 'silo effect' of investigating health in isolation and encourages more interdisciplinary, cross-level, and cross-sectoral ways of understanding health (Stokols, 1996).

For these reasons, the SEM serves as an important foundational framework for this dissertation because it captures the complex, multilevel nature of breastfeeding. It provides a way to think more dynamically about how health-relevant factors interact across multiple levels to influence breastfeeding. By using the SEM, it shifts the traditional framing of breastfeeding as an individual choice to one that is influenced by broader contextual factors.

Social Determinants of Health (SDOH) Framework

SDOH are defined as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life" (*Social Determinants of Health*, n.d.). These determinants are non-medical and include various social, economic, environmental, and political factors (*Social Determinants of Health*, n.d.). Research has shown that social and environmental factors account for approximately 50% of the variation in health outcomes, whereas medical care is responsible for only 34% (Hood et al., 2016). This suggests that SDOH are critical in shaping both individual and community health, above and beyond medical care.

Since its conception, several SDOH frameworks have been developed to better understand their role in addressing health inequities. Although distinct, these frameworks share a set of unifying principles for the mechanisms through which social determinants influence health (Thimm-Kaiser et al., 2023). These principles are rooted in concepts from various perspectives

such as fundamental cause theory, risk environment frameworks, SEM, life course theory, and biopsychosocial models (Thimm-Kaiser et al., 2023).

Through these paradigms and perspectives, the SDOH framework provides a more nuanced way to identify and understand the multilevel, non-medical conditions that shape health. While the SEM identifies the levels of influence on health, the SDOH identifies the types of non-medical factors that are relevant within each level of the SEM. Therefore, the integration of the SDOH framework, alongside the SEM, is central to this dissertation.

The concept of SDOH can be traced back to as early as the 1800s from the seminal works of scholars such as Edwin Chadwick and W. E. B. Du Bois (Davis, 2022). Through Chadwick's report on the Sanitary Condition of the Laboring Population of Great Britain (Chadwick, 1842) and Du Boi's book *The Philadelphia Negro: A Social Study (Du Bois, W. E. B. & Eaton, I., 1899),* these scholars began a paradigm shift toward social and structural determinants of health (Davis, 2022). Building on this foundation, the United Kingdom Whitehall Studies of British civil servants was conducted in the mid-1900s to investigate the influence of SDOH on mortality. Their work showed an inverse social gradient in mortality, which provided further support to the importance of SDOH (Marmot et al., 1991). This work contributed to the establishment of the World Health Organization (WHO) Commission on SDOH in 2005, to support countries in addressing social and structural factors of health inequities (Davis, 2022). The Commission's efforts were critical in bringing SDOH to a global scale and integrating them into political action. Following this, the concept of SDOH began to gain traction in the U.S. in 2010 through the Healthy People 2020 (Davis, 2022). Through this report, social determinants were formally recognized as key concepts for understanding health in the U.S.

Although the SDOH framework revolutionized the way determinants of health are conceptualized, scholars have identified theoretical and practical limitations of its application in modern times (Frank et al., 2020; Harvey et al., 2022). For example, the SDOH framework has been criticized for being overly descriptive about inequalities without adequately addressing the underlying processes that contribute to them (Frank et al., 2020). The SDOH framework has also been criticized for reducing complex social processes into isolated risk factors and overlooking the dynamic interplay of factors (Frank et al., 2020). Furthermore, the emphasis on disadvantage and social conditions within traditional SDOH frameworks continues to overlook the importance of more structural factors, such as political and economic forces that create and sustain inequities (Harvey et al., 2022). Despite these limitations, the SDOH offers a core framework for public health research, policy, and practice, to address health-relevant factors (Frank et al., 2020; Harvey et al., 2022). However, to remain relevant for indefinite use it must evolve (Frank et al., 2020; Harvey et al., 2022)..

Considering their significant impact on health, addressing SDOH remains a central strategy in public health efforts to improve population health, including Healthy People 2030 (Gómez et al., 2021; Palmer et al., 2019). One of the five overarching goals of Healthy People 2030 is directly related to addressing SDOH: “Create social, physical, and economic environments that promote attaining the full potential for health and well-being for all” (Healthy People 2030, n.d.). To guide this effort, Healthy People 2030 established a framework (see Figure 2) that categorizes SDOH into five key domains: 1) economic stability, 2) education access and quality, 3) health care access and quality, 4) neighborhood and built environment, and 5) social and community context (Healthy People 2030, n.d.). Detailed descriptions of each domain were discussed in Chapter 2.

The integrated use of the SDOH and the SEM in this dissertation brings a multilevel perspective to the SDOH framework that it currently lacks. A modified version of the Healthy People 2030 framework was used to guide the literature review in Chapter 2 and explore the connection between SDOH and breastfeeding. The literature review identified existing connections and potential pathways through which SDOH, across individual, setting, and structural levels, impact breastfeeding practices. Therefore, inclusion of a SDOH framework provides important additional theoretical grounding for this dissertation.

To better understand the role of SDOH in shaping health disparities, researchers and health organizations have emphasized the need to take a place-based approach (Palmer et al., 2019; Scribner et al., 2017). To address this growing need, this dissertation adopts a place-based perspective. While the Healthy People 2030 framework and the SEM provide a broad understanding of how SDOH at multiple levels influence health, there is less emphasis on the role of place. Therefore, this dissertation will draw on the neighborhood effects literature to center the role of place-based factors, which are overlooked in the SEM and SDOH frameworks. Additionally, drawing on the neighborhood literature helps address an identified limitation of SDOH frameworks, which is its inability to explain processes through which SDOH create and sustain health inequities.

Neighborhood Effects

This dissertation draws on a large body of interdisciplinary scholarship known as neighborhood effects. Rather than a single theory, the neighborhood effects literature consists of contributions from multiple scholars who have introduced distinct but complementary ideas. Broadly, neighborhood effects refer to the idea that where people live has a significant and independent influence on their health, behavior, and life outcomes, beyond their individual-level

characteristics (Sampson et al., 1997). Neighborhoods are conceptualized as comprising both social and physical environments (Diez Roux, 2001; Diez Roux & Mair, 2010). The physical environment encompasses the tangible characteristics, both natural and man-made, of a neighborhood (e.g., transportation, green spaces, sidewalks, environmental pollution, as well as access to healthy food and health facilities) (Diez Roux, 2001; Diez Roux & Mair, 2010). Whereas the social environment encompasses the social relationships, norms, and structures within a neighborhood (e.g., social cohesion, collective efficacy, social capital, social connection, as well as economic and employment opportunities) (Diez Roux, 2001; Diez Roux & Mair, 2010; Sampson et al., 1997).

Neighborhood conditions and access to resources within these environments are not distributed equally but instead are shaped by structural, historical, and policy-driven forces (Acevedo-Garcia et al., 2008; Diez Roux, 2001; Diez Roux & Mair, 2010; Sampson et al., 1997). Neighborhood racial/ethnic concentration is conceptualized as a key structural mechanism that shapes the distribution of resources and conditions within neighborhoods, with the potential to confer both risks and benefits.

These mechanisms are primarily understood through two distinct but complementary perspectives: the segregation literature and the ethnic density literature. The segregation literature highlights how the spatial concentration and physical separation of racial/ethnic minority populations can adversely affect health through concentration of structural disadvantage (e.g., neighborhood poverty) (Acevedo-Garcia et al., 2008; Diez Roux, 2001; Diez Roux & Mair, 2010; Sampson et al., 1997). In contrast, the ethnic density literature highlights how this spatial distribution may have protective effects on health through enhanced social and cultural processes (e.g., social support, social norms, and social capital) (Zhang, et al., 2017). This dissertation

takes an exploratory approach to examining how neighborhood racial/ethnic composition shapes breastfeeding practices, as these relationships operate through dual pathways reflecting both structural constraints and enhanced sociocultural processes.

Generally, these processes reflect the ways in which the neighborhood effects literature conceptualizes contextual influences on health. However, the field does not have a single unified theory, instead it consists of contributions from multiple scholars who have introduced distinct yet complementary frameworks and ideas. Drawing on this interdisciplinary body of work further strengthens the theoretical foundation established by the SEM and SDOH frameworks by centering place-based and contextual factors as key mechanisms through which the broader social, economic, and political factors are operationalized. Given this dissertation's focus on structural and contextual determinants, it is necessary to draw on concepts and theories from the neighborhood effects literature. In the following sections, the key scholars and frameworks used to guide this dissertation are described.

Robert J. Sampson is a sociologist and a foundational scholar who helped to introduce the concept of neighborhood effects (Sampson et al., 1997). Sampson argues that social structures of neighborhoods, such as social cohesion, collective efficacy, and social disorganization, shape an individual's life chances, including their health. He further emphasizes that these neighborhood conditions are shaped by broader structural processes that influence the distribution of resources and opportunities across neighborhoods.

A key structural mechanism shaping the neighborhood environment, according to Sampson, is residential segregation. He proposes that segregation produces and reinforces neighborhood inequality by creating differential access to social and institutional resources (e.g., quality schools and healthcare), thereby concentrating disadvantage and fostering disinvestment.

Sampson emphasizes that this differential access to resources can become embedded in the social mechanisms and processes of neighborhood. For example, Sampson's research shows that highly segregated and high-poverty neighborhoods experience increased exposure to violence and social disorganization. These neighborhood-level conditions can have an adverse impact on neighborhood-level social processes such as collective efficacy (i.e., a community's shared ability to maintain social order and foster mutual trust). Without this shared trust, neighborhoods may struggle to advocate for needed services to address disadvantage and inequity.

Overall, Sampson's work provides a foundational understanding of how neighborhood-level factors, particularly social processes, are shaped by structural forces and can impact access to resources, including those that support breastfeeding. His work is highly relevant to this dissertation because, as discussed in Chapter 2, social processes (e.g., collective efficacy) are critical to breastfeeding and their absence can have adverse consequences on outcomes. Building on this foundation, scholars such as Ana Diez Roux and Dolorez Acevado-Garcia have expanded the Sampson's neighborhood effects framework and extended its application to the field of public health.

Ana Diez Roux is credited as one of the first scholars to apply the neighborhood effects framework to the field of public health (Diez Roux, 2001). She has also made critical contributions to the methodological study of neighborhood health effects by introducing and advancing multilevel analyses to the field of public health. These methodological contributions will be discussed more in Chapter 5 of this dissertation.

According to Diez Roux, the integration of neighborhoods and health addressed four emerging trends in public health (Diez Roux & Mair, 2010). First, there was a growing recognition that individual-based explanations of health were insufficient on their own.

Neighborhoods, both their physical and social attributes, presented an underexplored but potentially relevant context to examine group- and context-level characteristics as determinants of health. Second, there was a continued interest in understanding racial/ethnic differences in health. Considering place of residence is patterned by socio-economic position and race/ethnicity, neighborhoods could be a relevant and significant contributor to health inequities. Third, there was a growing need to consider the health effects of non-health related policies. Neighborhoods are important settings for non-health policies, including housing policy or urban planning policy, that could affect health through their impact on where people live. Lastly, there was an increasing availability and advancement of methods to more accurately study neighborhood health effects (e.g., multilevel analysis, Geographic Information Systems, and spatial analysis techniques).

Diez Roux adopted Sampson's premise that place matters but expanded his initial framework beyond social processes to include physical and environmental factors (e.g., access to green space, walkability, pollution) (Diez Roux, 2001; Diez Roux & Mair, 2010). Figure 3 illustrates a framework she developed, along with her colleague, to describe the processes through which neighborhood social and physical environments contribute to health and health inequalities (Diez Roux & Mair, 2010). In line with Sampson, her framework emphasizes residential segregation as a key structural mechanism which contributes to inequalities in resources across neighborhoods. This relationship is mutually reinforcing, meaning the differential access to resources can lead to further segregation. The dynamics between these structural forces can impact the conditions and resources available in neighborhood social and physical environments. This is consistent with Sampson's original framework but expands it to include the critical role of physical environments. Importantly, she also views the relationship

between the neighborhood physical and social environment as mutually reinforcing. Another way Diez Roux extends Sampson's original framework is by including behavioral and stress processes at the individual-level as key pathways through which the neighborhood-level conditions in the social and physical environments impact health. Additionally, she suggests that the impact of neighborhood conditions on health may be modified by individual-level characteristics (e.g., maternal resources, psychological resources, and biological attributes).

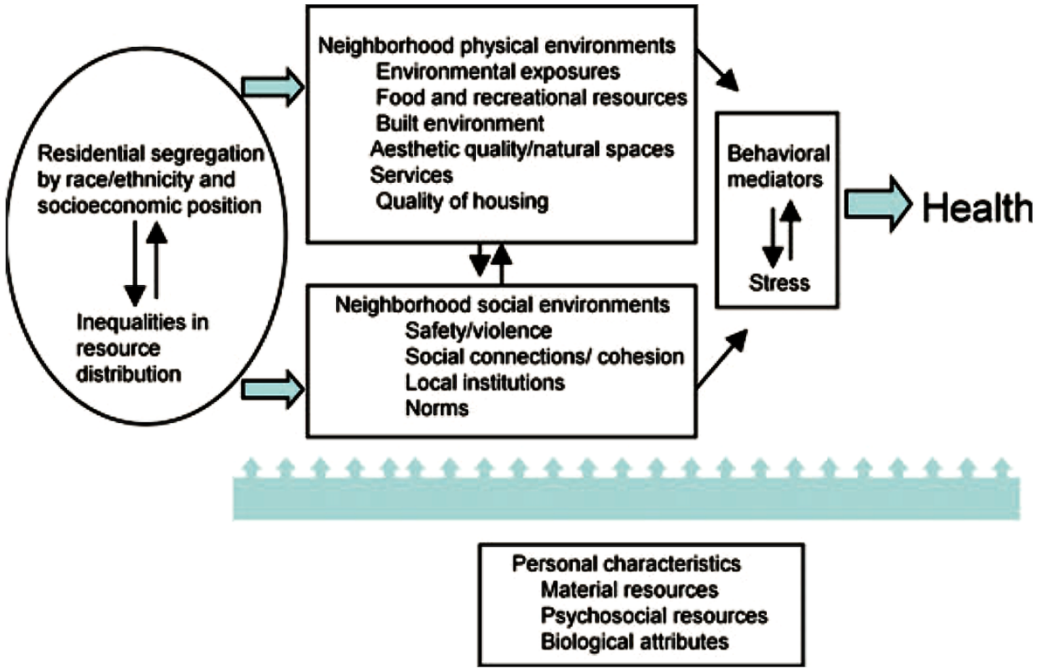


Figure 3. Schematic representation of the contributions of neighborhood environments to health inequalities (Diez Roux & Mair, 2010).

Diez Roux's introduction of neighborhood effects into the field of public health and her expansion of Sampson's framework provides important theoretical grounding for this dissertation. She builds on Sampson's work and makes it more relevant to this dissertation by incorporating both the physical and social environments and identifying pathways through which they influence health. (Diez Roux & Mair, 2010). As discussed in Chapter 2, features of the

neighborhood physical and social environment are relevant to breastfeeding. For these reasons, her work is relevant and central to this dissertation.

Using the groundwork laid by Diez Roux, Dolores Acevado-Garcia extended the application of neighborhood effects to child health and health disparities (Acevedo-Garcia et al., 2008). Her work is especially relevant to this dissertation, as the focus is on breastfeeding practices which is critical to child health. While there is much overlap with the work of Diez Roux and Sampson, Acevedo-Garcia's contributions have been critical in emphasizing the role of residential segregation in shaping unequal geographies of opportunity and their influence on child health disparities. Inclusion of her work further strengthens the theoretical foundation laid by Sampson and Diez Roux by demonstrating the relevance of neighborhood effects to child health and supporting its application to breastfeeding.

Acevado-Garcia (2008) created a policy framework to understand and address the geographic aspects of child health disparities known as the 'geography of opportunity framework.' Within this framework, she proposes that the neighborhood social and physical environments shape neighborhood-based opportunities which significantly influence the health and well-being of individuals and communities. An opportunity neighborhood is defined as a residential area that provides neighborhood-based opportunities that support health, including access to sustainable employment, high-performing schools, health care, adequate transportation, and neighborhood safety. These can span both the neighborhood social and physical environments. As discussed in Chapter 2, these neighborhood-level pathways can have an adverse impact on breastfeeding practices.

According to Acevado-Garcia, access to opportunity neighborhoods is deeply racialized. Children from racial/ethnic minority groups disproportionally have limited access to opportunity

neighborhoods compared to their White counterparts (Acevedo-Garcia et al., 2008, 2020). The Child Opportunity Score, which reflects neighborhood conditions and access to resources across domains such as education, health and environment, and social and economic factors, is more than three times higher for White children than for Black children and more than twice as high as for Hispanic children (Acevedo-Garcia et al., 2020). A substantially higher proportion of poor Black (66%) and Hispanic (50%) children live in very low-opportunity neighborhoods compared to poor White children (20%) (Acevedo-Garcia et al., 2020) . Similarly, mothers of color, particularly Black and Hispanic mothers, are disproportionately represented in lower-resourced communities, while White mothers are significantly more likely to reside in higher-resourced neighborhoods (LoCasale-Crouch et al., 2024). These disparities show that racial/ethnic minority children and women are disproportionately exposed to high-poverty environments, which often lack the resources and conditions needed to support healthy development.

These patterns of disproportionate access to resources are the result of residential segregation (Acevedo-Garcia et al., 2008). Greater residential segregation is associated with increased exposure to adverse neighborhood conditions including higher rates of crime, air pollution as well as limited access to quality education, transportation, healthy food outlets, and employment opportunities (Acevedo-Garcia et al., 2008). In metro areas with the highest levels of residential segregation, 86% of Black children reside in neighborhoods with poverty levels greater than those experienced by 25% of white children living in the highest poverty (Acevedo-Garcia et al., 2008). In contrast, in metro areas with the lowest segregation, this drops to 56%. A similar trend is seen among Latino children (74% and 44, respectively) (Acevedo-Garcia et al., 2008). These disparities underscore the critical role of racial residential segregation in creating

and maintaining unequal geographies of opportunity, disproportionately impacting racial/ethnic minorities (Acevedo-Garcia et al., 2008).

Studies examining patterns of neighborhood racial/ethnic concentration, often used as a proxy for racial residential segregation, provides further insight into how neighborhood racial composition influence health. As discussed above, segregation disproportionately impacts both Latino and Black communities. However, its effects have been shown to vary across populations (Bécares et al., 2012).

Among Black populations, higher levels of co-ethnic concentration have often been associated with poorer health outcomes. This has been attributed to the fact that high Black concentration frequently occurs within contexts of concentrated disadvantage, including higher rates of neighborhood poverty and is often linked to hypersegregation. In contrast, among Hispanic communities, high co-ethnic concentration is inconsistently associated with poorer health outcomes. One reason for these patterns is that Hispanic concentration, compared to Black concentration, is less likely to reflect extreme forms of disadvantage (e.g., hypersegregation). These mixed findings suggest a less clear influence of Hispanic neighborhood concentration, with the potential to confer both health risks and benefits.

The contributions presented by Sampson, Diez Roux, and Acevedo-García emphasize racial residential segregation as a critical structural force in creating unequal geographies. These processes reflect how the spatial distribution of racial/ethnic groups operate through pathways of structural disadvantage to adversely affect health. However, this body of research represents only one perspective. Other scholars have proposed an opposing perspective, known as the ethnic density effect, which posits neighborhood racial/ethnic concentration may have protective effects on health.

In contrast to the segregation perspective, the ethnic density perspective suggests that neighborhood racial/ethnic concentration, often discussed in relation to co-ethnic residence, may have protective effects on health. This perspective represents conceptually distinct processes from the structural pathways of disadvantage emphasized in the segregation literature. The mechanisms underlying these protective pathways are sociocultural processes including increased social cohesion, reduction in everyday discrimination, shared cultural norms, and stronger social support networks (Bécares et al., 2012; Bennett et al., 2020; Pickett & Wilkinson, 2008).

These protective processes have been observed across racial/ethnic minority populations (e.g., Black and Asian American groups) but appear to be most consistent and strongest among Hispanic populations (Bécares et al., 2012). For example, research among Hispanic populations has found that social cohesion mediates the relationship between neighborhood Hispanic concentration and mental health. Specifically, greater neighborhood Hispanic concentration is associated with increased social cohesion, which leads to improved mental health outcomes (Hong et al., 2014). Similarly, research among Hispanic women has found that higher collective efficacy (i.e., the extent to which communities exhibit social cohesion and informal social control) is associated with lower levels of depression (Vega et al., 2011).

As discussed in Chapter 2, social cohesion is an important aspect of the social environment through which neighborhoods may influence health outcomes. Socially cohesive neighborhoods are better able to mobilize collective action to enact social change and transformation through stronger community engagement and the development of local initiatives that benefit residents (e.g., community health clinics) (Ichiro Kawachi & Lisa Berkman, 2000). Additionally, social capital fosters a sense of collective responsibility, trust, and reciprocity,

which are essential for providing both emotional and practical support to cope with daily stressors (e.g., child-rearing) (Ichiro Kawachi & Lisa Berkman, 2000).

Another study among Hispanic populations found that the relationship between neighborhood racial/ethnic concentration and psychological distress was mediated primarily through reduced exposure to discrimination (Bécares, 2014). Discrimination is a key psychosocial stressor with well-documented negative effects on health (Williams et al., 2019). These effects have been attributed to the weathering process, in which chronic stress leads to sustained physiological strain and cumulative wear and tear (Simons et al., 2021). Therefore, reductions in exposure to discrimination may help interrupt this process and improve health outcomes.

The dynamics outlined in the ethnic density effect are most characteristic of ethnic enclaves, where these sociocultural processes are at play. Ethnic enclaves reflect neighborhood contexts characterized by concentrated co-ethnic residence along with shared social, economic, and cultural systems. In this way, they represent a more multidimensional measure of racial/ethnic concentration. In Latino populations, this has been described as the "barrio advantage" (Eschbach et al., 2004). This advantage is reflected in the phenomenon known as the Hispanic paradox, in which Hispanic populations exhibit more favorable health outcomes despite socioeconomic disadvantage (Velasco-Mondragon et al., 2016). These health benefits associated with high Hispanic neighborhood concentration extend beyond Hispanic populations and have also been observed for individuals of non-Hispanic origin (Shaw & Pickett, 2013).

Overall, the ethnic density perspective suggests that neighborhood racial/ethnic concentration may influence health through multiple social and cultural pathways, including social cohesion, reduced exposure to discrimination, and the reinforcement of shared cultural

norms. These findings highlight the importance of considering the potentially protective effects of neighborhood context on health among racial/ethnic minority populations, particularly Hispanic populations. This body of literature is critical to this dissertation as it expands on the structural disadvantage pathways proposed by the segregation literature. It builds on this by recognizing that even within disadvantaged contexts, co-ethnic concentration may shape sociocultural processes in ways that are protective for health behaviors and outcomes.

The two perspectives presented above are critical to this dissertation, as they provide a more complete understanding of the relationship between neighborhood racial/ethnic concentration and health. This is particularly important considering studies on ethnic density and health have resulted in inconsistent findings, with some demonstrating protective effects and others reporting detrimental or null associations (Bécares et al., 2012). Guided by these two bodies of research, this dissertation conceptualizes neighborhood racial/ethnic concentration as a multidimensional construct that reflects both structural inequalities and potential protective processes, rather than a single underlying mechanism. These bodies of work form the theoretical foundation for the exploratory approach used in this dissertation to examine how structural and neighborhood conditions shape breastfeeding practices.

Taken together, the neighborhood effects literature presented here provides important theoretical grounding that complements and helps address gaps in the SEM and SDOH frameworks. It offers a more focused lens on specific neighborhood factors that influence health that adds specificity to the broader perspectives of the SEM and SDOH frameworks that often overlook the role of place. Moreover, this literature helps explain the processes through which place-based SDOH create and sustain health inequities, while also emphasizing the influence of larger structural forces such as racial/ethnic concentration.

An Overarching Theoretical Framework Linking Structural and Neighborhood Factors to Breastfeeding

Figure 4 illustrates the overarching theoretical framework guiding this dissertation. This framework was adapted from a conceptual framework, developed by Northridge and colleagues (Northridge, 2003), outlining the pathways through which social, political, and economic processes interact with the built environment to affect health and well-being (Appendix B). Their framework integrates and reflects many of the key concepts from the SEM, SDOH, and neighborhood effects literature that form the theoretical grounding of this dissertation. To better align with the aims of this dissertation, their framework has been adapted to reflect the mechanisms and pathways through which neighborhood social and physical environments influence breastfeeding practices (Figure 4).

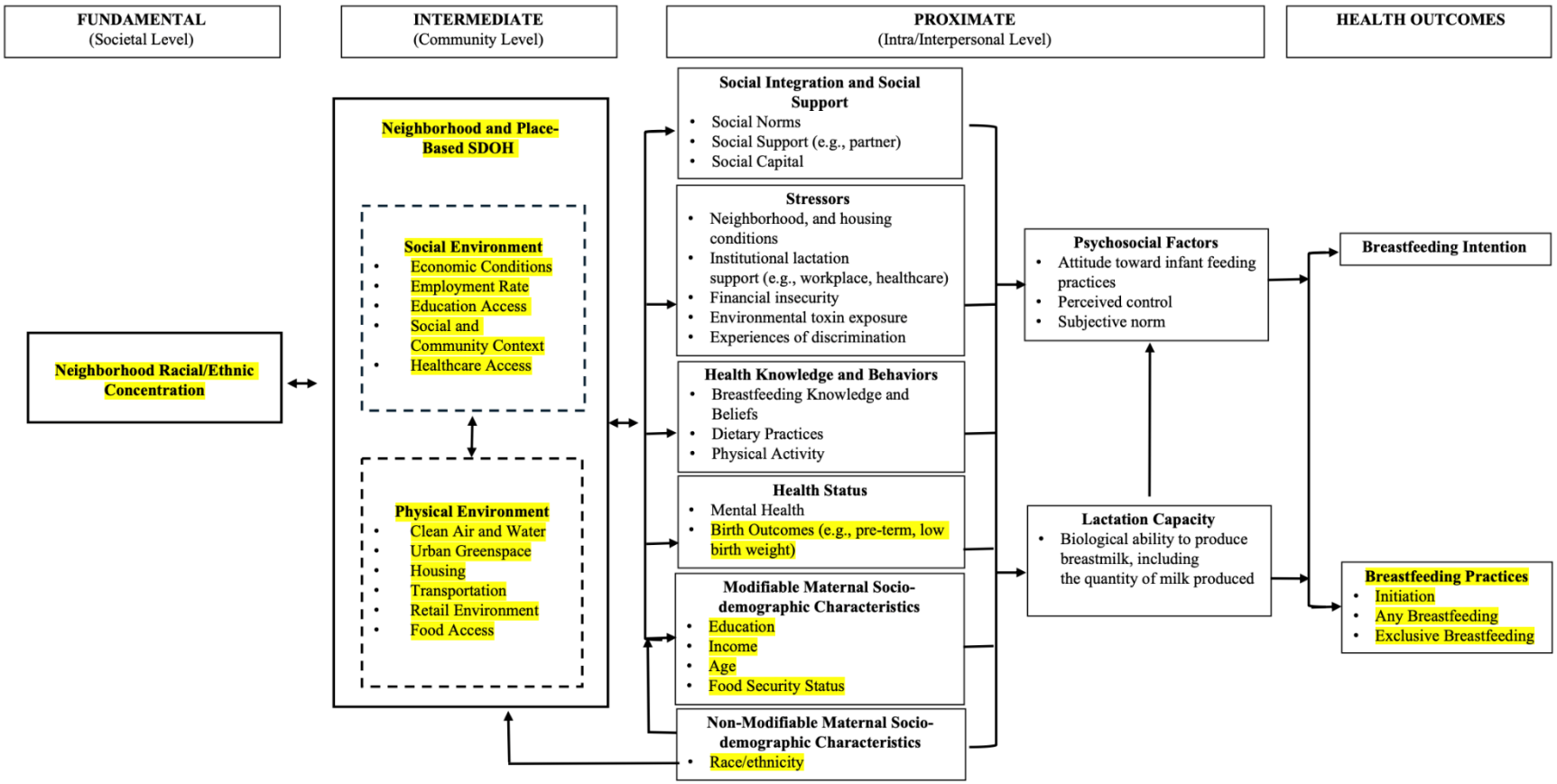


Figure 4. A theoretical framework outlining the mechanisms and pathways through which neighborhood social and physical environments function as determinants of breastfeeding. The framework is adapted from Northridge et al. (2003) and informed by the Socioecological Model, the Social Determinants of Health framework, and the neighborhood effects literature. The highlighted items represent the components most relevant to this dissertation.

The overarching theoretical framework (Figure 4) identifies various domains and factors across multiple levels that help to understand the pathways through which neighborhood social and physical environments function as determinants of breastfeeding. The arrows throughout the framework reflect the complex, dynamic, and interactive relationships between the levels and among the various domains.

At the *fundamental level*, neighborhood racial/ethnic concentration is conceptualized as a key structural mechanism that shapes neighborhood environments. It represents a multidimensional construct with the potential to confer both health risks and benefits. It is theorized to adversely impact health through pathways of structural disadvantage while also potentially protecting health through enhanced sociocultural pathways, including social cohesion, shared norms, and social support. These structural and social processes are expressed within the neighborhood context and shape the social and physical environments at the intermediate level.

At the *intermediate level,* neighborhood social and physical environments are key influences on breastfeeding and are shaped by structural conditions at the fundamental level. The social and physical domains of the neighborhood each contain distinct but mutually reinforcing neighborhood-level, place-based SDOH. The social domain contains determinants related to economic conditions, employment rate, education access, social and community context, and healthcare access. Whereas the physical domain contains determinants related to clean air and water, urban greenspace, housing, transportation, retail environment, and food access. These specific place-based SDOH were included in the framework for their theoretical and empirical relevance to breastfeeding (as discussed in Chapters 1 and 2).

The fundamental and intermediate factors impact breastfeeding through their influence on factors at the *proximate level*, which reflects factors at the intrapersonal (e.g., socio-demographic characteristics and health knowledge, behaviors, and status), interpersonal (e.g., social, familial, and partner support), and institutional/organizational levels (e.g., access to workplace lactation policies and accommodations) across many domains. These specific factors were included in the framework for their theoretical and empirical relevance to breastfeeding as well as being key conditions through which intermediate level factors influence breastfeeding practices (as discussed in Chapters 1 and 2).

The proximate level is organized into two separate columns to represent distinct conditions. The domains and factors on the left side of the model (e.g., social support, stressors, maternal sociodemographic characteristics, health knowledge, and health status) represent antecedent conditions that are known to shape breastfeeding indirectly through psychosocial (e.g., attitudes toward infant feeding, perceived control, and subjective norms) and biological (e.g., ability to produce breastmilk) processes represented on the right. The proximate level is, therefore, critical in identifying the underlying mechanisms and pathways through which place-based and structural factors (at the fundamental and intermediate level) influence breastfeeding practices.

Chapter Summary

This chapter provided an overview of the theories and frameworks that form the theoretical foundation for this dissertation. Considering breastfeeding is influenced by various multilevel factors, the theories and frameworks presented in this chapter were selected because they highlight the importance of both individual and contextual factors in understanding health behaviors. The frameworks discussed include the SEM, SDOH, and neighborhood effects. Each

of these frameworks contributes a distinct but complementary perspective to the theoretical grounding of this dissertation.

While the SEM is important for understanding the complex, multilevel factors that influence breastfeeding, the SDOH framework provides a more specific way to identify and understand the non-medical conditions that shape breastfeeding within each level of the SEM. The neighborhood effects literature provides additional theoretical grounding that both complements and addresses gaps in the SEM and SDOH frameworks. It offers a more focused lens on specific neighborhood factors that influence health, which adds specificity to the broader perspectives of SEM and SDOH that often overlook the role of place. Moreover, this literature helps explain the processes through which SDOH create and sustain health inequities, while also emphasizing the influence of larger structural forces such as residential segregation.

This chapter also presented the overarching theoretical framework guiding this dissertation's examination of the relationship between place-based SDOH and individual-level racial differences in breastfeeding practices. This framework was adapted from a conceptual framework, developed by Northridge and colleagues (2003), and integrates concepts from the SEM, SDOH, and neighborhood effects literature. The overarching theoretical framework identifies various domains and factors across multiple levels that help to understand the mechanisms and pathways through which neighborhood social and physical environments function as determinants of breastfeeding. The next chapter will provide a summary of the aims of the three proposed studies, including the supporting research questions, hypotheses, and conceptual models. Which are guided by the theoretical groundwork outlined in this chapter.

CHAPTER 4: Research Aims, Questions, Hypotheses, and Conceptual Models

Chapter Overview

This chapter provides a summary of the aims of the three studies, including the supporting research questions hypotheses, and conceptual models. The data sources and analytical plan used to answer these research questions are discussed in Chapter 5.

Overview of Research Aims

Primary Research Question: How do place-based structural and social determinants of health (SSDOH), measured through the neighborhood social and physical environment, influence individual-level racial differences in breastfeeding practices among low-income women?

This dissertation attempts to address a critical gap in the literature in understanding neighborhood effects on breastfeeding. Across the three studies, this dissertation examines how neighborhood-level SSDOH influence individual-level racial differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in Los Angeles County (LAC). WIC is a federal assistance program administered by the USDA that provides supplemental foods, nutrition education, breastfeeding support, and referrals to health and social services for low-income (household incomes at or below185 percent of the federal poverty income guidelines) and nutritionally at-risk (has at least one medical-based or dietary-based health condition) pregnant, postpartum, and breastfeeding women, as well as infants and children up to age five (*WIC Eligibility Requirements*, 2025).

A series of three studies were conducted. **Study 1** examined the relationship between place-based social determinants of health (SDOH), as measured through the neighborhood social and physical environment using the Healthy Places Index (HPI), and individual-level

breastfeeding practices (initiation, duration, and exclusivity). The HPI is a multidimensional measure of neighborhood quality that reflects overall community conditions as well as specific characteristics across eight domains: economic, education, social, housing, transportation, neighborhood-built environment, clean environment, and healthcare access. This study established a foundational understanding of how these place-based factors are related to breastfeeding practices.

Study 2 examined how neighborhood racial/ethnic concentration, measured as the percentage of Hispanic residents in a neighborhood, helps explain individual-level differences in breastfeeding practices. This exploratory study serves as a foundation for understanding how the spatial distribution of racial/ethnic groups may influence breastfeeding, with the potential to confer both risks and protective effects.

Lastly, **Study 3** examined the association between a neighborhood's food environment, specifically access to healthy foods, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity). This analysis builds on Study 1, which uses the HPI to assess place-based SDOH, by focusing on a critical but overlooked place-based factor (i.e., the food environment) that is not captured by the HPI.

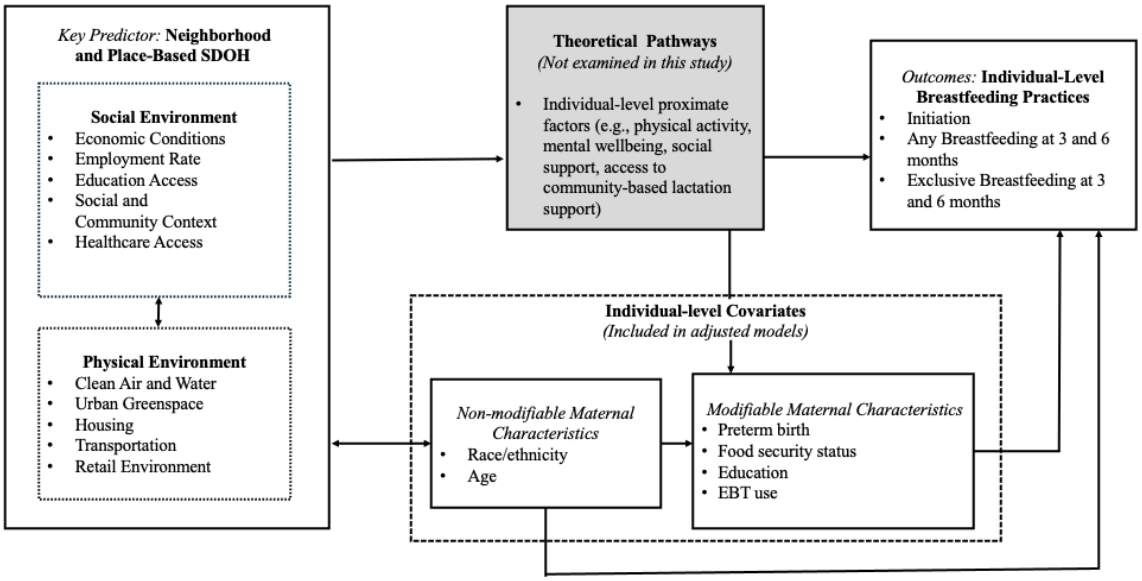
Together, this dissertation aims to deepen the limited understanding of how neighborhood social and physical environments shape differences in breastfeeding practices. To address persistent gaps in the literature, various understudied dimensions of place are examined across all three studies. This work underscores the importance of considering these distinct yet interconnected dimensions of the neighborhood environment to identify potential place-based strategies for reducing disparities.

Study 1

Study Aim: To examine how place-based SDOH, as measured through the neighborhood social and physical environment, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

Conceptual Model: Figure 5 illustrates the conceptual model for Study 1. In this study, place-based SDOH are conceptualized as the key predictor and are measured through various features of the neighborhood social and physical environments. Its association with the outcome of interest, individual-level breastfeeding practices (initiation, duration, and exclusivity), is examined independently first and then alongside individual-level maternal covariates associated with both the predictor and outcome, including race/ethnicity, education, EBT use, birth outcomes, and food security. These associations are examined using both overall neighborhood cumulative conditions and individual components. The model also includes theoretical pathways related to proximate individual-level factors, such as physical activity and social support, through which place-based SDOH may influence breastfeeding outcomes. However, these mechanisms were not directly examined in Study 1.

Figure 5. Conceptual Model for Study 1.



Research Questions and Hypotheses: To address this aim, the following research questions and corresponding hypotheses were tested:

Question 1.1: What is the association between place-based SDOH, as measured by the composite HPI score, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 1.1a:* The composite HPI score (where higher scores indicate healthier communities) is significantly and positively associated with the odds of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 1.1b:* The association between the composite HPI score and each breastfeeding practice (i.e., initiation, duration, and exclusivity) is attenuated but remains significant after adjusting for maternal characteristics, indicating that place-based SDOH help explain individual-level differences in breastfeeding beyond maternal characteristics.

- *Hypothesis 1.1c:* Although the composite HPI score is significantly and positively associated with each breastfeeding practice, the strength of the relationship differs by outcome (i.e., initiation, duration, and exclusivity).

Question 1.2: What is the association between place-based SDOH, as measured by the specific domains of the HPI (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access), and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 1.2a:* Each of the eight HPI domain scores (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access), where higher scores indicate healthier communities, is significantly and positively associated with the likelihood of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 1.2b:* The association between each of the eight HPI domain scores (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access) and breastfeeding practices (i.e., initiation, duration, and exclusivity) is attenuated but remains significant after adjusting for maternal characteristics, indicating that place-based SDOH help explain individual-level differences in breastfeeding beyond maternal characteristics.
- *Hypothesis 1.2c:* Although each of the eight HPI domain scores are significantly and positively associated with each breastfeeding practice (i.e., initiation, duration, and

exclusivity), the strength of the relationship differs by domain and outcome (i.e., initiation, duration, and exclusivity).

Study 2

Study Aim: To examine how neighborhood racial/ethnic concentration help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

Conceptual Model: Figure 6 illustrates the conceptual model for Study 2. In this study, neighborhood racial/ethnic concentration is conceptualized as the key predictor and is measured as the total percentage of Hispanic residents in a neighborhood. Its association with the outcome of interest, individual-level breastfeeding practices (initiation, duration, and exclusivity), is examined independently first and then alongside individual-level covariates associated with both the predictor and outcome, including race/ethnicity, education, EBT use, birth outcomes, and food security. The model also includes theoretical pathways related to intermediate-level factors, such as neighborhood physical and social environments, through which neighborhood racial/ethnic concentration may influence breastfeeding outcomes. However, these mechanisms were not directly examined in Study 2.

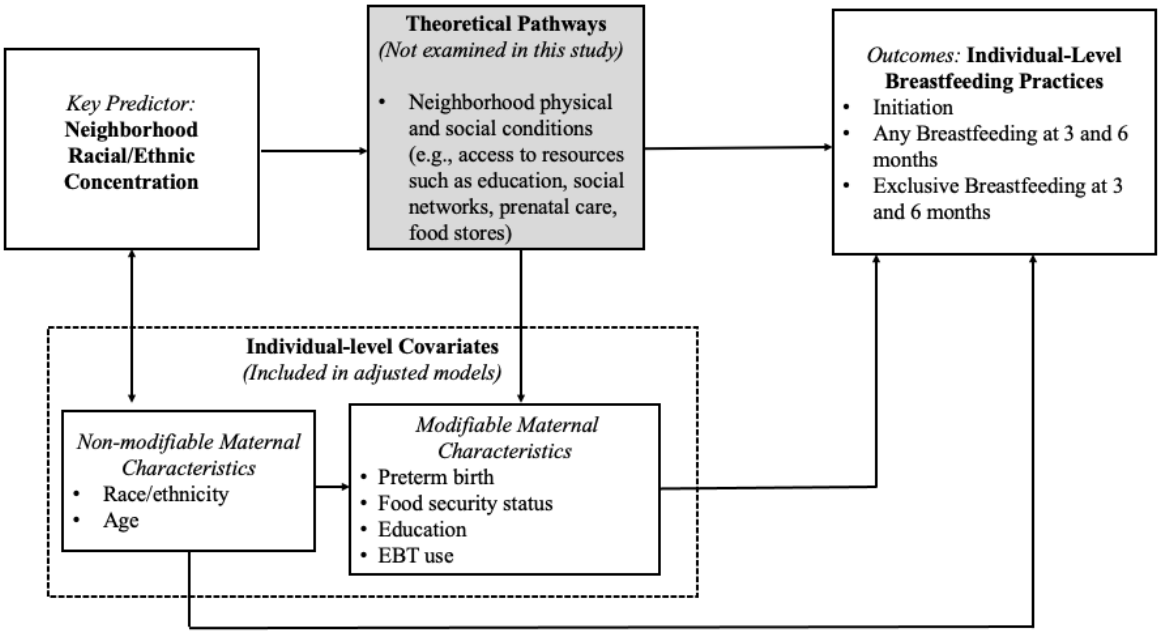


Figure 6. Conceptual Model for Study 2.

Research Questions and Hypotheses: To address this aim, the following research questions and corresponding hypotheses were tested:

Research Question: What is the association between racial/ethnic concentration of a neighborhood, as measured by the total percentage of Hispanic residents within a ZIP code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 2a:* Neighborhood Hispanic concentration is associated with breastfeeding initiation, duration, and exclusivity. However, the direction of this association is not specified due to the potential for both protective and adverse contextual influences.
- *Hypothesis 2b:* This association is attenuated but remains significant after adjusting for maternal characteristics, indicating that neighborhood Hispanic concentration helps explain individual-level differences in breastfeeding beyond maternal characteristics.

- *Hypothesis 2c:* The strength of the association differs across breastfeeding practices (i.e., initiation, duration, exclusivity).

Study 3

Study Aim: To examine how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

Conceptual Model: Figure 7 illustrates the conceptual model for Study 3. In this study, access to healthy foods is the key predictor. Its association with the outcome of interest, individual-level breastfeeding practices (initiation, duration, and exclusivity), are examined independently first and then alongside individual-level covariates associated with both the predictor and outcome, measured through various maternal characteristics (e.g., race/ethnicity, education, EBT use, birth outcomes, and food security). The model also includes theoretical pathways related to proximate individual-level factors, such as diet, through which the neighborhood food environment may influence breastfeeding outcomes. However, these mechanisms were not directly examined in Study 3.

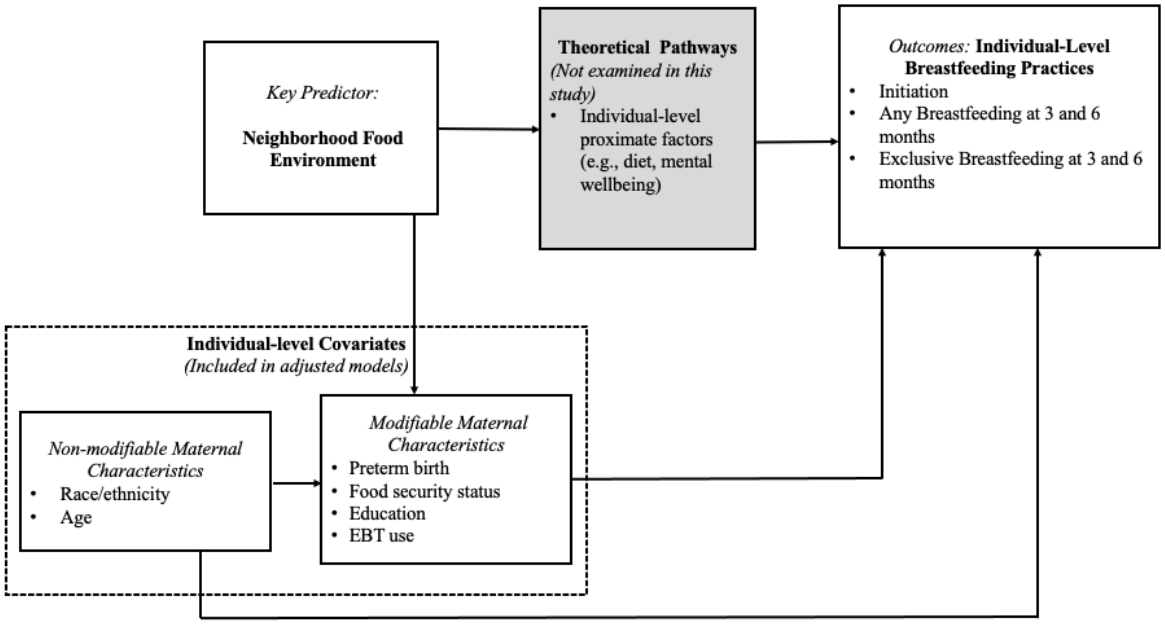


Figure 7. Conceptual Model for Study 3.

Research Questions and Hypotheses: To address this aim, the following research questions and corresponding hypotheses were tested:

Research Question: What is the association between access to healthy foods, as measured by the percentage of the ZIP code population living in food desert tracts, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for individual-level maternal characteristics?

- *Hypothesis 3a:* ZIP codes with a higher percent of residents living in food desert tracts is significantly associated with a lower likelihood of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 3b:* This association is attenuated but remains significant after adjusting for maternal characteristics, indicating that the ZIP-level food access measure helps explain individual-level differences in breastfeeding beyond maternal characteristics.

- *Hypothesis 3c:* The strength of the association differs across breastfeeding practices (i.e., initiation, duration, exclusivity).

Chapter Summary

This chapter provided a summary of the aims of the three studies, including the supporting research questions and hypotheses. The overarching research question guiding this dissertation is: how do place-based SSDOH, measured through the neighborhood social and physical environment, influence individual-level differences in breastfeeding practices among low-income women? A series of three interrelated studies were conducted. **Study 1** examined the relationship between place-based SDOH, as measured through the neighborhood social and physical environment using the HPI, and individual-level breastfeeding practices (initiation, duration, and exclusivity). **Study 2** examined how neighborhood racial/ethnic concentration, measured as the percentage of Hispanic residents in a neighborhood, helps explain individual-level racial differences in breastfeeding practices. Lastly, **Study 3** examined the association between a neighborhood's food environment, specifically access to healthy foods, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity). In the next chapter, I describe the data, methods, and analytic approaches used to address these aims and research questions.

CHAPTER 5: METHODS

Chapter Overview

This chapter describes the data, methods, and analytic approaches used in this dissertation. The databases in this dissertation are: 1) the Los Angeles County (LAC) Women, Infant, and Children (WIC) Survey, 2) the Healthy Places Index (HPI), and 3) the United States Department of Agriculture (USDA) Food Access Research Atlas (FARA), and 4) United States (U.S.) Census Bureau's Geographic Relationship and Decennial Census Files. Individual-level data used in this dissertation come from the 2014 and 2017 LAC WIC survey, while the neighborhood-level data come from the HPI, FARA, and Census Burreau files. These datasets were merged across the three studies, in different combinations, to create the multilevel datasets used to examine neighborhood effects on breastfeeding.

Given the multilevel nature of the data, all three studies employed multilevel analyses, using mixed models, to account for the nesting of individuals within ZIP codes. Multilevel analysis (with mixed models) is the recommended analytic strategy in neighborhood effects research because it allows for the simultaneous examination of the effects of group-level and individual-level variables on individual level outcomes, while accounting for the non-independence within groups (e.g., ZIP codes) (Diez Roux, 2001; Diez Roux & Mair, 2010; Diez-Roux, 1998, 2000).

Institutional Review Board (IRB) Approval

This study was granted exemption from review by the UCLA Institutional Review Board in January 2026 (IRB -25-2530).

Data Sources

Individual-Level Data

LAC WIC Survey

Data from the LAC WIC Survey was used to obtain individual-level socio-demographic characteristics and breastfeeding practices of WIC-participating women in LAC. The LAC WIC Survey is a triennial cross-sectional phone survey (data available from 2005-2020) that gathers sociodemographic information and health data on a random, representative sample designed to include approximately 5,500 WIC-participating families in LAC for each survey year (*L.A. County WIC Data Sources*, n.d.). WIC is a federal assistance program administered by the USDA that provides supplemental foods and breastfeeding support for low-income and nutritionally at-risk pregnant, postpartum, and breastfeeding women, as well as infants and children up to age five (*WIC Eligibility Requirements*, 2025).

The triennial WIC survey is administered by Los Angeles-based PHFE WIC, which is the largest local agency WIC program in the country (*L.A. County WIC Data Sources*, n.d.) The survey questionnaire is adapted from the LAC Health Survey (*Los Angeles County Health Survey*, n.d.). The WIC survey collects comprehensive data on maternal health, infant feeding, child nutrition and development, household conditions, social determinants, and WIC program experiences (*L.A. County WIC Data Sources*, n.d.). Although the survey questionnaire includes a set of core questions, a few questions are added or modified each survey cycle to address emerging issues.

The survey is conducted in English and Spanish by trained interviewers using a computer-assisted telephone interviewing system. The survey lasts approximately 20-25 minutes. A maximum of eight call attempts are made to interview each participant. For each survey, a random sample of about 5,000-6,000 is drawn from the population of all participants receiving

WIC services in LAC during January of the survey year. Eligible participants include English- or Spanish-speaking WIC recipients residing in LAC who are over the age of 18. If participants have more than one child in the household enrolled in WIC, data is only collected for the child with the most recent birthday.

WIC Data Used in This Dissertation

Data from the 2014 and 2017 LAC WIC surveys were used in all three studies. The 2014 and 2017 WIC survey instruments are provided in Appendix C and D, respectively. These data were used to measure individual-level breastfeeding practices and maternal socio-demographic characteristics. In total, 4,990 interviews were completed in 2014 and 4,232 were completed in 2017 (Jiang, 2021). This reflects a response rate of 50% in 2014 and 53% in 2017 (Jiang, 2021). Among those successfully reached by phone, the completion rate was 88% in 2014 and 82% in 2017 (Jiang, 2021).

It is important to note that the WIC data include only participants' ZIP codes of residence. Although an administrative database exists that contains participants' census tract information, there is no way to link the two datasets currently. Therefore, ZIP codes of participants were used to merge the LAC WIC survey data with the neighborhood-level data described in the next section.

The 2014 and 2017 years were selected because they align closely with timing of data collection across the other databases, which primarily use data from 2015-2019, and they also reflect pre-covid times. Although the most recent data release from 2020 is available, it is not included in the analysis to limit the focus to pre-COVID years (before 2020) and avoid pandemic-related factors that may have impacted breastfeeding. An analysis of 2020 LAC WIC survey data found that the prevalence of any breastfeeding at 3 and 6 months and exclusive

breastfeeding at 1, 3, and 6 months was significantly lower among mothers who gave birth during the pandemic compared with mothers who gave birth before the pandemic (Koleilat et al., 2022). The researchers concluded that the shift to remote service delivery and breastfeeding support within WIC may have contributed to this decline. By focusing on the 2014 and 2017 waves, this dissertation avoids potential bias introduced by pandemic-related disruptions to breastfeeding. Additionally, it maintains consistency with the other datasets used in this dissertation (e.g., the HPI and the FARA) which are mostly based on pre-2020 data.

Neighborhood-Level Data

United States (U.S.) Census Burreau Data

The U.S. Census Burreau, the federal government's largest statistical agency, collects a wide range of population data in the U.S. For this dissertation, the most relevant sources are the Decennial Census and Geographic Relationship Files (*Decennial Census of Population and Housing Datasets*, n.d.; United States Census Bureau, n.d.). The Decennial Census is a population and housing count conducted once every ten years (e.g., 2000, 2010, 2020) (*Decennial Census of Population and Housing Datasets*, n.d.). Although its primary purpose is to determine the apportionment of seats in the U.S. House of Representatives, the Census also collects information on the social, economic, housing, and demographic characteristics of the entire U.S. population (*Decennial Census of Population and Housing Datasets*, n.d.).

The Census employs a multi-mode, multi-phase enumeration approach to count all individuals residing in the U.S. (2010 Census Summary File 1: Technical Documentation, 2012). The primary method of data collection is self-response via online, mail, or telephone completion of the census questionnaire. For cases of nonresponse, data collection is supplemented by in-person follow-up and administrative records to ensure a complete population count. Census data

also include geospatial information and are available across various geographic units, including Zip Code Tabulation Areas (ZCTAs).

The U.S. Census Bureau also provides geographic relationship files to facilitate linkage of data across different geographic units. The data consists of population- or area-based weights to approximate the distribution of populations across geographic units (United States Census Bureau, n.d.). Relationship files are commonly used as crosswalks to translate data between geographies. For example, relationship files linking ZCTAs to census tracts allow tract-level data to be aggregated or assigned to ZCTAs.

These data are available in the same years as the Decennial Census files (e.g., 2000, 2010, 2020). This approach enables neighborhood-level characteristics measured at the census tract level to be linked to individual-level data available at the ZCTA level, although these relationships represent approximations rather than exact geographic matches (*ZIP Code Tabulation Areas (ZCTAs)*, 2023). This allows researchers to link datasets across geographic units and connect participants' place of residence with neighborhood-level conditions.

U.S. Census Burreau Data Used in This Dissertation

Data from the 2010 Decennial Census Summary File 1 was used to obtain population counts for measuring neighborhood racial/ethnic concentration in Study 2. The 2010 wave was selected to align with the timing of other data sources used in this dissertation. In Study 3, census tract to ZCTA relationship files were used to transform FARA data from the census tract level to 2010 ZCTAs. ZCTAs are Census-defined approximations of ZIP codes created to facilitate statistical analysis (*ZIP Code Tabulation Areas (ZCTAs)*, 2023).

The decision to use the 2010 Decennial Census over the more temporally aligned 2015 American Community Survey (ACS) was guided by existing critiques in the literature regarding the uncertainty of ACS estimates. Although the ACS provides more recent estimates, its use in neighborhood effects research has been critiqued due to sampling variability. The ACS is based on a substantially smaller sample (approximately 1 in 40 households) compared to the decennial Census long form (approximately 1 in 6 households) (Spielman et al., 2014). As a result, ACS estimates have reduced precision and larger margins of error. These limitations are amplified at smaller geographic units such as ZCTAs and census tracts. Prior research has shown that margins of error for ACS estimates at the tract level are approximately 75% larger than those of Census-based estimates (Spielman et al., 2014). This uncertainty may introduce measurement error and potential bias in analyses using small-area estimates (P. H. Jung et al., 2019; Wei et al., 2023).

These concerns are particularly salient for larger minority populations, including Hispanic communities. Prior research indicates that ACS estimates are less precise for Hispanic populations, with substantially wider confidence intervals than Census-based estimates, often over 400% wider (Napierala & Denton, 2017). This reduced precision has important implications for the present dissertation which focuses on a predominantly Hispanic population and ZIP code-level analyses. Given these concerns, Decennial Census data were used to obtain more precise and stable Hispanic population counts for ZIP Code–level analyses.

Additionally, the use of 2010 Decennial Census data is temporally appropriate given that the WIC dataset (2014–2017) includes mothers with children up to age five. This means that the use of 2010 data may better reflect the context of mothers with older children. This approach is

also consistent with prior research which used data from 2000 Decennial Census with LAC WIC data from 2003-2009 (Nobari et al., 2013).

Healthy Places Index (HPI)

The HPI was developed by the Public Health Alliance of Southern California, which is a coalition of leadership from 11 local health jurisdictions that works to promote equitable health policies and practices across the region. The HPI is an online tool created to advance health equity through open and accessible data (*Healthy Places Index*, n.d.). The HPI provides data on census tract-level indicators of place-based SDOH across eight domains or policy areas: 1) economic, 2) education, 3) social, 4) housing, 5) transportation, 6) neighborhood, 7) clean environment, and 8) healthcare access. The third and most recent iteration of the HPI (HPI 3.0) was released on April 6, 2022. This dissertation uses the HPI 3.0 and is referred to as the HPI unless otherwise indicated.

The HPI provides data for California census tracts based on 2010 census boundaries (Coline Bodenreider et al., 2022). This is because the data for the indicators included in the HPI come from data sources that are tied to 2010 census tract boundaries. Census tracts were included in the HPI if they had a population of 1,500 or greater and a group quarters population (i.e., persons living in college dormitories, nursing facilities, military barracks, and correctional facilities) less than 50% of the total population in 2015-2019 American Community Survey (ACS) estimates. Of the 8,057 California census tracts, 7,790 met this eligibility criteria and 2,836 of these eligible census tracts were in LAC.

The development of the HPI was guided by a steering committee consisting of public health practitioners and researchers (Coline Bodenreider et al., 2022). The committee used a hybrid approach to develop the HPI. First, domains were selected based on their policy relevance

and the evidence in the literature linking them to life expectancy at birth (LEB), which was the key outcome that guided the construction of the HPI. Empirical methods were then used to select specific indicators and assign weights to each domain to maximize their association with LEB. This approach ensured that the HPI was composed of domains and indicators that were both theoretically and empirically meaningful for policymakers.

The criteria for selection of individual indicators included: 1) accessible public data sources, 2) current data at the geographical level of census tract, 3) geographical coverage for all eligible 2010 census tracts, 4) linkage to policy and other actions, 5) association with LEB in California census tracts, 6) low levels of collinearity with other indicators within a domain, 7) continuity with previous HPI versions, and 8) alignment with indicator projects at California Department of Public Health (Coline Bodenreider et al., 2022). Data for the indicators are drawn from various publicly available data sources, including the 2015-2019 ACS, U.S. Census, Comprehensive Housing Assessment System, California Environmental Protection Agency, and National Land Cover Database. The data sources included in the HPI align closely with the 2014 and 2017 WIC survey years, as most were collected between 2015–2019 with only a few occurring slightly earlier or later.

Using the established criteria, the final HPI was developed using 23 indicators of SDOH categorized across eight domains: economic, education, social, housing, transportation, neighborhood built-environment, clean environment, and healthcare access (Coline Bodenreider et al., 2022). Details on each domain, including its indicators, data sources, and association with life expectancy at birth for the HPI 3.0 can be found in Appendix E. The economic domain focuses on indicators related to financial resources and stability of a community, including the percent of the population with an income exceeding 200% of federal poverty level. The

education domain focuses on indicators related to educational attainment and school enrollment, including the percentage of population over age 25 with a bachelor's education or higher. The social domain focuses on indicators related to social power and social cohesion, including the percentage of registered voters voting in the 2020 general election. The housing domain focuses on indicators related to access to transportation, including the percentage of households with access to an automobile. The neighborhood domain focuses on indicators related to neighborhood infrastructure and physical features, including the percentage of the population living within a half mile of a park, beach, or open space that is larger than 1 acre. The housing domain focuses on indicators related to affordability (e.g., rent burden), stability, and quality (housing habitability). The clean environment domain focuses on indicators related to clean air and water quality, including an index score combining information about 13 contaminants and 2 types of water quality violations. Lastly, the healthcare access domain focuses on access to medical care, specifically the percentage of adults aged 18 to 64 years with health insurance.

To create the HPI score, individual indicators within each domain were first standardized by computing a z-score, where higher values indicate greater advantage (Coline Bodenreider et al., 2022). These z-scores were then averaged to produce a score for each of the eight domains. The amount of weight assigned to each domain was determined using a weighted quantile sum regression that maximized the association between domain scores and LEB (i.e., more weight was given to domains that predicted LEB better). Each domain had a minimum weight of 5%, with the rest of the weight (60%) determined by the model. The economic domain was assigned the greatest weight (35%), followed by education (18%), transportation (13%), social (13%), housing (5.3%), healthcare access (5.3%), clean environment (5.2%), and neighborhood (5.2%).

The overall HPI score for each census tract was calculated by multiplying each domain score by its corresponding weight and summing these weighted domain scores across all eight domains (Coline Bodenreider et al., 2022). Each census tract's HPI score is then ranked against all eligible census tracts and assigned a percentile, ranging from 0 (least healthy conditions) to 100 (most healthy conditions). HPI scores are provided as continuous measures (raw scores ranging from -2.4 to 1.7 and percentile ranging from 0 to1) as well as a categorical measure using the percentile rank: Quartile 1 (0–25th percentile, least healthy), Quartile 2 (>25–50th percentile), Quartile 3 (>50–75th percentile), and Quartile 4 (>75–100th percentile, most healthy). In addition to the overall composite HPI score, domain-specific values are also available in the same continuous and categorical measures.

Although many indices of area-level disadvantage exist, the use of the HPI in this dissertation is intentional and relevant for three main reasons. First, a key feature of the HPI is that it is rooted in the SDOH using a positive, asset-based framing where a higher HPI score means a healthier community (Maizlish et al., 2019). Second, while there is some overlap in indicators with other indices, the HPI includes indicators across eight domains that cover a wider spectrum of SDOH (Coline Bodenreider et al., 2022; Maizlish et al., 2019). This broader approach contrasts with other indices that focus on specific SDOH, such as poverty or environmental pollution (e.g., CalEnviroScreen 4.0 and Social Vulnerability Index). The HPI's ability to capture a more comprehensive range of SDOH is an advantage and is especially important for this dissertation, which aims to examine a broad array of SDOH.

Third, despite the HPI being a relatively new index, several studies have demonstrated its association with several health outcomes including mortality, obesity, syphilis, and COVID-19 booster uptake (Cleveland et al., 2023; Johnson et al., 2022; Maizlish & Damicis, 2024; Romano

et al., 2025; South et al., 2022; Sullivan et al., 2025). However, its application in maternal and child health remains limited. To date, only one study has used the HPI to examine its association with preterm births among Black women in Oakland, California (Berkowitz et al., 2022). The study found that women living in higher-quality neighborhoods (as measured by the HPI) had a lower risk of preterm birth, even after adjusting for individual-level confounders. In sensitivity analyses using the HPI-specific domains, six of eight domains (education, health, housing, transportation, clean environment, and social) showed independent protective effects, meaning higher quality in those domains was associated with reduced risk of preterm birth. These findings highlight the HPI's potential relevance to maternal and child health outcomes and underscore the need to explore its association with other outcomes, such as breastfeeding.

HPI Data Used in This Dissertation

Data from the HPI were used to measure place-based SDOH in Study 1. The data sources included in the HPI were primarily collected between 2015–2019 with only a few occurring slightly earlier or later, which aligns closely with the 2014 and 2017 WIC survey years. Although the HPI is publicly available at the census tract level, a ZIP code–level file provided by the Public Health Alliance of Southern California was used to align with the geographic data available in the WIC survey. To create the multilevel data used in Study 1, the HPI data was merged with the 2014 and 2017 LAC WIC Survey data using ZIP codes.

Food Access Research Atlas (FARA)

The FARA, developed by the USDA's Economic Research Service in response to a 2008 Farm Bill mandate, is a publicly accessible online mapping tool and database that provides food store access data at the census-tract level across the U.S (*Introduction to the Food Access Research Atlas*, n.d.). It is a widely recognized mapping tool for identifying areas with limited food access and is frequently used by policymakers, community organizations, and researchers.

The USDA defines a food desert as “low-income census tracts with a substantial number or share of residents with low levels of access to retail outlets selling healthy and affordable foods” (Ver Ploeg et al., 2011)

In line with this definition, the FARA categorizes food deserts as census tracts that are both low-income and low access (LILA) (*Measuring Access to Food*, n.d.). Tracts are considered low-income if they meet either of these conditions: 1) the tract’s poverty rate is 20 percent or greater, 2) the tract’s median family income is less than or equal to 80 percent of the state-wide median family income, or 3) for metropolitan tracts, the tract has a median family income less than or equal to 80 percent of the metropolitan area's median family income (*Measuring Access to Food*, n.d.).

Tracts are considered to have low access if a significant number (at least 500) or share (at least 33%) of individuals in the tract live far from the nearest supercenter, supermarket, or large grocery store using distance thresholds ranging from ½ mile to 20 miles (*Measuring Access to Food*, n.d.). Supercenters are defined as very large, “big box” stores and food warehouses which sell grocery and other store merchandise such as clothes, electronics, and home goods (e.g., Walmart, Costco) (*Introduction to the Food Access Research Atlas*, n.d.). Though smaller than supercenters, supermarkets are still large (with 10 or more checkout lanes) but mainly focused on food with some household items (e.g., Vons, Safeway, and Kroger). Large grocery stores are smaller than supermarkets (with less than 10 checkout lanes) but are still full-service grocery stores and have at least $2 million in annual sales.

The FARA provides three measures of food access based on distance to the nearest food store (i.e., supercenter, supermarket, or large grocery store): 1) low access at 1 mile (urban) and 10 miles (rural) from the nearest food store, 2) low access at 0.5 mile (urban) and 10 miles

(rural), and 3) low access at 1 mile (urban) and 20 miles (rural) (*Measuring Access to Food*, n.d.). In the FARA, a census tract is considered urban if the center of the tract is in an area with more than 2,500 people while all other tracts are considered rural (*Food Access Research Atlas - Documentation*, 2025). The FARA also includes a fourth indicator using vehicle access, which incorporates low-income tracts where a significant number of households are located far from a food store and do not have access to a vehicle. Specifically, tracts are considered low access when "more than 100 housing units do not have a vehicle and are more than 0.5 mile from the nearest food store, or a significant number or share of residents are more than 20 miles from the nearest food store" (*Measuring Access to Food*, n.d.).

To assess distance to the nearest food store the same multi-step approach was used for each of these measures (*Food Access Research Atlas - Documentation*, 2025). First, the entire U.S. is geographically divided into small square grids (about 0.19-mile). Then, population data from the Census (block-level counts of residents) are assigned to these grids. After, the distance from each populated grid cell to the nearest supermarket or large grocery store is calculated. Finally, those grid-level results are aggregated to the census tract level, so the proportion of a tract's residents who live farther than ½ mile (urban) or 10 miles (rural) from a food store can be determined.

Using these criteria for low-income and low access, the FARA provides four ways to operationalize food desert residence: 1) low-income census tracts where a significant number (at least 500) or share (at least 33%) of residents is more than 1 mile (urban) or 10 miles (rural) from the nearest food store, 2) low-income census tracts where a significant number (at least 500) or share (at least 33%) of residents is more than 0.5 mile (urban) or 10 miles (rural) from the nearest food store, 3) low-income census tracts where a significant number (at least 500) or share

(at least 33%) of residents is more than 1 mile (urban) or 20 miles (rural) from the nearest food store, and 4) low-income census tract where more than 100 housing units do not have a vehicle and are more than 0.5 mile from the nearest food store, or a significant number or share of residents are more than 20 miles from the nearest food store (*Food Access Research Atlas - Documentation*, 2025).

FARA Data Used in This Dissertation

This dissertation used data from the 2015 and 2019 FARA to measure the food environment, specifically access to food stores. The FARA data were merged with the LAC WIC Survey data at the ZIP code to examine associations between food access and breastfeeding. As discussed earlier, the U.S. Census Burreau's census tract to ZCTA relationship files were used to facilitate this merge. The 2015 FARA was matched with the 2014 LAC WIC Survey and the 2019 FARA was matched with the 2017 LAC WIC Survey. These years were matched because the timing of data collection across sources closely aligns, apart from the food retail data. While the 2019 FARA uses food retail data from 2019 and the WIC data are from 2017, this is not a concern, as the neighborhood food environment is expected to be relatively stable across those years. Prior longitudinal research suggests that changes in retail food environments occur gradually over decades rather than abruptly within a few years (James et al., 2017).

Analytic Plan

The analytic plan is guided by established approaches within the neighborhood effects literature as described below.

Multilevel Approaches in Neighborhood Effects Research

Since this dissertation is situated within the neighborhood effects research, it is important to briefly describe the dominant approaches used in this field to provide the rationale for their inclusion. When studying neighborhood effects (i.e. the effects of specific neighborhood

attributes on individual-level outcomes), multilevel or contextual analysis is the most widely recognized and recommended analytic approach (Diez Roux, 2001; Diez Roux & Mair, 2010; Diez-Roux, 1998, 2000). The terms multilevel and contextual analysis are often used interchangeably but both refer to an analytic approach which examines the effect of contextual (also referred to as group-level, ecological, or aggregate) variables on individual-level outcomes, while simultaneously controlling for individual-level factors. This is critical for distinguishing between "composition" (the individual characteristics of residents) and "context" (the properties of the area). These approaches, therefore, provide a way to evaluate whether neighborhood context influences outcomes independent of individual characteristics.

Given these advantages, multilevel analysis, compared to traditional single-level analytic approaches, addresses two major critiques in neighborhood research: the ecological fallacy and the atomistic fallacy (Diez-Roux, 1998). Both issues are rooted in the problem of selection, which refers to the idea that individuals are often selected into neighborhoods based on individual attributes that are themselves related to health (Diez Roux, 2001). This makes it difficult to delineate composition (the characteristics of individuals) from context (the properties of the area). The ecological fallacy arises when inferences are mistakenly drawn at the individual level based on group-level data (i.e., overlooks context), while atomistic fallacy arises when inferences are mistakenly drawn at the group-level based on individual-level data (overstates composition) (Diez-Roux, 1998).

While multilevel analysis is the preferred statistical technique to effectively examine neighborhood effects, scholars have recommended first evaluating whether the use of multilevel models is appropriate by using statistical diagnostics (e.g., intraclass correlation coefficients, design effects, and cluster size) (Diez-Roux, 2000). Regardless of whether your data is nested, if

your data do not support the use of multilevel modeling, as determined by statistics, it should not be applied. However, Diez Roux challenges this perspective by emphasizing that the appropriateness of multilevel models in neighborhood effects research should be guided primarily by theory and a study's research questions, rather than statistical diagnostics alone (Diez Roux, 2004). While these metrics are useful for describing between-group variance and potential power limitations, she emphasizes that they should not be treated as definitive criteria of whether multilevel modeling is warranted (Diez Roux, 2004). This is because a study may lack sufficient power to detect random effects (between-neighborhood variance) but still have adequate power to identify the effect of a specific neighborhood factor on individual-level outcomes (Diez Roux, 2004).

Analytic Approach

The analytic approach used in this dissertation was guided by the established methodological approaches outlined above and was applied across all three studies. All data merging, cleaning, and analyses were conducted in R software (R Core Team, 2025). The distribution of the data was initially explored using descriptive univariate statistics and bivariate analyses (e.g., chi-square tests and paired t-tests) to examine relationships between key predictors, covariates, and outcomes.

Because the data reflect participants nested within ZIP codes, standard multilevel analytic practice requires evaluating the degree of clustering and sample efficiency of the data. Common metrics, including the intraclass correlation coefficient (ICC), design effect (DEFF), and information on cluster counts and sizes, were calculated (Hox et al., 2017; Maas & Hox, 2005). An ICC provides a measurement of the proportion of the total variance in breastfeeding practices that is attributable to differences between ZIP codes. The value ranges from 0 to 1, with an ICC

of 0 reflecting no clustering (i.e., no variance explained by group-level membership) and 1 reflecting perfect clustering (i.e., all variation is between groups) (Hox et al., 2017; Maas & Hox, 2005). The DEFF represents how much clustering inflates variance estimates relative to simple random sampling (Hox et al., 2017; Maas & Hox, 2005). To calculate the DEFF, the following formula is used: $DEFF=1+(m-1)p$, where m is the average cluster size and p is the ICC. A DEFF ≥ 2 typically indicates that clustering meaningfully reduces the effective sample size (Kish, 1965).

These indicators were reported to provide information on the structure and limitations of the data as well as guide interpretation of results within these parameters, however they were not used to determine whether multilevel analysis was appropriate (Hox et al., 2017; Maas & Hox, 2005). The decision to use multilevel analyses was theory-driven and guided by this dissertation's focus on neighborhood effects and breastfeeding. This approach is consistent with recommendations by Diez Roux to prioritize theoretical considerations over empirical criteria.

Accordingly, all three studies in this dissertation used multilevel analyses to account for the nesting of individuals within ZIP codes. Multilevel models were created to examine neighborhood effects using a theory-driven model-building approach. Crude associations between the key neighborhood-level predictor and breastfeeding were assessed first (Model 1), followed by the addition of individual-level maternal covariates (Model 2). This strategy was chosen because it is widely used and recommended in the neighborhood effects literature for its ability to systematically assess associations as individual-level (composition) and neighborhood-level (contextual) factors are added sequentially (Diez Roux, 2001; Diez Roux & Mair, 2010; Diez-Roux, 1998, 2000). Details of the specific modeling steps for each study are discussed in the subsequent study overview sections.

To evaluate the extent to which neighborhood-level associations are independent of individual-level factors, changes across Model 1 and Model 2 were examined. Changes were evaluated by examining the magnitude, direction, and statistical significance of the predictor coefficients across models. This approach allowed for the assessment of whether neighborhood-level associations remain robust, attenuate, or strengthen after adjustment for individual-level factors. Shifts in neighborhood coefficients across models provide insights into whether the neighborhood context has an independent effect on breastfeeding beyond individual-level factors. However, due to the observational nature of the study, these findings were not interpreted as evidence of causal effects.

Overview of Study 1, 2, and 3

Study 1

Aim & Research Questions

The purpose of the first study was to examine how place-based SDOH, measured through the neighborhood social and physical environment, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The research questions are:

> **Question 1.1:** What is the association between place-based SDOH, as measured by the composite HPI score, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?
>
> **Question 1.2:** What is the association between place-based SDOH, as measured by the specific domains of the HPI score (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and

healthcare access), and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

Data

The two main databases for Study 1 are the LAC WIC Survey (2014 and 2017 waves), which provides individual-level data, and the HPI which provides neighborhood-level data. These datasets were merged at the ZIP code level to create a multilevel dataset.

Measures

Data from the LAC WIC survey was used to measure individual-level breastfeeding practices and maternal covariates included in this study. Breastfeeding practices were measured as binary variables (Yes/No) for the following outcomes: breastfeeding initiation, any breastfeeding at 1, 3,6, 9 and 12 months; and exclusive breastfeeding at 1, 3 and 6 months. The operationalization of these breastfeeding measures is based on prior studies using LAC WIC Survey data in the breastfeeding literature (Jiang, 2021, 2021; S. Jung et al., 2019; Langellier et al., 2012, 2014; Nobari et al., 2017). The survey questions used to create these variables are provided in Table 2.

The maternal covariates included: maternal education level (less than high school, high school graduate, some college or associated degree, college graduate or above), maternal age, maternal race/ethnicity (Hispanic, Non-Hispanic White, Non-Hispanic Black, and Non-Hispanic Asian, etc.), EBT use (proxy for income), food security status (high or marginal food security, low food security, and very low food security), as well as maternal birth outcomes (e.g., preterm birth). These factors were selected because they are theoretically relevant and reflect factors that are widely used as confounders in studies of neighborhood effects and breastfeeding (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Kummer et al., 2020;

LoCasale-Crouch et al., 2024; Riley et al., 2016; Yourkavitch et al., 2018). The survey questions used to create these variables are provided in Table 2.

Table 2. Survey questions used to measure individual-level variables from the 2014 and 2017 LAC WIC Survey.

Variable	Survey Question
Breastfeeding Initiation	• Have you ever breast-fed NAME? • Did you breastfeed NAME in the hospital?
Any breastfeeding	• Are you currently breast-feeding NAME? • IF NO: How old was NAME when you completely stopped breast-feeding (him/her)?
Exclusive breastfeeding	• How old was NAME the first time (he/she) was given anything besides breast milk? This includes formula, baby food, juice, cow's milk, sugar water or anything else you fed your baby.
Maternal race/ethnicity	• Are you of Latino or Hispanic origin? • Are you White, Black or African American, Asian, Pacific Islander, American Indian or an Alaskan native, a member of another race or a combination of these?
Maternal Education	• What is the highest level of school you have completed or the highest degree you have received?
Maternal Age	• What is your age?
EBT use	• In the last twelve months, have you or has anyone in your household used an EBT card for food stamps to buy food?
Food Security Status	• I'm going to read several statements that people have made about their food situation. For each please tell me whether the statement was often true, sometimes true or never true for your household in the last 12 months, that is, since last (April/May/June/July). o The food that we bought just didn't last, and we didn't have money to get more." Was that often, sometimes or never true for your household in the last 12 months? o "We couldn't afford to eat balanced meals." Was that often, sometimes or never true for your household in the last 12 months? o In the last 12 months, that is since last (April/May/June/July), did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food? o IF YES: How often did this happen – almost every month, some months but not every month or in only 1 or 2 months? o In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food? o In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?
Pre-term birth	• Was NAME born early as a pre-term baby? (If necessary:) A pre-term baby is one born at 36 weeks or earlier in pregnancy. How many weeks pregnant were you when NAME was born?

Source: *L.A. County WIC Data Sources*. (n.d.). WIC Data L.A. County. https://lawicdata.org/survey/

Data from the HPI were used to measure the neighborhood-level exposures (i.e., place-based SDOH) in this study. The HPI is a multidimensional measure of neighborhood quality that provides data on overall community conditions as well as specific conditions across eight domains: economic, education, social, housing, transportation, neighborhood-built environment, clean environment, and healthcare access. The composite HPI score, as well as scores for each of its eight domains, were used in the analysis.

The HPI composite and domain scores was operationalized using quartiles: Quartile 1 represents tracts in the 0–25th percentile (least healthy conditions), Quartile 2 represents those in the >25–50th percentile, Quartile 3 represents those in the >50–75th percentile, and Quartile 4 represents those in the >75–100th percentile (most healthy conditions). These quartiles are derived from a continuous HPI score, which is calculated and then ranked against all eligible census tracts in California to generate a percentile ranging from 0 (least healthy) to 100 (most healthy). The categorical quartile measure is based on this continuous percentile score. Quartiles are the most common approach for operationalizing the HPI in health research,and offer clearer implications for practice and policy. (Berkowitz et al., 2022; Johnson et al., Romano et al., 2025; South et al., 2022; Sullivan et al., 2025).

The HPI is publicly available at the census tract-level. However, ZIP code–level data are also available upon request. Considering the unit of analysis in this study is ZIP codes, the ZIP code–level HPI file was used. These data were merged with the LAC WIC survey data using ZIP codes to create the multilevel dataset for this study.

Analytic Plan

The analytic plan described in the previous section was applied to this study. The specific modeling steps used in this study are outlined in Table 3.

Table 3. Theory-Driven Multi-Level Model Building Approach in Study 1

Model (M)	Variables Included	Outcomes	Model Type
M1	Healthy Places Index (HPI; continuous score or quartiles)	Breastfeeding initiation; any breastfeeding at 1, 3, and 6 months; exclusive breastfeeding at 1, 3, and 6 months	Multilevel (mixed model)
M2	M1 + individual-level maternal covariates (age, education, income, federal poverty level, food security status, race/ethnicity, preterm birth)	Same as above	Multilevel (mixed model)

Study 2

Aim & Research Questions

The purpose of the second study was to examine how neighborhood racial/ethnic concentration help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The research question is: What is the association between racial/ethnic concentration of a neighborhood, as measured by the total percentage of Hispanic residents within a ZIP code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

Data

The two main databases for Study 2 are the LAC WIC Survey (2014 and 2017 waves), which provides individual-level data, and the 2010 Decennial Census File, which provides neighborhood-level data. These datasets were merged at the ZIP code level to create a multilevel dataset. The survey questions used to create these variables are provided in Table 2.

Measures

Breastfeeding practices and maternal covariates were measured using the same data and operationalized in the same way as described in Study 1. The survey questions used to create these variables are provided in Table 2.

Data from the 2010 Decennial Census Summary File 1 were used to measure neighborhood racial/ethnic concentration, specifically neighborhood Hispanic concentration. This measure was selected because the sample is predominately Hispanic. The variable was operationalized using total and Hispanic population counts from the 2010 Decennial Census. Hispanic concentration was calculated by dividing the Hispanic population by the total population within each ZIP code. This operationalization was selected due to its widespread use in neighborhood effects research (Kershaw et al., 2023). Additionally, neighborhood concentration was chosen because it reflects a broad measure of the spatial distribution of racial/ethnic groups. This conceptual neutrality allows for a more exploratory examination of relationships without assuming a specific underlying mechanism (e.g., segregation or co-ethnic residence).

Analytic Plan

The analytic plan described in the previous section was applied to this study. The specific modeling steps used in this study are outlined in Table 4.

Table 4. Theory-Driven Multi-Level Model Building Approach in Study 2

Model (M)	Variables Included	Outcomes	Model Type
M1	Neighborhood Hispanic Concentration (e.g., percentage of Hispanic residents within a ZIP code)	Breastfeeding initiation; any breastfeeding at 3 and 6 months; exclusive breastfeeding at 3 and 6 months	Multilevel (mixed model)
M2	M1 + individual-level maternal covariates (age, education, income, EBT use, food security status, race/ethnicity, and preterm birth)	Breastfeeding initiation; any breastfeeding at 3 and 6 months; exclusive breastfeeding at 3 and 6 months	Multilevel (mixed model)

Study 3

Aim & Research Questions

The purpose of the third study was to examine how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The research question is: What is the association between access to healthy foods, as measured by the percentage of the ZIP code population living in food desert tracts, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for individual-level maternal characteristics?

Data

The three main databases for Study 3 are the: 1) 2014 and 2017 LAC WIC Survey, 2) 2015 and 2019 USDA FARA, and 3) 2010 U.S. Census Burreau ZCTA-to-Census Tract relationship file. These datasets were merged using ZIP-ZCTA approximations to create a multilevel dataset.

Measures

Breastfeeding practices and maternal covariates were measured using the same data and operationalized in the same way as described in Study 1. The survey questions used to create these variables are provided in Table 2.

Data from the USDA FARA were used to measure food access. Because these data are only available at the census tract level, they were aggregated to the ZCTA level to align with the geographic unit used in the LAC WIC survey. The U.S. Census Bureau 2010 tract-to-ZCTA relationship file was used to facilitate this process. ZCTAs are approximations of ZIP codes and are commonly used to link census-based data to ZIP code–level analyses.

The final measure used for analyses reflected a ZIP code-level food access measure, defined as the percent of ZIP code population living in a food desert tract. A food desert tract was defined using the USDA FARA definition as a census tract that is both low-income (poverty rate ≥20% or median income ≤80% of area median) and low-access (≥500 people or ≥33% of residents live more than 0.5 miles in urban areas or 10 miles in rural areas from a supermarket or large grocery store) (Measuring Access to Food, n.d.).

Analytic Plan

The analytic plan described in the previous section was applied to this study. The specific modeling steps used in this study are outlined in Table 5.

Table 5. Theory-Driven Multi-Level Model Building Approach in Study 3

Model (M)	Variables Included	Outcomes	Model Type
M1	ZIP-level food measure	Breastfeeding initiation; any breastfeeding at 3 and 6 months; exclusive breastfeeding at 3 and 6 months	Multilevel (mixed model)
M2	M1 + individual-level maternal covariates (age, education, income, EBT use, food security status, race/ethnicity, and preterm birth)	Breastfeeding initiation; any breastfeeding at 3 and 6 months; exclusive breastfeeding at 3 and 6 months	Multilevel (mixed model)

Chapter Summary

This chapter provided an overview of the data, methods, and analytic approaches used in this dissertation. The primary datasets include individual-level data from the LAC WIC Survey and neighborhood level data from the HPI, USDA FARA, and U.S. Census Bureau's Geographic Relationship and Decennial Census files. These datasets were merged across the three studies, in different combinations, to create the multilevel datasets used to examine neighborhood effects on breastfeeding. Given the multilevel nature of the data, all three studies employed multilevel analyses, using mixed models, to account for the nesting of individuals within ZIP codes. This approach was selected because it is widely used in neighborhood effects research and allows for the simultaneous examination of the effects of group-level and individual-level variables on individual level outcomes.

CHAPTER 6: Examination of Place-Based Social Determinants of Health (SDOH) and Breastfeeding Practices: A Multilevel Analysis of WIC Participants in Los Angeles County (Study 1)

Study Overview

The present study is the first of three studies in this dissertation (Study 1). This study examined the relationship between place-based SDOH, measured through the neighborhood social and physical environment using the Healthy Places Index (HPI), and individual-level breastfeeding practices (initiation, duration, and exclusivity) among low-income women. The goal of this study was to establish a foundational understanding of how neighborhood quality is related to breastfeeding practices of Woman, Infant, and Children (WIC) program participants living in Los Angeles County (LAC).

Research Questions and Hypotheses

To address the aim of this study, the following research questions and corresponding hypotheses were tested:

Question 1.1: What is the association between place-based SDOH, as measured by the composite HPI score, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 1.1a:* The composite HPI score (where higher scores indicate healthier communities) is significantly and positively associated with the likelihood of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 1.1b:* The association between the composite HPI score and each breastfeeding practice (i.e., initiation, duration, and exclusivity) is attenuated but remains significant after adjusting for maternal characteristics, indicating that place-

based SDOH help explain individual-level differences in breastfeeding beyond maternal characteristics.

- *Hypothesis 1.1c:* Although the composite HPI score is significantly and positively associated with each breastfeeding practice, the strength of the relationship differs by outcome (i.e., initiation, duration, and exclusivity). Due to limited prior research linking the neighborhood environment to breastfeeding practices and the exploratory nature of this analysis, specific predictions regarding these relationships are not proposed.

Question 1.2: What is the association between place-based SDOH, as measured by the specific domains of the HPI (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access), and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 1.2a:* Each of the eight HPI domain scores (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access), where higher scores indicate healthier communities, is significantly and positively associated with the likelihood of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 1.2b:* The association between each of the eight HPI domain scores (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access) and breastfeeding practices (i.e., initiation, duration, and exclusivity) is attenuated but remains significant after adjusting for maternal characteristics, indicating that place-based

SDOH help explain individual-level differences in breastfeeding beyond maternal characteristics.

- *Hypothesis 1.2c:* Although each of the eight HPI domain scores are significantly and positively associated with each breastfeeding practice (i.e., initiation, duration, and exclusivity), the strength of the relationship differs by domain and outcome (i.e., initiation, duration, and exclusivity).

Methods

Key predictor: Place-based SDOH

Data on place-based SDOH was obtained from the HPI, which is an online mapping tool that provides data on neighborhood conditions in California across eight domains or policy areas: 1) economic, 2) education, 3) social, 4) housing, 5) transportation, 6) neighborhood, 7) clean environment, and 8) healthcare access (*Healthy Places Index*, n.d.). Details on each domain, including their indicators, and data sources can be found in Appendix E.

The HPI composite score and the eight domain-specific scores were used to measure place-based SDOH at the ZIP code level. The composite score reflects overall neighborhood conditions across the eight domains, whereas the domain-specific scores reflect specific aspects of the neighborhood physical and social environments. HPI scores were categorized into quartiles based on the distribution across California. Quartile 1 represents ZIP codes in the 0–25th percentile (least healthy), Quartile 2 represents those in the >25–50th percentile, Quartile 3 represents those in the >50–75th percentile, and Quartile 4 represents those in the >75–100th percentile (most healthy). The quartile version of the HPI is the most common approach for operationalizing the HPI in health research and provides clearer implications for practice and policy (Berkowitz et al., 2022; Johnson et al., 2022; Romano et al., 2025; South et al., 2022;

Sullivan et al., 2025). For these reasons, the HPI quartiles were used as the primary operationalization of neighborhood quality in this study.

Outcomes: Individual-level Breastfeeding Practices

Data to measure breastfeeding practices were obtained through the 2014 and 2017 LAC WIC Survey and assessed as a binary variable (Yes/No) for the following outcomes: initiation, any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months, and exclusive breastfeeding at 6 months. Breastfeeding initiation refers to whether the infant was ever breastfed, either in the hospital or after returning home. Any breastfeeding refers to the infant receiving any amount of breast milk, either by nursing or bottle-feeding. Exclusive breastfeeding refers to the infant receiving only breast milk, either through nursing or bottle, with no other liquids or solids, including water. The operationalization of these breastfeeding measures is based on prior studies using LAC WIC Survey data in the breastfeeding literature (Jiang, 2021, 2021; S. Jung et al., 2019; Langellier et al., 2012, 2014; Nobari et al., 2017).The specific survey questions used to operationalize each variable are listed in Table 2 (Chapter 5).

Covariates: Individual-level Maternal Characteristics

Data for the individual-level maternal covariates were obtained from the LAC WIC survey and included: race/ethnicity (Hispanic/Latinx, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic Pacific Islander, Non-Hispanic American Indian or Alaskan native, and other/multi-racial), education level (less than high school, high school graduate, some college or associated degree, college graduate or above), age (younger than 20 years, 20-29 years, and 30 years and older), whether they used EBT in the past 12 month (yes/no), food security status (high or marginal food security, low food security, and very low food security), and whether they had a pre-term birth (yes/no). These covariates were selected because they are

widely used in studies of neighborhood effects and breastfeeding (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Kummer et al., 2020; LoCasale-Crouch et al., 2024; Riley et al., 2016; Yourkavitch et al., 2018). All covariates were included in fully adjusted models. The specific survey questions used to operationalize each variable are listed in Table 2 (Chapter 5).

Analytic Plan

All data merging, cleaning, and analyses were conducted using R statistical software (R Core Team, 2025). Descriptive univariate statistics and bivariate analyses were conducted to summarize and explore the distribution of all key predictors, covariates, and outcomes. Chi-square tests were used to examine preliminary associations between analytic variables to assess patterns across groups.

Considering the multilevel nature of the data, various metrics related to the degree of clustering and sample efficiency of the data were calculated, including the intraclass correlation coefficient (ICC), the design effect (DEFF), and distribution of cluster counts and sizes (Hox et al., 2017; Maas & Hox, 2005). These indicators were used to describe the structure and limitations of the data as well as guide interpretation of results within these parameters.

Multilevel analysis, guided by a theory-driven model-building approach, was used to examine the association between place-based SDOH and individual-level breastfeeding practices. A two-step modeling process was followed and is outlined in Table 3 (Chapter 5). In the unadjusted model (Model 1), the crude association between the quartiles of the HPI score and each breastfeeding practice was estimated. In the adjusted model (Model 2), the individual-level maternal covariates (i.e., education, race/ethnicity, use of EBT, food security status, maternal age, and preterm birth) were added to Model 1. This sequence of modeling was applied to each

breastfeeding practice first using the composite HPI score to address Question 1.1 and then using each of the HPI domain scores to address Question 1.2. Separate regressions were estimated for each breastfeeding practice.

Using the same modeling approach, sensitivity analyses were conducted with the HPI percentile composite and domain scores to assess the robustness of the findings. These percentiles were available in the dataset and represent the raw HPI score ranked across all eligible census tracts in California, converted into a percentile scale ranging from 0 (least healthy conditions) to 100 (most healthy conditions).

Results

Sample

The 2014 and 2017 LAC WIC Surveys were merged with the HPI database. The HPI data are available at the ZCT-level, while the WIC survey data are at the ZIP code level. In this study, ZIP codes from the LAC WIC survey were linked to HPI data using ZIP–ZCTA approximations. As discussed earlier, these geographic boundaries do not perfectly align and may result in imperfect matches between ZIP codes and ZCTAs (Grubesic, 2008; Grubesic & Matisziw, 2006). Merging of the data resulted in minimal data loss, with a total of 240 participants, representing 158 ZIP codes, being dropped from the WIC survey due to missing HPI data. The final analytic sample consisted of 8,780 participants and was restricted to biological mothers to improve the reliability of recalled breastfeeding history. Table 6 describes the socio-demographic, breastfeeding, and neighborhood characteristics of the sample overall and by breastfeeding practice.

Table 6. Sociodemographic, Breastfeeding, and Neighborhood Characteristics of the Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,780)

Characteristic	**N (%)**
Maternal Race/Ethnicity	
Hispanic	7527 (85.7)
Non-Hispanic Black	598 (6.8)
Non-Hispanic White	352 (4.0)
Non-Hispanic Asian	173 (2.0)
Non-Hispanic Pacific Islander	22 (0.3)
Non-Hispanic American Indian/Alaska Native	11 (0.1)
Other/multi-racial	78 (0.9)
Maternal Education	
Less than high school	3099 (35.3)
High school graduate	2465 (28.1)
Some college/trade school/associate degree	2449 (27.9)
4-year degree or higher	735 (8.4)
Preterm Birth	
Yes	776 (8.8)
No	7989 (91.0)
Food Security Status	
High/marginal food security	6173 (70.3)
Low food security	1778 (20.3)
Very low food security	674 (7.7)
Maternal Age	
Younger than 20	837 (9.5)
20-29	4350 (49.5)
30 and older	3572 (40.7)
Used EBT in the past 12 months	
Yes	4229 (48.2)
No	4527 (51.6)
Breastfeeding practice	
Initiation	8211 (93.5)
Any breastfeeding at 3 months	5831 (66.4)
Any Breastfeeding at 6 months	4350 (57.1)
Exclusive breastfeeding at 3 months	1781 (21.6)
Exclusive breastfeeding at 6 months	874 (10.9)
Healthy Places Index Quartile	
Quartile 1 (Least Healthy)	5645 (64.3)
Quartile 2	2334 (26.0)
Quartile 3	691 (7.9)
Quartile 4 (Most Healthy)	110 (1.30)

Individual-Level and Neighborhood-level Maternal Characteristics

As seen in Table 6, the majority of the sample identifies as Hispanic (N=7,527; 85.7%), followed by Black (N=598; 6.8%), White (N=352, 4.0%), Asian (N=173; 2.0%), Other/multiracial N=78; 0.9%), Pacific Islander (N=22; 0.3%), and American Indian/Alaska Native (AI/AN) (N=11; 0.1%). Over half of the sample has a high school education or less (N= 5,564; 63.4%). Nearly half of the sample is between the ages of 20-29 years (N = 4,350; 49.5%). The majority of the sample is classified as food secure (N=6,173; 70.3%) and did not have a preterm birth (N=7,989; 90.0%). About half of the participants did not use EBT in the past 12 months (N=4,502; 51.5%), whereas the other half did (N=4,209; 48.2%).

In terms of breastfeeding practices, the sample reported high initiation rates (N=8,211; 93.5%) but substantially lower duration and exclusivity rates across time points (Table 6). Any breastfeeding declined drastically from 66.4% (N=5,831) at 3 months to 57% (N=4,350) at 6 months. Prevalence of exclusive breastfeeding was even lower, with rates dropping from 21.6% (N = 1,781) at 3 months to 10.9% (N = 874) at 6 months. These patterns suggest that while most participants initiate breastfeeding, maintaining breastfeeding, particularly exclusive breastfeeding, remains a challenge in the WIC population.

Table 6 also describes the neighborhood-level characteristics of the sample, measured using the quartiles of the HPI composite score (Quartile 1: Least Healthy to Quartile 4: Most Healthy). Most of the sample resides in ZIP codes in the least healthy quartiles (Quartile 1: 64.3%, N = 5,645; 26.0%, Quartile 2: N = 2,334), with much less in the healthier quartiles (Quartile 3: 7.9%, N=691 and Quartile 4: 1.3%, N=110). This suggests some variation in neighborhood conditions across the sample, with majority residing in the least healthy areas.

Missing data on individual-level factors were minimal, ranging from 0.2% to 1.8%, except for breastfeeding practices which ranged from approximately 0.1-22.9%. The large missingness for breastfeeding is because timepoints were defined based on child age and breastfeeding duration. At later timepoints missingness increased due to a combination of right-censoring for children who had not yet reached the specified age and incomplete reporting of breastfeeding cessation timing. Therefore, the missing values for breastfeeding reflect true missingness and was not imputed. Additionally, there were no missing cases for the neighborhood-level variable.

Tables 7-11 present the sociodemographic and neighborhood characteristics of the sample by each breastfeeding practice. Overall, significant differences between those who breastfed and those who did not were consistently observed for maternal race/ethnicity and education level ($p \leq 0.01$) at all timepoints except exclusivity at 3 and 6 months. In general, lower breastfeeding prevalence across outcomes were observed among participants with lower educational attainment and among Black mothers. These patterns suggest that social and structural factors tied to education and race/ethnicity may influence breastfeeding behaviors.

Other individual-level characteristics, including EBT use, food security status, preterm birth, and maternal age, showed less consistent associations across breastfeeding outcomes. Preterm birth was significantly associated with breastfeeding, with those experiencing a preterm birth overrepresented among participants who did not initiate breastfeeding and who did not exclusively breastfeed at 3 and 6 months. For EBT use, participants receiving EBT were overrepresented among those who did not initiate breastfeeding and those who did not report any breastfeeding at 3 months ($p < .0.01$). Differences were also observed by food security status, with greater food security associated with lower prevalence of any breastfeeding at 3 months (p

< 0.01). For maternal age, a mixed pattern was observed. Participants aged 30 years and older had higher prevalence of any breastfeeding at 3 and 6 months (all p-values < 0.01), whereas participants aged 20-29 years were overrepresented among those who exclusively breastfed at 6 months. Overall, these findings suggest that associations between these individual-level characteristics and breastfeeding vary depending on the specific breastfeeding measure.

Regarding the neighborhood-level variables, no significant differences were detected across HPI quartiles for all breastfeeding practices (p >0.01). The lack of association may be due to the limited variability in neighborhood conditions within the sample, as most participants resided in the least healthy HPI quartiles (Quartiles 1 and 2). Overall, these bivariate analyses suggest that differences in breastfeeding behaviors are more strongly associated with individual-level characteristics than neighborhood-level factors in this sample.

Table 7. Sociodemographic and Neighborhood Characteristics by **Initiation** for Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,711)

	Yes	**No**	**P-value**[a]
Characteristic	**N (%)**	**N (%)**	
Total Population	8211 (93.5)	560 (6.4)	
Maternal Race/Ethnicity			**0.00**
Hispanic	7071 (86.3)	449 (80.2)	
Non-Hispanic Black	524 (6.4)	73 (13.0)	
Non-Hispanic White	328 (4.0)	24 (4.3)	
Non-Hispanic Asian	171 (2.1)	1 (0.2)	
Non-Hispanic Pacific Islander	20 (0.2)	2 (0.4)	
Non-Hispanic American Indian/Alaska Native	7 (4 (0.7))	4 (0.7)	
Other/multi-racial	71 (0.9)	7 (1.2)	
Maternal Education			**0.00**
Less than high school	2863 (35.0)	234 (42.1)	
High school graduate	2306 (28.2)	156 (28.1)	
Some college/trade school/ associate degree	2310 (28.2)	135 (24.3)	
4-year degree or higher	704 (8.6)	31 (5.6)	
Preterm Birth			**0.00**
Yes	680 (8.3)	96 (17.2)	
No	7518 (91.7)	462 (82.8)	
Food Security Status			0.27
High/marginal food security	5758 (71.4)	409 (74.4)	
Low food security	1677 (20.8)	99 (18.0)	
Very low food security	631 (7.8)	42 (7.6)	
Maternal Age			0.24
Younger than 20	794 (9.7)	43 (7.7)	
20-29	4069 (49.7)	275 (49.3)	
30 and older	3329 (40.6)	240 (43)	
Used EBT in the past 12 months			**0.00**
Yes	3913 (47.8)	309 (55.3)	
No	4275 (52.2)	250 (44.7)	
Healthy Places Index Quartile			0.31
Quartile 1 (Least Healthy)	5259 (64.0)	380 (67.9)	
Quartile 2	2194 (26.7)	137 (24.5)	
Quartile 3	654 (8.0)	37 (6.6)	
Quartile 4 (Most Healthy)	104 (1.3)	6 (1.1)	

Bolded values = significant at p = 0.01

a. p-values for chi-square test

Table 8. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 3 Months** for Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=7,912)

	Yes	**No**	**P-value**[a]
Characteristic	**N (%)**	**N (%)**	
Total Population	5831 (66.4)	2081 (23.7)	
Maternal Race/Ethnicity			**0.00**
Hispanic	5063 (87.1)	1763 (84.9)	
Non-Hispanic Black	327 (5.6)	175 (8.4)	
Non-Hispanic White	229 (3.9)	80 (3.9)	
Non-Hispanic Asian	125 (2.1)	40 (1.9)	
Non-Hispanic Pacific Islander	15 (0.3)	3 (0.1)	
Non-Hispanic American Indian/Alaska Native	5 (0.1)	1 (0.0)	
Other/multi-racial	52 (0.9)	15 (0.7)	
Maternal Education			**0.00**
Less than high school	2073 (35.7)	695 (33.6)	
High school graduate	1576 (27.1)	642 (31.0)	
Some college/trade school/ associate degree	1630 (28)	589 (28.4)	
4-year degree or higher	535 (9.2)	145 (7.0)	
Preterm Birth			0.59
Yes	475 (8.2)	178 (8.6)	
No	5347 (91.8)	1899 (91.4)	
Food Security Status			**0.01**
High/marginal food security	4030 (70.4)	1514 (73.9)	
Low food security	1230 (21.5)	387 (18.9)	
Very low food security	463 (8.1)	149 (7.3)	
Maternal Age			**0.00**
Younger than 20	473 (8.1)	288 (13.9)	
20-29	2805 (48.2)	1130 (54.5)	
30 and older	2544 (43.7)	656 (31.6)	
Used EBT in the past 12 months			**0.00**
Yes	2702 (46.4)	1072 (51.7)	
No	3116 (53.6)	1003 (48.3)	
Healthy Places Index Quartile			0.43
Quartile 1 (Least Healthy)	3721 (63.8)	1356 (65.2)	
Quartile 2	1564 (26.8)	548 (26.3)	
Quartile 3	465 (8.0)	156 (7.5)	
Quartile 4 (Most Healthy)	81 (1.4)	21 (1.0)	

Bolded values = significant at p = 0.01

a. p-values for chi-square test

Table 9. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 6 Months** for Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=7,612)

	Yes	**No**	**P-value[a]**
Characteristic	**N (%)**	**N (%)**	
Total Population	4350 (57.1)	3262 (42.9)	
Maternal Race/Ethnicity			**0.00**
Hispanic	3805 (87.7)	2768 (85.0)	
Non-Hispanic Black	220 (5.1)	263 (8.1)	
Non-Hispanic White	172 (4.0)	121 (3.7)	
Non-Hispanic Asian	90 (2.1)	68 (2.1)	
Non-Hispanic Pacific Islander	7 (0.2)	11 (0.3)	
Non-Hispanic American Indian/Alaska Native	4 (0.1)	0 (0.0)	
Other/multi-racial	40 (0.9)	25 (0.8)	
Maternal Education			**0.00**
Less than high school	1659 (38.3)	1027 (31.6)	
High school graduate	1132 (26.1)	1001 (30.8)	
Some college/trade school/ associate degree	1127 (26.0)	984 (30.3)	
4-year degree or higher	419 (9.7)	237 (7.3)	
Preterm Birth			0.18
Yes	347 (8.0)	289 (8.9)	
No	3995 (92.0)	2969 (91.1)	
Food Security Status			0.06
High/marginal food security	2997 (70.3)	2334 (72.7)	
Low food security	930 (21.8)	631 (19.7)	
Very low food security	339 (7.9)	245 (7.6)	
Maternal Age			**0.00**
Younger than 20	296 (6.8)	435 (13.4)	
20-29	2050 (47.2)	1722 (52.9)	
30 and older	1997 (46.0)	1097 (33.7)	
Used EBT in the past 12 months			0.06
Yes	2042 (47.0)	1601 (49.2)	
No	2300 (53.0)	1651 (50.8)	
Healthy Places Index Quartile			0.15
Quartile 1 (Least Healthy)	2795 (64.3)	2111 (64.7)	
Quartile 2	1140 (26.2)	879 (26.9)	
Quartile 3	349 (8.0)	239 (7.3)	
Quartile 4 (Most Healthy)	66 (1.5)	33 (1.0)	

Bolded values = significant at p = 0.01

a. p-values for chi-square test

Table 10. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 3 Months** for Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 8,254)

	Yes	**No**	**P-value[a]**
Characteristic	**N (%)**	**N (%)**	
Total Population	1781 (21.6)	6473 (78.4)	
Maternal Race/Ethnicity			0.02
Hispanic	1491 (83.9)	5586 (86.5)	
Non-Hispanic Black	128 (7.2)	436 (6.8)	
Non-Hispanic White	92 (5.2)	236 (3.7)	
Non-Hispanic Asian	40 (2.3)	121 (1.9)	
Non-Hispanic Pacific Islander	5 (0.3)	16 (0.2)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	10 (0.2)	
Other/multi-racial	21 (1.2)	53 (0.8)	
Maternal Education			0.02
Less than high school	581 (32.7	2324 (36.0)	
High school graduate	507 (28.5)	1810 (28.1)	
Some college/trade school/ associate degree	515 (29.0)	1799 (27.9)	
4-year degree or higher	173 (9.7)	514 (8.0)	
Preterm Birth			**0.00**
Yes	108 (6.1)	570 (8.8)	
No	1670 (93.9)	5891 (91.2)	
Food Security Status			0.56
High/marginal food security	1268 (72.5)	4529 (71.2)	
Low food security	347 (19.8)	1332 (20.9)	
Very low food security	134 (7.7)	498 (7.8)	
Maternal Age			0.12
Younger than 20	147 (8.3)	635 (9.8)	
20-29	909 (51.1)	3206 (49.7)	
30 and older	723 (40.6)	2614 (40.5)	
Used EBT in the past 12 months			0.14
Yes	831 (46.8)	3148 (48.8)	
No	946 (53.2)	3308 (51.2)	
Healthy Places Index Quartile			0.10
Quartile 1 (Least Healthy)	1128 (63.3)	4175 (64.5)	
Quartile 2	463 (26.0)	1729 (26.7)	
Quartile 3	162 (9.1)	494 (7.6)	
Quartile 4 (Most Healthy)	28 (1.6)	75 (1.2)	

Bolded values = significant at p = 0.01

a. p-values for chi-square test

Table 11. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 6 Months** for Study 1 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 8,019)

	Yes	**No**	**P-value**[a]
Characteristic	**N (%)**	**N (%)**	
Total Population	874 (10.9)	7145 (89.1)	
Maternal Race/Ethnicity			0.42
Hispanic	738 (84.5)	6151 (86.3	
Non-Hispanic Black	59 (6.8)	487 (6.8)	
Non-Hispanic White	42 (4.8)	269 (3.8)	
Non-Hispanic Asian	21 (2.4)	134 (1.9)	
Non-Hispanic Pacific Islander	2 (0.2)	18 (0.3)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	8 (0.1)	
Other/multi-racial	11 (1.3)	61 (0.9)	
Maternal Education			0.25
Less than high school	304 (34.9)	2537 (35.6)	
High school graduate	248 (28.4)	2002 (28.1)	
Some college/trade school/ associate degree	232 (26.6)	1995 (28.0)	
4-year degree or higher	88 (10.1)	583 (8.2)	
Preterm Birth			**0.00**
Yes	44 (5.0)	635 (8.9)	
No	829 (95.0)	6497 (91.1)	
Food Security Status			0.52
High/marginal food security	625 (73.1)	5001 (71.2)	
Low food security	168 (19.6)	1472 (21.0)	
Very low food security	62 (7.3)	549 (7.8)	
Maternal Age			**0.00**
Younger than 20	58 (6.6)	703 (9.9)	
20-29	465 (53.2)	3517 (49.4)	
30 and older	351 (40.2)	2906 (40.8)	
Used EBT in the past 12 months			0.05
Yes	395 (45.2)	3479 (48.8)	
No	478 (54.8)	3647 (51.2)	
Healthy Places Index Quartile			0.18
Quartile 1 (Least Healthy)	545 (62.4)	4628 (64.8)	
Quartile 2	233 (26.7)	1888 (26.4)	
Quartile 3	82 (9.4)	542 (7.6)	
Quartile 4 (Most Healthy)	14 (1.6)	87 (1.2)	

Bolded values = significant at p = 0.01

a. p-values for chi-square test

ZIP Code Distribution and Between-ZIP Variability

Los Angeles County is composed of over 500 ZIP codes, and the sample includes WIC participants from 279 unique ZIP codes across LAC. The number of participants per ZIP code ranges from 1 to 252, with an average of 31.5 participants (SD: 41.7) A common guideline recommends at least 30 level 2 units with 30 observations per unit to be considered sufficient for multilevel analyses (Hox et al., 2017; Maas & Hox, 2005). In the present sample, 228 ZIP codes (81.7%) included at least 30 participants, which meets the recommended threshold for multilevel analyses.

The intraclass correlation coefficient (ICC) was calculated to assess the proportion of variance in breastfeeding practices attributable to differences between ZIP codes (Table 12). The ICCs indicated minimal clustering, accounting for 0.1% to 3.0% of the variance in breastfeeding outcomes being attributable to differences between ZIP codes. This low variance, while typical in neighborhood effects research, may make it more difficult to detect neighborhood-level effects. For exclusivity at 6 months, the ICC was negligible (0.001), indicating virtually no between-ZIP variation. As a result, multilevel modeling was not supported by the data and several of the models for this outcome were ran as standard logistic regressions instead.

Table 12. Intraclass Correlation Coefficients (ICC), Mean Cluster Sizes, and Design Effects (DEFF) for Breastfeeding Practices Across ZIP Codes

Outcome	N	Mean Cluster Size	ICC	DEFF
Initiation	8,771	31.4	0.03	1.81
Any at 3 months	7,912	28.5	0.01	1.27
Any at 6 months	7,612	27.5	0.03	1.44
Exclusivity at 3 months	8,254	30.0	0.01	1.27
Exclusivity at 6 months	8,019	29.1	0.00	1.04

Additionally, a DEFF was calculated for each outcome to assess the impact of clustering within ZIP codes (Table 12) on sample size and standard errors. The DEFFs observed in this study indicated that accounting for clustering increased standard errors and modestly reduced the effective sample size (range: 1.04–1.81), both of which may make it more difficult to detect neighborhood-level effects.

Primary Analyses

The primary analyses consisted of using quartile versions of the HPI composite and domain scores to examine their association with breastfeeding practices in multilevel models with ZIP code as the level 2 identifier. While most models ran as multilevel models, several models for the exclusivity at 6 months outcome ran as standard logistic regressions since the variance in the level 2 identifier (ZIP code) was negligible (near 0). Additionally, very few individuals were in Quartile 4 (N=4) of the clean environment domain. Therefore, Quartiles 3 and 4 of the clean environment domain were combined in multilevel analyses to increase the sample size within categories.

To minimize potential noise and reduce the likelihood of spurious findings that may arise with the conventional $p < 0.05$ threshold, a more conservative threshold for significance was used (0.01) (Benjamin et al., 2017). The results are organized by breastfeeding practice (initiation, duration, and exclusivity), with associations presented first for the HPI composite and then for HPI specific domains. This chapter only presents results for certain breastfeeding practices: initiation, any at 3 months, any at 6 months, exclusivity at 3 months, and exclusivity at 6 months. A summary table indicating which models demonstrated statistically significant associations across breastfeeding outcomes for the HPI composite and domains is presented in

Table 13. Results of the full analyses (Odds ratios, Confidence Intervals, and p-values) with all other outcomes can be found in the appendices (Appendices F.1-F.9).

Table 13. Summary of statistically significant associations across breastfeeding outcomes for HPI composite and domain models (Quartiles)

	Initiation		Any at 3 months		Any at 6 months		Exclusivity at 3 months		Exclusivity at 6 months	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
HPI COMPSOITE (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X
ECONOMIC (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	0.02**	X	0.01*	X	0.00*	0.00*	0.01*	0.02**
EDUCATION (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	0.02**	0.01*	X	X	X	X	X	X	0.01*	0.02**
Quartile 4	0.02**	0.01*	0.00*	0.01*	0.00*	0.00*	0.00*	0.00*	0.01*	0.02**
INSURANCE (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	0.00*	0.00*	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X
HOUSING (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X
NEIGHBORHOOD (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X

TRANSPORTATION (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X
SOCIAL (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3	X	X	X	X	X	X	X	X	X	X
Quartile 4	X	X	X	X	X	X	X	X	X	X
CLEAN ENVIRO (Ref = Quartile 1)										
Quartile 2	X	X	X	X	X	X	X	X	X	X
Quartile 3/4	X	X	X	X	X	X	X	X	X	X

*Significant at 0.01
** Marginal significance at 0.02
X = Not significant
Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Breastfeeding Initiation

The results for the adjusted models are presented in the forest plot in Figure 8. The full results (Odds ratios, Confidence Intervals, and p-values) for these analyses can be found in Appendix F.1.

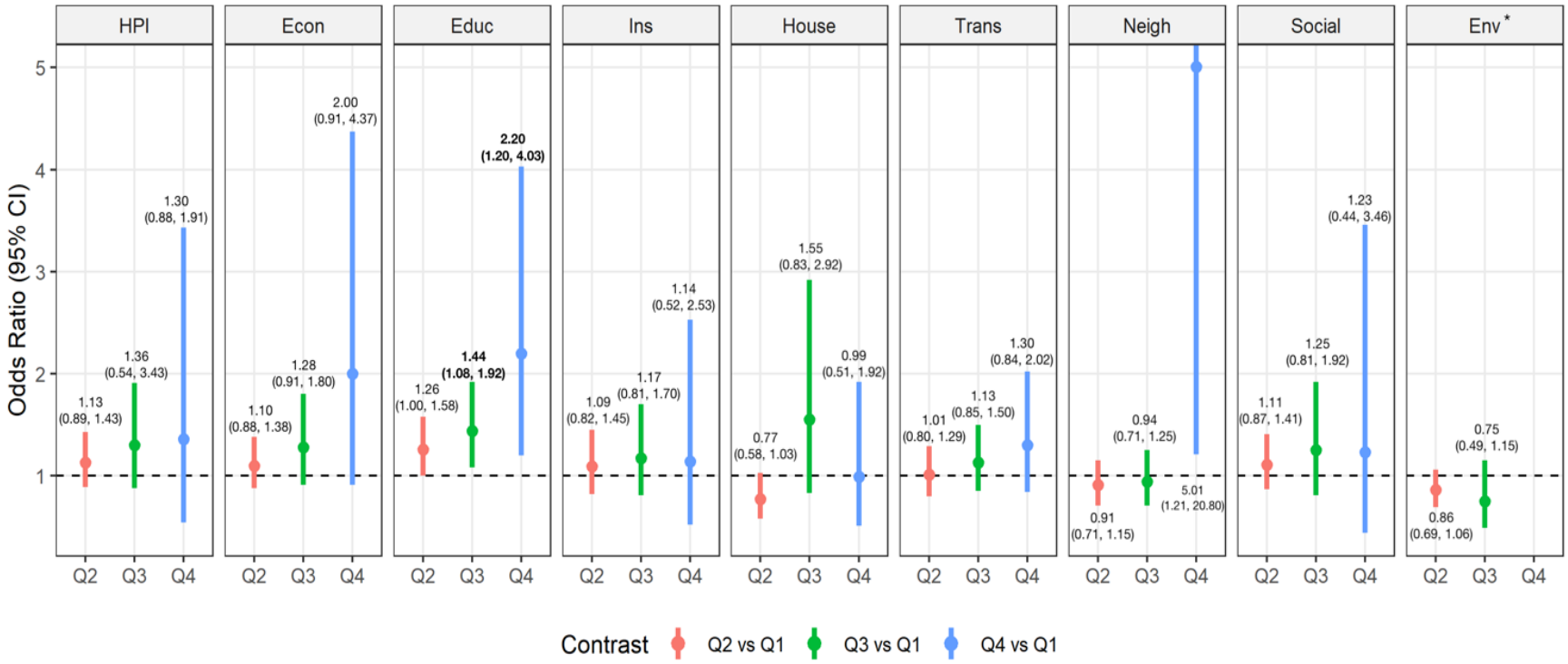


Figure 8. Adjusted odds ratios and 95% confidence intervals for the association between Healthy Places Index (HPI) composite and domain quartiles and **breastfeeding initiation.**

Notes: Models are adjusted for individual-level maternal characteristics (education, race/ethnicity, pre-term birth, EBT use, and food security status). Bolded estimates indicate statistical significance at the 0.01 level. * = Quartiles 3 and 4 were combined due to the small sample size in Quartile 4.

HPI composite

Across both models (Models 1 and 2), HPI composite quartiles were not significantly associated with breastfeeding initiation (all p-values > 0.01). However, a trend was observed where healthier HPI quartiles were associated with higher odds of initiation, although it was not statistically significant (all p-values > 0.01). This suggests a potential positive relationship between overall neighborhood quality and breastfeeding initiation.

HPI Domains

Domain-specific analyses showed that all domains, except the education domain, were not statistically significant with breastfeeding initiation (p-values > 0.01). The education domain was marginally associated with breastfeeding initiation in the unadjusted model (p = 0.02) and became statistically significant in the adjusted model (p = 0.01). In the unadjusted model (Model 1), higher odds of initiation were observed among participants living in Quartile 3 (OR = 1.42; 95% CI: 1.07-1.10) and Quartile 4 (OR = 1.93; 95% CI:1.10-3.38), compared to those living in Quartile 1 (p=0.02). Although the significance fell just short of the threshold, results suggest that residing in neighborhoods in healthier quartiles of the education domain is associated with higher odds of breastfeeding initiation.

After adjusting for maternal-level covariates, these associations reached significance at the .01 threshold (p = 0.01) and were slightly strengthened. In the adjusted model (Model 2), the odds of initiation were approximately 44% higher for those living in Quartile 3 (OR = 1.44; 95% CI: 1.08-1.92) and more than two times higher for those living in Quartile 4 (OR = 2.20; 95% CI: 1.20-4.03), compared to those living in Quartile 1. These results suggest a gradient effect, where residing in neighborhoods in healthier quartiles of the education domain is associated with higher odds of breastfeeding initiation, independent of individual-level maternal characteristics. Although Quartile 2 did not reach statistical significance at the 0.01 threshold in either model, it

was significant at the conventional 0.05 level ($p = 0.05$) and demonstrated a similar pattern of higher odds.

The other seven HPI domains (social, transportation, economic, housing, clean environment, built environment, and insurance) were not significantly associated with breastfeeding initiation (all p-values > 0.01) in either Model 1 or Model 2. The odds ratios were largely consistent across models, with only slight attenuation or strengthening. Although these associations were not statistically significant, the odds ratios for some domains (i.e., social, transportation, and housing) displayed a positive gradient effect. This suggests a potential positive relationship between these domains and breastfeeding initiation.

Any Breastfeeding at 3 and 6 Months

The results for the adjusted models for any breastfeeding at 3 and 6 months are presented in the forest plots in Figures 9 and 10, respectively. The full results for these analyses can be found in Appendices F.3 and F.4.

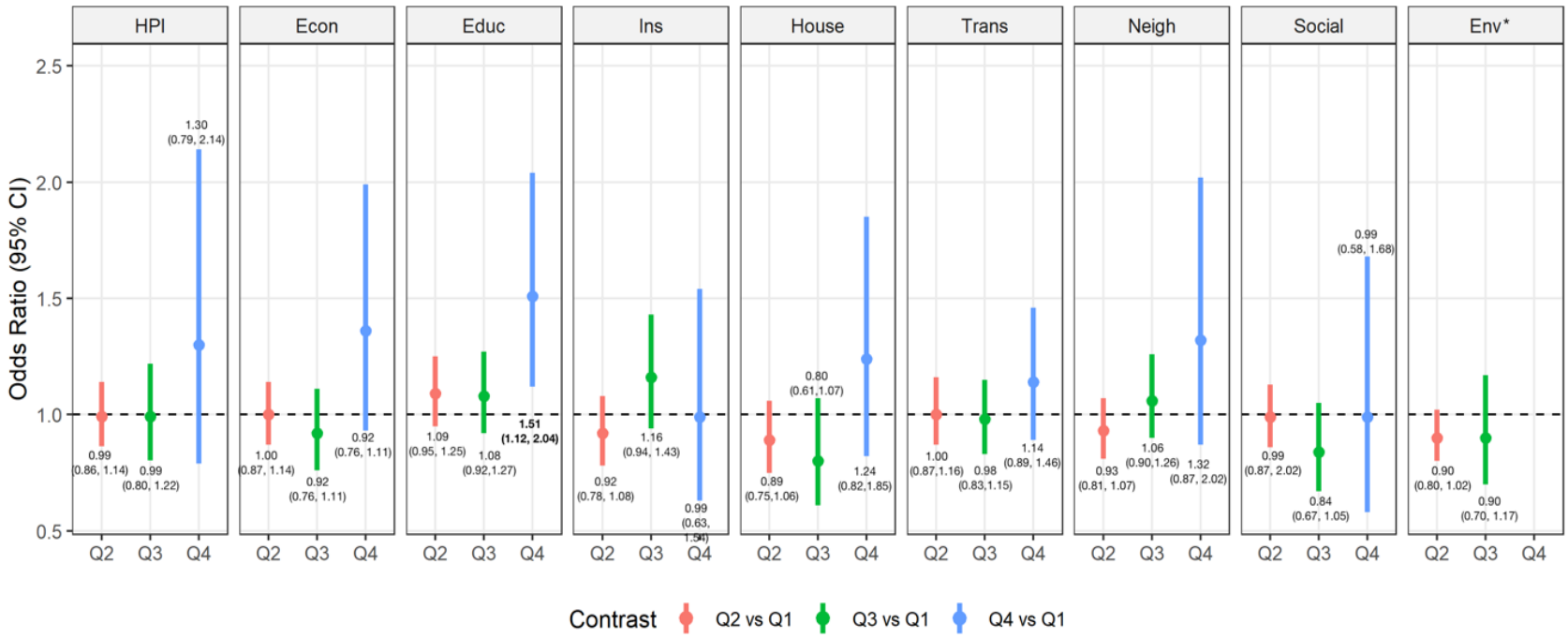


Figure 9. Adjusted odds ratios and 95% confidence intervals for the association between Healthy Places Index (HPI) composite and domain quartiles and **any breastfeeding at 3 months**.

Notes: Models are adjusted for individual-level maternal characteristics (education, race/ethnicity, pre-term birth, EBT use, and food security status). Bolded estimates indicate statistical significance at the 0.01 level. ***** = Quartiles 3 and 4 were combined due to the small sample size in Quartile 4.

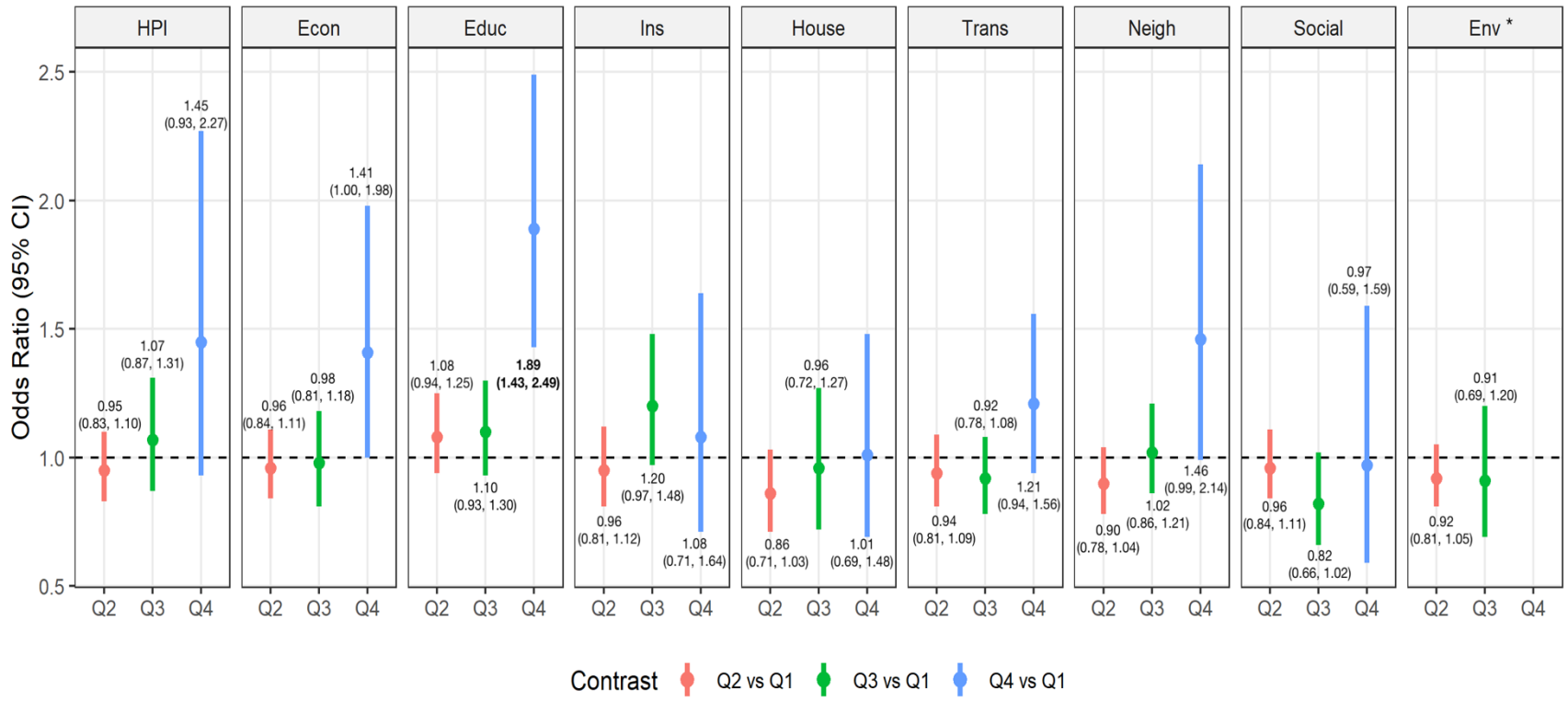


Figure 10. Adjusted odds ratios and 95% confidence intervals for the association between Healthy Places Index (HPI) composite and domain quartiles and **any breastfeeding at 6 months.**

Notes: Models are adjusted for individual-level maternal characteristics (education, race/ethnicity, pre-term birth, EBT use, and food security status). Bolded estimates indicate statistical significance at the 0.01 level. * = Quartiles 3 and 4 were combined due to the small sample size in Quartile 4.

HPI Composite

Across both models (Models 1 and 2), quartiles of the HPI composite score were not significantly associated with any breastfeeding at 3 and 6 months (all p-values > 0.01). However, a trend was observed in which Quartile 4 (vs. Quartile 1) at both time points was associated with higher odds of breastfeeding, although the associations were not statistically significant (all p-values > 0.01). This pattern suggests a potential threshold effect where only the highest HPI quartile is associated with higher odds of continued breastfeeding compared with the lowest quartile.

HPI Domains

Domain-specific analyses showed that all domains, except the education and economic domains, were not statistically significant with any breastfeeding at 3 or 6 months (all p-values > 0.01). The education domain was significantly associated with breastfeeding practices at both timepoints in both models ($p \leq 0.01$). In the unadjusted model (Model 1), significantly higher odds of breastfeeding were observed for participants living in Quartile 4 (vs Quartile 1) at 3 months (OR = 1.68; 95% CI: 1.25-2.25) and 6 months (OR = 1.98; 95% CI: 1.51-2.60). This pattern suggests a potential threshold effect, where only the highest quartile of the education domain is associated with higher odds of continued breastfeeding when compared with the lowest quartile.

After adjusting for maternal-level covariates, these associations remained significant and were slightly weakened ($p \leq 0.01$). In the adjusted model (Model 2), the odds of any breastfeeding for those living in Quartile 4 (vs Quartile 1) were approximately 51% higher at 3 months (OR = 1.51; 95% CI: 1.12-2.04), and 89% higher at 6 months (OR = 1.89; 95% CI: 1.43-2.49). The observed attenuation in the association post-adjustment suggests that the relationship

between the education domain and breastfeeding is independent of individual-level maternal characteristics but only partially explains it.

The economic domain showed a significant association with any breastfeeding at 6 months ($p \leq 0.01$), with a marginally significant association observed at 3 months ($p = 0.02$). For any breastfeeding at 6 months, Quartile 4 (vs. Quartile 1) was significantly associated with higher odds of breastfeeding in Model 1 ($p = 0.01$) However, this association did not remain significant after adjustment for maternal-level covariates in Model 2 ($p=0.05$). This suggests that the association is not independent of individual-level maternal characteristics. Associations between the other HPI domains and any breastfeeding at 3 and 6 months were not statistically significant (all p-values > 0.01) and showed inconsistent patterns across quartiles and models for each time point.

Exclusive Breastfeeding at 3 and 6 Months

The results for the adjusted models for exclusive breastfeeding at 3 and 6 months are presented in the forest plots in Figures 11 and 12, respectively. The full results for these analyses can be found in Appendix F.8 and F.9.

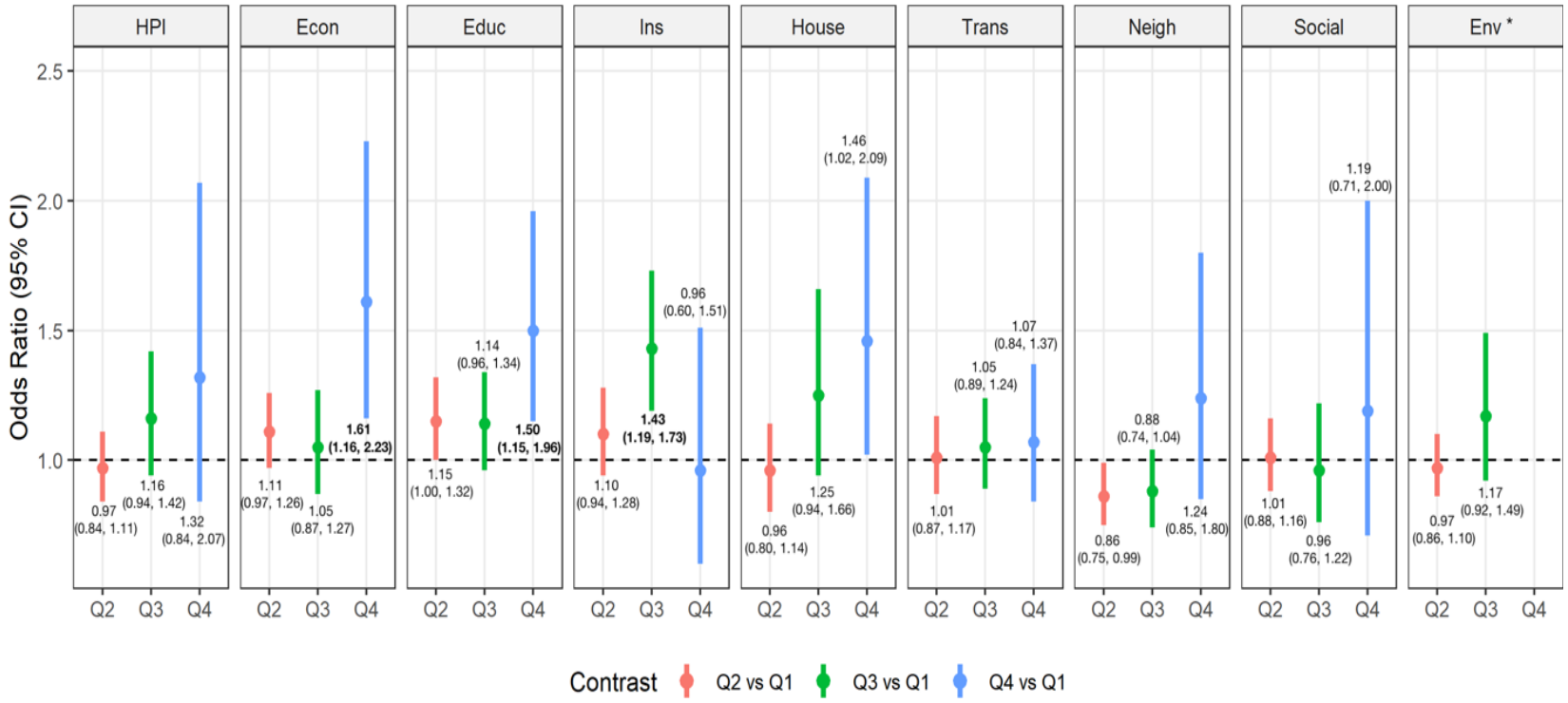


Figure 11. Adjusted odds ratios and 95% confidence intervals for the association between Healthy Places Index (HPI) composite and domain quartiles and **exclusive breastfeeding at 3 months.**

Notes: Models are adjusted for individual-level maternal characteristics (education, race/ethnicity, pre-term birth, EBT use, and food security status). Bolded estimates indicate statistical significance at the 0.01 level. ***** = Quartiles 3 and 4 were combined due to the small sample size in Quartile 4.

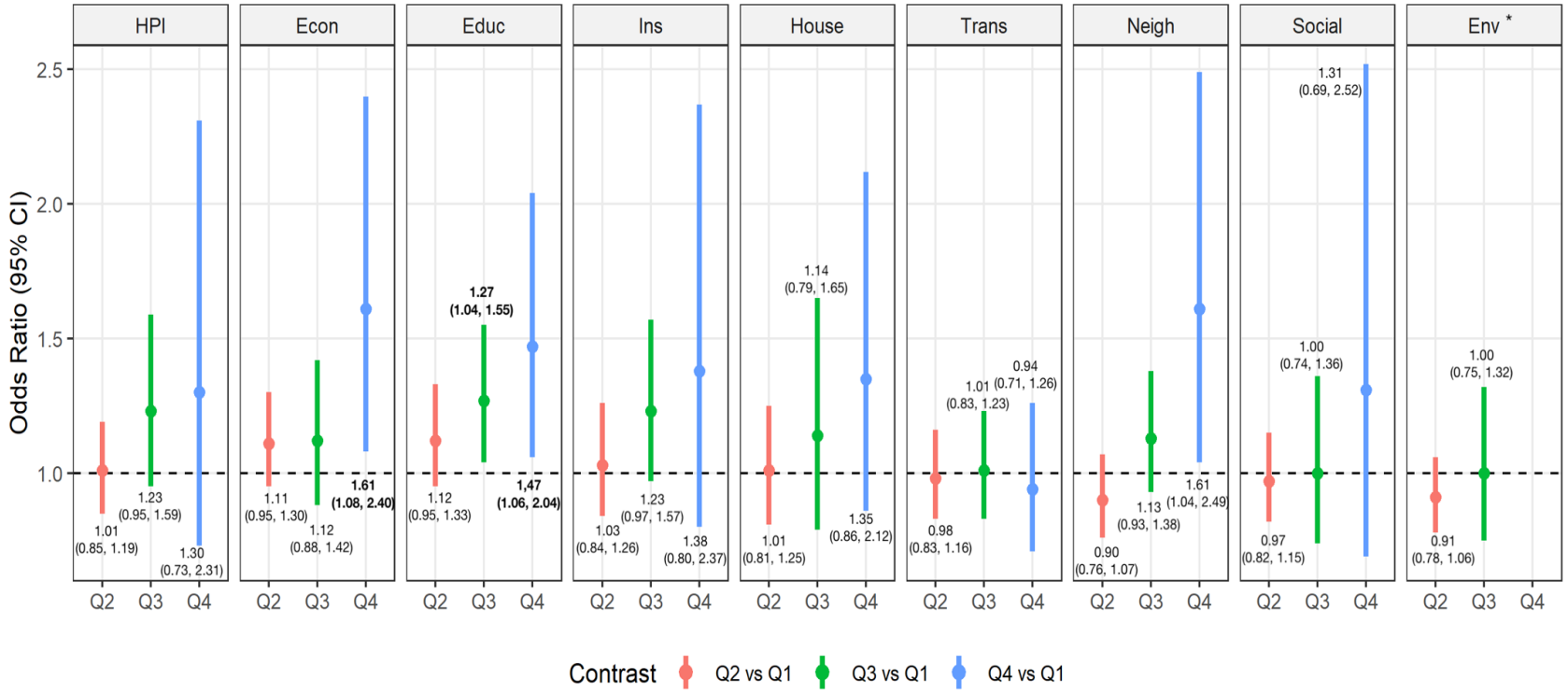


Figure 12. Adjusted odds ratios and 95% confidence intervals for the association between Healthy Places Index (HPI) composite and domain quartiles and **exclusive breastfeeding at 6 months.**

Notes: Models are adjusted for individual-level maternal characteristics (education, race/ethnicity, pre-term birth, EBT use, and food security status). Bolded estimates indicate marginal significance at the 0.02 level. * = Quartiles 3 and 4 were combined due to the small sample size in Quartile 4. Most outcomes were analyzed using single-level logistic regression due to negligible ZIP code–level variance, except for transportation and social domain measures.

HPI Composite

Across both models (Models 1 and 2), HPI composite quartiles were not significantly associated with breastfeeding exclusivity at 3 and 6 months (all p-values > 0.01). However, a trend was observed where healthier HPI quartiles were associated with higher odds of initiation, although it was not statistically significant (all p-values > 0.01). This suggests a potential positive relationship between overall neighborhood quality and exclusive breastfeeding.

HPI Domains

Domain-specific analyses showed that only the education, insurance, and economic domains were statistically significant with exclusive breastfeeding at 3 or 6 months (p-values < 0.01). For exclusive breastfeeding at 3 months, the education, insurance, and economic domains were significantly associated with breastfeeding practices at the 0.01 threshold in both models. After adjusting for maternal-level covariates, higher odds of exclusive breastfeeding at 3 months were observed among participants living in Quartile 4 (vs. Quartile 1) of the economic (OR = 1.61; 95% CI: 1.16–2.23) and education (OR = 1.50; 95% CI: 1.15–1.96) domains, as well as Quartile 3 (vs. Quartile 1) of the insurance domain (OR = 1.43; 95% CI: 1.19, 1.73). These associations attenuated post-adjustment, which suggests that the relationship between these domains and exclusive breastfeeding at 3 months is independent of individual maternal characteristics but only partially explains these relationships.

Additionally, for exclusive breastfeeding at 6 months, the economic domain was significantly associated in the unadjusted models (p=0.01) but were only marginally significant after adjustment (p = 0.02). This suggests that the relationship between these domains and exclusive breastfeeding at 6 months is not independent of maternal-level covariates. Associations between the other HPI domains and exclusive breastfeeding at 3 and 6 months were not

statistically significant and showed inconsistent patterns across quartiles and models at each time point.

Sensitivity Analyses

Sensitivity analyses were conducted using the HPI percentile composite and domain-specific scores. The full results (Odds Ratios, Confidence Intervals, and p-values) of these analyses are provided in Appendices G.1-G.9. In general, the results from the sensitivity analyses were consistent with the primary analyses using HPI quartiles and provide support for the robustness of the primary findings.

The HPI composite percentile score was not significantly associated with any breastfeeding at 3 and 6 months in either unadjusted or adjusted models, which is aligned with the primary findings. However, significant associations between the composite percentile score and initiation as well as exclusive breastfeeding at 3 and 6 months (all p values=0.01) were identified. These associations were significant in Model 1 (p=0.01) but did not remain significant after adjusting for maternal-level covariates in Model 2 (p-values > 0.01). These findings suggest that the observed associations are not independent of individual-level maternal characteristics, which aligns with the primary analyses. Additionally, a trend was observed where higher HPI scores were associated with higher odds of breastfeeding across models at all time points. This suggests a potential positive relationship between neighborhood quality and breastfeeding, which is consistent with the trends observed in the primary findings.

Domain-specific analyses using the HPI percentile scores were also consistent with the primary findings, which identified the education domain as the most robust domain associated with breastfeeding across outcomes, even after accounting for individual-level maternal characteristics.

Examination of model fit indices, including the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), showed a slight improvement in model fit when using the percentile measure compared with quartiles (Appendix I). Considering the improvement in fit was negligible, interpretation focused on the quartile-based models because they are more commonly used in research and have clearer policy implications.

Follow up analyses were also conducted using individual-level lactation support as additional maternal covariates in Model 2. These variables were included to assess whether the associations observed in the primary analyses remained robust after adjusting for proximal sources of breastfeeding support. Using methods from a previous study, the LAC WIC survey data were used to construct the lactation support covariates (Jiang, 2021). These measures included partner support (1 = Partner lives in household, 2 = partner does not live in household but active, and does not live in household and not active) and workplace accommodations (1=returned to work within three months and the workplace did not have breastfeeding accommodations, 2=returned to work within three months and the workplace provided breastfeeding accommodations, and 3=did not return to work within three months (Jiang, 2021). The survey questions used to operationalize these variables are provided in Appendix J.

Findings were largely consistent, with slight changes observed in the education domain. Associations that were initially statistically significant became marginally due to small increases in p-values for initiation (new p-value: 0.03), any at 3 months (new p-value: 0.02), and exclusivity at 6 months (new p-value: 0.02). Overall, the results remain mostly consistent with the main analyses.

Lastly, follow-up analyses were conducted with the sample restricted to mothers with children aged 2 years and younger (N = 3,590). These analyses were conducted to assess the

robustness of findings when restricted to participants whose neighborhood conditions may more accurately reflect their current environment (i.e., those with younger children). Results were largely consistent with the main findings, although some initial associations were attenuated or changed. Changes were primarily observed for exclusivity, with associations for breastfeeding exclusivity at 3 and 6 months no longer significant ($p > 0.01$) in either model (only marginally significant in Model 2) for the education and economic domains. One reason for the differences could be attributed to the smaller sample which may have reduced statistical power, making previously significant associations fall slightly below the threshold. In contrast, the neighborhood domain, which was not significant in the primary analysis, became statistically significant in the sensitivity analyses.

Summary of Key Findings

Three key findings emerged from these results. First, overall neighborhood quality is not significantly associated with breastfeeding. However, a trend was consistently observed where healthier HPI quartiles were associated with higher odds of breastfeeding. Although these associations are not statistically significant, they suggest potential positive relationships between neighborhood quality and breastfeeding (i.e., initiation, duration at 3 and 6 months, and exclusivity at 3 and 6 months) that warrant further investigation. Second, the education domain emerged as the most robust neighborhood indicator consistently associated with higher odds of breastfeeding (i.e., initiation, duration at 3 and 6 months, and exclusivity at 3 and 6 months), even after accounting for individual maternal characteristics. Third, compared to the other outcomes, a greater number of HPI domains are significantly associated with exclusive breastfeeding, including the education, economic, and insurance domains. This pattern suggests that specific neighborhood-level socioeconomic indicators may play a particularly important role in supporting exclusive breastfeeding.

Discussion

The present study examined the relationship between place-based SDOH, measured using the HPI, and individual-level breastfeeding practices (i.e., initiation, duration at 3 and 6 months, and exclusivity at 3 and 6 months) among WIC participants living in LAC. This study addresses a major gap in the current understanding of how broader environmental and social conditions shape breastfeeding practices. To date, breastfeeding research has primarily focused on individual-level measures of SDOH, with limited use of multidimensional, place-based measures that capture both the collective and distinct influences of neighborhood conditions (Standish & Parker, 2022). SDOH do not operate in isolation, they are interconnected and interact in ways that collectively shape health behaviors and outcomes (Liang et al., 2024; Ozieh et al., 2021). Understanding both the collective influence of neighborhood environments and the specific contributions of individual aspects is critical for advancing breastfeeding research and informing interventions.

To address these gaps, the present study examined both the associations between breastfeeding and overall neighborhood quality (HPI composite) as well as specific aspects of the neighborhood environment (HPI domains). The two primary research questions were: 1) What is the association between the HPI composite score and individual-level breastfeeding practices, after accounting for maternal characteristics? and 2) What is the association between the specific domains of the HPI (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access) and individual-level breastfeeding practices, after accounting for maternal characteristics?

Research Question 1: HPI Composite and Breastfeeding Practices

To address the first research question, a series of multilevel models were created to examine the association between overall neighborhood quality, using the HPI composite score, and breastfeeding practices. It was hypothesized that the HPI composite score (where higher HPI quartiles indicate healthier communities) would be significantly and positively associated with breastfeeding practices both before and after adjusting for individual-level maternal characteristics. The association was hypothesized to attenuate after adjustment but remain significant, indicating that neighborhood environments have an independent association with breastfeeding beyond individual-level characteristics. Further, it was expected that the direction of the association would remain consistent, but the magnitude of the associations would vary across different breastfeeding practices.

Contrary to the proposed hypotheses, this study found that the HPI composite score was not significantly associated with breastfeeding practices across all outcomes in either unadjusted or adjusted models. This finding suggests that overall neighborhood quality, as measured by the HPI composite score, may not play as strong of a role in breastfeeding as expected. A possible explanation for these findings could be related to how the HPI was constructed. The HPI was constructed using life expectancy at birth as its primary outcome, therefore this measure may be capturing broader population health conditions rather than factors specifically related to child health or early life environments (Coline Bodenreider et al., 2022) .

Specifically, the HPI does not incorporate measures of neighborhood health services that are important for breastfeeding, such as distribution of Baby-Friendly hospitals, WIC clinics, and community-based lactation support (e.g., Baby Cafés). These forms of infrastructure are known to improve breastfeeding and represent critical, place-based supports for WIC populations (Gleason et al., 2020; S. Jung et al., 2019, 2019; Nobari et al., 2017). For WIC participants, who

rely more heavily on community-based services, availability and quality of these resources may be more influential than broader neighborhood conditions. Therefore, the minimal effects observed in this study should not be interpreted as evidence that neighborhoods do not matter, but rather that the HPI may overlook important dimensions of the environment that are important for breastfeeding. Future research should utilize indices of neighborhood quality that incorporate breastfeeding support (e.g., distribution of Baby-Friendly hospitals, WIC clinics, and community-based lactation support programs) to better understand how place shapes breastfeeding behaviors among WIC populations.

Another possible explanation for these findings is that the present study used ZIP codes to define neighborhoods. ZIP codes are administrative units created for mail delivery and were not designed for statistical analysis (Grubesic, 2008; Grubesic & Matisziw, 2006). In neighborhood effects research, census tracts are the preferred and most widely used unit of analysis because they better capture neighborhood contexts and are specifically designed for research purposes. Compared to census tracts, ZIP codes are larger and often contain multiple census tracts with varying socioeconomic and environmental conditions (Grubesic, 2008; Grubesic & Matisziw, 2006). Additionally, ZIP codes can vary widely in size and population and are not standardized, whereas census tracts are designed with population thresholds to ensure statistical reliability across areas (Grubesic, 2008; Grubesic & Matisziw, 2006). As a result, the use of ZIP codes provides less granular data, making it more difficult to detect meaningful differences because conditions are aggregated across heterogeneous areas.

Finally, these results may reflect the relatively small proportion of variation in breastfeeding outcomes attributable to differences between ZIP codes (ICC range: 0.001–0.03) found in this sample. The low ICCs detected in this study suggest that most variability in

breastfeeding outcomes is occurring at the individual-level, rather than at the neighborhood-level. This limited variability could make it harder to detect neighborhood effects. Additionally, the DEFF values (range: 1.04–1.81) detected in this study indicate that accounting for neighborhood-level clustering increased standard errors and reduced the effective sample size, both of which can reduce the power to detect neighborhood effects. These issues coupled with the use of multilevel models, may have made it even more difficult to detect statistically significant associations. Multilevel models are the appropriate analytic approach for neighborhood effects research as they can account for clustering of mothers within ZIP codes. However, they produce more conservative estimates and can make neighborhood effects harder to detect.

Although results did not support the proposed hypotheses, a positive and gradient trend was consistently observed. Healthier neighborhoods (higher HPI quartiles) were generally associated with higher odds of breastfeeding. While these trends were not statistically significant, they are consistent with prior research that has found a positive association between overall neighborhood quality and breastfeeding.

In the United States, the only study examining this relationship used the Childhood Opportunity Index 2.0 (COI 2.0) to assess neighborhood resources and breastfeeding at two- to six-month follow-up (LoCasale-Crouch et al., 2024). Mothers in the highest-resourced neighborhoods had higher odds of any and exclusive breastfeeding after adjusting for maternal characteristics. These findings underscore both the influence of neighborhood context on breastfeeding and the importance of measurement choice. Compared with the HPI used in the present study, the Childhood Opportunity Index 2.0 may better reflect neighborhood

environments relevant to maternal and child health and more accurately capture breastfeeding-related resources.

Internationally, studies in the United Kingdom have examined the relationship between neighborhood environments and breastfeeding using a multidimensional measure of neighborhood deprivation, the Index of Multiple Deprivation (IMD) (Oakley et al., 2013; Peregrino et al., 2018). In line with the trends observed in the present study, Oakley et al. (2013) found that areas with higher deprivation, as measured by quintiles of the IMD, had lower odds of area-level breastfeeding initiation, any breastfeeding at 6–8 weeks, and exclusive breastfeeding at 6–8 weeks. After adjustment for area-level covariates, these associations remained significant when comparing the most deprived areas (Quintiles 4 and 5) with the least deprived areas (Quintile 1). Likewise, Peregrino et al. (2018) found that neighborhood deprivation, as measured by the IMD, was independently and inversely associated with breastfeeding initiation even after adjustment for maternal-level characteristics. Together, these studies support the trends observed in the present study and provide evidence of potential neighborhood effects on breastfeeding.

Research Question 2: HPI Domains and Breastfeeding Practices

Regarding the second research question, a series of multilevel models were created to examine the association between specific aspects of the neighborhood environment, using the HPI domains, and breastfeeding practices. It was hypothesized that the HPI domain-specific scores (where higher quartiles indicate healthier communities) would be significantly and positively associated with breastfeeding practices both before and after adjusting for individual-level maternal characteristics. The association was hypothesized to attenuate after adjustment but remain significant, indicating that neighborhood environments have an independent association with breastfeeding, beyond individual-level characteristics. Additionally, it was expected that the

direction of the association would remain consistent across breastfeeding outcomes, though the magnitude and strength of the associations would vary across different breastfeeding practices and HPI domains.

Findings from this study provide minimal support for the proposed hypotheses. Although a few domains showed significant associations with the outcomes, majority of the HPI domains were not significantly associated with breastfeeding at all time points in either unadjusted or adjusted models. This finding suggests that specific aspects of the neighborhood environment, as measured by the HPI, may not play as strong of a role in breastfeeding as expected. As discussed earlier, measurement considerations related to the construction of the HPI, the use of ZIP codes as a proxy for neighborhoods, and limited neighborhood-level variation may partly explain these domain-specific findings.

Contrary to this main finding, a different association was observed for the education domain compared to the other domains. Participants residing in neighborhoods in higher quartiles of the education domain had consistently higher odds of breastfeeding across outcomes, independent of individual maternal characteristics. This finding is consistent with prior research showing that a higher percentage of college-educated individuals within a neighborhood is significantly and independently associated with higher odds of breastfeeding initiation and any breastfeeding at 6 months (Burdette, 2013). Other studies which use area-level education related indicators as part of broader indices of neighborhood socioeconomic conditions, provide further support for this association. These studies have found that greater neighborhood disadvantage (e.g., lower percentage of adults who completed college) is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to 6 months, independent of maternal socio-

demographic characteristics (Galante et al., 2022; Griswold et al., 2025; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018).

A possible explanation for this finding is that the education domain is the only domain that reflect neighborhood conditions related to children and families. The HPI operationalizes the education domain through three indicators: 1) the percentage 3- and 4-year-olds in school, 2) percentage of people over age 25 with a bachelor's education or higher, and 3) the percentage of 15–17-year-olds enrolled in high school. Indicators such as preschool and high school enrollment may better reflect the presence of youth and community investments in early childhood development. These factors could lead to the availability of stronger institutional and community support systems in neighborhoods that are better able to support and promote breastfeeding. Additionally, higher levels of educational attainment may influence community knowledge, norms, and access to information that support breastfeeding practices. Higher levels of educational attainment may also reflect communities with greater economic resources and investments in health-supporting infrastructure (Hawthorne & Kwan, 2013; Moore et al., 2008). These community-level advantages and increased access to resources can promote breastfeeding by helping women overcome barriers and increase knowledge, self-efficacy, and confidence.

For exclusive breastfeeding practices, a different pattern emerged compared with the other outcomes. In unadjusted and adjusted models, significant associations were observed for exclusive breastfeeding at 3 months across the education, economic, and insurance domains. Likewise, significant associations were observed for exclusive breastfeeding at 6 months across the education and economic domains. These were the only outcomes in which domains beyond education demonstrated significant associations.

These findings suggest that indicators related to neighborhood-level socioeconomic conditions included in the HPI economic domain (e.g., area-level poverty rate, mean income, and employment rate) are critical place-based factors in supporting exclusive breastfeeding. One possible explanation is that exclusive breastfeeding may be more sensitive to neighborhood socioeconomic conditions because maintaining exclusivity requires sustained access to resources and support, which may be more available in higher-income neighborhoods.

Research has shown that women in low-income neighborhoods, compared to those in high-income neighborhoods, have less access to community-based lactation support including mother-to-mother support groups and breastfeeding peer counselors (Grubesic & Durbin, 2021). These types of support play a critical role in a mother's ability to initiate and sustain breastfeeding, as they provide both shared knowledge and hands-on assistance (Raisler, 2000). Compared to mothers in higher-income neighborhoods, those in lower-income neighborhoods also report living in areas with a lack of breastfeeding-friendly public spaces such as having access to large parks with benches and high streets with breastfeeding-friendly spaces like cafés and coffeeshops (Isherwood et al., 2019).

In line with the present findings, prior neighborhood effects research has also identified a link between socioeconomic neighborhood conditions and breastfeeding, independent of individual-level maternal characteristics. Bonet et al. (2013) examined the independent association between area-level unemployment rates and breastfeeding at hospital discharge in the U.K. and France. In fully adjusted models, accounting for maternal sociodemographic characteristics, mothers living in neighborhoods in the highest unemployment quartile had lower odds of initiating breastfeeding (Bonet et al., 2013).

Other studies using composite indices of neighborhood socioeconomic status, which are composed of area-level employment-related (e.g., the percentage of white-collar employed persons and percentage of unemployed persons) and income-related (e.g., the percentage of households living below poverty level and the percentage of households receiving public assistance) indicators, have shown significant associations with breastfeeding practices independent of individual-level maternal characteristics (Galante et al., 2022; Griswold et al., 2018a; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). In general, greater neighborhood disadvantage (e.g., higher proportions of unemployed persons) has been found to be significantly associated with lower odds of breastfeeding initiation, duration, and exclusivity up to 6 months (Galante et al., 2022; Griswold et al., 2018a; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). Together, these studies support the associations observed in the present study and provide evidence of neighborhood effects on breastfeeding.

In the present study, the insurance domain was significantly associated with exclusive breastfeeding at 3 months. While this study is the first to examine the association between neighborhood-level insurance coverage and breastfeeding, the importance of healthcare access in ensuring women receive the necessary education, support, and resources to breastfeed is well-documented. For example, research shows that the percentage of uninsured women is twice as high in maternity care deserts, where access to maternity care services is limited or nonexistent, compared to areas with full access (Nowhere to Go: Maternity Care Deserts Across the US, 2024). This finding demonstrates how area-level insurance coverage can serve as an important indicator of healthcare access with potential implications for breastfeeding outcomes.

Healthcare access is critical to ensuring mothers have access to prenatal care and breastfeeding education. Breastfeeding education provided by qualified healthcare professionals during prenatal care visits are associated with higher rates of breastfeeding initiation, longer duration, and exclusivity up to 6 months (Ahlers-Schmidt et al., 2020; Kehinde et al., 2023; Rosen et al., 2008; Ugurlu & Yavan, 2016). Insurance coverage is critical to ensuring mothers have access to free or low-cost breastfeeding support and supplies (e.g., lactation counseling, education, and breast pumps), which may be especially important for low-income populations (Gurley-Calvez et al., 2018). While the existing research indicate that neighborhood-level measures of healthcare coverage can serve as an important indicator of overall availability of care, the present findings demonstrate that it may have important implications for breastfeeding.

Limitations

The present findings should be interpreted with the study's limitations in mind. First, this study focuses on a low-income population, specifically participants in the WIC program living in LAC. Because WIC eligibility is limited to individuals at or below 185% of the federal poverty level, this sample is low-income and socioeconomically homogeneous. This likely contributed to the limited variation in neighborhood conditions observed, as most participants resided in ZIP codes with the least healthy conditions (Quartiles 1 and 2). The limited variation in neighborhood conditions may explain the minimal variation in breastfeeding outcomes that was attributable to differences between ZIP codes. Taken together, these factors could have reduced the ability to detect neighborhood-level effects in this study sample and should not be interpreted as evidence that neighborhood effects do not exist.

Using a WIC sample also presents limitations related to generalizability and potential selection bias. Considering the WIC population is low-income, the present findings may not

apply to middle- or higher-income families, or even to low-income families who are not WIC-eligible or who do not participate in the program. Additionally, the study sample is not racially/ethnically diverse, with the majority of participants identifying as Hispanic (85.7%). Although overrepresented in this sample, this racial/ethnic makeup is consistent with the national WIC population which is majority Hispanic (63%) (*National and State Level Estimates of WIC Eligibility and Program Reach in 2020*, 2025). While the findings from this study may be generalizable to the broader WIC population, especially in areas with similar demographics, the lack of diversity limits the application of findings to populations with different racial and ethnic compositions. Lastly, because the study sample was restricted to LAC, the present findings may not generalize to other areas of California or to regions of the United States outside Los Angeles. Future research should examine more socioeconomically and racially/ethnically diverse populations across different geographic contexts, as greater variation in neighborhood exposures may improve the ability to detect contextual effects on breastfeeding practices.

The second limitation relates to the use of the HPI to measure neighborhood quality. As discussed earlier, the HPI reflects broader population health conditions associated with life expectancy at birth and does not specifically capture neighborhood conditions relevant to maternal and child health and resources associated with breastfeeding. Therefore, the present findings should not be interpreted as evidence that contextual effects do not exist, but rather that they may not be adequately captured by the indicators included in the HPI. Future research should consider using neighborhood-level indices specifically designed to capture conditions relevant to child health and development, such as the Childhood Opportunity Index 2.0, to accurately capture contextual influences specific to breastfeeding.

A third limitation is the use of ZIP codes to define neighborhoods. Census tracts are the preferred and most widely used unit in neighborhood effects research because they are smaller and more standardized. These advantages allow census tracts to more accurately capture an individual's neighborhood context. In contrast, ZIP codes are larger and not standardized, which can vary in both population and geographic size. Despite this, ZIP codes are commonly used in public health research and are considered acceptable when less granular geographic data (e.g., census tracts) is not available (Grubesic, 2008; Grubesic & Matisziw, 2006). However, using a larger geographic unit in this study may have reduced variability in neighborhood context within an already relatively homogeneous sample. This aggregation likely limited the ability to detect more granular neighborhood differences and may have contributed to the limited variation observed in neighborhood-level measures

Conclusion

Research has shown that adverse SDOH related to education, employment, neighborhood conditions, and housing instability significantly contribute to racial disparities in breastfeeding practices in the U.S. (Standish & Parker, 2022). However, much of the existing research has focused on individual-level measures of SDOH (Standish & Parker, 2022). While these measures provide important insights into how personal attributes and circumstances influence breastfeeding practices, they do not fully account for how the physical, social, and economic conditions of neighborhoods shape breastfeeding behaviors. This overemphasis on individual-level measures of SDOH have left the role of neighborhood-level structural and social determinants in breastfeeding remains understudied.

Findings from the present study support existing literature and provides further evidence that SES-related indicators (e.g., area-level educational attainment, employment, and income) are

critical neighborhood-level determinants of breastfeeding. This study extends the existing literature and is the first to examine these associations within a WIC population. The persistence of SES-related associations in this sample suggests that, although WIC provides targeted nutrition and lactation support, broader structural and contextual socioeconomic factors play an important role in shaping breastfeeding beyond program support.

The observed trends indicate that neighborhood socioeconomic conditions warrant further investigation. Future research should examine not only the mechanisms through which neighborhood disadvantage influence breastfeeding, but also how neighborhood environments affect mothers' ability to access and utilize available WIC benefits and services. Additionally, the role of upstream factors, such as residential segregation, in concentrating poverty and shaping neighborhood conditions should be further explored.

By examining neighborhood-level factors, this study contributes to a small but growing body of literature examining how neighborhood environments influence breastfeeding practices. This study represents an important shift from the traditional individual-level framing of breastfeeding to one that considers the structural and community contexts that shape breastfeeding practices. Addressing these place-based factors will advance maternal and child health equity by targeting the upstream factors that have undermined progress.

CHAPTER 7: An Exploratory Study of Neighborhood Hispanic Concentration and Breastfeeding Among WIC Participants in Los Angeles (Study 2)

Study Overview

The present study is the second of three studies in this dissertation (Study 2). This study examined the association between neighborhood racial/ethnic concentration, measured as the percentage of Hispanic residents in a ZIP code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The goal of this study was to establish a foundational understanding of how the spatial distribution of racial/ethnic groups in a neighborhood is related to breastfeeding practices of Woman, Infant, and Children (WIC) program participants living in Los Angeles County (LAC). The present study further expands the understanding of the role of the neighborhood environment in shaping breastfeeding practices and identifying potential place-based strategies for mitigation.

Research Aim, Question, and Hypothesis

Study Aim: To examine how neighborhood racial/ethnic concentration helps explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women.

Research Question: What is the association between racial/ethnic concentration of a neighborhood, as measured by the total percentage of Hispanic residents within a ZIP code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

- *Hypothesis 2a:* Neighborhood Hispanic concentration is associated with breastfeeding initiation, duration, and exclusivity. However, the direction of this association is not specified due to the potential for both protective and adverse contextual influences.

- *Hypothesis 2b:* This association is attenuated but remains significant after adjusting for maternal characteristics, indicating that neighborhood Hispanic concentration helps explain individual-level differences in breastfeeding beyond maternal characteristics.
- *Hypothesis 2c:* The strength of the association differs across breastfeeding practices (i.e., initiation, duration, exclusivity).

Methods

Outcomes: Individual-level Breastfeeding Practices

Breastfeeding practices were operationalized using data from the 2014 and 2017 LAC WIC Surveys. The variables were measured as binary variables (Yes/No) using the following outcomes: initiation, any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months, and exclusive breastfeeding at 6 months. Breastfeeding initiation refers to whether the infant was ever breastfed, either in the hospital or after discharge. Any breastfeeding refers to whether the infant is receiving any amount of breast milk, either by nursing or bottle-feeding. Exclusive breastfeeding refers to whether the infant is receiving only breast milk, either through nursing or bottle, with no other liquids or solids (e.g., water). These measures were created based on methods from prior studies using LAC WIC Survey data. (Jiang, 2021, 2021; S. Jung et al., 2019; Langellier et al., 2012, 2014; Nobari et al., 2017). The specific survey questions used to operationalize each variable are listed in Table 2 (Chapter 5).

Key predictor: Neighborhood Racial/Ethnic Concentration

The key predictor was neighborhood racial/ethnic concentration, defined as the percentage of Hispanic residents within a ZIP Code. A measure of Hispanic concentration was selected because the study sample is predominately Hispanic. The variable was operationalized

using total and Hispanic population counts from the 2010 Decennial Census Summary File 1 (*Decennial Census of Population and Housing Datasets*, n.d.). Hispanic concentration was calculated by dividing the Hispanic population by the total population. For interpretability, the variable was scaled so that estimates reflect a 10-percentage-point increase in Hispanic concentration.

This operationalization was selected for its widespread use in neighborhood effects research (Kershaw et al., 2023) and its ability to capture a broad, neutral measure of the spatial distribution of racial/ethnic groups without assuming a specific underlying mechanism. This is important because it allows for an exploratory analysis and acknowledges that neighborhood concentration may be associated with both health risks and benefits.

In sensitivity analyses, the continuous neighborhood concentration measure was categorized into both a binary and a three-level variable based on the distribution across ZIP codes. For the binary measure, the mean of the ZIP code–level distribution of Hispanic concentration (rather than the individual-level distribution of the sample) was used as the cutoff. ZIP codes with a percentage of Hispanic concentration below the mean were classified as low concentration and values at or above the mean were classified as high concentration. The mean was selected as the cutoff because the distribution was not substantially skewed. For the three-level variable, cutoffs were defined using tertiles of the ZIP code–level distribution. These alternative measures are commonly used to examine neighborhood racial/ethnic concentration and were used in the present study to assess the robustness of the primary findings. These alternative measures are commonly used in studies of neighborhood racial/ethnic concentration and were applied in the present study to assess the robustness of the primary findings (Kershaw et al., 2023).

Covariates: Individual-level Maternal Characteristics

The following individual-level maternal covariates were obtained from the 2014 and 2017 LAC WIC survey and included: race/ethnicity (Hispanic/Latinx, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic Pacific Islander, Non-Hispanic American Indian or Alaskan native, and other/multi-racial), education level (less than high school, high school graduate, some college or associated degree, college graduate or above), age (younger than 20 years, 20-29 years, and 30 years and older), whether they used EBT in the past 12 month (yes/no), food security status (high or marginal food security, low food security, and very low food security), and whether they had a pre-term birth (yes/no). These factors were selected because they are theoretically relevant, available in the dataset, and reflect factors that are widely used in studies of neighborhood effects and breastfeeding (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Kummer et al., 2020; LoCasale-Crouch et al., 2024; Riley et al., 2016; Yourkavitch et al., 2018). All covariates were included in fully adjusted models. The specific survey questions used to operationalize each variable are listed in Table 2 (Chapter 5).

Analytic Plan

All data merging, cleaning, and analyses were conducted using R statistical software (R Core Team, 2025). A combination of univariate and bivariate (e.g., chi-square tests and paired t-tests) statistics were conducted to summarize and explore the distribution of all key predictors, covariates, and outcomes. Additionally, various metrics were calculated to understand the degree of clustering and distribution of cluster sizes in the sample, including the intraclass correlation coefficients (ICC) and design effect (DEFF) (Hox et al., 2017; Maas & Hox, 2005). These indicators were used to describe the structure and limitations of the data as well as guide interpretation of results within these parameters.

A theory-driven multilevel model-building approach was applied to examine the association between neighborhood Hispanic concentration and breastfeeding, both before and after adjusting for maternal covariates. ZIP codes were used as the level 2 identifier in the multilevel models. The specific modeling steps are outlined in Table 4 (Chapter 5). In Model 1, the crude association between neighborhood Hispanic concentration and each breastfeeding practice was estimated in unadjusted models. In Model 2, individual-level maternal covariates (i.e., education, race/ethnicity, use of EBT, food security status, maternal age, and preterm birth) were added to assess adjusted associations. Separate regressions were estimated for each breastfeeding practice: initiation; any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months and exclusive breastfeeding at 6 months. The same modeling approach was applied in sensitivity analyses using the binary and three-level measures to assess the robustness of the main findings.

Results

Sample

The 2014 and 2017 LAC WIC surveys were merged with the 2010 Decennial Census Summary File 1 using ZIP–ZCTA approximations (*Decennial Census of Population and Housing Datasets*, n.d.). ZCTAs are geographic units created by the U.S. Census Bureau to approximate ZIP codes for reporting Census data. Because ZCTAs are approximations, linking them with ZIP codes can result in a many-to-many relationship (Grubesic, 2008; Grubesic & Matisziw, 2006). This did not present a major issue in the present study as merging resulted in minimal data loss, with 234 participants, representing 148 ZIP codes, being dropped due to ZIP-ZCTA mismatch. The final analytic sample consists of 8,792 participants and is restricted to biological mothers to improve the reliability of recalled breastfeeding history. Table 14 describes

the socio-demographic, breastfeeding, and neighborhood characteristics of the sample. This sample closely resembles the sociodemographic profile of the Study 1 sample. However, it differs slightly due to the use of different databases, which resulted in fewer unmatched cases after merging and a slightly larger final sample.

Table 14. Sociodemographic, Breastfeeding, and Neighborhood Characteristics of the Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,792)

Individual-Level Characteristic	**N (%)**
Maternal Race/Ethnicity	
Hispanic	7535 (85.9)
Non-Hispanic Black	601 (6.9)
Non-Hispanic White	353 (4.0)
Non-Hispanic Asian	173 (2.0)
Non-Hispanic Pacific Islander	22 (0.3)
Non-Hispanic American Indian/Alaska Native	11 (0.1)
Other/multi-racial	78 (0.9)
Maternal Education	
Less than high school	3103 (35.4)
High school graduate	2470 (28.2)
Some college/trade school/associate degree	2452 (28.0)
4-year degree or higher	735 (8.4)
Preterm Birth	
Yes	776 (8.8)
No	8001 (91.2)
Food Security Status	
High/marginal food security	6182 (71.6)
Low food security	1780 (20.6)
Very low food security	675 (7.8)
Maternal Age	
Younger than 20	839 (9.6)
20-29	4358 (49.7)
30 and older	3574 (40.7)
Used EBT in the past 12 months	
Yes	4237 (48.3)
No	4531 (51.7)
Breastfeeding practice	
Initiation	8222 (93.6)
Any breastfeeding at 3 months	5838 (73.7)
Any Breastfeeding at 6 months	4355 (57.1)
Exclusive breastfeeding at 3 months	1783 (21.6)
Exclusive breastfeeding at 6 months	874 (10.9)
Neighborhood-Level Characteristic	**Mean (SD)**
Neighborhood Hispanic Concentration[a]	64.0 (21.3)[b]

a. Defined as the percent of Hispanic population in a ZIP code
b. Values represent the mean (standard deviation)

Individual-Level and Neighborhood-level Maternal Characteristics

As seen in Table 14, the majority of the sample identifies as Hispanic (N=7,535; 85.9%), followed by Black (N=601; 6.9%), White (N=353, 4.0%), Asian (N=173; 2.0%), Other/multiracial N=78; 0.9%), Pacific Islander (N=22; 0.3%), and American Indian/Alaska Native (AI/AN) (N=11; 0.1%). A substantial proportion of the sample is between the ages of 20-29 years (N = 4,358; 49.7%) and has a high school education or less (N=5,573; 63.6%). The majority of the sample is classified as food secure (N=6,182; 71.6%) and did not have a preterm birth (N=8,001; 91.2%). About half of the participants did not use EBT in the past 12 months (N= 4,531; 51.7%), whereas the other half did (N= 4,237; 48.3%). On average, participants live in ZIP codes where 64.0% of the population is Hispanic (SD = 21.3; range: 3.6–97.7). This suggests that, on average, participants live in neighborhoods with high Hispanic concentration.

Although the sample reported high breastfeeding initiation rates (N = 8,222; 93.5%), substantially lower rates were observed for both duration and exclusivity (Table 14). Any breastfeeding declined from 73.7% (N = 5,838) at 3 months to 57.1% (N = 4,355) at 6 months. Rates for exclusivity were even lower, which decreased from 21.6% (N = 1,783) at 3 months to 10.9% (N = 874) at 6 months. These patterns highlight that sustaining breastfeeding, especially exclusivity, remains a challenge within the WIC population.

Missing data on individual-level factors were minimal, ranging from 0.2% to 1.8%. In contrast, missingness for breastfeeding ranged from approximately 0.1% to 9.9%. This large missingness is because the breastfeeding variables were constructed using child age and breastfeeding duration. As such, missingness at later timepoints increased due to right-censoring for children who had not yet reached the specified age as well as incomplete reporting of

breastfeeding cessation timing. The missing values, therefore, reflect true missingness and was not imputed.

Tables 15–19 present the sociodemographic and neighborhood characteristics of the sample by each breastfeeding practice. Significant differences for maternal race/ethnicity and education level ($p \leq 0.01$) were observed for all outcomes, except exclusivity at 3 and 6 months. In general, lower breastfeeding prevalence was observed among participants with lower educational attainment and among Black mothers.

Other individual-level characteristics, including EBT use, food security status, preterm birth, and maternal age, showed less consistent associations across breastfeeding outcomes. EBT use was associated with initiation and any breastfeeding at 3 months ($p \leq 0.01$). In general, lower breastfeeding prevalence was observed among participants receiving EBT. Preterm birth was significantly associated with breastfeeding initiation and exclusivity at 3 and 6 months, with those experiencing a preterm birth overrepresented among participants not breastfeeding ($p < 0.01$). Differences were also observed by food security status for any breastfeeding at 3 months, with greater food security associated with lower prevalence breastfeeding ($p < 0.01$). Maternal age was associated with any breastfeeding at 3 and 6 months as well as exclusivity at 6 months. A mixed pattern was observed, whereby participants aged 30 years and older had higher prevalence of any breastfeeding at 3 and 6 (all p-values < 0.01) and participants aged 20-29 years were overrepresented among those who exclusively breastfed at 6 months.

Regarding neighborhood-level factors, Hispanic concentration was significantly associated with any breastfeeding at 6 months and exclusive breastfeeding at 3 and 6 months (all p-values ≤ 0.01). On average, participants who were breastfeeding lived in ZIP Codes with consistently lower neighborhood Hispanic concentration compared to those who were not.

Overall, these findings suggest that associations between these individual-level and neighborhood-level characteristics and breastfeeding vary depending on the specific breastfeeding measure.

Table 15. Sociodemographic and Neighborhood Characteristics by **Initiation** for Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,783)

	Yes	**No**	**P-value**
Individual-Level Characteristic	**N (%)**	**N (%)**	
Total Population	8222 (93.6)	561 (6.4)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	7078 (86.3)	450 (80.2)	
Non-Hispanic Black	527 (6.4)	24(13.0)	
Non-Hispanic White	329 (4.0)	73 (4.3)	
Non-Hispanic Asian	171 (2.1)	1 (0.2)	
Non-Hispanic Pacific Islander	20 (0.2)	2 (0.4)	
Non-Hispanic American Indian/Alaska Native	7 (0.1)	4 (0.7)	
Other/multi-Racial	71 (0.9)	7 (1.2)	
Maternal Education			**0.00**[b]
Less than high school	2867 (35.0)	234 (42.0)	
High school graduate	2310 (28.2)	157 (28.2)	
Some college/trade school/associate degree	2313 (28.2)	135 (24.2)	
4-year degree or higher	704 (8.6)	31 (5.6)	
Preterm Birth			**0.00**[b]
Yes	680 (8.3)	96 (17.2)	
No	7529 (91.7)	462 (82.8)	
Food Security Status			0.27[b]
High/marginal food security	5767 (71.4)	409 (74.2)	
Low food security	1678 (20.8)	100 (18.1)	
Very low food security	632 (7.8)	42 (7.6)	
Maternal Age			0.23[b]
Younger than 20	796 (9.7)	43 (7.7)	
20-29	4076 (49.7)	276 (49.4)	
30 and older	3331 (40.6)	240 (42.9)	
Used EBT in the past 12 months			**0.00**[b]
Yes	4279 (52.2)	250 (44.6)	
No	3920 (47.8)	310 (55.4)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Neighborhood Hispanic Concentration[c]	63.9 (21.4)[d]	65.2 (19.8)[d]	0.14[e]

Bolded values = significant at p = 0.01

a. Chi-square p-values were estimated using simulation due to small expected cell counts.
b. p-values for chi-square test
c. Defined as the percent of Hispanic population in a ZIP code
d. Values represent the mean (standard deviation).
e. p-values for paired t-test

Table 16. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 3 Months** for Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=7,922)

	Yes	No	P-value
Individual-Level Characteristic	**N (%)**	**N (%)**	
Total Population	5838 (73.7)	2084 (26.3)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	5068 (87.0)	1764 (84.8)	
Non-Hispanic Black	328 (5.6)	177 (8.5)	
Non-Hispanic White	230 (3.9)	80 (3.8)	
Non-Hispanic Asian	125 (2.1)	40 (1.9)	
Non-Hispanic Pacific Islander	15 (0.3)	3 (0.1)	
Non-Hispanic American Indian/Alaska Native	5 (0.1)	1 (0.0)	
Other/multi-Racial	52 (0.9)	15 (0.7)	
Maternal Education			**0.00**[b]
Less than high school	2075 (35.6)	696 (33.6)	
Highschool graduate	1578 (27.1)	644 (31.1)	
Some college/trade school/associate degree	1633 (28.1)	589 (28.4)	
4-year degree or higher	535 (9.2)	145 (7.0)	
Preterm Birth			0.59[b]
Yes	475 (8.1)	178 (8.6)	
No	5354 (91.9)	1902 (91.4)	
Food Security Status			**0.01**[b]
High or marginal food security	4036 (70.4)	1517 (73.9)	
Low food security	1231 (21.5)	387 (18.9)	
Very low food security	463 (8.1)	149 (7.3)	
Maternal Age			**0.00**[b]
Younger than 20	474 (8.1)	288 (13.9)	
20-29	2809 (48.2)	1133 (54.5)	
30 and older	2546 (43.7)	656 (31.6)	
Used EBT in the past 12 months			**0.00**[b]
Yes	2706 (46.5)	1075 (51.7)	
No	3119 (53.5)	1003 (48.3)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Neighborhood Hispanic Concentration[c]	63.8 (21.5)[d]	64.7 (21.1)[d]	0.09[e]

Bolded values = significant at p = 0.01

a. Chi-square p-values were estimated using simulation due to small expected cell counts.
b. p-values for chi-square test
c. Defined as the percent of Hispanic population in a ZIP code
d. Values represent the mean (standard deviation).
e. p-values for paired t-test

Table 17. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 6 Months** for Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 7,621)

	Yes	**No**	**P-value**
Individual-Level Characteristic	**N (%)**	**N (%)**	
Total Population	4355 (57.1)	3266 (42.9)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	3810 (87.7)	2769 (84.9)	
Non-Hispanic Black	220 (5.1)	266 (8.2)	
Non-Hispanic White	172 (4.0)	121 (3.7)	
Non-Hispanic Asian	90 (2.1)	68 (2.1)	
Non-Hispanic Pacific Islander	7 (0.2)	11 (0.3)	
Non-Hispanic American Indian/Alaska Native	4 (0.1)	0 (0.0)	
Other/multi-Racial	40 (0.9)	25 (0.8)	
Maternal Education			**0.00**[b]
Less than high school	1661 (38.3)	1028 (31.6)	
High school graduate	1133 (26.1)	1004 (30.9)	
Some college/trade school/associate degree	1129 (26.0)	984 (30.2)	
4-year degree or higher	419 (9.6)	237 (7.3)	
Preterm Birth			0.19[b]
Yes	347 (8.0)	289 (8.9)	
No	4000 (92.0)	2973 (91.1)	
Food Security Status			0.05[b]
High/marginal food security	3001(70.3)	2338 (72.7)	
Low food security	931(21.8)	631 (19.7)	
Very low food security	339 (7.9)	245 (7.6)	
Maternal Age			**0.00**[b]
Younger than 20	296 (6.8)	436 (13.4)	
20-29	2054 (47.2)	1725 (52.9)	
30 and older	1998 (46.0)	1097 (33.7)	
Used EBT in the past 12 months			0.05[b]
Yes	2044 (47.0)	1605 (49.3)	
No	2303(53.0)	1651 (50.7)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Neighborhood Hispanic Concentration[c]	63.5 (21.6)[d]	64.8 (21.0)[d]	**0.01**[e]

Bolded values = significant at p = 0.01

a. Chi-square p-values were estimated using simulation due to small expected cell counts.
b. p-values for chi-square test
c. Defined as the percent of Hispanic population in a ZIP code
d. Values represent the mean (standard deviation).
e. p-values for paired t-test

Table 18. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 3 Months** for Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 8,264)

	Yes	**No**	**P-value**
Individual-Level Characteristic	**N (%)**	**N (%)**	
Total Population	1783 (21.6)	6481 (78.4)	
Maternal Race/Ethnicity			0.02[a]
Hispanic	1493 (83.9)	5590 (86.5)	
Non-Hispanic Black	128 (7.2)	439 (6.8)	
Non-Hispanic White	92 (5.2)	237 (3.7)	
Non-Hispanic Asian	40 (2.3)	121 (1.9)	
Non-Hispanic Pacific Islander	5 (0.3)	16 (0.2)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	10 (0.2)	
Other/multi-Racial	21 (1.2)	53 (0.8)	
Maternal Education			0.02[b]
Less than high school	582 (32.7)	2326 (36.0)	
High school graduate	507 (28.5)	1815 (28.1)	
Some college/trade school/associate degree	516 (29.0)	1800 (27.9)	
4-year degree or higher	173 (9.7)	514 (8.0)	
Preterm Birth			**0.00[b]**
Yes	108 (6.1)	570 (8.8)	
No	1672 (93.9)	5899 (91.2)	
Food Security Status			0.56[b]
High/marginal food security	1270 (72.5)	4536 (71.2)	
Low food security	347 (19.8)	1333 (20.9)	
Very low food security	134 (7.7)	498 (7.8)	
Maternal Age			0.12[b]
Younger than 20	147 (8.3)	636 (9.8)	
20-29	910 (51.1)	3212 (49.7)	
30 and older	724 (40.6)	2615 (40.5)	
Used EBT in the past 12 months			0.12[b]
Yes	831 (46.7)	3155 (48.8)	
No	948 (53.3)	3309 (51.2)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Neighborhood Hispanic Concentration[c]	62.2 (22.2)[d]	64.5 (21.0)[d]	**0.00[e]**

Bolded values = significant at p = 0.01

a. Chi-square p-values were estimated using simulation due to small expected cell counts.
b. p-values for chi-square test
c. Defined as the percent of Hispanic population in a ZIP code
d. Values represent the mean (standard deviation).
e. p-values for paired t-test

Table 19. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 6 Months** for Study 2 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,028)

	Yes	**No**	**P-value**
Individual-Level Characteristic	**N (%)**	**N (%)**	
Total Population	874 (10.9)	7154 (89.1)	
Maternal Race/Ethnicity			0.42[a]
Hispanic	738 (84.5)	6157 (86.3)	
Non-Hispanic Black	59 (6.8)	490 (6.8)	
Non-Hispanic White	42 (4.8)	269 (3.8)	
Non-Hispanic Asian	21 (2.4)	134 (1.9)	
Non-Hispanic Pacific Islander	2 (0.2)	18 (0.3)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	8 (0.1)	
Other/multi-Racial	11 (1.3)	61 (0.9)	
Maternal Education			0.25[b]
Less than high school	304 (34.9)	2540 (35.6)	
High school graduate	248 (28.4)	2007 (28.1)	
Some college/trade school/associate degree	232 (26.6)	1996 (28.0)	
4-year degree or higher	88 (10.1)	583 (8.2)	
Preterm Birth			**0.00**[b]
Yes	44 (5.0)	635 (8.9)	
No	829 (95.0)	6506 (91.1)	
Food Security Status			0.52[b]
High/marginal food security	625 (73.1)	5009 (71.2)	
Low food security	168 (19.6)	1473 (21.0)	
Very low food security	62 (7.3)	549 (7.8)	
Maternal Age			**0.00**[b]
Younger than 20	58 (6.6)	704 (9.9)	
20-29	465 (53.2)	3524 (49.4)	
30 and older	351 (40.2)	2907 (40.7)	
Used EBT in the past 12 months			0.05[b]
Yes	395 (45.2)	3485 (48.8)	
No	478 (54.8)	3650 (51.2)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Neighborhood Hispanic Concentration[c]	62.2 (22.1)[d]	64.3 (21.2)[d]	**0.01**[e]

Bolded values = significant at p = 0.01

a. Chi-square p-values were estimated using simulation due to small expected cell counts.
b. p-values for chi-square test
c. Defined as the percent of Hispanic population in a ZIP code
d. Values represent the mean (standard deviation).
e. p-values for paired t-test

ZIP Code Distribution and Between-ZIP Variability

Of the over 500 ZIP codes in LAC, the sample includes WIC participants from 290 unique ZIP codes in LAC. The number of participants per ZIP code ranges from 1 to 252, with an average of 30.3 participants (SD: 41.3) It is typically recommended to have at least 30 level 2 units with 30 observations per unit to be considered sufficient for multilevel analyses (Hox et al., 2017; Maas & Hox, 2005). In the present sample, 96 ZIP codes (33.1%) included at least 30 participants, which meets the 30/30 rule for multilevel analyses.

To assess the proportion of variance in breastfeeding practices attributable to differences between ZIP codes an ICC was calculated for each outcome (Table 20). The ICCs indicated minimal variance of breastfeeding practices between ZIP codes, accounting for only 0.1% to 3.0% of the variance. Although low ICCs are typical in neighborhoods, the limited variation may make it harder to detect neighborhood-level effects. A DEFF was also calculated for each breastfeeding practice to assess how clustering effects sample size and standard errors (Table 20). In the present study, the DEFFs ranged from 1.03 to 1.78, which suggests that clustering in the sample increases standard errors and modestly reduces the effective sample size. This can produce more conservative estimates and may make it more difficult to detect neighborhood-level effects (Hox et al., 2017; Maas & Hox, 2005). Both the ICCs and DEFFs are presented to help in the interpretation of the results, rather than to guide the decision to use multilevel modeling.

Table 20. Intraclass Correlation Coefficients (ICC), Mean Cluster Sizes, and Design Effects (DEFF) for Breastfeeding Practices Across ZIP Codes

Outcome	N	Mean Cluster Size	ICC	DEFF
Initiation	8,783	30.3	0.03	1.78
Any at 3 months	7,922	27.6	0.01	1.27
Any at 6 months	7,621	26.7	0.02	1.43
Exclusivity at 3 months	8,264	29.1	0.01	1.26
Exclusivity at 6 months	8,028	28.3	0.00	1.03

Primary Analyses

The results for the multilevel analyses for each breastfeeding practice are outlined in Figure 13 (initiation, any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months, and exclusive breastfeeding at 6 months). Results of the full analyses, including all other breastfeeding outcomes, can be found in Appendices K.1-K.9.

All breastfeeding outcomes, except exclusivity at 6 months, were analyzed using multilevel models. Exclusivity at 6 months was analyzed using standard logistic regression due to negligible variance at the ZIP code level, which led the model to default to a single-level specification. To reduce noise and limit the risk of spurious findings associated with the conventional $p < 0.05$ threshold, a more conservative significance level of $p < 0.01$ was used (Benjamin et al., 2017).

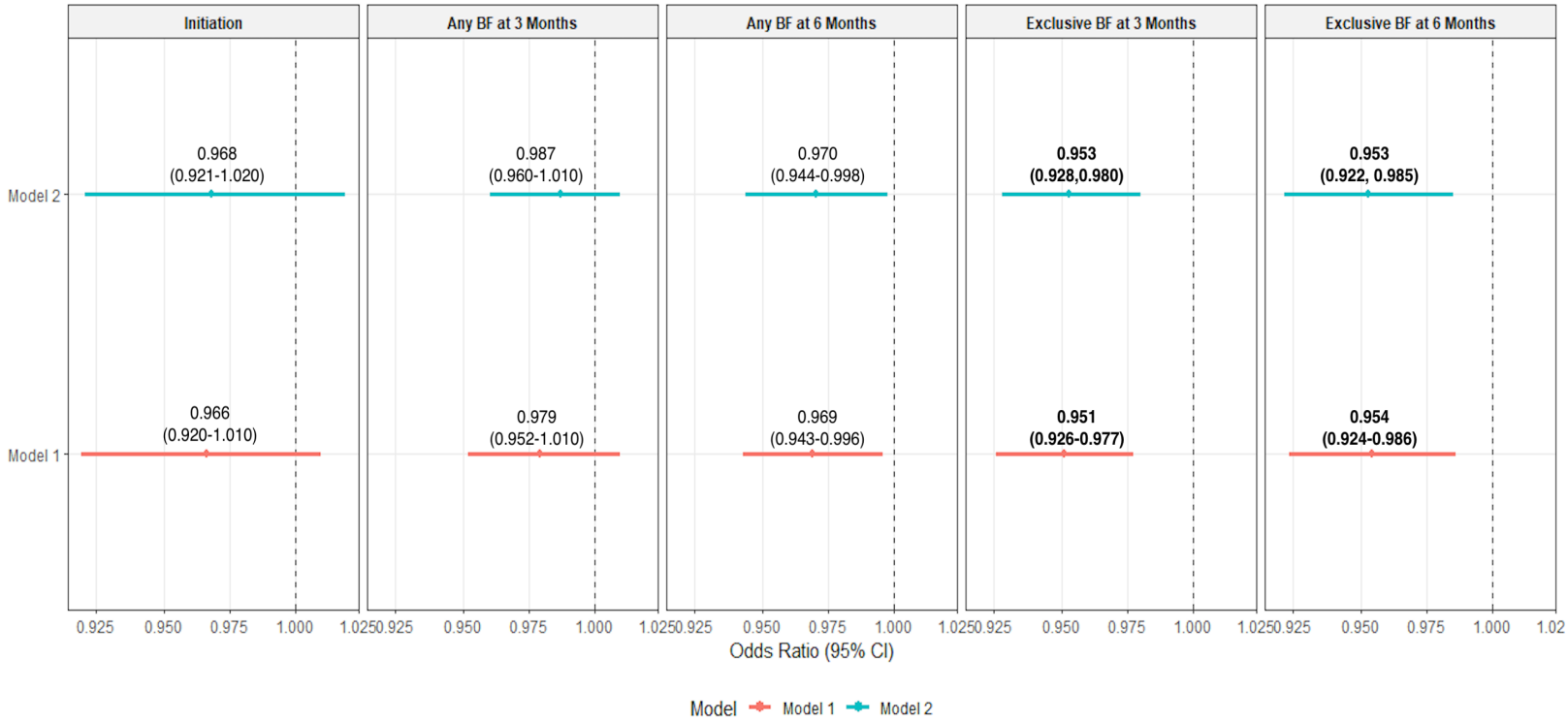


Figure 13. Odds ratios and 95% confidence intervals from multilevel analyses examining the association between neighborhood Hispanic concentration and breastfeeding practices.

Notes: Model 1 (Unadjusted Model): Examines the unadjusted association. Model 2 (Adjusted Model): Examines the adjusted associations after adding individual-level maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education. Bolded estimates indicate statistical significance at the 0.01 level. Exclusivity at 6 months was analyzed using a single-level logistic regression model due to negligible variance at the ZIP code level.

Breastfeeding Initiation

Results show that the percentage of Hispanic residents within a ZIP code was not significantly associated with breastfeeding initiation in both unadjusted and adjusted models (p-values > 0.01). The odds ratios, however, suggest a potential negative trend where lower odds of initiation are observed with increases in neighborhood Hispanic concentration (Model 1 OR: 0.966; Model 2 OR: 0.968). However, the effect is tiny and not significant.

Any Breastfeeding at 3 and 6 Months

Results show that the percentage of Hispanic residents within a ZIP code was not significantly associated with any breastfeeding at 3 months in unadjusted and adjusted models (p-values > 0.01). For any breastfeeding at 6 months, the association was marginally significant in the unadjusted model (p = 0.02; OR = 0.969; 95% CI: 0.943–0.996) but the association attenuated after adjustment for maternal covariates (p >0.02). The odds ratios across both outcomes were consistently below 1. This suggests a potential negative trend, where lower odds of breastfeeding are observed with increases in the percentage of Hispanic residents within a ZIP code.

Exclusive Breastfeeding at 3 and 6 months

Results show that the percentage of Hispanic residents within a ZIP code is significantly associated with breastfeeding exclusivity at 3 and 6 months (p-values < 0.01). Higher neighborhood Hispanic concentration is associated with lower odds of exclusivity at both 3 months (OR = 0.951; 95% CI: 0.926–0.977) and 6 months (OR = 0.954; 95% CI: 0.924–0.986). After adjustment for maternal covariates, the associations remained similar and statistically significant (3 months: OR = 0.953; 95% CI: 0.928–0.980; 6 months: OR = 0.953; 95% CI: 0.922–0.985; p-values < 0.01). Post-adjustment results indicate that a 10 percentage-point

increase in neighborhood Hispanic concentration is associated with 4.7% lower odds of exclusive breastfeeding at both 3 and 6 months. These results suggest that percentage of Hispanic residents within a ZIP code is independently associated with exclusive breastfeeding beyond maternal covariates.

Sensitivity Analyses

Sensitivity analyses were conducted using a binary version of the continuous neighborhood Hispanic concentration measure (high vs. low concentration). The variable was created using the distribution of the percentage of Hispanic residents across ZIP codes (mean = 41.6%). ZIP codes below the mean were categorized as low (N = 159) and those at or above the mean categorized as high (N= 131). The majority of participants lived in ZIP codes categorized as high concentration (N= 7,326; 83.3%). In line with the primary findings, results indicate that the binary measure is not associated with breastfeeding initiation or any breastfeeding in either model ($p > 0.01$) but is significantly associated with exclusivity at both 3 and 6 months in both models (Appendices K.1–K.9). Post-adjustment results suggest that higher neighborhood Hispanic concentration was associated with lower odds of exclusivity at both 3 months (OR = 0.760; 95% CI: 0.655–0.881) and 6 months (OR = 0.810; 95% CI: 0.674–0.975). These findings are consistent with the primary analyses.

Sensitivity analyses were also conducted with a tertile version of the continuous neighborhood Hispanic concentration measure (high, moderate, and low concentration). ZIP codes with percentages between 0% and 25.8% were categorized as low (n = 97), those between 25.9% and 53.8% as moderate (n = 96), and those between 53.9% and 100% as high (n = 97). The majority of participants resided in ZIP codes classified as high concentration (N = 6,077; 69.1%), followed by moderate (N = 2,291; 26.1%) and low (N = 424; 4.8%). In line with the

primary analyses, the tertile measure is not associated with breastfeeding initiation or any breastfeeding in either unadjusted or adjusted models (p-values > 0.01) and is significantly associated with exclusivity at 3 months in both models ($p < 0.01$). The main difference was observed for exclusivity at 6 months, where the association attenuated from the primary analyses and became marginally significant in Model 2. Although these findings differ slightly from the primary analyses, they are generally consistent and do not meaningfully change the overall interpretation.

Follow up analyses were also conducted with individual-level lactation support added as additional individual-level covariates to Model 2. Including these variables allowed for a more rigorous assessment of whether the observed associations were robust to adjustment for proximal sources of breastfeeding support. The LAC WIC survey data were used to construct the lactation support covariates, which included measures of partner support (1 = Partner lives in household, 2 = partner does not live in household but active, and does not live in household and not active) and workplace accommodations (1=returned to work within three months and the workplace did not have breastfeeding accommodations, 2=returned to work within three months and the workplace provided breastfeeding accommodations, and 3=did not return to work within three months. These variables were operationalized based on how prior research using LAC WIC survey data (Jiang, 2021). The survey questions used to operationalize these variables are provided in Appendix J.

The results were primarily consistent with the primary analyses, with only slight differences. Consistent with the main findings, results indicate that neighborhood Hispanic concentration (continuous) is not associated with breastfeeding initiation and any breastfeeding ($p > 0.01$) but is associated with exclusivity at both 3 and 6 months ($p < 0.01$). Post adjustment

results suggest that higher neighborhood Hispanic concentration is associated with lower odds of breastfeeding at both 3 months (OR = 0.996; 95% CI: 0.993-0.998) and 6 months (OR = 0.996; 95% CI: 0.992-0.999).

Lastly, follow-up analyses were conducted on a subset of mothers with children aged 2 years and younger (N = 3,598) to better reflect neighborhood environments during the period when breastfeeding is most likely to occur. These results deviated slightly from the primary findings. Unlike the primary findings, associations for initiation became significant in both models and associations for any breastfeeding at 6 months became significant in the adjusted models. Additionally, associations with exclusivity as 3 and 6 months was no longer significant in either model. Although these findings differ slightly, significant neighborhood effects were still observed. These differences may be due to the smaller sample size.

Discussion

The present study examined the association between neighborhood racial/ethnic concentration and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity) among WIC participants in LAC. This study is one of few to examine this relationship and, therefore, addresses a critical gap in the literature. Given the limited research on this topic, this study was designed as an exploratory analysis to better understand how neighborhood racial/ethnic concentration, specifically Hispanic concentration, may influence breastfeeding practices.

The exploratory nature of this study recognizes that neighborhood racial/ethnic concentration, particularly for Hispanic communities, may have both protective and adverse effects on breastfeeding. To better understand the potential pathways through which these effects may operate, this study draws on two theoretically distinct but complementary perspectives: the

segregation literature and the ethnic density literature. The racial residential segregation literature conceptualizes concentration as a structural mechanism that produces disadvantage and unequal access to neighborhood-level resources, which has potential negative implications for health. In contrast, the ethnic density literature highlights how concentration, particularly co-ethnic residence, may provide social support, shared norms, and other protective benefits for health. These pathways are not mutually exclusive, so neighborhoods may simultaneously experience structural disadvantage while also benefiting from shared norms and social support. As discussed in Chapters 2 and 3, these dynamics have important implications for breastfeeding practices, as they shape the social, cultural, and structural conditions that influence a mothers' ability to initiate and sustain breastfeeding.

Given the potential for these dual influences and the limited research in this area, the present study is framed as an exploratory study to examine which pathways may be more salient for breastfeeding among WIC participants in LAC. The present study addressed the following question: What is the association between neighborhood racial/ethnic concentration, measured as the percentage of Hispanic residents within a ZIP Code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity) after accounting for maternal characteristics? It was hypothesized that neighborhood racial/ethnic concentration is associated with breastfeeding initiation, duration, and exclusivity. However, the direction of this association is not specified due to the potential for both protective and adverse contextual influences. These associations are expected to attenuate but remain significant after adjusting for maternal characteristics. Additionally, the strength of the association is hypothesized to vary across breastfeeding practices (initiation, duration, and exclusivity).

The present findings provided mixed support for the proposed hypotheses. Contrary to the hypothesized relationships, neighborhood Hispanic concentration was not significantly associated with breastfeeding initiation or duration ($p > 0.01$) in both unadjusted and adjusted models. However, a significant and negative association was observed for breastfeeding exclusivity at both 3 and 6 months. Specifically, higher neighborhood concentration was associated with lower odds of exclusivity. Although the odds ratios were consistently less than 1 across all outcomes, suggesting a potentially negative association, these associations reached statistical significance only for breastfeeding exclusivity. Overall, the present findings suggest that neighborhood Hispanic concentration may be associated with more adverse than protective effects for breastfeeding in this population, with particular importance for exclusivity.

Existing research, while limited, has begun to suggest that neighborhood racial/ethnic concentration may be associated with negative breastfeeding outcomes. One study assessed neighborhood concentration using three different measures: percentage of Hispanic residents, African American residents, and immigrants within a census tract (Burdette, 2013). The researchers found no statistically significant associations between these measures and any breastfeeding at 6 months or more. However, the odds ratios were consistently lower than 1, suggesting increases in neighborhood concentration leads to lower odds of breastfeeding. Another study examined the association between subjective reports of neighborhood racial concentration during childhood and breastfeeding (i.e., initiation and any breastfeeding at 6 months or more) (Griswold et al., 2018b). They found that living in a predominantly Black neighborhood up to age 18 (compared to a predominantly White neighborhood) is associated with lower odds of breastfeeding.

Consistent with this emerging evidence, the associations observed in this study indicate that neighborhood racial/ethnic concentration may be impacting breastfeeding through structural pathways of disadvantage that are more consistent with the segregation literature. Drawing on this body of work, a potential explanation for these findings is that they may reflect underlying socioeconomic disadvantage.

Prior research shows Hispanic populations are disproportionately concentrated in high-poverty and highly segregated neighborhoods. In 2024, Black and Hispanic individuals were overrepresented among those living in poverty relative to their share of the general population (Shrider, E. A., & Bijou, C, 2025). Hispanic individuals are consistently about twice as likely to live in poverty as non-Hispanic White individuals (Shrider, E. A., & Bijou, C, 2025). In Los Angeles this pattern is evident, where Hispanics comprise approximately 73% of residents in high-poverty neighborhoods despite representing less than half of the total population (Benzow & Fikri, 2020). These patterns suggest that neighborhood Hispanic concentration overlaps with socioeconomic disadvantage (e.g., poverty, deprivation). As a result, the observed associations may reflect broader structural inequalities related to neighborhood socioeconomic status (NSES).

Thus, NSES represents an important pathway through which neighborhood racial/ethnic concentration may be adversely influencing breastfeeding. Prior research has identified NSES as a critical factor shaping breastfeeding. In general, higher NSES (i.e., higher proportions of families living in poverty and receiving income-related benefits) is associated with lower odds of breastfeeding initiation, duration, and exclusivity up to six months (Galante et al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Riley et al., 2016; Yourkavitch et al., 2018). These associations often attenuate but remain statistically significant after adjusting for maternal socio-demographic characteristics (Galante et

al., 2022; Griswold et al., 2018; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018). The present findings provide further support for the importance of NSES for breastfeeding and extend existing research by identifying neighborhood racial/ethnic concentration as a potential key structural factor shaping this relationship.

As discussed in Chapter 2, NSES may be influencing breastfeeding through several factors, including reduced access to and quality of healthcare and lactation-related support. Women in high-income neighborhoods, compared to those in low-income neighborhoods, lack access to breastfeeding-friendly public spaces (i.e., cafes and coffee shops) and community-based lactation support, such as mother-to-mother support groups, breastfeeding peer counselors, and board-certified lactation consultants (Grubesic & Durbin, 2021; Isherwood et al., 2019). Additionally, low-income women are disproportionately affected by the growing presence of maternity care deserts in their neighborhoods, as obstetric units are more likely to close in low-income communities (Nowhere to Go: Maternity Care Deserts Across the US, 2024; Tung et al., 2024). These closures have led some women to give birth in settings not equipped to provide comprehensive lactation support, such as emergency departments (*As LA Maternity Wards Close, Patients Are Giving Birth in ERs: 'There's No System to Care for These Women,'* 2026). Those living in maternity care deserts are also more likely to receive inadequate prenatal care or none at all (Nowhere to Go: Maternity Care Deserts Across the US, 2024), which can lead to missed opportunities for prenatal breastfeeding education critical for increasing initiation, duration, and exclusivity.

Racial/ethnic concentration may also contribute to disparities in breastfeeding by shaping the distribution of health-promoting resources in neighborhoods, including access to green space, transportation, and healthy food, as well as greater exposure to environmental toxins. As

discussed in Chapter 2, these neighborhood conditions can influence breastfeeding through pathways related to maternal health, mental well-being, and access to supportive resources that shape a woman's ability and decision to breastfeed. While these pathways are less studied in the literature, they remain theoretically important for understanding how neighborhood concentration may influence breastfeeding.

Future studies should examine how neighborhood-level pathways mediate the relationship between racial/ethnic concentration and breastfeeding. This would help clarify the mechanisms driving the associations observed in this study. In particular, neighborhood NSES warrants further investigation as a key pathway through which structural conditions influence access to resources and support for breastfeeding. Additionally, future studies should incorporate more rigorous and multidimensional measures of racial residential segregation to explicitly test these pathways and assess how these findings align with the broader segregation literature.

Although racial/ethnic concentration has been identified as a potential protective factor (via shared norms, increased social support, and cultural practices) for health, these mechanisms were not salient in the present study. Instead, the observed associations suggest that neighborhood concentration may operate more through structural pathways of disadvantage in this sample. One potential explanation for the lack of a protective effect could be related to the predominately Hispanic WIC study population.

While breastfeeding is culturally valued and the norm among Hispanic populations, mixed feeding (i.e., *"las dos cosas")* is also widely accepted (Fisher et al., 2024). Mixed feeding has emerged as a common practice that deviates from cultural norms around breastfeeding without formula supplementation. This has become a significant barrier to exclusive breastfeeding among Hispanic populations, including those participating in WIC. The increasing

adoption of “las dos cosas” is a result of exposure to U.S. norms around acceptance of formula feeding and increased access to formula through programs such as WIC. Additionally, economic pressures to return to work add another barrier to breastfeeding that may encourage mixed feeding practices out of convenience (Fisher et al., 2024).

This pattern is consistent with evidence demonstrating higher breastfeeding rates among non–U.S.-born Hispanic women, compared to U.S born women, having higher breastfeeding rates, but advantages decline with increased time in the U.S. and greater acculturation (Bigman et al., 2018; Gibson et al., 2005). These findings suggest that adaptation to U.S. cultural norms, including greater exposure to formula feeding, may contribute to mixed feeding practices among Hispanic populations. Previous studies have shown that maintaining cultural identity is protective to health when living with co-ethnic contexts (Jurcik et al., 2013). Future studies should examine the role of acculturation as a potential effect modifier to understand how the relationship between racial/ethnic concentration and breastfeeding varies with integration into U.S. culture.

Despite cultural expectations to exclusively breastfeed, external social and structural factors can outweigh these norms and may limit women’s ability to sustain breastfeeding, particularly exclusivity. Consequently, cultural influences may be weakened in the presence of competing demands that normalize and make formula use more convenient. This may have been the case in the present study, where increased economic pressures and access to formula are amplified by participation in WIC and may have attenuated any potential protective effects.

The use of a broad measure of racial/ethnic concentration in this study may have also limited the ability to detect protective effects, as it does not capture the social and cultural dimensions needed to adequately examine these pathways. More specific measures of

neighborhood concentration, such as ethnic enclaves (i.e., areas with high co-ethnic concentration and shared social and cultural networks), may better capture these protective processes. Future studies should incorporate neighborhood-level measures such as language use and nativity to more precisely examine how an ethnic enclave context may influence protective pathways in breastfeeding outcomes. This would allow for a more robust examination of theoretical pathways outlined in the ethnic density literature.

As discussed earlier, high levels of racial/ethnic concentration often co-occur with socioeconomic disadvantage. Therefore, the protective effects of co-ethnic environments may be obscured if these factors are not accounted for. Prior research suggests that adjusting for individual- and area-level deprivation is necessary to better isolate the protective effects of ethnic density independent of structural and material disadvantage (N. Zhang et al., 2017). Future studies should examine these relationships while adjusting for socioeconomic disadvantage to more directly assess the protective pathways.

Limitations

There are several limitations in the present study that should be considered when interpreting the findings. A major limitation of this study is the use of ZIP codes to define an individual's neighborhood. ZIP codes were not designed to represent neighborhood boundaries, they are based on mail delivery routes and are constantly changing with shifting routes (Grubesic, 2008; Grubesic & Matisziw, 2006). ZIP codes do not use standardized methods to create its boundaries, so they vary widely in both geographic size and population. They also represent larger, heterogenous geographic units that often do not accurately represent an individual's immediate environment (Grubesic, 2008; Grubesic & Matisziw, 2006). Because ZIP

codes aggregate data across smaller units, such as census tracts, they often group individuals from diverse neighborhoods into a single area.

These limitations could have contributed to the low ICCs observed in this sample (ICC range: 0.001–0.030), which indicated minimal variation in breastfeeding outcomes between ZIP codes. The use of multilevel analyses may have further limited the ability to detect effects, as the design effects (DEFF range: 1.04–1.81) suggest that neighborhood-level clustering increased standard errors and reduced the effective sample size. The results of the multilevel models, therefore, likely yielded more conservative estimates.

Together, these factors may have reduced the ability to detect neighborhood effects in the present study. Future research should examine these relationships using smaller, more homogeneous units, such as census tracts, which better capture local neighborhood contexts and are considered the standard.

Another limitation is the use of a broad measure of neighborhood racial/ethnic concentration. While this measure offers a neutral assessment of neighborhood concentration, it also limits the strength of the inferences that can be drawn. Examining concentration solely as a percentage aligns with the exploratory goals of this study, however it does not fully capture more complex constructs such as segregation or ethnic enclaves. As a result, the pathways identified in this study should be interpreted as suggestive rather than definitive. Future studies should incorporate multidimensional measures, including segregation indices and indicators of ethnic enclaves, to better capture these contexts and directly examine the pathways underlying these findings.

The use of a WIC population in LAC also presents potential limitations. Because WIC participants are a low-income population (i.e., household income must be at or below 185% of

the federal poverty level), they may be more socioeconomically homogeneous than the general population. These characteristics may have contributed to the limited variance detected at the neighborhood level, as reflected in the low ICCs. This limited variation, which was further exacerbated by the use of ZIP codes, may have attenuated neighborhood-level effects and led to more conservative estimates.

The use of a LAC WIC sample also presents potential limitations in generalizability of findings to different socio-demographic populations and geographic regions. Because WIC is a low-income population, the present findings may not apply to middle- or higher-income families. The findings may also not generalize to other low-income populations not participating in WIC (e.g., those who are eligible but do not participate and those who are ineligible) as they do not receive the same assistance. Additionally, since the present sample is predominantly Hispanic (85.7%), the present findings may not be generalizable to populations with different racial/ethnic compositions. Lastly, the present study's focus on LAC limits generalizability of findings to other geographic areas outside of Los Angeles. Future research is needed to examine the association between neighborhood racial/ethnic concentration and breastfeeding in a more socioeconomically and racially diverse populations across geographic contexts.

Conclusion

Few studies have examined the relationship between neighborhood racial/ethnic concentration and breastfeeding, leaving this association not well understood. Accordingly, an exploratory approach was taken in the present study. In doing so, this study contributes to the growing literature by expanding understanding of how neighborhood racial/ethnic concentration may be related to breastfeeding.

An overall trend was observed where higher neighborhood Hispanic concentration was associated with lower odds of breastfeeding, even after adjusting for maternal covariates. However, these associations reached statistical significance only for exclusivity at 3 and 6 months. These findings are in line with early studies suggesting that neighborhood racial/ethnic concentration may be more harmful, than protective, to breastfeeding. This is consistent with the racial residential segregation literature, which suggests that neighborhood racial/ethnic concentration functions as a structural mechanism creating neighborhood disadvantage and, in turn, adversely affecting health.

These results also highlight the potential utility of neighborhood racial/ethnic concentration as a marker for targeted intervention. Neighborhoods with high concentrations of Hispanic residents may be facing structural disadvantage and constrained resources that create less supportive infrastructures for breastfeeding. Even within a predominantly Hispanic population, where co-ethnic residence is often thought to have protective effects, deleterious effects on breastfeeding were observed.

Therefore, interventions addressing neighborhood-level structural conditions need to be integrated into public health efforts to improve breastfeeding, especially among populations in socioeconomically disadvantaged communities. Considering this is an emerging area of research, further studies are warranted to examine different dimensions of neighborhood racial/ethnic concentration (e.g., ethnic enclaves and residential racial segregation) in diverse populations and geographic contexts to assess the consistency of these relationships across study settings.

CHAPTER 8: A Multilevel Analysis of Neighborhood Food Access and Breastfeeding Practices Among WIC Participants in Los Angeles County (Study 3)

Study Overview

The present study is the third of three studies in this dissertation (Study 3). This study examined the association between a neighborhood's food environment, measured through access to healthy foods, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The goal of this study was to establish a foundational understanding of how the neighborhood food environment is related to breastfeeding practices of Woman, Infant, and Children (WIC) program participants living in Los Angeles County (LAC). This analysis extended Study 1 by examining the neighborhood food environment, a key place-based social determinant of health (SDOH) not captured by the Healthy Places Index (HPI). The present study continues to deepen our understanding of the impact of a neighborhood's social and physical environment on breastfeeding practices and identify potential place-based strategies for mitigation.

Research Aims, Questions, and Hypotheses

The aim of this study was to examine how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. To address this aim, the following research question and corresponding hypotheses were tested:
Research Question: What is the association between access to healthy foods, as measured by the percentage of the ZIP code population living in food desert tracts, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for individual-level maternal characteristics?

- *Hypothesis 3a:* ZIP codes with a higher percent of residents living in food desert tracts is significantly associated with a lower likelihood of breastfeeding initiation, duration, and exclusivity.
- *Hypothesis 3b:* This association is attenuated but remains significant after adjusting for maternal characteristics, indicating that the ZIP-level food access measure helps explain individual-level differences in breastfeeding beyond maternal characteristics.
- *Hypothesis 3c:* The strength of the association differs across breastfeeding practices (initiation, duration, exclusivity).

Methods

Outcomes: Individual-level Breastfeeding Practices

Data regarding breastfeeding practices were obtained through the 2014 and 2017 LAC WIC Survey and were assessed as binary variables (Yes/No) using the following outcomes: initiation, any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months, and exclusive breastfeeding at 6 months. Breastfeeding initiation refers to whether the infant was ever breastfed, either in the hospital or after returning home. Any breastfeeding refers to the infant receiving any amount of breast milk, either by nursing or bottle-feeding. Exclusive breastfeeding refers to the infant receiving only breast milk, either through nursing or bottle, with no other liquids or solids (e.g., water). Operationalization of these measures are based on prior studies using LAC WIC Survey data (Jiang, 2021, 2021; S. Jung et al., 2019; Langellier et al., 2012, 2014; Nobari et al., 2017). The specific survey questions used to operationalize each variable are listed in Table 2.

Key predictor: ZIP-level food desert exposure

The key predictor was a ZIP code-level food access measure, defined as the percent of ZIP code population living in a food desert tract. Data from the 2015 and 2019 USDA FARA were used to create this variable. The FARA is a publicly accessible online mapping tool and database that provides food store access data at the census-tract level across the U.S. (*Introduction to the Food Access Research Atlas*, n.d.).

The FARA defines food desert residence as living in a low-income and low-access (LILA) census tract (*Measuring Access to Food*, n.d.). Tracts are considered low-income if they meet either of these conditions: 1) the tract's poverty rate is 20 percent or greater, 2) the tract's median family income is less than or equal to 80 percent of the state-wide median family income, or 3) for metropolitan tracts, the tract has a median family income less than or equal to 80 percent of the metropolitan area's median family income. Tracts are considered to have low access if a significant number (at least 500) or share (at least 33%) of individuals in the tract live far from the nearest supercenter, supermarket, or large grocery store based on different distance thresholds, including 0.5 or 1 mile in urban areas and 10 or 20 miles in rural areas The FARA provides three measures of food desert residence using LILA criteria at varying distances to the nearest food store (i.e., supercenter, supermarket, or large grocery store): 1) 1 mile in urban areas and 10 miles in rural areas, 2) 0.5 mile in urban areas and 10 miles in rural areas, and 3) 1 mile in urban areas and 20 miles in rural areas.

Because the geographic unit of analysis in this study is ZIP codes, census tract–level FARA data were aggregated to the ZIP Code Tabulation Area (ZCTA) level. FARA data were first merged with the U.S. Census Bureau 2010 tract-to–ZCTA relationship file (United States Census Bureau, n.d.). ZCTAs are geographic approximations of ZIP codes commonly used to crosswalk data. However, this tract-to-ZCTA relationship is many-to-many, meaning that a

single census tract can overlap multiple ZCTAs and a single ZCTA can include portions of multiple census tracts (United States Census Bureau, n.d.).

To address these discrepancies, a population-weighted approach was used. Census tract populations were allocated to ZIP codes based on the proportion of each tract's population within each ZIP code. For tracts classified as food deserts, these proportions were used to estimate the number of ZIP code residents living in food desert tracts. This value was then divided by the total ZIP code population to create a continuous measure of exposure. Separate proportions were calculated for each distance threshold used by the FARA to define low access: 1 mile in urban areas and 10 miles in rural areas, 0.5 mile in urban areas and 10 miles in rural areas, and 1 mile in urban areas and 20 miles in rural areas. For ease of interpretability, the proportions were multiplied by 100 to express them as percentages.

In the present study, the neighborhood food environment was measured as the percentage of ZIP code residents living in a food desert tract. A food desert tract was defined using the USDA FARA definition as a census tract that is both low-income (poverty rate ≥20% or median income ≤80% of area median) and low-access (≥500 people or ≥33% of residents live more than 0.5 miles in urban areas or 10 miles in rural areas from a supermarket or large grocery store) (*Measuring Access to Food*, n.d.). The decision to use the 0.5-mile definition, rather than the 1-mile threshold, was both empirically and theoretically driven. Examination of the data distribution showed that the 1-mile measure reflected participants from only six ZIP codes, whereas the 0.5-mile measure reflected participants from 63 ZIP codes. Given the limited geographic variability and concerns about potential ZIP code–level confounding with the 1-mile measure, the 0.5 measure was selected for analysis. This decision was further supported by prior research that used the 0.5-mile definition in Los Angeles (Algert et al., 2006; Payán et al., 2020).

In sensitivity analyses, the continuous ZIP code–level measure was categorized into a binary variable (yes/no) based on the percentage of residents living in food desert tracts. ZIP codes were classified as food deserts if at least 33% of the ZIP code population lives in food desert tracts (e.g., LILA using the 0.5-mile urban and 10-mile rural distance threshold). The 33% cutoff was selected to align with the USDA definition of low access (*Measuring Access to Food*, n.d.).

Covariates: Individual-level Maternal Characteristics

The following individual-level maternal covariates were obtained from the 2014 and 2017 LAC WIC survey and included: race/ethnicity (Hispanic/Latinx, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic Pacific Islander, Non-Hispanic American Indian or Alaskan native, and other/multi-racial), education level (less than high school, high school graduate, some college or associated degree, college graduate or above), age (younger than 20 years, 20-29 years, and 30 years and older), whether they used EBT in the past 12 month (yes/no), food security status (high or marginal food security, low food security, and very low food security), and whether they had a pre-term birth (yes/no). These factors were selected because they are theoretically relevant, available in the dataset, and reflect factors that are widely used as confounders in studies of neighborhood effects and breastfeeding (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Kummer et al., 2020; LoCasale-Crouch et al., 2024; Riley et al., 2016; Yourkavitch et al., 2018). All covariates were included in fully adjusted models. The specific survey questions used to operationalize each variable are listed in Table 2.

Analytic Plan

All data merging, cleaning, and analyses were conducted using R statistical software (R Core Team, 2025). Descriptive univariate statistics were conducted to summarize and explore the distribution of all key predictors, covariates, and outcomes. For bivariate analyses, chi-square tests and paired t-tests were used to examine associations between analytic variables to assess patterns across groups and help inform modeling structure. Various metrics were calculated to understand the between ZIP variation in breastfeeding (i.e., intraclass correlation coefficient: ICC), degree of clustering (e.g., design effect: DEFF), and distribution of cluster sizes (Hox et al., 2017; Maas & Hox, 2005). These indicators were used to describe the structure and limitations of the data as well as guide interpretation of results within these parameters.

Multilevel modeling, guided by a theory-driven model-building approach, was used to examine the association between food desert residence and individual-level breastfeeding practices. The specific modeling steps are outlined in Table 3. In Model 1, the crude association between the ZIP-level food measure and each breastfeeding practice was estimated in unadjusted models. In Model 2, individual-level maternal covariates (i.e., education, race/ethnicity, use of EBT, food security status, maternal age, and preterm birth) were added to assess adjusted associations. Separate regressions were estimated for each breastfeeding practice: initiation; any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months and exclusive breastfeeding at 6 months. The same modeling approach was applied in sensitivity analyses using the binary ZIP-level measure to assess the robustness of the main findings.

Results

Sample

The 2014 and 2017 LAC WIC Surveys were merged with the 2015 and 2019 FARA dataset using ZIP–ZCTA approximations. Because ZCTAs are approximations of ZIP codes, these geographic boundaries do not align one-to-one and can result in imperfect matches between ZIP codes and ZCTAs (Grubesic, 2008; Grubesic & Matisziw, 2006). Due to this limitation, after merging the data 291 out of 9,026 participants (representing 187 out of 438 ZIP codes) were dropped due to ZIP–ZCTA mismatch. The final analytic sample consists of 8,735 participants (representing 251 ZIP codes) and is restricted to biological mothers to improve the reliability of recalled breastfeeding history. Table 21 describes the socio-demographic, breastfeeding, and neighborhood characteristics of the sample overall and by breastfeeding practice. This sample closely resembles the sociodemographic profile of the Study 1 and Study 2 sample. However, it differs slightly due to the use of different databases, which resulted in more unmatched cases after merging and a slightly smaller final sample.

Table 21. Sociodemographic, Breastfeeding, and Neighborhood Characteristics of the Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,735)

Individual-level Characteristic	**N (%)**
Maternal Race/Ethnicity	
Hispanic	7485 (85.7)
Non-Hispanic Black	597 (6.8)
Non-Hispanic White	350 (4.0)
Non-Hispanic Asian	173 (2.0)
Non-Hispanic Pacific Islander	22 (0.3)
Non-Hispanic American Indian/Alaska Native	11 (0.1)
Other/multi-racial	78 (0.9)
Maternal Education	
Less than high school	3081 (35.3)
High school graduate	2448 (28.0)
Some college/trade school/associate degree	2440 (27.9)
4-year degree or higher	734 (8.4)
Preterm Birth	
Yes	773 (8.8)
No	7947 (91.0)
Food Security Status	
High/marginal food security	6143 (70.3)
Low food security	1767 (20.2)
Very low food security	671 (7.7)
Maternal Age	
Younger than 20	824 (9.4)
20-29	4330 (49.6)
30 and older	3560 (40.8)
Used EBT in the past 12 months	
Yes	4209 (48.2)
No	4502 (51.5)
Breastfeeding practice	
Initiation	8167 (93.6)
Any breastfeeding at 3 months	5802 (73.7)
Any Breastfeeding at 6 months	4334 (57.2)
Exclusive breastfeeding at 3 months	1773 (21.6)
Exclusive breastfeeding at 6 months	870 (10.9)
Neighborhood-Level Characteristic	**Mean (SD)**
Percent of ZIP population in food desert tract	37.6 (25.8)[a]

a. Values represent the mean (standard deviation).

Individual-Level and Neighborhood-level Maternal Characteristics

As seen in Table 21, the majority of the sample identifies as Hispanic (N=7,485; 85.7%), followed by Black (N=597; 6.8%), White (N=350, 4.0%), Asian (N=173; 2.0%), Other/multiracial N=78; 0.9%), Pacific Islander (N=22; 0.3%), and American Indian/Alaska Native (AI/AN) (N=11; 0.1%). A substantial proportion of the sample is between the ages of 20-29 years (N = 4,330; 49.6%) and has a high school education or less (N=5,529; 63.3%). The majority of the sample is classified as food secure (N=6,143; 70.3%) and did not have a preterm birth (N=7,947; 91.0%). About half of the participants did not use EBT in the past 12 months (N=4,527; 51.6%), whereas the other half did (N=4,229; 48.2%). On average, participants live in ZIP Codes where approximately 37.6% (SD = 25.8; range: 0.0–97.8) of residents live in a food desert (i.e., a low-income tract with low food access within 0.5 miles in urban settings and 20 miles in rural settings).

Although the sample reported high breastfeeding initiation rates (N = 8,167; 93.5%), substantially lower rates were observed for both duration and exclusivity over time (Table 21). Any breastfeeding declined to 73.7% (N = 5,802) at 3 months to 57.2% (N = 4,334) at 6 months. Even lower rates were observed for exclusive breastfeeding, which decreased from 21.6% (N = 1,773) at 3 months to 10.9% (N = 870) at 6 months. These patterns suggest that while the majority of participants initiate breastfeeding, sustaining breastfeeding, particularly exclusivity, remains a significant challenge within the WIC population.

Missing data on individual-level factors were minimal, ranging from 0.2% to 1.8%, with the exception of breastfeeding practices, which ranged from approximately 0.1% to 13.3%. The large missingness for breastfeeding is related to how the variable was constructed. Breastfeeding practices were constructed using child age and breastfeeding duration. Missingness increased at

later timepoints due to right-censoring for children who had not yet reached the specified age and incomplete reporting of breastfeeding cessation timing. Therefore, the missing values reflect true missingness and was not imputed.

Tables 22–26 present the sociodemographic and neighborhood characteristics of the sample by each breastfeeding practice. Overall, significant differences between those who breastfed and those who did not were consistently observed for maternal race/ethnicity and education level ($p < 0.01$) at all timepoints except exclusivity at 3 and 6 months. In general, lower breastfeeding prevalence across outcomes were observed among participants with lower educational attainment and among Black mothers. Additionally preterm birth was significantly associated with breastfeeding at all time points except any breastfeeding at 3 and 6 months ($p < 0.01$) with those experiencing a preterm birth overrepresented among participants who did not initiate breastfeeding and who did not exclusively breastfeed at 3 and 6 months.

Other individual-level characteristics, including EBT use, food security status, preterm birth, and maternal age, showed less consistent associations across breastfeeding outcomes. EBT use was significantly associated with initiation and any breastfeeding at 6 months, with lower breastfeeding prevalence among participants receiving EBT (all p-values ≤ 0.01). Differences were also observed by food security status, with greater food security associated with lower prevalence of any breastfeeding at 3 ($p \leq 0.01$). For maternal age, a mixed pattern was observed. Participants aged 30 years and older had higher prevalence of any breastfeeding at 3 and 6 months (all p-values < 0.01), whereas participants aged 20-29 years were overrepresented among those who exclusively breastfed at 6 months. Similarly, the neighborhood-level variable showed inconsistent patterns. The ZIP Code–level food access measure was associated with differences in any breastfeeding at 3 and 6 months (all p-values < 0.01), with individuals who were

breastfeeding residing in ZIP Codes with a slightly lower mean population classified as living in a food deserts. Overall, these findings suggest that associations between individual-level and neighborhood-level characteristics and breastfeeding outcomes vary depending on the specific breastfeeding measure.

Table 22. Sociodemographic and Neighborhood Characteristics by **Initiation** for Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=8,726)

	Yes	**No**	**P-value**
Individual-level Characteristic	**N (%)**	**N (%)**	
Total Population	8167 (93.6)	559 (6.4)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	7071 (86.3)	449 (80.2)	
Non-Hispanic Black	524 (6.4)	73 (13.0)	
Non-Hispanic White	328 (4.0)	24 (4.3)	
Non-Hispanic Asian	171 (2.1)	1 (0.2)	
Non-Hispanic Pacific Islander	20 (0.2)	2 (0.4)	
Non-Hispanic American Indian/Alaska Native	7 (0.1)	4 (0.7)	
Other/multi-Racial	71 (0.9)	7 (1.2)	
Maternal Education			**0.00**[a]
Less than high school	2863 (35.0)	234 (42.1)	
High school graduate	2306 (28.2)	156 (28.1)	
Some college/trade school/associate degree	2310 (28.2)	135 (24.3)	
4-year degree or higher	704 (8.6)	31 (5.6)	
Preterm Birth			**0.00**[a]
Yes	680 (8.3)	96 (17.2)	
No	7518 (91.7)	462 (82.8)	
Food Security Status			0.27[a]
High/marginal food security	5758 (71.4)	409 (74.4)	
Low food security	1677 (20.8)	99 (18.0)	
Very low food security	631 (7.8)	42 (7.6)	
Maternal Age			0.24[a]
Younger than 20	794 (9.7)	43 (7.7)	
20-29	4069 (49.7)	275 (49.3)	
30 and older	3329 (40.6)	240 (43)	
Used EBT in the past 12 months			**0.00**[a]
Yes	3913 (47.8)	309 (55.3)	
No	4275 (52.2)	250 (44.7)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Percent of ZIP population in food desert tract	37.5 (25.8)[b]	39.3 (25.9)[b]	0.11[c]

Bolded values = significant at p = 0.01

a. p-values for chi-square test
b. Values represent the mean (standard deviation).
c. p-values for paired t-test

Table 23. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 3 Months** for Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N=7,869)

	Yes	**No**	**P-value**
Individual-level Characteristic	**N (%)**	**N (%)**	
Total Population	5802 (73.7)	2067 (26.3)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	5063 (87.1)	1763 (84.9)	
Non-Hispanic Black	327 (5.6)	175 (8.4)	
Non-Hispanic White	229 (3.9)	80 (3.9)	
Non-Hispanic Asian	125 (2.1)	40 (1.9)	
Non-Hispanic Pacific Islander	15 (0.3)	3 (0.1)	
Non-Hispanic American Indian/Alaska Native	5 (0.1)	1 (0.0)	
Other/multi-Racial	52 (0.9)	15 (0.7)	
Maternal Education			**0.00**[a]
Less than high school	2073 (35.7)	695 (33.6)	
High school graduate	1576 (27.1)	642 (31.0)	
Some college/trade school/associate degree	1630 (28.0)	589 (28.4)	
4-year degree or higher	535 (9.2)	145 (7.0)	
Preterm Birth			0.59[a]
Yes	475 (8.2)	178 (8.6)	
No	5347 (91.8)	1899 (91.4)	
Food Security Status			**0.01**[a]
High/marginal food security	4030 (70.4)	1514 (73.9)	
Low food security	1230 (21.5)	387 (18.9)	
Very low food security	463 (8.1)	149 (7.3)	
Maternal Age			**0.00**[a]
Younger than 20	473 (8.1)	288 (13.9)	
20-29	2805 (48.2)	1130 (54.5)	
30 and older	2544 (43.7)	656 (31.6)	
Used EBT in the past 12 months			**0.00**[a]
Yes	2702 (46.4)	1072 (51.7)	
No	3116 (53.6)	1003 (48.3)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Percent of ZIP population in food desert tract	36.9 (25.8)[b]	39.1 (25.6)[b]	**0.00**[c]

Bolded values = significant at p = 0.01

a. p-values for chi-square test
b. Values represent the mean (standard deviation).
c. p-values for paired t-test

Table 24. Sociodemographic and Neighborhood Characteristics by **Any Breastfeeding at 6 Months** for Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 7,573)

	Yes	**No**	**P-value**
Individual-level Characteristic	**N (%)**	**N (%)**	
Total Population	4334 (57.2)	3239 (42.8)	
Maternal Race/Ethnicity			**0.00**[a]
Hispanic	3805 (87.7)	2768 (85.0)	
Non-Hispanic Black	220 (5.1)	263 (8.1)	
Non-Hispanic White	172 (4.0)	121 (3.7)	
Non-Hispanic Asian	90 (2.1)	68 (2.1)	
Non-Hispanic Pacific Islander	7 (0.2)	11 (0.3)	
Non-Hispanic American Indian/Alaska Native	4 (0.1)	0 (0.0)	
Other/multi-Racial	40 (0.9)	25 (0.8)	
Maternal Education			**0.00**[a]
Less than high school	1659 (38.3)	1027 (31.6)	
High school graduate	1132 (26.1)	1001 (30.8)	
Some college/trade school/associate degree	1127 (26.0)	984 (30.3)	
4-year degree or higher	419 (9.7)	237 (7.3)	
Preterm Birth			0.18[a]
Yes	347 (8.0)	289 (8.9)	
No	3995 (92.0)	2969 (91.1)	
Food Security Status			0.05[a]
High/marginal food security	2997 (70.3)	2334 (72.7)	
Low food security	930 (21.8)	631 (19.7)	
Very low food security	339 (7.9)	245 (7.6)	
Maternal Age			**0.00**[a]
Younger than 20	296 (6.8)	435 (13.4)	
20-29	2050 (47.2)	1722 (52.9)	
30 and older	1997 (46.0)	1097 (33.7)	
Used EBT in the past 12 months			0.06[a]
Yes	2042 (47.0)	1601 (49.2)	
No	2300 (53.0)	1651 (50.8)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Percent of ZIP population in food desert tract	36.4 (25.8)[b]	39.1 (25.6)[b]	**0.00**[c]

Bolded values = significant at p = 0.01

a. p-values for chi-square test

b. Values represent the mean (standard deviation).

c. p-values for paired t-test

Table 25. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 3 Months** for Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 8,212)

	Yes	**No**	**P-value**
Individual-level Characteristic	**N (%)**	**N (%)**	
Total Population	1773 (21.6)	6439 (78.4)	
Maternal Race/Ethnicity			0.02[a]
Hispanic	1491 (83.9)	5586 (86.5)	
Non-Hispanic Black	128 (7.2)	436 (6.8)	
Non-Hispanic White	92 (5.2)	236 (3.7)	
Non-Hispanic Asian	40 (2.3)	121 (1.9)	
Non-Hispanic Pacific Islander	5 (0.3)	16 (0.2)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	10 (0.2)	
Other/multi-Racial	21 (1.2)	53 (0.8)	
Maternal Education			0.02[a]
Less than high school	581 (32.7)	2324 (36.0)	
High school graduate	507 (28.5)	1810 (28.1)	
Some college/trade school/associate degree	515 (29.0)	1799 (27.9)	
4-year degree or higher	173 (9.7)	514 (8.0)	
Preterm Birth			**0.00[a]**
Yes	108 (6.1)	570 (8.8)	
No	1670 (93.9)	5891 (91.2)	
Food Security Status			0.56[a]
High/marginal food security	1268 (72.5)	4529 (71.2)	
Low food security	347 (19.8)	1332 (20.9)	
Very low food security	134 (7.7)	498 (7.8)	
Maternal Age			0.12[a]
Younger than 20	147 (8.3)	635 (9.8)	
20-29	909 (51.1)	3206 (49.7)	
30 and older	723 (40.6)	2614 (40.5)	
Used EBT in the past 12 months			0.14[a]
Yes	831 (46.8)	3148 (48.8)	
No	946 (53.2)	3308 (51.2)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Percent of ZIP population in food desert tract	37.4 (26.5)[b]	39.6 (25.6)[b]	0.81[c]

Bolded values = significant at p = 0.01

a. p-values for chi-square test
b. Values represent the mean (standard deviation).
c. p-values for paired t-test

Table 26. Sociodemographic and Neighborhood Characteristics by **Exclusive Breastfeeding at 6 Months** for Study 3 Sample of Los Angeles County WIC Participants, 2014 and 2017 (N= 7,979)

	Yes	**No**	**P-value**
Individual-level Characteristic	**N (%)**	**N (%)**	
Total Population	870 (10.9)	7109 (89.1)	
Maternal Race/Ethnicity			0.41[a]
Hispanic	738 (84.5)	6151 (86.3)	
Non-Hispanic Black	59 (6.8)	487 (6.8)	
Non-Hispanic White	42 (4.8)	269 (3.8)	
Non-Hispanic Asian	21 (2.4)	134 (1.9)	
Non-Hispanic Pacific Islander	2 (0.2)	18 (0.3)	
Non-Hispanic American Indian/Alaska Native	0 (0.0)	8 (0.1)	
Other/multi-Racial	11 (1.3)	61 (0.9)	
Maternal Education			0.25[a]
Less than high school	304 (34.9)	2537 (35.6)	
Highschool graduate	248 (28.4)	2002 (28.1)	
Some college/trade school/associate degree	232 (26.6)	1995 (28.0)	
4-year degree or higher	88 (10.1)	583 (8.2)	
Preterm Birth			**0.00**[a]
Yes	44 (5.0)	635 (8.9)	
No	829 (95.0)	6497 (91.1)	
Food Security Status			0.52[a]
High or marginal food security	625 (73.1)	5001 (71.2)	
Low food security	168 (19.6)	1472 (21.0)	
Very low food security	62 (7.3)	549 (7.8)	
Maternal Age			**0.00**[a]
Younger than 20	58 (6.6)	703 (9.9)	
20-29	465 (53.2)	3517 (49.4)	
30 and older	351 (40.2)	2906 (40.8)	
Used EBT in the past 12 months			0.05[a]
Yes	395 (45.2)	3479 (48.8)	
No	478 (54.8)	3647 (51.2)	
Neighborhood-Level Characteristic	**Yes Mean (SD)**	**No Mean (SD)**	**P-value**
Percent of ZIP population in food desert tract	36.9 (26.2)[b]	37.7 (25.7)[b]	0.40[c]

Bolded values = significant at p = 0.01

a. p-values for chi-square test
b. Values represent the mean (standard deviation)
c. p-values for paired t-test

ZIP Code Distribution and Between-ZIP Variability

Of the over 500 ZIP codes in LAC, the sample includes WIC participants from 251 unique ZIP codes in LAC. The number of participants per ZIP code ranges from 1 to 252, with an average of 34.8 participants (SD: 42.7) A common guideline recommends at least 30 level 2 units with 30 observations per unit to be considered sufficient for multilevel analyses (Hox et al., 2017; Maas & Hox, 2005). In the present sample, 97 ZIP codes (38.6%) included at least 30 participants, which meets the recommended threshold for multilevel analyses.

The intraclass correlation coefficient (ICC) was calculated to assess the proportion of variance in breastfeeding practices attributable to differences between ZIP codes (Table 27). The ICCs indicated minimal variance, accounting for 0.1% to 3.0% of the variance in breastfeeding practices between ZIP codes. While low variance is typical in neighborhood effects research, it may make it more difficult to detect neighborhood-level effects. Additionally, a DEFF was calculated for each breastfeeding practice to estimate the impact of clustering on sample size and standard errors. The Design Effects (DEFF) observed in this study suggest accounting for clustering increases standard errors and modestly reduces the effective sample size (range: 1.04–1.89). These attributes can make it more difficult to detect neighborhood-level effects and are important to consider when interpreting the results (Hox et al., 2017; Maas & Hox, 2005).

Table 27. Intraclass Correlation Coefficients (ICC), Mean Cluster Sizes, and Design Effects (DEFF) for Breastfeeding Practices Across ZIP Codes

Outcome	N	Mean Cluster Size	ICC	DEFF
Initiation	8,726	34.8	0.03	1.89
Any at 3 months	7,869	31.4	0.01	1.30
Any at 6 months	7,573	30.2	0.02	1.49
Exclusivity at 3 months	8,212	33.0	0.01	1.30
Exclusivity at 6 months	7,979	32.0	0.00	1.04

Primary Analyses

The results for the multilevel analyses for each breastfeeding practice are outlined in Figure 14 (initiation, any breastfeeding at 3 months, any breastfeeding at 6 months, exclusive breastfeeding at 3 months, and exclusive breastfeeding at 6 months). Results of the full analyses, including all outcomes, can be found in the appendices (Appendices L.1-L.9).

All breastfeeding outcomes were analyzed using multilevel models, except exclusivity at 6 months. This outcome was analyzed using standard logistic regression due to negligible variance at the ZIP code level (0.00), which led the model to default to a single-level specification. Additionally, a more conservative significance level of $p < 0.01$ was used to reduce potential noise and limit the risk of spurious findings that could arise with the conventional $p < 0.05$ threshold, (Benjamin et al., 2017).

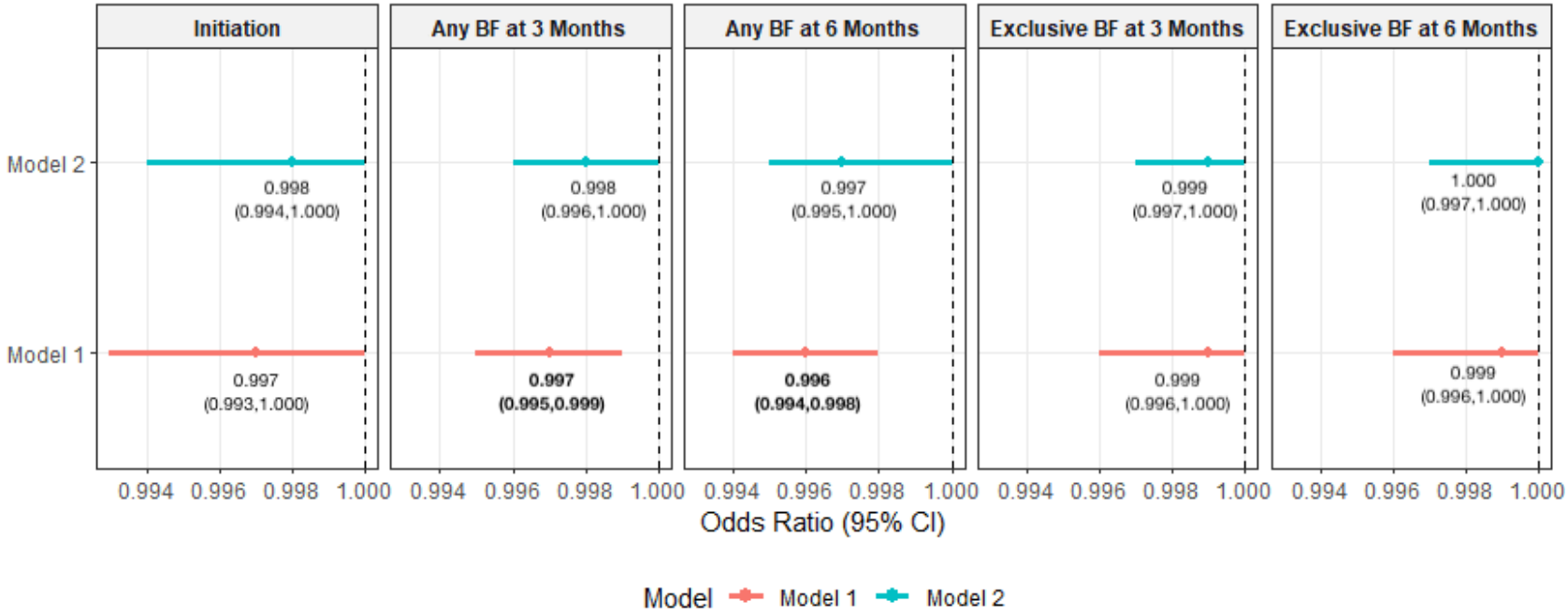


Figure 14. Odds ratios and 95% confidence intervals from multilevel analyses examining the association between ZIP-level food desert exposure and breastfeeding practices.

Notes: Model 1 (Unadjusted Model): Examines the unadjusted association. Model 2 (Adjusted Model): Examines the adjusted associations after adding individual-level maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education. Bolded estimates indicate statistical significance at the 0.01 level. Exclusivity at 6 months was analyzed using a single-level logistic regression model due to negligible variance at the ZIP code level.

Breastfeeding Initiation

Results show that the key predictor, a measure of ZIP-level food desert exposure, is not significantly associated with breastfeeding initiation in unadjusted and adjusted models (p-values > 0.01). The odds ratios, however, suggest a potential negative trend where slightly lower odds of breastfeeding are observed with increases in the percentage of the ZIP code population living in a food desert (Model 1 OR: 0.997; Model 2 OR: 0.998), but the effect is tiny and not significant.

Any Breastfeeding at 3 and 6 Months

For both any breastfeeding at 3 and 6 months, results show that increases in the percentage of the ZIP code population living in a food desert is significantly associated with lower odds of breastfeeding in the unadjusted models (OR = 0.997, 95% CI: 0.995-0.999 and OR = 0.996, 95% CI: 0.994-0.998, respectively). After adjustment for individual-level maternal covariates, the direction of the association remained but it was no longer significant (p-values > 0.01). This suggests that the associations are largely explained by maternal characteristics, rather than the ZIP-level food desert exposure. However, the odds ratios do suggest a potential negative trend where slightly lower odds of breastfeeding are observed with increases in the percentage of the ZIP code population living in a food desert.

Exclusive Breastfeeding at 3 and 6 months

Results show that ZIP-level food desert exposure is not significantly associated with exclusive breastfeeding in unadjusted and adjusted models (p-values > 0.01). The odds ratios, however, suggest a potential negative trend where slightly lower odds of breastfeeding are observed with increases in the percentage of the ZIP code population living in a food desert, but the effects are tiny and not significant.

Sensitivity Analyses

Sensitivity analyses were conducted using a binary (categorical) version of the ZIP-level food desert exposure measure (defined as ZIP codes where ≥33% of residents live in food desert tracts). Results show that this ZIP-level food desert measure is not associated with breastfeeding practices across all outcomes in either unadjusted or adjusted models, which is consistent with the primary analyses (Appendices L.1-L.9).

Follow up analyses were also conducted with individual-level lactation support added as additional individual-level maternal covariates to Model 2. Including these variables allowed for a more rigorous assessment of whether the observed associations were robust to adjustment for proximal sources of breastfeeding support. The LAC WIC survey data were used to construct the lactation support covariates, which included measures of partner support (1 = Partner lives in household, 2 = partner does not live in household but active, and does not live in household and not active) and workplace accommodations (1=returned to work within three months and the workplace did not have breastfeeding accommodations, 2=returned to work within three months and the workplace provided breastfeeding accommodations, and 3=did not return to work within three months. These variables were operationalized based on how prior research using LAC WIC survey data have done it (Jiang, 2021). The survey questions used to operationalize these variables are provided in Appendix J. Consistent with the main findings, results showed that the continuous ZIP-level food desert exposure measure was not significantly associated with breastfeeding practices across all outcomes after adjustment for maternal individual-level covariates.

Lastly, follow-up analyses were conducted on a subset of mothers with children aged 2 years and younger (N = 3,572). This approach was used to focus on women whose experiences better reflect neighborhood environments during the period when children are most likely to be

breastfeeding. In line with the main findings, the results showed that the continuous ZIP-level food desert exposure measure was not significantly associated with breastfeeding practices across all outcomes after adjustment for maternal individual-level covariates. Overall, the results from the various sensitivity analyses were consistent with the main findings and provide further support for the robustness of the primary analyses.

Discussion

This study attempted to address a critical gap in the literature by examining the association between a neighborhood's food environment and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity) among WIC participants in LAC. While prior research has identified food-related determinants at the individual-level (e.g., food insecurity) as critical determinants to breastfeeding, this study is the second to directly examine food access at the neighborhood level. This gap in literature is concerning as the neighborhood food environment has significant implications for breastfeeding.

Existing research provides evidence of potential pathways linking the neighborhood food environment to a mother's ability and choice to breastfeed. A key pathway that limited access to affordable, healthy foods may influence breastfeeding is through maternal nutrition and diet quality. Prior research has found that better diet quality, characterized by increases in maternal intake of fruits and vegetables are associated with two times higher odds of breastfeeding for 6 months (Amir & Donath, 2012). Another study found that nutrient deficiencies in maternal diets have adverse effects on milk production, secretion, and composition (Lee & Kelleher, 2016). Consequently, these factors may negatively impact a mother's biological capacity to breastfeed as well as her perceptions of the quality of her milk (Gross et al., 2019).

These consequences have been shown to be especially detrimental to breastfeeding among WIC participants. Gross et al. (2019) found that Hispanic WIC mothers experiencing food insecurity (e.g., do not have consistent, reliable access to enough affordable and nutritious food) often perceived their diet as poor (e.g., low fruit and vegetable intake) and nutritionally inadequate. These perceptions contributed to decisions to supplement with formula or discontinue breastfeeding due to concerns that their breast milk did not provide sufficient nutrients for their infant. This pathway may contribute to perceived insufficient milk (PIM) in mothers, which is a major reason for breastfeeding cessation among mothers in LAC (Janice French et al., 2013). PIM describes maternal concerns about the adequacy of milk supply and confidence in the ability to produce enough milk. When mothers are unable to consistently access foods they believe support lactation, they may perceive their bodies as incapable of producing sufficient milk (Gross et al., 2019).

Dietary intake also plays a role in maternal mental health, which has important implications for breastfeeding. Poor maternal diet quality has been associated with an increased risk of prenatal and postpartum depression (Khan et al., 2020). Poor maternal mental health, including conditions such as depression and anxiety, are linked to greater challenges with breastfeeding, as well as lower breastfeeding initiation, duration, and exclusivity (Billings et al., 2024; Dias & Figueiredo, 2015; Hoff et al., 2019).

Given the potential pathways linking the neighborhood food environment and breastfeeding, the present study examined the following research question: What is the association between access to healthy foods, as measured by the percentage of the ZIP code population living in food desert tracts, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics? It was

hypothesized that ZIP codes with a higher percentage of residents living in food desert tracts would be significantly associated with a lower likelihood of breastfeeding initiation, duration, and exclusivity. This association was expected to attenuate but remain significant after adjusting for maternal characteristics. Further, the strength of the association was hypothesized to differ across breastfeeding outcomes (initiation, duration, exclusivity).

The present findings did not support the proposed hypotheses. Contrary to the hypothesized relationships, the association between ZIP-level food desert exposure and breastfeeding practices is not statistically significant across all outcomes ($p > 0.01$), after adjustment for individual-level maternal covariates. This suggests that the neighborhood food environment, as measured by the percentage of the ZIP code population living in food desert tracts, is not independently associated with breastfeeding beyond individual-level characteristics.

One possible explanation for the lack of association in the present study is that WIC participants in LAC are not constrained to their immediate food environments. Prior research in LAC has shown that WIC participants living in food-desert areas often travel outside of their local environments to do their grocery shopping (Qi Wu, 2016). These compensatory behaviors allow participants to overcome constraints of their immediate food environments and have shopping patterns comparable to non–food desert participants. As a result, the measure of food access used in this study may not accurately reflect participants' true food access could have contributed to the null findings. However, despite these mobility patterns, participants report that traveling beyond their immediate neighborhoods requires additional time, transportation, and shopping across multiple vendors (Qi Wu, 2016). Even though participants are able to access food, these added demands may introduce burdens that indirectly affect breastfeeding. This suggests that traditional measures of food desert exposure, which rely on geographic access, may

not fully capture the nuance ways in which food environments are shaping breastfeeding, particularly in LAC WIC participants.

Additionally, WIC participation may have attenuated the effects of the neighborhood food environment. WIC participants receive targeted nutritional, educational, and breastfeeding supports including supplemental food assistance delivered through targeted food packages (via EBT) (National WIC Association., n.d.). These programmatic factors may play a protective role in mitigating the adverse effects of limited access to healthy foods for participants in food deserts. WIC food packages are tiered to incentivize breastfeeding, with packages at the top tier having higher monetary value and a wider variety of nutrient-dense foods compared to lower tiers. Packages with the greatest benefits are given to fully breastfeeding mothers, followed by partially breastfeeding mothers, and then fully formula feeding.

Prior research has shown that implementation of the tiered packages promotes breastfeeding, with increases in exclusive breastfeeding at 3 and 6 months approximately doubling (Langellier et al., 2014). Additionally, prenatal participation in WIC is associated with lower odds of postpartum food insecurity and improvements in maternal diet quality, including increased fruit and vegetable consumption (Caulfield et al., 2022; Metallinos-Katsaras et al., 2011). These programmatic features, which aim to improve access to nutritious foods and incentivize breastfeeding, may contribute to the null findings observed in this study.

While compensatory shopping behaviors and supplemental food assistance may have attenuated or masked associations in this WIC sample, the influence of the food environment should not be interpreted as inconsequential to breastfeeding in the WIC population broadly. Although WIC provides critical nutritional support, it does not fully mitigate food insecurity. Prior research shows that households participating in WIC experience higher rates of food

insecurity and have poorer quality of diet compared to WIC-eligible non-participants (Chaparro & Lopez, 2024; Melo Herrera et al., 2023). This suggests that WIC participants may still face gaps in access to adequate and nutritious foods despite program benefits.

Furthermore, the food environment may constrain how WIC benefits are utilized. Factors related to availability and accessibility may influence the extent that benefits are used and how they are used. These barriers are especially relevant for participants in food deserts. For example, a lack of transportation has been identified as a barrier to WIC benefit redemption (National Academies of Sciences, Engineering, and Medicine (U.S.), 2017). This is especially consequential for food desert residents, who may need to travel beyond their immediate neighborhoods to access WIC-approved foods. For these individuals, their local food environment is even more important. Research has shown, however, that many food retail outlets in neighborhoods characterized by a higher concentration of food desert tracts have limited availability of healthy food sources that carry fresh produce (Payán et al., 2020). These structural constraints may shape purchasing patterns. While the increased WIC packages has been shown to increase redemption of fruit and vegetables, redemption remains incomplete (69.6%) (Chaparro et al., 2025; Tsai, M.M et al., 2024). These factors highlight gaps in utilization and may contribute to the poorer quality of diet in WIC participants compared to WIC eligible non-participants.

Even with WIC support, mothers may still experience challenges that come with limited access to healthy, fresh foods. While these consequences may not have been pronounced in this study sample, issues of accessibility and availability remain salient within the WIC population, particularly for those constrained to their immediate food environments. Further investigation of the relationship between the neighborhood food environment and breastfeeding is needed in WIC

populations beyond LAC. Future research should also consider how and for whom the food environment is most influential, as its effects may vary across populations.

Another potential reason for the null association found in the present study could be attributed to the measurement used to assess the neighborhood food environment. The present study used a ZIP-level construct reflecting the percentage of the ZIP code population living in food desert tracts rather than a direct measure of individual food desert residence. This distinction is important, as it represents a related measure of the neighborhood food environment but conceptually different than food desert residence.

Aggregating food desert tract–level data to the ZIP code level may mask meaningful variation in food access within neighborhoods. Although individuals living within the same ZIP code may experience different food environments (e.g., live in a food desert versus do not), they are assigned the same food environment measure. exposure values. Consequently, the ZIP code–level measure used in this study may not accurately capture an individual's localized food environment because it is aggregating heterogeneous areas, potentially leading to misclassification. Issues of misclassification not only raise concerns about whether the neighborhood food environment is being accurately measured, but also about whether the theoretical pathways discussed earlier are applicable. Because this ZIP code–level measure does not reflect localized neighborhood environments, the mechanisms through which the food environment impacts breastfeeding may operate differently at the ZIP –level than at the tract level.

The present finding that the neighborhood food environment is not associated with breastfeeding is not consistent with existing research. The one other study which examined this relationship did so between food desert residence and initiation using individual-level birth data

from the Florida Department of Health and neighborhood-level FARA data (Ajoseh et al., 2025). In this study, food desert residence was measured as a binary (Yes/No) variable reflecting whether or not someone lived in a food desert based on the FARA definition: LILA census tract at 1 mile (urban areas) and 20 miles (rural areas). After adjusting for maternal characteristics, mothers living in food deserts had 23% higher odds of not initiating breastfeeding compared to those not living in food deserts (OR = 1.23; 95% CI: 1.20–1.27). In contrast, the present study found no association between neighborhood food environment and breastfeeding initiation.

Key differences in methodology may explain these contrasting findings. A major difference between the two studies relates to the operationalization of an individual's neighborhood food environment. The measure used by Ajoseh et al. (2025) was based on the FARA definition of food desert residence as living in a LILA census tract with the 1-mile (urban) and 10-mile (rural) thresholds. Unlike ZIP codes, which are used in the present study, census tracts are smaller and more homogeneous geographic units that can better capture localized variation in food access (Grubesic, 2008; Grubesic & Matisziw, 2006). Furthermore, the measures used in each study reflect related but distinct constructs of the neighborhood food environment. Ajoseh et al. (2025) utilized a binary indicator of food desert residence that measures whether or not someone lives in a food desert tract, whereas the present study measured neighborhood food environment as a continuous percent of the ZIP Code population living in food desert tracts. Another key difference relates to the study population. Ajoseh et al. (2025) examined a general population sample that was more socioeconomically and racially diverse, with higher levels of educational attainment compared to the WIC population in the present study. In light of these mixed findings, the results of this study should be interpreted within the context of the study's limitations and methodological constraints.

Limitations

In addition to the considerations discussed earlier in this section, there are several limitations that may explain why the expected relationships were not observed. First, the present study defined an individual's neighborhood using ZIP codes as the geographic unit of analysis. ZIP codes represent large, heterogenous areas based on mail delivery routes and are not designed for statistical analysis (Grubesic, 2008; Grubesic & Matisziw, 2006). Consequently, ZIP codes provide less granular data and reflect aggregated neighborhood conditions across smaller, heterogeneous areas (i.e., census tracts) that may not capture a neighborhood's localized environment (Grubesic, 2008; Grubesic & Matisziw, 2006). Because of this, census tracts are the preferred unit of analysis in neighborhood effects research as they are smaller, standardized units designed for analyses. Although not ideal, ZIP codes are still used in public health research when data are not available at smaller units. However, using ZIP codes as a proxy for neighborhoods can make it harder to detect meaningful neighborhood effects for the reasons described above.

These concerns are reflected in the low ICCs found in this sample, which indicate that 0.1% to 3% variation in breastfeeding outcomes are attributable to differences between ZIP codes (ICC range: 0.001–0.030). Additionally, the DEFF values (range: 1.04–1.81) observed in this study indicate that neighborhood-level clustering increases standard errors and reduces the effective sample size. Taken together, these metrics indicate limited variability at the neighborhood-level and suggest that the use of multilevel modeling in the present study yielded more conservative estimates. These factors may have reduced the ability to detect meaningful neighborhood effects in the present study.

Future research should consider using smaller and more standardized geographic units, such as census tracts, to define neighborhood contexts. Census tracts are the preferred and most

widely used unit of analysis because they represent smaller, standardized geographic areas that can better capture neighborhood contexts and are specifically designed for research purposes (Grubesic, 2008; Grubesic & Matisziw, 2006) These features allow census tracts to better capture residents' localized food environments and improve the ability to detect contextual influences on breastfeeding.

The focus on the WIC population in LAC in the present study also introduces potential limitations. First, the WIC population represents a low-income population (i.e., household income must be at or below 185% of the federal poverty level). This attribute makes the WIC population more socioeconomically homogeneous and increases the likelihood of limited variability in neighborhood exposures. This limitation was reflected in the low ICCS observed in this study, indicating minimal variation in breastfeeding outcomes between ZIP codes. Consequently, the limited variation at the neighborhood level likely reduced the ability to detect meaningful neighborhood-level effects in this study and the present findings should not be interpreted as evidence that neighborhood effects do not exist.

Next, the sample used in this study presents potential limitations in generalizability of findings to different socio-demographic populations and geographic regions. Considering WIC is a low-income population, the present findings may not apply to middle- or higher-income families. Furthermore, the WIC-participating population differs from eligible nonparticipants and non-eligible low-income individuals, as they do not receive the same assistance or face the same barriers as participants. Therefore, findings may not apply to other low-income populations. The study sample, which is predominantly Hispanic (85.7%), further limits the generalizability of the findings to populations with different racial/ethnic compositions. Additionally, the present study's focus on LAC limits generalizability of findings to other geographic areas outside of Los

Angeles. Future research is needed to examine the association between the neighborhood food environment and breastfeeding in a more socioeconomically and racially diverse populations across geographic contexts. This would allow for greater variation in neighborhood exposures and may improve the ability to detect meaningful neighborhood effects on breastfeeding practices.

Conclusion

Despite existing research supporting a link between the neighborhood food environment and breastfeeding, the present study found no independent association between food desert exposure and breastfeeding outcomes beyond individual-level maternal characteristics. Although no neighborhood effects were identified, methodological limitations and sample characteristics may have limited the ability to detect such associations. Although no neighborhood effects were identified in this study, several methodological limitations and characteristics of the study sample may have limited the ability to detect such associations. The findings suggest that for LAC WIC participants, the detrimental effects of the local food environment may be less apparent. Whereas other factors, such as access to Baby-Friendly hospitals and peer counselors, may play a more significant role in shaping infant feeding decisions.

These findings should not, however, be interpreted as neighborhood food environments are inconsequential. Instead, they suggest these effects may be less pronounced in WIC populations who have access to targeted support and may shop outside their local food environments. While these factors may mitigate the consequences associated with limited food access in this sample, this does not reflect the experiences of all WIC participants. Issues related to food insecurity and limited access to healthy, affordable foods remain salient in the WIC population despite program benefits. In this way, the broader food environment may still shape

breastfeeding outcomes, particularly for those constrained to their immediate food environments. This relationship warrants further investigation, as WIC populations remain nutritionally at risk and vulnerable to the adverse impacts of limited food access.

CHAPTER 9: DISCUSSION

Chapter Overview

This chapter summarizes the research presented in this dissertation, discusses its strengths and limitations, and highlights its significance.

Overview of Dissertation

The overarching goal of this dissertation is to deepen the currently limited understanding of how a neighborhood's social and physical environment shapes individual-level differences in breastfeeding practices among low-income women. The primary research question is: How do place-based structural and social determinants of health, measured through the neighborhood social and physical environment, influence individual-level racial differences in breastfeeding practices among low-income women? To address this question, a series of three distinct but interrelated studies were conducted.

Study 1 examines the relationship between place-based social determinants of health (SDOH), measured by a multidimensional index of community conditions known as the Healthy Places Index (HPI), and individual-level breastfeeding practices (initiation, duration, and exclusivity).

The research questions addressed in this study were:

- *Question 1.1:* What is the association between place-based SDOH, as measured by the composite HPI score, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?
- *Question 1.2:* What is the association between place-based SDOH, as measured by the specific domains of the HPI (i.e., economic, education, social, housing, transportation, neighborhood and built environment, air and drinking water quality, and healthcare access),

and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

Although neighborhood effects were limited overall, the results revealed three important findings First, overall neighborhood quality (as indicated by the HPI composite score) is not significantly associated with breastfeeding initiation, duration, and exclusivity. However, the odds ratios were consistently above 1 which suggests a positive trend, where higher odds of breastfeeding were observed for healthier HPI quartiles. Second, the education domain showed the strongest and most consistent association with breastfeeding, with higher scores linked to increased odds of initiation, duration (3 and 6 months), and exclusivity (3 and 6 months) even after accounting for maternal characteristics. Third, exclusive breastfeeding was the only outcome significantly associated with multiple HPI domains beyond education, including the economic and insurance domains.

Study 2 examines how neighborhood racial/ethnic concentration help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The research question addressed in this study was: What is the association between racial/ethnic concentration of a neighborhood, as measured by the total percentage of Hispanic residents within a ZIP code, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for maternal characteristics?

Findings from this study indicate that neighborhood Hispanic concentration has a significant and negative association with breastfeeding exclusivity at both 3 and 6 months. Specifically, higher Hispanic concentration is associated with lower odds of exclusivity, even after adjusting for maternal covariates. Although odds ratios for initiation and any breastfeeding

were also less than 1, suggesting a negative association, statistical significance was observed only for exclusive breastfeeding.

Study 3 examines how the neighborhood food environment, as measured through access to healthy foods, help explain individual-level differences in breastfeeding practices (i.e., initiation, duration, and exclusivity) among low-income women. The research question addressed in this study was: What is the association between access to healthy foods, as measured by the percentage of the ZIP code population living in food desert tracts, and individual-level breastfeeding practices (i.e., initiation, duration, and exclusivity), after accounting for individual-level maternal characteristics?

Findings from this study indicate that food access, as measured by ZIP-level food desert exposure, is not associated with breastfeeding across all outcomes after adjustment for individual-level maternal covariates. ($p > 0.01$). These findings suggest that the neighborhood food environment, as measured in this sample, is not independently associated with breastfeeding beyond individual-level characteristics.

Strengths and Limitations

The strengths and limitations of this dissertation are outlined below and apply across all studies.

Limitation #1: The use of the ZIP codes as proxies

A major limitation of this dissertation is the use of ZIP codes as a proxy for neighborhoods across all three studies. ZIP codes represent large, unstandardized geographic areas based on mail delivery routes. They are highly unstable as they are constantly changing to align with shifting routes and can vary widely in both size and population (Grubesic, 2008; Grubesic & Matisziw, 2006). ZIP codes also reflect aggregated conditions across smaller

geographic units (e.g., census tracts), with highly variable socioeconomic characteristics (Grubesic, 2008; Grubesic & Matisziw, 2006). As a result, ZIP codes are known to obscure within-area inequities by averaging conditions across more and less advantaged populations. This heterogeneity makes ZIP codes an imprecise measure for understanding exposure or health disparities.

Another issue associated with the use of ZIP codes is their lack of alignment with other administrative geographic units, including ZIP Code Tabulation Areas (ZCTAs) and census tracts. The relationship between ZIP codes and these units are many-to-many, meaning a single census tract (or ZCTA) may overlap multiple ZIP codes and vice versa. In this study, this misalignment posed a limitation because ZCTAs and census tracts were used to crosswalk and merge food access data with WIC survey data, which were only available at the ZIP code level. This is problematic as it can introduce measurement error and lead to potential misclassification of participants' neighborhood environments.

Although ZIP codes are used when smaller geographic units are unavailable, they remain a less precise and less preferred unit of analysis in neighborhood effects research. Instead, census tracts are widely considered the standard proxy for neighborhoods. Compared to ZIP codes, census tracts are smaller, more stable geographic units designed for statistical analysis (Grubesic, 2008; Grubesic & Matisziw, 2006). As a result, census tracts tend to be more internally homogeneous than ZIP codes.

Future research should examine the associations explored in this dissertation using census tracts as the proxy for neighborhoods. This would allow for a more rigorous assessment of neighborhood effects and better align with existing studies (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Diez Roux, 2001; Diez Roux & Mair, 2010; LoCasale-Crouch et al., 2024;

Riley et al., 2016; Yourkavitch et al., 2018). Because census tracts are smaller geographic units, they are better able to reflect localized environments and capture nuanced differences in neighborhood exposures. This is especially important in low-income populations, where there may be greater socioeconomic homogeneity and limited variability in neighborhood conditions. Using smaller units can, therefore, improve the ability to detect meaningful variation across neighborhoods. Additionally, the use of census tracts reduces the potential for misrepresenting levels of disadvantage that can occur when individuals are aggregated at the ZIP code-level.

Beyond the specific limitations of ZIP codes, neighborhood effects research has been largely criticized for its overreliance on administrative geographic boundaries (e.g., census tracts and ZIP codes) as proxies for neighborhoods. Although use of administrative geographic units is widespread, they often do not reflect an individual's lived experiences or perceptions of their neighborhoods (Diez Roux, 2001; Diez-Roux, 1998, 2000). People often experience their neighborhoods subjectively, in ways that cannot be accurately captured by administratively defined boundaries. A related limitation is that these predefined boundaries often fail to capture contexts not bound by geography, such as individuals' daily mobility patterns.

This limitation is present across all three studies but is particularly salient in Study 3, which examined the association between the neighborhood food environment and breastfeeding. Using administrative boundaries, such as ZIP codes, to assess food access overlooks important contextual factors that are not geographically bound. These include food quality, affordability, availability, cultural acceptability, and residents' daily mobility patterns (Shannon et al., 2021). In the context of Study 3, the inability of the food access measure to capture these dimensions, particularly resident mobility, was especially limiting considering prior research has found that LAC WIC participants often do their grocery shop outside of their residential neighborhoods

(Woodruff et al., 2020). As a result, the ZIP code-level measure used in this dissertation is not accurately capturing participants' true food environments or the contexts that shape their food access and related behaviors.

To address these issues, alternative approaches integrating functional and perceptual methods of defining neighborhood have been proposed. These approaches include systematic social observation, resident-defined neighborhood mapping, person-centric buffers, and GPS (Global Positioning System) (Coulton, 2012; Lohmann & McMurran, 2009; Robinson & Oreskovic, 2013; Weiss et al., 2007; Wilson, 2009). Future studies examining neighborhood effects and breastfeeding should incorporate more non-traditional measures to better capture neighborhood contexts that align with an individual's lived experiences.

Neighborhoods are subjective, with no single way to define their boundaries (Weiss et al., 2007). These challenges reflect a broader methodological issue in neighborhood effects research known as the Modifiable Areal Unit Problem (MAUP). MAUP refers to the idea that findings can change significantly depending on the scale and definition of geographic units (Mehra et al., 2017). As such, the present findings reflect relationships within ZIP code–defined neighborhoods and the observed associations may be sensitive to the choice of geographic unit. The MAUP further underscores the need for future studies to use multiple definitions and methods to define neighborhoods in order to better understand these relationships and assess the robustness of the current findings across different neighborhood definitions.

Limitation #2: Use of a LAC WIC study population

Another major limitation of this dissertation relates to the potential for selection biases and limited generalizability due to the study population (i.e., LAC WIC participants). WIC participants represent a low-income population (i.e., live at or below 185% of the federal poverty

level). As a result, the WIC population is more socioeconomically homogenous compared to the non-WIC population. This homogeneity can potentially limit the variation in neighborhood exposures and like where they live. This homogeneity may limit variation in neighborhood exposures and residential environments. This issue was further exacerbated by the use of ZIP codes, which may mask important within-neighborhood variation by aggregating heterogeneous areas.

This limitation was present across all three studies, as indicated by consistently low intraclass correlation coefficients. These values indicated that the variation in breastfeeding attributable at the ZIP-code level ranged from 0.1% to 3.0%, which is very minimal. While low values are typical of neighborhood effects research, this limited variation within the study population may have reduced the ability to detect meaningful differences across neighborhood contexts.

In addition to WIC participants being low-income, they represent a population that receives targeted nutritional and breastfeeding support shown to improve breastfeeding among this population (Metallinos-Katsaras et al., 2015; Rasmussen et al., 2017). This programmatic support could have attenuated neighborhood-level effects as it may reduce disparities in access to resources that would otherwise differ across neighborhoods.

In other words, the structured support provided by WIC may buffer against adverse neighborhood conditions on breastfeeding. WIC services, such as breastfeeding counseling, peer support, and supplemental foods may compensate for structural disadvantages that would otherwise adversely impact breastfeeding. This may have led to an underestimation of neighborhood effects, as associations may be stronger in populations without similar levels of support.

Additionally, this programmatic support may make the WIC population systematically different not only from higher-income populations but also from low-income individuals who are not enrolled in WIC or do not have access to similar services. This introduces the potential for selection bias, as individuals who choose to enroll in WIC may be more motivated to engage with health services or may differ in unobserved ways, such as health beliefs, social support, or access to care. Future research should examine these relationships among non-WIC populations, including both WIC-eligible nonparticipants and non-WIC eligible populations, to better understand how these associations may change in the absence of WIC support.

The use of a LAC WIC sample also limits the generalizability of these findings. Results may not be applicable to middle- or higher-income families, as well as low-income families who are neither WIC-eligible nor WIC participants. Generalizability is also limited by the geographic scope of the study, which focused on LAC. Consequently, the findings may not apply to other regions of California or the broader United States. Lastly, the sample is predominantly Hispanic. While this reflects the demographic composition of the national WIC population (*National and State Level Estimates of WIC Eligibility and Program Reach in 2020*, 2025), the findings may not be generalizable to WIC populations with different racial/ethnic compositions.

Despite these limitations, the WIC population remains widely studied in the breastfeeding research and offers important strengths. WIC participants are both vulnerable and highly relevant to maternal and child health research, making the study of neighborhood effects within this group especially valuable. Considering WIC participants are low-income women and children, they are disproportionately affected by adverse SDOH, including food insecurity, housing instability, and limited access to healthcare. Despite programmatic support, breastfeeding rates among WIC participants remain lower than those of non-WIC and WIC-eligible nonparticipants

(*About Breastfeeding Data*, 2025; Bunik et al., 2009), and racial disparities exist within the WIC population (Jiang, 2021). For these reasons, studying neighborhood effects within this population will help to identify how structural and contextual factors may shape breastfeeding practices in those most at risk.

While WIC provides important programmatic support, the disparities indicate that engagement with and receipt of these services may vary across participants. For example, availability of services in WIC clinics nationwide is known to vary. Approximately 78% of local WIC agencies nationwide have at least one staff member with certification in lactation and only about 69% operate a peer counseling program (WIC Breastfeeding Policy Inventory (Summary), 2015). WIC clinics that operate peer counseling programs report having an average of four peer counselors, but clinic size may influence time per client and counselor-to-participant ratios. This is problematic as limited time has been identified as a key barrier to providing adequate breastfeeding support to WIC participants (Cueva et al., 2017). Additionally, only about one-third of WIC clinics provide in-hospital breastfeeding support to WIC participants (WIC Breastfeeding Policy Inventory (Summary), 2015).

Another important factor influencing the effectiveness of WIC are gaps in the utilization of services. Common barriers to participation include challenges attending WIC appointments, misperceptions of EBT benefits, and challenging shopping experiences (e.g., difficulty identifying WIC-eligible foods and stigma) (Arteaga et al., 2025; Negro et al., 2024). These challenges may lead to differences in how participants engage with available services. Research has shown that WIC benefits, particularly supplemental food assistance, are used at different rates depending on household characteristics (Anderson, C.E. & Whaley, 2025). These barriers and inconsistencies in use highlight that access to WIC services does not necessarily translate to

utilization. This may contribute to variability in breastfeeding outcomes and the overall effectiveness of the program.

While WIC participation may have attenuated observed neighborhood-level effects, these findings should not be interpreted as evidence that such effects are unimportant or irrelevant within the broader WIC population. As discussed before, participation in WIC does not guarantee that individuals receive uniform levels of support. This means that participants who receive less support or face greater barriers to accessing WIC services may not be able to overcome breastfeeding challenges as easily as those who receive more comprehensive support.

Neighborhood conditions, therefore, may still play a meaningful role in shaping experiences and outcomes despite program participation. Future research is needed to examine these relationships in different states to better understand how neighborhood environments influence breastfeeding across WIC populations with varying levels of support and access to resources. Gaining a better understanding of these contextual influences will have important policy implications and can inform WIC programmatic strategies to address persistent disparities.

Limitation #3: Selection, Confounding, and Residual Bias in Neighborhood Effects Research

A common critique of neighborhood effects research is that the associations are the result of confounding by individual-level variables, rather than neighborhoods themselves (Diez Roux, 2001; Diez-Roux, 1998, 2000). This reflects a broader challenge in neighborhood effects research, where observed associations may be driven by individual-level characteristics rather than neighborhood contexts themselves (Diez-Roux, 1998, 2000). At the root of this criticism is the selection problem, which refers to the idea that people may be sorted into their

neighborhoods based on individual-level characteristics that may be related to the outcome (Diez-Roux, 1998, 2000). In other words, individuals may sort themselves into neighborhoods based on unmeasured characteristics that are not included in the analysis (Diez-Roux, 2000). This is problematic because it may result in unmeasured confounding or residual bias, which complicates the interpretation of observed contextual effects (Diez-Roux, 2000).

This dissertation addresses these concerns in two complementary ways by: 1) using theory and empirically guided variable selection and 2) applying a sequential modeling strategy. First, the selected individual-level covariates are theoretically relevant and reflect factors that are widely used as confounders in studies of neighborhood effects and breastfeeding (Bonet et al., 2013; Burdette, 2013; Cubbin et al., 2008; Galante et al., 2022; Kummer et al., 2020; LoCasale-Crouch et al., 2024; Riley et al., 2016; Yourkavitch et al., 2018). This list is not exhaustive and reflects only the measures available in the selected datasets, therefore, the potential for unmeasured confounding remains a plausible limitation.

Second, the sequential modeling strategy used in this dissertation is a common approach applied in studies of neighborhood effects and breastfeeding (Bonet et al., 2013, 2013; Cubbin et al., 2008; Kummer et al., 2020; LoCasale-Crouch et al., 2024; Oakley et al., 2013; Peregrino et al., 2018; Yourkavitch et al., 2018). This approach is advantageous because it provides a more nuanced way of understanding how neighborhood effects change when individual factors are added and helps to distinguish whether attenuation reflects confounding, potential mediation, or both. The need to develop multilevel theories to explain how group- and individual-level factors shape health and disease is a critical challenge in neighborhood effects research (Diez-Roux, 2000). Without this, multilevel analysis risks becoming a method that shows differences across arbitrary groups or associations to group-level variables that have no real meaning. This is

concerning as it may lead to findings or patterns that are hard to interpret (Diez-Roux, 2000). Additionally, multilevel theories are also critical in guiding variable selection and deciding which variables to include in the model and how they are operationalized (e.g., whether an individual-level variable is a confounder or a mediator) (Diez-Roux, 2000).

This dissertation draws on a multilevel theoretical framework which integrates concepts and theories from the Socioecological Model, Social Determinants of Health framework, and neighborhood effects literature. This framework delineates both theoretically and empirically relevant pathways through which neighborhood-level and individual-level factors impact breastfeeding practices. The use of a comprehensive multilevel framework is a major strength of this dissertation because it not only provided a strong foundation for the study aims but it also helped facilitate the interpretation of findings with more clarity and meaning.

Limitation #4: Reliance on observational survey data

This dissertation's reliance on retrospective self-reported data raises concerns about the accuracy of maternal recall of breastfeeding behaviors. Participants in the dataset had children up to 5 years of age, meaning it may have been several years since they gave birth. The potential for recall bias has been found to be more problematic for exclusivity than for duration. Research has found that maternal recall of breastfeeding duration remains accurate up to 6 years after childbirth, whereas recall for exclusive breastfeeding has been shown to be less accurate and are often overestimated (Amissah et al., 2017; Mulol & Coutsoudis, 2018; Stewart et al., 2025). Additionally, the time between delivery and survey completion may introduce measurement error in neighborhood exposure. This is because participants' reported residence at the time of survey completion may not correspond to their location at the time when they were breastfeeding.

To address these concerns, sensitivity analyses were conducted on a subset of women with children aged 2 years and younger across all three studies. These follow-up analyses further strengthened the interpretation as it allowed for the assessment of the robustness of the main findings in a subsample of women with more recent births.

Significance of Dissertation

Despite public health efforts, racial/ethnic disparities in breastfeeding remain a major barrier to maternal and child health equity. Minority women (e.g., Black and Hispanic) continue to experience lower breastfeeding rates than White women (California Department of Public Health, 2026). Extensive research has attributed these inequities to individual-level social and economic factors (e.g., income, education, and employment), often referred to as social determinants of health (SDOH) (Standish & Parker, 2022).

Beyond these individual-level factors, place-based SDOH, such as neighborhood racial/ethnic concentration and neighborhood conditions, may be key drivers of these disparities. Although research on their role in breastfeeding remains limited, existing studies have indicated an association that warrants further investigation. This persistent gap reflects the dominant individualistic framing of breastfeeding as a personal choice, which has narrowly placed responsibility on mothers while ignoring the structural inequities that limit their choice to breastfeed. Overlooking these structural forces allows systems that fail mothers to persist and reinforce inequities.

To address this critical gap, this dissertation examines how place-based social and structural determinants, measured through the neighborhood social and physical environment, influence individual-level differences in breastfeeding practices among low-income women. This work expands the limited understanding of these relationships and aligns with increasing calls

for place-based approaches in health disparities research to better understand how SDOH shape health outcomes (Gómez et al., 2021; Palmer et al., 2019). This dissertation addresses the following gaps in the literature:

- *Gap #1:* Limited understanding of how place-based SDOH shape breastfeeding practices
- *Gap #2:* Limited utilization and understanding of aggregate, place-based measures of SDOH and breastfeeding practices
- G*ap #3:* Limited understanding of how structural determinants, such as neighborhood racial/ethnic concentration, shape breastfeeding practices

The findings of this dissertation provide evidence that breastfeeding behaviors are shaped not only by individual-level factors but also by some broader neighborhood contexts and offer important insights for policy and practice. Even within a low-income population participating in a federal assistance program and receiving support, structural neighborhood conditions are influential. Public health efforts aimed at reducing concentrated poverty and improving educational and economic opportunities in disadvantaged and predominately Hispanic neighborhoods may help create environments that are more supportive of breastfeeding.

These place-based strategies offer valuable approaches that can strengthen existing efforts and should be integrated alongside individual-level interventions to enhance overall effectiveness. This multilevel, cross-sectoral approach aligns with a Health in All Policies framework, which recognizes that health outcomes are shaped by policies across multiple sectors. As such, improving breastfeeding outcomes requires coordinated policy action beyond the healthcare system, including in areas such as education, housing, and economic policy.

By adopting a place-based approach, this dissertation integrated a contextual dimension to the understanding of breastfeeding inequities that has been largely overlooked in the existing

body of research. The limited attention to place-based structural and social determinants contributes to an oversimplified understanding of breastfeeding as a personal choice rather than a product of broader structural issues. This dissertation represents a pivotal shift away from the dominant, individual-level discourse toward a greater focus on structural and neighborhood-level factors. It provides a valuable contribution to the literature and lays the foundation for future research to examine these relationships in more rigorous and nuanced ways. Continuing to grow this body of research is critical to advancing maternal and child health equity by shifting the framing of breastfeeding from an individual choice to one shaped by broader structural conditions.

APPENDICES

Appendix A. The *Ten Steps to Successful Breastfeeding are:*

CRITICAL MANAGEMENT PROCEDURES:

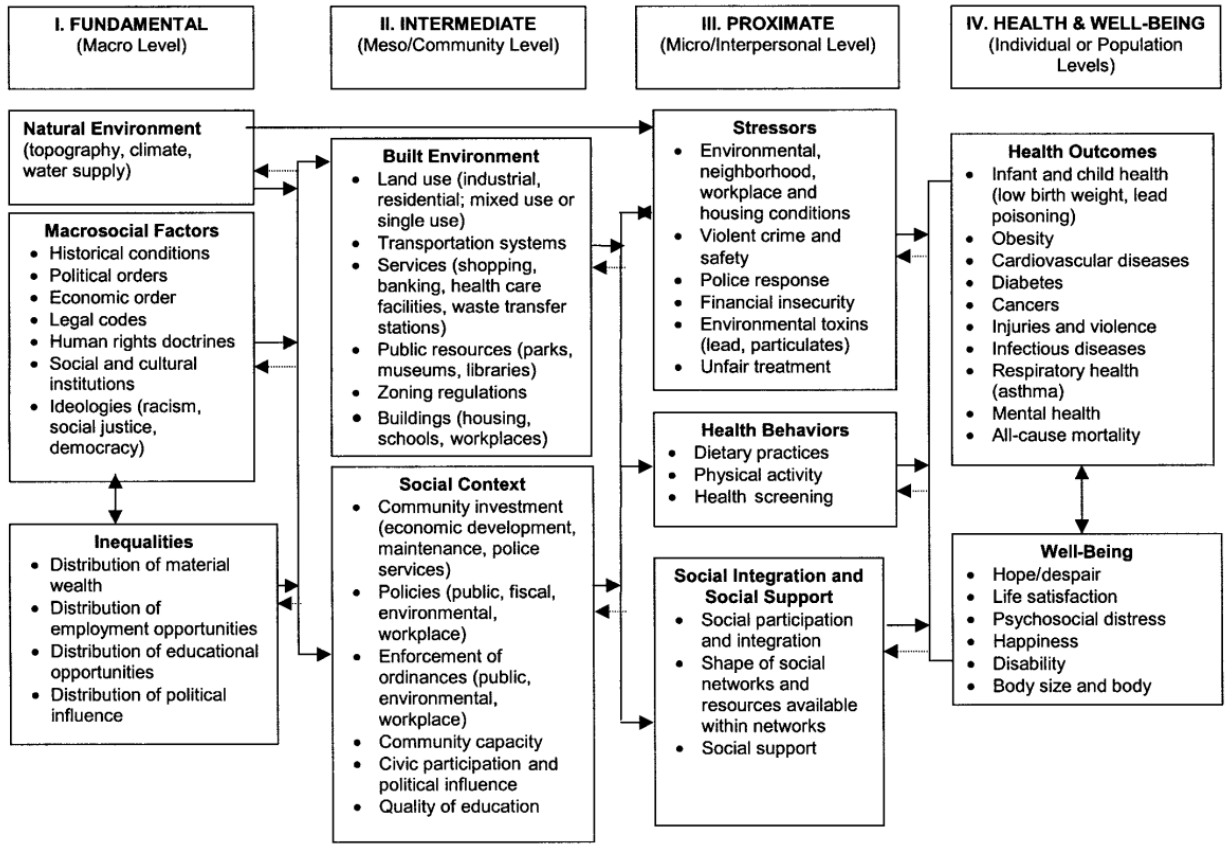
1 A. Comply fully with the International Code of Marketing of Breast-milk Substitutes and relevant World Health Assembly resolutions.
1 B. Have a written infant feeding policy that is routinely communicated to staff and parents.
1 C. Establish ongoing monitoring and data-management systems.
2. Ensure that staff have sufficient knowledge, competence, and skills to support breastfeeding.

KEY CLINICAL PRACTICES:

3. Discuss the importance and management of breastfeeding with pregnant women and their families.
4. Facilitate immediate and uninterrupted skin-to-skin contact and support mothers to initiate breastfeeding as soon as possible after birth.
5. Support mothers to initiate and maintain breastfeeding and manage common difficulties.
6. Do not provide breastfed newborns any food or fluids other than breast milk, unless medically indicated.
7. Enable mothers and their infants to remain together and to practice rooming-in 24 hours a day.
8. Support mothers to recognize and respond to their infants' cues for feeding.
9. Counsel mothers on the use and risks of feeding bottles, artificial nipples (teats) and pacifiers.
10. Coordinate discharge so that parents and their infants have timely access to ongoing support and care.

Source: Abrahams, S. W., & Labbok, M. H. (2009). Exploring the impact of the Baby-Friendly Hospital Initiative on trends in exclusive breastfeeding. International Breastfeeding Journal, 4(1), 11. https://doi.org/10.1186/1746-4358-4-11

Appendix B. The conceptual framework, developed by Northridge at al. (2003), that was adapted to create the overarching theoretical framework guiding this dissertation.



Source: Northridge, M. E. (2003). Sorting Out the Connections Between the Built Environment and Health: A Conceptual Framework for Navigating Pathways and Planning Healthy Cities. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *80*(4), 556–568. https://doi.org/10.1093/jurban/jtg064

Appendix C. LAC WIC Survey 2014: Download

Appendix D. LAC WIC Survey 2017: Download

Appendix E. Policy Action Areas (Domains), Indicators and their Data Sources for the Healthy Places Index (HPI) 3.0

Policy Action/Indicator	Definition	Correlation with LEB	Data Source, Year
Economic			
abovepoverty	Percent of the population with an income exceeding 200% of federal poverty level	0.58	ACS, 2015-2019
employed	Percentage of population aged 25-64 who are employed	0.4	ACS, 2015-2019
percapitaincome	Per capita income	0.53	ACS, 2015-2019
Education			
bachelorsed	Percentage of population over age 25 with a bachelor's education or higher	0.57	ACS, 2015-2019
inhighschool	Percentage of 15–17-year-olds enrolled in school	0.08	ACS, 2015-2019
inpreschool	Percentage of 3- and 4-year-olds enrolled in pre-school	0.29	ACS, 2015-2019
Social			
voting	Percentage of registered voters voting in the 2020 general election	0.52	UC Berkeley, 2020
censusresponse	Percentage of 2020 decennial households who completed census forms online, by mail, or by phone	0.37	Decennial Census 2020
Transportation			
automobile	Percentage of households with access to an automobile	0.25	ACS, 2015-2019
commute	Percentage of workers (16 years and older) commuting by walking, cycling, or transit (excluding working from home)	0.02	ACS, 2015-2019
Healthcare Access			
insured	Percentage of adults aged 18 to 64 years currently insured	0.37	ACS, 2015-2019
Neighborhood			
parkaccess	Percentage of the population living within ½-mile of a park, beach, or open space greater than 1 acre	0.08	GreenInfo, 2012
treecanopy	Population-weighted percentage of the census tract area with tree canopy	0.13	NLCD, 2011
retail	Combined employment density for retail, entertainment, and educational uses (jobs/acre)	0.02	USEPA, 2010
Housing			

homeownership	Percentage of occupied housing units occupied by property owners	0.33	ACS, 2015-2019
houserepair	Percent of households with complete kitchen facilities and plumbing	0.09	ACS, 2015-2019
ownsvsere	Percentage of low-income homeowners paying more than 50% of income on housing costs	-0.13	CHAS, 2010-2014
rentsvcre	Percentage of low-income renter households paying more than 50% of income on housing costs	-0.26	CHAS, 2010-2014
uncrowded	Percentage of households with less or equal to 1 occupant per room	0.29	ACS, 2015-2019
Clean Environment			
dieselpm	Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2016 summer day in July (kg/day) Census tracts were ordered by diesel PM concentration values and assigned a percentile based on the statewide distribution of values.	-0.08	CalEPA, 2016
h2ocontam	Cal EnviroScreen 4.0 drinking water contaminant index for selected contaminants	-0.06	CalEPA, 2011-2019
ozone	Mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2017 to 2019). Census tracts were ordered by ozone concentration values and assigned a percentile based on the statewide distribution of values.	-0.21	CalEPA, 2017-2019
pm25	Annual mean concentration of PM2.5 (average of quarterly means, $\mu g/m^3$), over three years (2015 to 2017) Census tracts were ordered by PM2.5 concentration values and assigned a percentile based on the statewide distribution of values.	-0.09	CalEPA, 2015-2017

Note: ACS: American Community Survey; CHAS: Comprehensive Housing Assessment System; CalEPA; California Environmental Protection Agency; GreenInfo (CaLANDS), NLCD: National Land Cover Database; USEPA:U.S. Environmental Protection Agency; LODES: LEHD Origin-Destination Employment Statistics; UC Berkeley: University of California, Berkeley
Source: Coline Bodenreider, Adrienne Damicis, Tracy Delaney, Helen Dowling, Neil Maizlish, Alexander Nikolai, Courtney Oei, & Bill Sadler. (2022). Healthy Places Index 3.0. Public Health Alliance of Southern California. https://cdn.prod.website-files.com/613a633a3add5db901277f96/63320a9e98493bbdcc03d509_HPI3TechnicalReport2022-09-20

Appendix F.1 Results of Multilevel Analysis of **Breastfeeding Initiation** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N= 8,771)				Model 2[b] (N=8,521)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.18	1.18	0.93	0.18	1.13	0.89	1.43	0.33
Quartile 3	1.25	1.25	0.87	0.23	1.30	0.88	1.91	0.19
Quartile 4	1.22	1.22	0.53	0.64	1.36	0.54	3.43	0.51
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.16	0.93	1.44	0.20	1.10	0.88	1.38	0.38
Quartile 3	1.27	0.91	1.76	0.16	1.28	0.91	1.80	0.16
Quartile 4	2.13	0.98	4.64	0.06	2.00	0.91	4.37	0.08
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.26	1.00	1.59	0.05	1.26	1.00	1.58	0.05
Quartile 3	1.42	1.07	1.88	0.02**	1.44	1.08	1.92	0.01*
Quartile 4	1.93	1.10	3.38	0.02**	2.20	1.20	4.03	0.01*
INSURANCE (Ref = Quartile 1)								
Quartile 2	1.08	0.82	1.42	0.59	1.09	0.82	1.45	0.55
Quartile 3	1.16	0.81	1.67	0.41	1.17	0.81	1.70	0.40
Quartile 4	1.01	0.48	2.11	0.98	1.14	0.52	2.53	0.74
HOUSING (Ref = Quartile 1)								
Quartile 2	0.81	0.61	1.07	0.14	0.77	0.58	1.03	0.07
Quartile 3	1.65	0.90	3.02	0.11	1.55	0.83	2.92	0.17
Quartile 4	1.00	0.52	1.93	1.00	0.99	0.51	1.92	0.97
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.93	0.73	1.18	0.57	0.91	0.71	1.15	0.43
Quartile 3	0.92	0.70	1.23	0.59	0.94	0.71	1.25	0.68
Quartile 4	3.68	1.14	11.90	0.03	5.01	1.21	20.80	0.03
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	1.11	0.87	1.40	0.41	1.01	0.80	1.29	0.91
Quartile 3	1.25	0.95	1.65	0.12	1.13	0.85	1.50	0.39
Quartile 4	1.42	0.92	2.19	0.11	1.30	0.84	2.02	0.25
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.22	0.96	1.54	0.11	1.11	0.87	1.41	0.40
Quartile 3	1.15	0.77	1.71	0.49	1.25	0.81	1.92	0.31
Quartile 4	1.45	0.52	4.04	0.48	1.23	0.44	3.46	0.69
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.84	0.68	1.04	0.10	0.86	0.69	1.06	0.16
Quartile 3/4[c]	0.66	0.43	1.01	0.06	0.75	0.49	1.15	0.18

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.2. Results of Multilevel Analysis of **Any Breastfeeding at 1 Month** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,093)				Model 2[b] (N=7,865)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.06	1.06	0.89	0.53	1.00	0.83	1.20	0.98
Quartile 3	1.21	1.21	0.90	0.21	1.10	0.82	1.50	0.52
Quartile 4	1.45	1.45	0.70	0.32	1.32	0.63	2.75	0.47
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.05	0.89	1.25	0.58	0.99	0.84	1.18	0.94
Quartile 3	1.15	0.89	1.49	0.29	1.04	0.80	1.35	0.77
Quartile 4	1.94	1.06	3.53	0.03	1.67	0.91	3.05	0.10
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.14	0.95	1.36	0.16	1.08	0.90	1.30	0.41
Quartile 3	1.20	0.96	1.49	0.11	1.14	0.91	1.42	0.27
Quartile 4	1.97	1.24	3.12	0.00*	1.79	1.11	2.87	0.02**
INSURANCE (Ref = Quartile 1)								
Quartile 2	0.96	0.78	1.18	0.68	0.94	0.76	1.15	0.53
Quartile 3	1.34	1.00	1.80	0.05	1.40	1.04	1.89	0.03
Quartile 4	1.13	0.60	2.12	0.71	1.00	0.53	1.89	1.00
HOUSING (Ref = Quartile 1)								
Quartile 2	1.01	0.80	1.28	0.93	0.99	0.78	1.25	0.92
Quartile 3	1.06	0.71	1.59	0.76	0.99	0.66	1.48	0.96
Quartile 4	1.52	0.83	2.81	0.18	1.48	0.80	2.74	0.21
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.92	0.77	1.10	0.37	0.88	0.73	1.05	0.15
Quartile 3	1.12	0.89	1.41	0.32	1.05	0.84	1.32	0.66
Quartile 4	1.07	0.63	1.82	0.80	1.06	0.61	1.87	0.83
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	1.10	0.91	1.33	0.31	1.07	0.88	1.30	0.48
Quartile 3	1.10	0.89	1.36	0.39	1.01	0.81	1.26	0.90
Quartile 4	1.26	0.90	1.76	0.18	1.19	0.85	1.67	0.32
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.02	0.85	1.22	0.86	0.95	0.79	1.15	0.62
Quartile 3	0.91	0.67	1.22	0.52	0.82	0.60	1.12	0.21
Quartile 4	2.27	0.82	6.26	0.11	1.99	0.72	5.52	0.19
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.93	0.78	1.09	0.35	0.94	0.79	1.11	0.44
Quartile 3/4 [c]	1.04	0.74	1.48	0.82	1.21	0.85	1.72	0.29

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.3. Results of Multilevel Analysis of **Any Breastfeeding at 3 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,912)				Model 2[b] ((N=7,693)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.04	1.04	0.91	0.61	0.99	0.86	1.14	0.90
Quartile 3	1.08	1.08	0.88	0.45	0.99	0.80	1.22	0.93
Quartile 4	1.40	1.40	0.86	0.18	1.30	0.79	2.14	0.30
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.03	0.91	1.18	0.63	1.00	0.87	1.14	0.96
Quartile 3	1.00	0.83	1.20	1.00	0.92	0.76	1.11	0.37
Quartile 4	1.56	1.07	2.28	0.02**	1.36	0.93	1.99	0.11
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.13	0.99	1.29	0.08	1.09	0.95	1.25	0.21
Quartile 3	1.14	0.97	1.34	0.11	1.08	0.92	1.27	0.34
Quartile 4	1.68	1.25	2.25	0.00*	1.51	1.12	2.04	0.01*
INSURANCE (Ref = Quartile 1)								
Quartile 2	0.95	0.81	1.11	0.53	0.92	0.78	1.08	0.29
Quartile 3	1.14	0.93	1.40	0.21	1.16	0.94	1.43	0.17
Quartile 4	1.08	0.70	1.68	0.73	0.99	0.63	1.54	0.95
HOUSING (Ref = Quartile 1)								
Quartile 2	0.91	0.77	1.08	0.28	0.89	0.75	1.06	0.19
Quartile 3	0.84	0.64	1.11	0.22	0.80	0.61	1.07	0.13
Quartile 4	1.25	0.84	1.86	0.28	1.24	0.82	1.85	0.31
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.97	0.85	1.11	0.67	0.93	0.81	1.07	0.32
Quartile 3	1.13	0.95	1.33	0.17	1.06	0.90	1.26	0.49
Quartile 4	1.32	0.89	1.98	0.17	1.32	0.87	2.02	0.19
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	1.03	0.90	1.20	0.64	1.00	0.87	1.16	0.95
Quartile 3	1.02	0.86	1.19	0.85	0.98	0.83	1.15	0.77
Quartile 4	1.22	0.95	1.56	0.12	1.14	0.89	1.46	0.30
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.04	0.90	1.19	0.61	0.99	0.86	1.13	0.85
Quartile 3	0.90	0.72	1.13	0.37	0.84	0.67	1.05	0.13
Quartile 4	1.09	0.65	1.84	0.74	0.99	0.58	1.68	0.98
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.90	0.79	1.01	0.08	0.90	0.80	1.02	0.11
Quartile 3/4 [c]	0.81	0.63	1.04	0.10	0.90	0.70	1.17	0.43

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.4. Results of Multilevel Analysis of **Any Breastfeeding at 6 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,612)				Model 2[b] (N=7,400)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	0.97	0.97	0.85	0.67	0.95	0.83	1.10	0.50
Quartile 3	1.09	1.09	0.90	0.38	1.07	0.87	1.31	0.53
Quartile 4	1.50	1.50	0.96	0.07	1.45	0.93	2.27	0.11
ECONOMIC (Ref = Quartile 1)								
Quartile 2	0.98	0.86	1.12	0.75	0.96	0.84	1.11	0.61
Quartile 3	1.00	0.84	1.20	0.96	0.98	0.81	1.18	0.80
Quartile 4	1.55	1.11	2.17	0.01*	1.41	1.00	1.98	0.05
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.10	0.95	1.26	0.20	1.08	0.94	1.25	0.29
Quartile 3	1.12	0.95	1.31	0.17	1.10	0.93	1.30	0.25
Quartile 4	1.98	1.51	2.60	0.00*	1.89	1.43	2.49	0.00*
INSURANCE (Ref = Quartile 1)								
Quartile 2	0.98	0.84	1.15	0.81	0.95	0.81	1.12	0.57
Quartile 3	1.13	0.93	1.39	0.23	1.20	0.97	1.48	0.09
Quartile 4	1.13	0.75	1.70	0.56	1.08	0.71	1.64	0.71
HOUSING (Ref = Quartile 1)								
Quartile 2	0.87	0.73	1.04	0.12	0.86	0.71	1.03	0.09
Quartile 3	0.95	0.72	1.25	0.69	0.96	0.72	1.27	0.76
Quartile 4	0.97	0.67	1.40	0.87	1.01	0.69	1.48	0.96
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.93	0.81	1.08	0.35	0.90	0.78	1.04	0.16
Quartile 3	1.07	0.90	1.26	0.46	1.02	0.86	1.21	0.83
Quartile 4	1.52	1.04	2.20	0.03	1.46	0.99	2.14	0.05
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	0.97	0.84	1.12	0.67	0.94	0.81	1.09	0.43
Quartile 3	0.95	0.80	1.11	0.50	0.92	0.78	1.08	0.31
Quartile 4	1.29	1.00	1.65	0.05	1.21	0.94	1.56	0.14
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.00	0.87	1.15	0.98	0.96	0.84	1.11	0.61
Quartile 3	0.84	0.68	1.04	0.12	0.82	0.66	1.02	0.08
Quartile 4	0.97	0.59	1.57	0.89	0.97	0.59	1.59	0.89
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.91	0.80	1.03	0.13	0.92	0.81	1.05	0.23
Quartile 3/4[c]	0.82	0.63	1.08	0.16	0.91	0.69	1.20	0.50

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.5. Results of Multilevel Analysis of **Any Breastfeeding at 9 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,219)				Model 2[b] (N=7,020)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.04	1.04	0.88	0.66	1.03	0.88	1.20	0.74
Quartile 3	1.07	1.07	0.86	0.54	1.08	0.87	1.35	0.48
Quartile 4	1.40	1.40	0.90	0.13	1.35	0.87	2.12	0.18
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.00	0.86	1.18	0.97	0.99	0.84	1.16	0.89
Quartile 3	1.00	0.82	1.23	0.99	0.99	0.80	1.21	0.89
Quartile 4	1.48	1.05	2.07	0.03	1.43	1.01	2.02	0.04
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.04	0.88	1.23	0.65	1.03	0.88	1.22	0.69
Quartile 3	1.25	1.04	1.50	0.02**	1.25	1.04	1.50	0.02**
Quartile 4	1.68	1.28	2.21	0.00*	1.64	1.25	2.17	0.00*
INSURANCE (Ref = Quartile 1)								
Quartile 2	0.96	0.80	1.15	0.69	0.93	0.78	1.11	0.42
Quartile 3	1.10	0.87	1.37	0.43	1.17	0.93	1.47	0.18
Quartile 4	0.90	0.59	1.38	0.62	0.87	0.56	1.35	0.54
HOUSING (Ref = Quartile 1)								
Quartile 2	0.76	0.62	0.93	0.01*	0.75	0.61	0.92	0.01*
Quartile 3	1.01	0.75	1.36	0.95	1.03	0.76	1.40	0.84
Quartile 4	1.00	0.66	1.50	0.98	1.08	0.71	1.63	0.72
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.95	0.80	1.12	0.52	0.92	0.78	1.09	0.32
Quartile 3	1.14	0.93	1.38	0.20	1.10	0.91	1.34	0.33
Quartile 4	1.42	0.96	2.09	0.08	1.36	0.92	2.02	0.13
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	0.92	0.77	1.09	0.31	0.91	0.77	1.08	0.30
Quartile 3	0.93	0.77	1.13	0.48	0.91	0.76	1.10	0.35
Quartile 4	1.22	0.92	1.61	0.17	1.14	0.87	1.50	0.35
SOCIAL (Ref = Quartile 1)								
Quartile 2	0.97	0.83	1.13	0.68	0.94	0.80	1.10	0.43
Quartile 3	0.85	0.67	1.09	0.20	0.86	0.67	1.09	0.21
Quartile 4	0.74	0.44	1.25	0.27	0.77	0.45	1.31	0.34
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.83	0.72	0.96	0.01*	0.85	0.73	0.98	0.02**
Quartile 3/4[c]	0.70	0.50	0.96	0.03	0.77	0.56	1.06	0.11

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.6. Results of Multilevel Analysis of **Any Breastfeeding at 12 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=6,773)				Model 2[b] (N=7,586)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.03	1.03	0.88	0.69	1.04	0.89	1.23	0.60
Quartile 3	0.94	0.94	0.75	0.62	0.98	0.78	1.23	0.84
Quartile 4	1.22	1.22	0.77	0.40	1.20	0.75	1.92	0.44
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.01	0.86	1.19	0.90	1.00	0.86	1.18	0.97
Quartile 3	0.94	0.76	1.16	0.57	0.95	0.77	1.18	0.67
Quartile 4	1.32	0.93	1.88	0.12	1.29	0.90	1.84	0.17
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.02	0.86	1.21	0.79	1.02	0.86	1.20	0.84
Quartile 3	1.25	1.04	1.50	0.02**	1.27	1.05	1.52	0.01*
Quartile 4	1.44	1.08	1.90	0.01*	1.43	1.08	1.91	0.01*
INSURANCE (Ref = Quartile 1)								
Quartile 2	0.97	0.81	1.17	0.77	0.95	0.79	1.15	0.62
Quartile 3	1.01	0.80	1.27	0.95	1.10	0.87	1.40	0.41
Quartile 4	0.74	0.46	1.18	0.20	0.71	0.44	1.16	0.17
HOUSING (Ref = Quartile 1)								
Quartile 2	0.76	0.61	0.93	0.01*	0.75	0.61	0.93	0.01*
Quartile 3	0.83	0.61	1.13	0.23	0.86	0.63	1.18	0.35
Quartile 4	0.96	0.63	1.47	0.86	1.07	0.69	1.64	0.77
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	1.01	0.86	1.20	0.86	0.99	0.84	1.17	0.91
Quartile 3	1.24	1.02	1.50	0.03	1.23	1.01	1.49	0.04
Quartile 4	1.53	1.03	2.27	0.04	1.48	0.99	2.21	0.06
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	0.88	0.74	1.04	0.14	0.87	0.73	1.03	0.12
Quartile 3	0.89	0.73	1.07	0.22	0.87	0.72	1.05	0.15
Quartile 4	1.07	0.81	1.42	0.63	1.00	0.76	1.33	0.99
SOCIAL (Ref = Quartile 1)								
Quartile 2	0.97	0.82	1.13	0.67	0.94	0.80	1.11	0.48
Quartile 3	0.81	0.63	1.04	0.10	0.83	0.65	1.07	0.15
Quartile 4	0.53	0.29	0.96	0.04	0.55	0.30	1.03	0.06
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.81	0.70	0.94	0.00*	0.84	0.73	0.97	0.02**
Quartile 3/4[c]	0.66	0.48	0.91	0.01*	0.72	0.52	1.00	0.05

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.7. Results of Multilevel Analysis of **Exclusive Breastfeeding at 1 Month** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,269)				Model 2[b] (N=8,030)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.13	0.98	0.86	0.70	0.94	0.82	1.07	0.33
Quartile 3	1.30	1.13	0.94	0.20	1.06	0.88	1.28	0.53
Quartile 4	1.36	1.23	0.82	0.32	1.14	0.76	1.72	0.53
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.16	1.02	1.31	0.02**	1.14	1.01	1.29	0.04
Quartile 3	1.08	0.91	1.27	0.39	1.01	0.85	1.20	0.91
Quartile 4	1.68	1.24	2.26	0.00*	1.63	1.20	2.22	0.00*
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.11	0.97	1.27	0.12	1.12	0.98	1.28	0.09
Quartile 3	1.15	0.99	1.33	0.07	1.14	0.98	1.33	0.09
Quartile 4	1.52	1.19	1.93	0.00*	1.49	1.17	1.91	0.00*
INSURANCE (Ref = Quartile 1)								
Quartile 2	1.09	0.95	1.26	0.23	1.05	0.91	1.23	0.49
Quartile 3	1.27	1.06	1.52	0.01*	1.20	0.99	1.46	0.06
Quartile 4	1.01	0.68	1.49	0.96	0.97	0.65	1.44	0.86
HOUSING (Ref = Quartile 1)								
Quartile 2	0.98	0.83	1.15	0.79	0.94	0.79	1.11	0.47
Quartile 3	1.12	0.86	1.45	0.40	1.02	0.79	1.34	0.85
Quartile 4	1.27	0.90	1.78	0.18	1.22	0.86	1.73	0.27
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.81	0.71	0.92	0.00*	0.81	0.71	0.93	0.00
Quartile 3	0.90	0.77	1.05	0.18	0.88	0.76	1.03	0.12
Quartile 4	1.05	0.74	1.48	0.79	1.11	0.78	1.57	0.57
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	1.00	0.88	1.15	0.95	1.01	0.88	1.16	0.91
Quartile 3	1.00	0.86	1.17	0.96	0.98	0.83	1.14	0.76
Quartile 4	1.11	0.88	1.39	0.37	1.06	0.84	1.33	0.64
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.05	0.93	1.20	0.44	1.01	0.89	1.15	0.90
Quartile 3	0.94	0.76	1.16	0.56	0.88	0.71	1.09	0.24
Quartile 4	1.03	0.65	1.64	0.90	0.95	0.59	1.53	0.84
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.94	0.83	1.05	0.28	0.93	0.82	1.05	0.24
Quartile 3/4[c]	1.04	0.81	1.33	0.78	1.04	0.81	1.34	0.76

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.8. Results of Multilevel Analysis of **Exclusive Breastfeeding at 3 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,254)				Model 2[b] (N=8,017)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	0.99	0.99	0.86	0.88	0.97	0.84	1.11	0.62
Quartile 3	1.21	1.21	0.99	0.06	1.16	0.94	1.42	0.17
Quartile 4	1.38	1.38	0.88	0.16	1.32	0.84	2.07	0.23
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.12	0.98	1.28	0.09	1.11	0.97	1.26	0.14
Quartile 3	1.11	0.92	1.34	0.28	1.05	0.87	1.27	0.63
Quartile 4	1.67	1.21	2.31	0.00*	1.61	1.16	2.23	0.00*
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.15	1.00	1.32	0.06	1.15	1.00	1.32	0.06
Quartile 3	1.15	0.98	1.36	0.10	1.14	0.96	1.34	0.13
Quartile 4	1.57	1.21	2.04	0.00*	1.50	1.15	1.96	0.00*
INSURANCE (Ref = Quartile 1)								
Quartile 2	1.12	0.96	1.31	0.14	1.10	0.94	1.28	0.24
Quartile 3	1.50	1.25	1.80	0.00*	1.43	1.19	1.73	0.00*
Quartile 4	0.98	0.62	1.55	0.94	0.96	0.60	1.51	0.85
HOUSING (Ref = Quartile 1)								
Quartile 2	0.97	0.81	1.16	0.77	0.96	0.80	1.14	0.61
Quartile 3	1.35	1.02	1.78	0.03	1.25	0.94	1.66	0.12
Quartile 4	1.47	1.03	2.10	0.03	1.46	1.02	2.09	0.04
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.86	0.75	0.99	0.04	0.86	0.75	0.99	0.03
Quartile 3	0.90	0.76	1.06	0.22	0.88	0.74	1.04	0.13
Quartile 4	1.20	0.82	1.74	0.35	1.24	0.85	1.80	0.27
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	1.00	0.87	1.17	0.95	1.01	0.87	1.17	0.86
Quartile 3	1.07	0.90	1.26	0.45	1.05	0.89	1.24	0.57
Quartile 4	1.12	0.87	1.43	0.39	1.07	0.84	1.37	0.58
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.04	0.91	1.20	0.58	1.01	0.88	1.16	0.91
Quartile 3	1.03	0.81	1.30	0.83	0.96	0.76	1.22	0.75
Quartile 4	1.23	0.74	2.05	0.43	1.19	0.71	2.00	0.50
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.98	0.86	1.11	0.72	0.97	0.86	1.10	0.62
Quartile 3/4[c]	1.16	0.90	1.50	0.25	1.17	0.92	1.49	0.21

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Appendix F.9. Results of Multilevel Analysis of **Exclusive Breastfeeding at 6 Months** by Healthy Places Index (HPI) Quartile Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,019)				Model 2[b] (N=7,790)			
HPI Quartile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI COMPSOITE (Ref = Quartile 1)								
Quartile 2	1.05	1.05	0.89	0.57	1.01	0.85	1.19	0.93
Quartile 3	1.28	1.28	1.00	0.05	1.23	0.95	1.59	0.12
Quartile 4	1.37	1.37	0.77	0.28	1.30	0.73	2.31	0.37
ECONOMIC (Ref = Quartile 1)								
Quartile 2	1.14	0.98	1.33	0.09	1.11	0.95	1.30	0.20
Quartile 3	1.20	0.95	1.51	0.13	1.12	0.88	1.42	0.34
Quartile 4	1.68	1.13	2.50	0.01*	1.61	1.08	2.40	0.02**
EDUCATION (Ref = Quartile 1)								
Quartile 2	1.13	0.96	1.34	0.14	1.12	0.95	1.33	0.18
Quartile 3	1.29	1.06	1.56	0.01*	1.27	1.04	1.55	0.02**
Quartile 4	1.53	1.11	2.12	0.01*	1.47	1.06	2.04	0.02**
INSURANCE (Ref = Quartile 1)								
Quartile 2	1.07	0.88	1.30	0.48	1.03	0.84	1.26	0.79
Quartile 3	1.25	0.99	1.58	0.06	1.23	0.97	1.57	0.09
Quartile 4	1.40	0.82	2.39	0.22	1.38	0.80	2.37	0.24
HOUSING (Ref = Quartile 1)								
Quartile 2	1.03	0.84	1.28	0.76	1.00	0.81	1.25	0.96
Quartile 3	1.26	0.88	1.80	0.21	1.14	0.79	1.65	0.49
Quartile 4	1.36	0.88	2.11	0.17	1.35	0.86	2.12	0.20
NEIGHBORHOOD (Ref = Quartile 1)								
Quartile 2	0.92	0.78	1.09	0.33	0.90	0.76	1.07	0.24
Quartile 3	1.18	0.97	1.43	0.10	1.13	0.93	1.38	0.22
Quartile 4	1.60	1.04	2.47	0.03	1.61	1.04	2.49	0.03
TRANSPORTATION (Ref = Quartile 1)								
Quartile 2	0.99	0.84	1.18	0.92	0.98	0.83	1.16	0.82
Quartile 3	1.05	0.86	1.28	0.62	1.01	0.83	1.23	0.95
Quartile 4	1.02	0.77	1.36	0.90	0.94	0.71	1.26	0.69
SOCIAL (Ref = Quartile 1)								
Quartile 2	1.01	0.86	1.19	0.92	0.97	0.82	1.15	0.75
Quartile 3	1.08	0.81	1.45	0.58	1.00	0.74	1.36	1.00
Quartile 4	1.34	0.70	2.54	0.38	1.31	0.69	2.52	0.41
CLEAN ENVIRO (Ref = Quartile 1)								
Quartile 2	0.92	0.79	1.07	0.27	0.91	0.78	1.06	0.22
Quartile 3/4[c]	0.98	0.74	1.30	0.91	1.00	0.75	1.32	0.98

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI quartile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI quartile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Due to the small sample size in Quartile 4, Quartiles 3 and 4 were combined for analysis.

Note: Most outcomes were analyzed using single-level logistic regression due to negligible ZIP code–level variance, except for transportation and social domain measures.

Appendix G.1 Results of Multilevel Analysis of **Breastfeeding Initiation** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N= 8,771)				Model 2[b] (N=8,521)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	2.12	1.20	3.75	0.01*	2.03	1.13	3.66	0.02**
Education	2.33	1.44	3.78	0.00*	2.48	1.51	4.06	0.00*
Economic	2.24	1.29	3.90	0.00*	2.09	1.19	3.69	0.01*
Insurance	1.32	0.77	2.24	0.31	1.37	0.79	2.38	0.27
Social	1.96	1.08	3.55	0.03	1.79	0.97	3.32	0.06
Transportation	1.55	0.99	2.43	0.05	1.34	0.85	2.10	0.22
Housing	1.20	0.69	2.10	0.52	1.10	0.62	1.94	0.76
Clean Environment	0.41	0.20	0.87	0.02	0.50	0.24	1.08	0.08
Neighborhood	1.20	0.70	2.07	0.51	1.24	0.71	2.15	0.45

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.2 Results of Multilevel Analysis of **Any Breastfeeding at 1 Month** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,093)				Model 2[b] (N=7,865)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.52	0.98	2.36	0.06	1.24	0.79	1.94	0.36
Education	1.89	1.30	2.75	0.00*	1.67	1.13	2.46	0.01*
Economic	1.49	0.97	2.29	0.07	1.21	0.78	1.87	0.41
Insurance	1.15	0.76	1.74	0.51	1.09	0.71	1.67	0.71
Social	1.22	0.78	1.93	0.39	0.99	0.62	1.58	0.97
Transportation	1.45	1.03	2.05	0.03	1.26	0.89	1.80	0.19
Housing	1.21	0.78	1.88	0.40	1.11	0.70	1.74	0.66
Clean Environment	0.81	0.45	1.44	0.47	0.97	0.54	1.75	0.92
Neighborhood	1.01	0.66	1.53	0.98	0.88	0.58	1.34	0.54

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.3 Results of Multilevel Analysis of **Any Breastfeeding at 3 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,912)				Model 2[b] ((N=7,693)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.27	0.92	1.74	0.14	1.07	0.78	1.49	0.66
Education	1.60	1.23	2.09	0.00*	1.42	1.08	1.87	0.01*
Economic	1.35	0.99	1.85	0.06	1.13	0.82	1.56	0.45
Insurance	0.99	0.73	1.34	0.95	0.94	0.69	1.28	0.69
Social	0.98	0.70	1.36	0.90	0.83	0.59	1.17	0.29
Transportation	1.14	0.88	1.48	0.33	1.04	0.80	1.36	0.78
Housing	0.93	0.68	1.28	0.67	0.88	0.64	1.22	0.44
Clean Environment	0.61	0.40	0.93	0.02**	0.68	0.44	1.06	0.09
Neighborhood	1.21	0.89	1.66	0.23	1.09	0.79	1.50	0.61

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.4 Results of Multilevel Analysis of **Any Breastfeeding at 6 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,612)				Model 2 [b] (N=7,400)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.24	0.91	1.70	0.17	1.17	0.85	1.61	0.35
Education	1.84	1.42	2.39	0.00*	1.75	1.33	2.30	0.00*
Economic	1.37	1.01	1.88	0.05	1.27	0.92	1.75	0.15
Insurance	1.00	0.74	1.34	0.98	1.02	0.75	1.38	0.92
Social	0.80	0.58	1.11	0.19	0.75	0.54	1.06	0.10
Transportation	1.04	0.79	1.35	0.80	0.96	0.73	1.27	0.79
Housing	0.87	0.63	1.19	0.38	0.89	0.64	1.23	0.47
Clean Environment	0.63	0.41	0.98	0.04	0.73	0.46	1.15	0.17
Neighborhood	1.32	0.96	1.82	0.08	1.22	0.88	1.68	0.24

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.5 Results of Multilevel Analysis of **Any Breastfeeding at 9 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=7,219)				Model 2[b] (N=7,020)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.20	0.85	1.70	0.30	1.18	0.83	1.68	0.36
Education	1.89	1.41	2.53	0.00*	1.84	1.37	2.48	0.00*
Economic	1.42	1.00	2.00	0.05	1.37	0.96	1.94	0.08
Insurance	0.88	0.63	1.23	0.46	0.92	0.66	1.29	0.63
Social	0.74	0.51	1.07	0.11	0.73	0.50	1.06	0.10
Transportation	1.00	0.73	1.36	1.00	0.94	0.69	1.28	0.69
Housing	0.81	0.57	1.16	0.25	0.85	0.59	1.22	0.38
Clean Environment	0.42	0.25	0.70	0.00*	0.49	0.29	0.81	0.01*
Neighborhood	1.46	1.02	2.09	0.04	1.38	0.97	1.98	0.07

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.6 Results of Multilevel Analysis of **Any Breastfeeding at 12 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=6,773)				Model 2[b] (N =6,586)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.00	0.70	1.43	1.00	1.02	0.71	1.47	0.90
Education	1.71	1.27	2.32	0.00*	1.73	1.28	2.34	0.00*
Economic	1.21	0.85	1.72	0.30	1.22	0.85	1.75	0.28
Insurance	0.75	0.54	1.06	0.11	0.82	0.58	1.17	0.27
Social	0.61	0.42	0.90	0.01*	0.63	0.42	0.93	0.02**
Transportation	0.86	0.63	1.18	0.36	0.81	0.59	1.11	0.19
Housing	0.67	0.46	0.96	0.03	0.72	0.50	1.05	0.09
Clean Environment	0.38	0.23	0.63	0.00*	0.45	0.27	0.76	0.00*
Neighborhood	1.71	1.20	2.45	0.00*	1.67	1.16	2.38	0.01*

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.7 Results of Multilevel Analysis of **Exclusive Breastfeeding at 1 Month** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,269)				Model 2[b] (N=8,030)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.31	0.98	1.75	0.07	1.18	0.87	1.59	0.29
Education	1.47	1.15	1.89	0.00*	1.44	1.12	1.86	0.00*
Economic	1.36	1.02	1.82	0.03	1.24	0.92	1.67	0.15
Insurance	1.38	1.04	1.81	0.02**	1.25	0.93	1.66	0.14
Social	1.07	0.79	1.46	0.66	0.94	0.68	1.29	0.70
Transportation	1.05	0.82	1.35	0.70	0.99	0.77	1.28	0.96
Housing	1.30	0.97	1.74	0.08	1.16	0.86	1.57	0.34
Clean Environment	0.77	0.51	1.18	0.23	0.74	0.48	1.13	0.16
Neighborhood	0.87	0.65	1.18	0.37	0.86	0.64	1.16	0.32

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.8 Results of Multilevel Analysis of **Exclusive Breastfeeding at 3 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,254)				Model 2[b] (N=8,017)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.51	1.10	2.07	0.01*	1.38	1.00	1.90	0.05
Education	1.53	1.17	2.02	0.00*	1.47	1.12	1.94	0.01*
Economic	1.47	1.07	2.01	0.02**	1.34	0.98	1.85	0.07
Insurance	1.77	1.33	2.36	0.00*	1.65	1.23	2.22	0.00*
Social	1.26	0.90	1.76	0.18	1.13	0.80	1.60	0.47
Transportation	1.17	0.89	1.54	0.26	1.12	0.86	1.47	0.41
Housing	1.66	1.23	2.25	0.00*	1.54	1.13	2.11	0.01*
Clean Environment	1.09	0.69	1.70	0.72	1.05	0.67	1.64	0.84
Neighborhood	0.88	0.64	1.22	0.46	0.85	0.62	1.17	0.32

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix G.9 Results of Multilevel Analysis of **Exclusive Breastfeeding at 6 Months** by Healthy Places Index (HPI) Percentile Score Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N=8,019)				Model 2[b] (N=7,790)			
HPI Percentile	OR	CI low	CI high	P-value	OR	CI low	CI high	P-value
HPI Composite	1.61	1.10	2.34	0.01*	1.43	0.97	2.12	0.07
Education	1.78	1.29	2.46	0.00*	1.69	1.21	2.35	0.00*
Economic	1.62	1.12	2.34	0.01*	1.45	0.99	2.13	0.06
Insurance	1.54	1.08	2.20	0.02**	1.47	1.01	2.14	0.04
Social	1.26	0.84	1.90	0.26	1.10	0.72	1.69	0.65
Transportation	1.08	0.78	1.48	0.65	0.99	0.72	1.35	0.93
Housing	1.50	1.03	2.18	0.03	1.40	0.95	2.07	0.09
Clean Environment	0.66	0.39	1.11	0.12	0.64	0.37	1.09	0.10
Neighborhood	1.58	1.08	2.31	0.02**	1.49	1.01	2.19	0.04

*Significant at 0.01

** Marginal significance at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

b. Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix H. Summary of statistically significant associations across breastfeeding outcomes for HPI composite and domain models (Percentile)

	Initiation		Any at 3 months		Any at 6 months		Exclusivity at 3 months		Exclusivity at 6 months	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
HPI Composite	0.01*	0.02**	X	X	X	X	0.01*	X	0.01*	X
Education	0.00*	0.00*	0.00*	0.01*	0.00*	0.00*	0.00*	0.01*	0.00*	0.00*
Economic	0.00*	0.01*	X	X	X	X	0.02**	X	0.01*	X
Insurance	X	X	X	X	X	X	0.00*	0.00*	0.02**	X
Social	X	X	X	X	X	X	X	X	X	X
Transportation	X	X	X	X	X	X	X	X	X	X
Housing	X	X	X	X	X	X	0.00*	0.01*	X	X
Clean Environment	X	X	0.02**	X	X	X	X	X	X	X
Neighborhood	X	X	X	X	X	X	X	X	0.02**	X

Notes:
*Significant at 0.01
** Marginal significance at 0.02
X = Not significant
Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.
Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix I. Model Fit Indices Comparing Model 1 and Model 2 for HPI Operationalized as Quartiles Versus Percentiles

	Breastfeeding Initiation				Any at 3 Months				Any at 6 Months			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
	HPI COMPOSITE				HPI COMPOSITE				HPI COMPOSITE			
Quartile	4162.1	4197.5	3952.6	4030.2	9118.8	9153.6	8733.2	8809.7	10377.5	10412.2	9916.1	9992.1
Percentile	4154	4175.3	3945.5	4008.9	9115	9135.9	8730.2	8792.8	10376.1	10396.9	9915.2	9977.4
	ECONOMIC				ECONOMIC				ECONOMIC			
Quartile	4158.7	4194.1	3952.6	4030.2	9115.2	9150.1	8733.2	8809.7	10374.4	10409.1	9916.1	9992.1
Percentile	4152.6	4173.9	3944.6	4008.1	9113.6	9134.5	8729.8	8792.4	10374	10394.8	9914	9976.2
	EDUCATION				EDUCATION				EDUCATION			
Quartile	4153.8	4189.2	3950.1	4027.7	9106.7	9141.6	8730.6	8807	10356.1	10390.7	9915.1	9991.1
Percentile	4149	4170.3	3938.1	4001.6	9105.4	9126.3	8724.3	8786.8	10357.8	10378.6	9900.1	9962.3
	INSURANCE				INSURANCE				INSURANCE			
Quartile	4164.1	4199.5	3954.2	4031.7	9118.8	9153.7	8730.9	8807.3	10380	10414.7	9916.4	9992.4
Percentile	4159.9	4181.1	3950	4013.4	9117.1	9138.1	8730.3	8792.8	10378	10398.8	9916.1	9978.3
	SOCIAL				SOCIAL				SOCIAL			
Quartile	4161.7	4197.1	3953.6	4031.1	9119.8	9154.6	8732.1	8808.6	10379.5	10414.2	9917.1	9993.1
Percentile	4155.9	4177.1	3947.7	4011.1	5415.7	5436.7	8729.3	8791.8	10376.3	10397.1	9913.5	9975.7
	TRANSPORTATION				TRANSPORTATION				TRANSPORTATION			
Quartile	4160.9	4196.3	3953.2	4030.8	9118.6	9153.4	8733	8809.4	10376	10410.7	9915.1	9991.1
Percentile	4157.3	4178.5	3949.7	4013.1	9116.2	9137.1	8730.3	8792.9	10378	10398.8	9916.1	9978.3
	CLEAN ENVIRO				CLEAN ENVIRO				CLEAN ENVIRO			
Quartile	4157.8	4186.1	3950.1	4020.6	9114.5	9142.4	8729.6	8799.1	10376.6	10404.3	9916.5	9985.6
Percentile	4155.5	4176.8	3948.1	4011.6	9112.1	9133	8727.6	8790.1	10373.9	10394.7	9914.3	9976.5
	HOUSING				HOUSING				HOUSING			
Quartile	4159.5	4194.9	3949.7	4027.2	9117.3	9152.2	8729.4	8805.8	10379.5	10414.2	9917.2	9993.3
Percentile	4160.5	4181.8	3951.1	4014.6	9117	9137.9	8729.8	8792.4	10377.3	10398.1	9915.6	9977.8
	NEIGHBORHOOD				NEIGHBORHOOD				NEIGHBORHOOD			
Quartile	4156.6	4192	3945.2	4022.8	9115.7	9150.6	8729.3	8805.7	10373.4	10408.1	9911.8	9987.8
Percentile	4160.5	4181.7	3950.6	4014.1	9115.7	9136.6	8730.2	8792.7	10375	10395.8	9914.7	9976.9

Appendix I (cont.)

	Exclusivity at 3 months				Exclusivity at 6 months			
	Model 1		Model 2		Model 1		Model 2	
	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
	HPI COMPOSITE				HPI COMPOSITE			
Quartile	8607.3	8642.4	8353.8	8430.7	5528.9	5563.8	5364.3	5440.9
Percentile	8602.3	8623.3	8349.9	8412.8	5523.6	5544.5	5360.1	5422.8
	ECONOMIC				ECONOMIC			
Quartile	8602.3	8637.4	8353.8	8430.7	5524.9	5559.9	5364.3	5440.9
Percentile	8603.1	8624.1	8350.4	8413.3	5523.1	5544	5359.7	5422.4
	EDUCATION				EDUCATION			
Quartile	8599.9	8635	8349	8425.9	5522.3	5557.3	5361.4	5438
Percentile	8599.4	8620.5	8346.1	8409	5517.5	5538.4	5353.9	5416.6
	INSURANCE				INSURANCE			
Quartile	8595.7	8630.8	8344.7	8421.5	5528.7	5563.6	5363.6	5440.1
Percentile	8595	8616.1	8343.6	8406.5	5523.9	5544.9	5359.3	5421.9
	SOCIAL				SOCIAL			
Quartile	8611.9	8647	8357.1	8434	5532.5	5567.4	5366.5	5443.1
Percentile	8607	8628.1	8353.2	8416.1	5528.2	5549.2	5363.1	5425.8
	TRANSPORTATION				TRANSPORTATION			
Quartile	8611.5	8646.6	8357.2	8434	5533.1	5568	5367.1	5443.7
Percentile	8607.5	8628.6	8353	8415.9	5529.3	5550.2	5363.3	5426
	CLEAN ENVIRO				CLEAN ENVIRO			
Quartile	8609.2	8637.3	8353.7	8423.6	5530.3	5558.2	5363.7	5433.4
Percentile	8608.7	8629.7	8353.6	8416.5	5527	5548	5360.6	5423.2
	HOUSING				HOUSING			
Quartile	8604.3	8639.4	8351	8427.9	5530.3	5565.3	5365.4	5441.9
Percentile	8598.9	8620	8346.8	8409.7	5525.1	5546.1	5360.6	5423.2
	NEIGHBORHOOD				NEIGHBORHOOD			
Quartile	8606.5	8641.6	8350.4	8427.3	5522.1	5557.1	5356.7	5433.3
Percentile	8608.2	8629.3	8352.7	8415.6	5523.9	5544.9	5359.2	5421.8

Note: AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion. Lower values indicate better model fit.

** Marginal significance at 0.02

X = Not significant

Model 1 (Unadjusted Model): Examines the unadjusted association between HPI percentile and breastfeeding practices.

Model 2 (Adjusted Model): Examines the association between HPI percentile and breastfeeding practices after adjusting for maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.

Appendix J. Survey questions used to measure individual-level maternal covariates from the 2014 and 2017 LAC WIC Survey.

Variable	Survey Question
Partner Support	• Does NAME's other parent or legal guardian live in this household? • Is NAME'S (father) (mother) an active part of (his) (her) life?
Workplace accommodations	• Since the birth of NAME did you return to work or begin a new job? o (If yes): How old was NAME when you first returned to work or began work? • When you went back to work, did your workplace have accommodations for you to breast-feed? This includes giving you a break time and a place to pump milk or breast-feed your baby.

Source: *L.A. County WIC Data Sources*. (n.d.). WIC Data L.A. County. https://lawicdata.org/survey/

Appendix K.1 Results of Multilevel Analysis examining ZIP Code-Level Measure of Food Access and **Initiation** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.966	0.920–1.010	0.16	0.968	0.921–1.020	0.20
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.784	0.595–1.030	0.09	0.799	0.600–1.060	0.13
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.963	0.600–1.550	0.876	1.010	0.622–1.650	0.96
High Concentration	0.821	0.525–1.280	0.389	0.875	0.551–1.390	0.57

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.2 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 1 Month** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.971	0.936–1.010	0.12	0.981	0.944–1.020	0.31
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.863	0.696–1.070	0.17	0.907	0.728–1.130	0.39
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.870	0.591–1.280	0.48	0.920	0.620–1.370	0.68
High Concentration	0.785	0.543–1.130	0.20	0.854	0.586–1.250	0.41

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.3 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 3 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.979	0.952–1.010	0.12	0.987	0.960–1.010	0.34
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.929	0.798–1.080	0.35	0.976	0.834–1.140	0.76
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.908	0.697–1.180	0.48	0.927	0.708–1.220	0.59
High Concentration	0.879	0.684–1.130	0.31	0.929	0.718–1.200	0.57

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.4 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 6 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.969	0.943–0.996	0.02**	0.97	0.944–0.998	0.04
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.902	0.777–1.040	0.17	0.917	0.788–1.070	0.27
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.842	0.657–1.080	0.17	0.853	0.662–1.100	0.22
High Concentration	0.804	0.636–1.020	0.07	0.817	0.642–1.040	0.10

*Significant at 0.01

**Marginally Significant at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.5 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 9 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.968	0.939–0.999	0.04	0.967	0.937–0.997	0.03
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.898	0.762–1.060	0.20	0.905	0.767–1.070	0.24
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.940	0.722–1.230	0.65	0.947	0.724–1.240	0.69
High Concentration	0.891	0.694–1.140	0.36	0.885	0.686–1.140	0.35

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.6 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 12 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.979	0.949–1.010	0.19	0.974	0.943–1.000	0.10
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.943	0.797–1.120	0.50	0.93	0.784–1.100	0.41
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	1.030	0.785–1.360	0.81	1.030	0.781–1.370	0.82
High Concentration	0.962	0.741–1.250	0.77	0.934	0.715–1.220	0.62

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.7. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 1 Month** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.954	0.931–0.978	0.00*	0.957	0.933–0.981	0.00*
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.795	0.694–0.911	0.00*	0.808	0.703–0.928	0.00*
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.785	0.625–0.986	0.03	0.804	0.638–1.010	0.07
High Concentration	0.695	0.560–0.863	0.00*	0.719	0.576–0.896	0.00*

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.8. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 3 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.951	0.926–0.977	0.00*	0.953	0.928–0.980	0.00*
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.76	0.655–0.881	0.00*	0.774	0.666–0.900	0.00*
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.784	0.612–1.000	0.06	0.805	0.627–1.030	0.09
High Concentration	0.661	0.523–0.835	0.00*	0.683	0.538–0.866	0.00*

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix K.9. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 6 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Neighborhood Racial/Ethnic Concentration	Model 1[a] (N= 8,783)			Model 2[b] (N= 8,547)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMARY ANALYSES						
Percentage of Hispanic residents within a ZIP code[c]	0.954	0.924–0.986	0.00*	0.953	0.922–0.985	0.00*
SENSITIVITY ANALYSES						
Binary neighborhood Hispanic concentration *(Ref: Low)*[d]	0.81	0.674–0.975	0.03	0.814	0.673–0.984	0.03
Tertile neighborhood Hispanic concentration *(Ref: Low)*[e]	-	-	-	-	-	-
Moderate Concentration	0.837	0.610–1.150	0.27	0.828	0.602–1.140	0.25
High Concentration	0.71	0.526–0.958	0.03	0.701	0.517–0.950	0.02**

*Significant at 0.01

**Marginally Significant at 0.02

a. Model 1 (Unadjusted Model): Examines the unadjusted association between neighborhood Hispanic concentration and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percentage Hispanic residents within a ZIP code.
d. ZIP codes with a percentage of Hispanic residents below 41.6% were categorized as low concentration and those with 41.6% or higher were categorized as high concentration.
e. ZIP codes with 3.63%–25.8% Hispanic residents were categorized as low, 25.9%–53.8% as moderate, and 53.9%–97.7% as high.

Appendix L.1 Results of Multilevel Analysis examining ZIP Code-Level Measure of Food Access and **Initiation** Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N= 8,726)			Model 2[b] (N=8,477)		
Food Environment Measure	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.997	(0.993, 1.000)	0.11	0.998	(0.994, 1.000)	0.34
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.856	(0.696, 1.050)	0.142	0.888	(0.720, 1.090)	0.26

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.2 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 1 Month** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 8,771)			Model 2[b] (N=8,521)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.996	(0.993, 0.999)	0.00*	0.99	(0.994, 1.000)	0.13
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.867	(0.742, 1.010)	0.08	0.92	(0.783, 1.080)	0.31

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.3 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 3 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 7,869)			Model 2[b] (N=7,651)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.997	(0.995, 0.999)	0.01*	0.998	(0.996, 1.000)	0.19
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.900	(0.800, 1.010)	0.08	0.953	(0.844, 1080)	0.44

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.4 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 6 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 7,573)			Model 2[b] (N=7,362)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.996	(0.994, 0.998)	0.00*	0.997	(0.995, 1.000)	0.03
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.888	(0.786, 1.000)	0.06	0.939	(0.828, 1.060)	0.32

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.5 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 9 Months** Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N= 7,181)			**Model 2[b] (N=6,983)**		
Food Environment Measure	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.995	(0.992, 0.998)	0.00*	0.996	(0.993, 0.999)	0.00*
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.854	(0.741, 0.984)	0.03	0.888	(0.771, 1.020)	0.09

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.6 Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Any Breastfeeding at 12 Months** Among Los Angeles County WIC Participants, 2014 and 2017

	Model 1[a] (N= 6,735)			**Model 2[b] (N=6,549)**		
Food Environment Measure	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.995	(0.993, 0.998)	0.00*	0.996	(0.993, 0.999)	0.00*
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.855	(0.741, 0.984)	0.03	0.87	(0.763, 1.01	0.07

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.7. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 1 Month** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 8,226)			Model 2[b] (N=7,988)		
	OR	95% CI	P-value	OR	95% CI	P-value
PRIMMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.999	(0.997, 1.000)	0.34	0.999	(0.997, 1.000)	0.66
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.948	(0.845, 1.060)	0.36	0.982	(0.874, 1.10)	0.76

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.8. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 3 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 8,212)			Model 2[b] (N=7,976)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.999	(0.996, 1.000)	0.42	0.990	(0.997, 1.000)	0.69
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.978	(0.863, 1.110)	0.73	1.000	(0.888,1.130)	0.96

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

Appendix L.9. Results of Multilevel Analysis Examining ZIP Code-Level Measure of Food Access and **Exclusive Breastfeeding at 6 Months** Among Los Angeles County WIC Participants, 2014 and 2017

Food Environment Measure	Model 1[a] (N= 7,979)			Model 2[b] (N=7,751)		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
PRIMMARY ANALYSES						
Percent of ZIP residents living in a food desert tract[c]	0.999	(0.996, 1.000)	0.44	1.000	(0.997, 1.000)	0.78
SENSITIVITY ANALYSES						
Food Desert ZIP code *(Ref: Food Desert)*[d]	0.990	(0.857, 1.140)	0.89	1.030	(0.890,1.190)	0.70

*Significant at 0.01

a. Model 1 (Unadjusted Model): Examines the unadjusted association between ZIP-level food access measure and breastfeeding practices.
b. Model 2 (Adjusted Model): Examines the adjusted association after adding maternal covariates, including maternal age, race/ethnicity, preterm birth, food security status, use of EBT, and maternal education.
c. Continuous variable defined as the percent of ZIP code population residing in a food desert tract. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.
d. Binary variable defined as whether ≥33% of the ZIP code population resides in food desert tracts. Food desert tracts are defined as low-income, low-access areas using a 0.5-mile threshold in urban areas and a 10-mile threshold in rural areas.

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